International Trade: Lecture 13

The Standard Trade Model, Gravity, and Welfare

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Fall 2025

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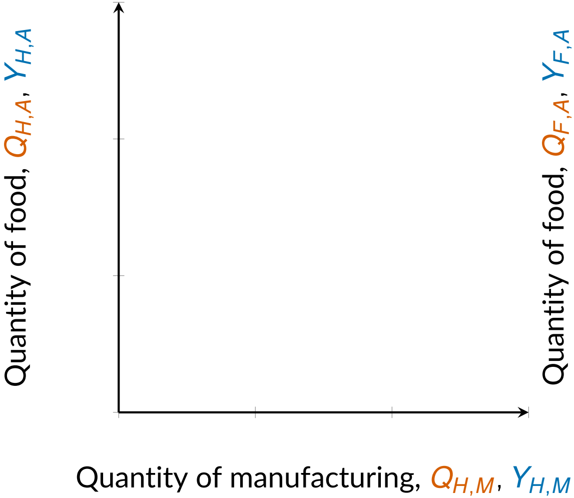
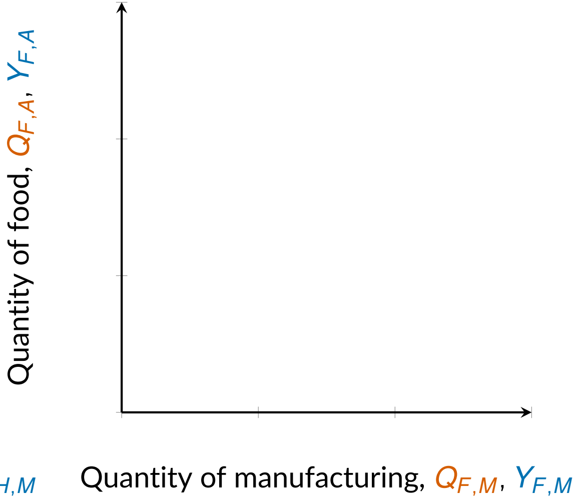
  (Florida is good at producing oranges, Georgia is good at producing peaches)
- Next: interindustry trade – Krugman (time permitting) Melitz models
  (American cars are *differentiated* from Euro cars; demand for both)

This class

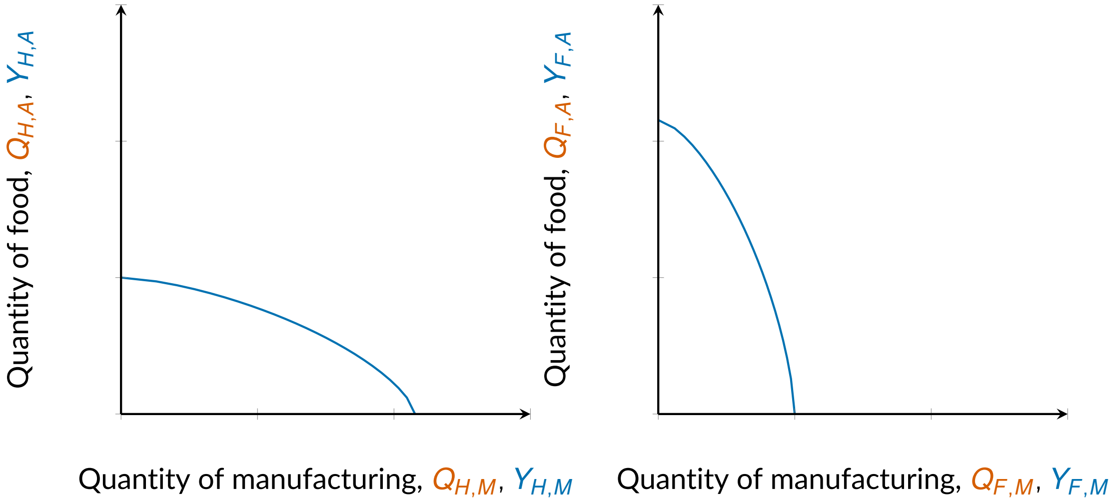
- Shared patterns of all of these models: “standard trade model”
- The Gravity Equation
- Empirical estimates of welfare gains
- Data Lab will go hands-on later.

Graphical representation

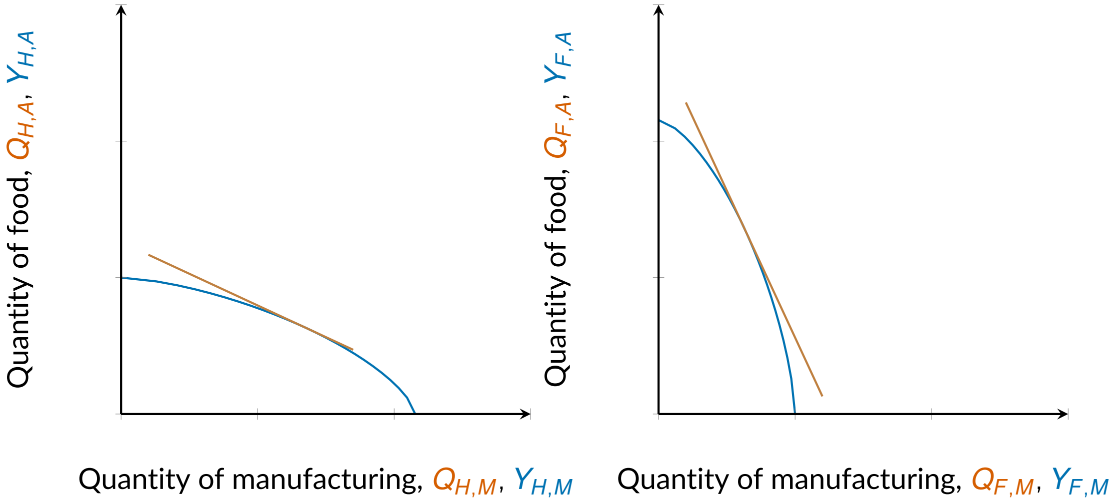




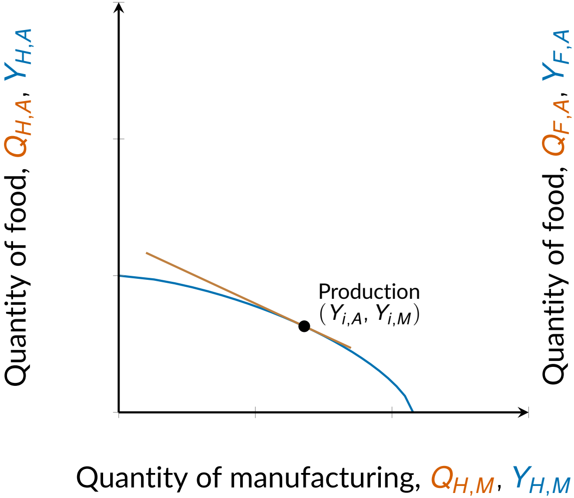
Graphical representation: PPF

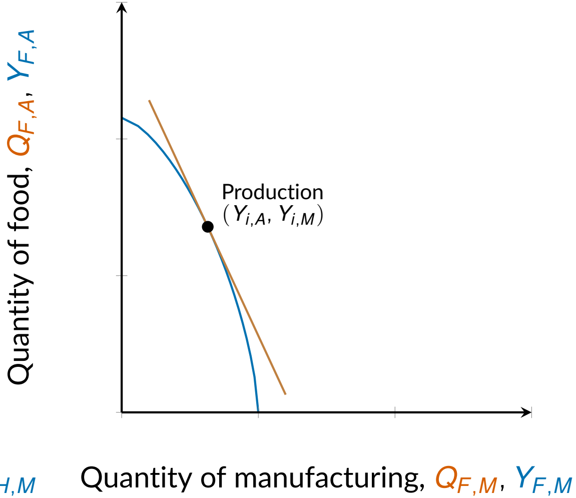


Graphical representation: autarky prices

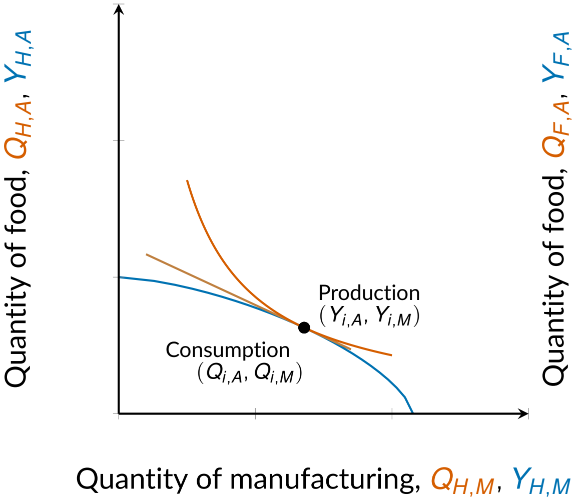


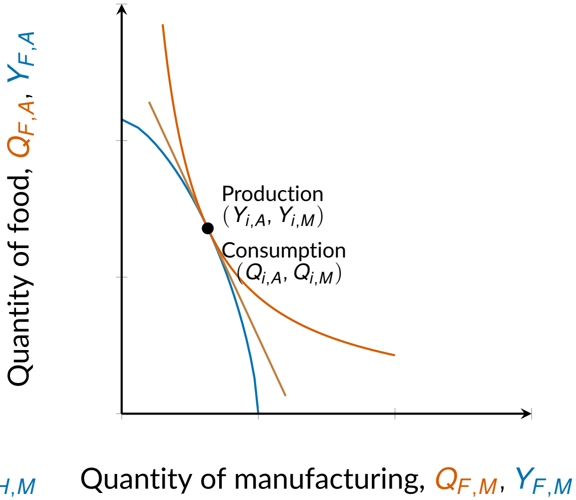
Graphical representation: autarky production





Graphical representation: autarky equilibrium (consumption + production)





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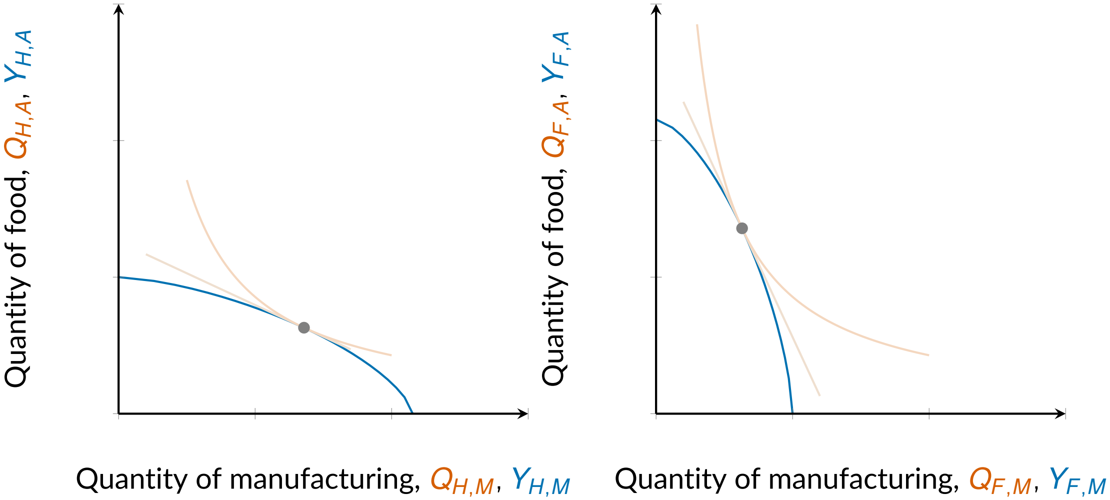
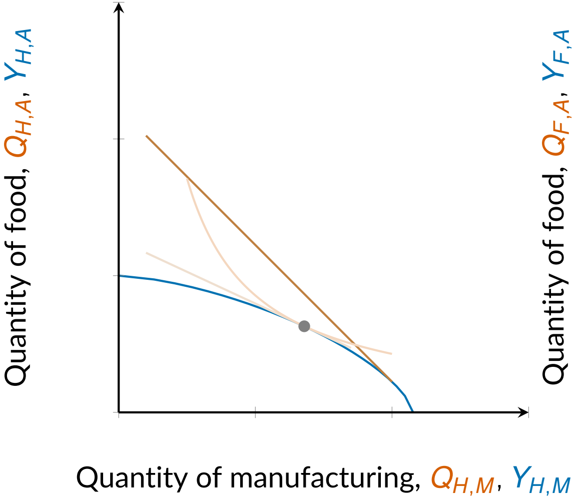
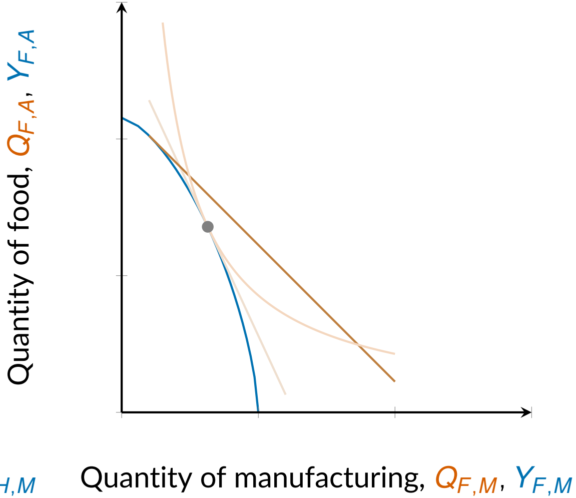
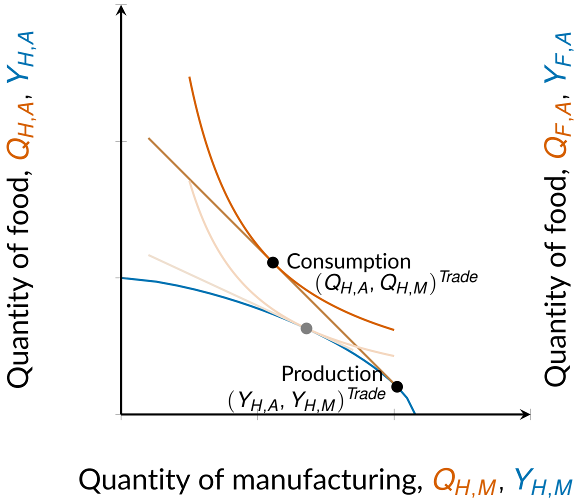


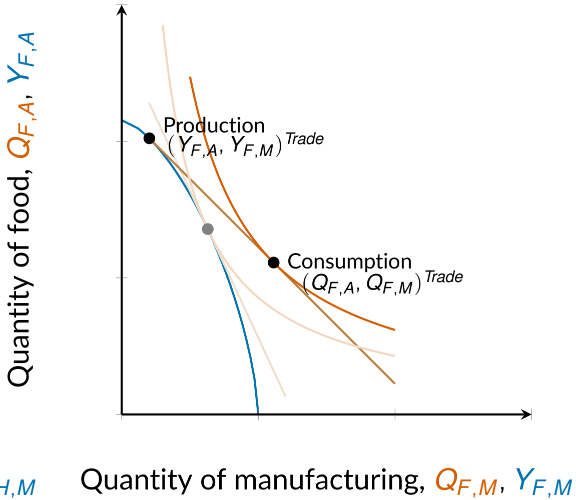
Graphical representation: free trade prices



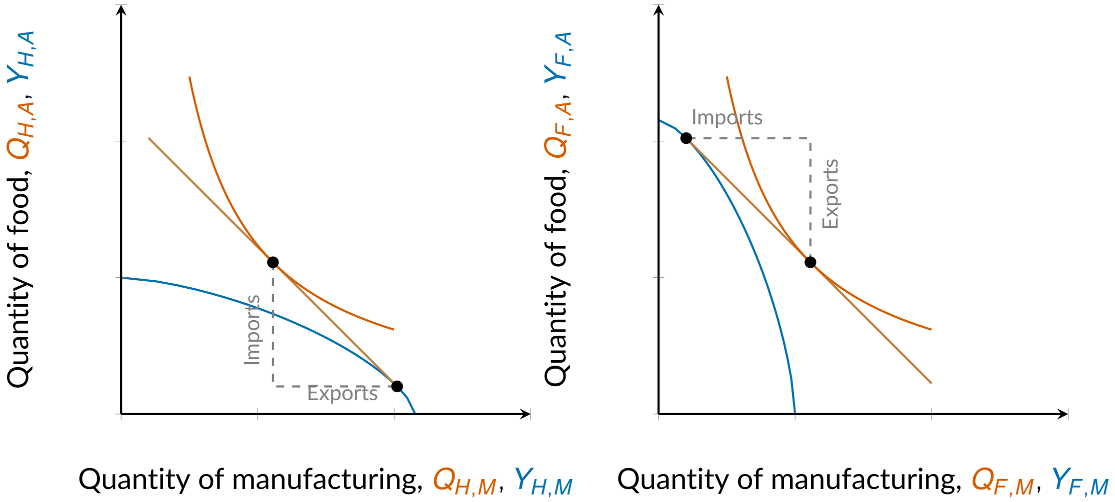


Graphical representation: trade equilibrium

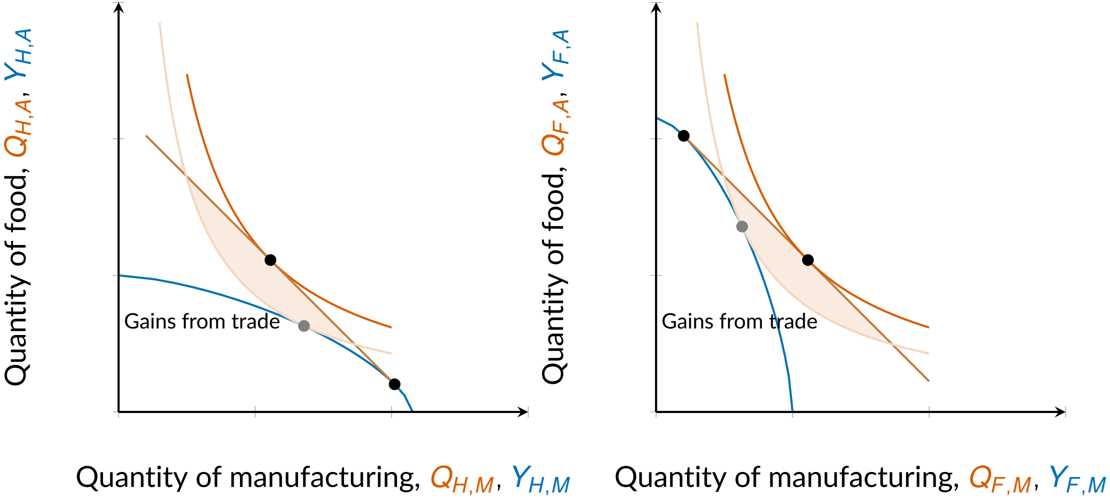




Graphical representation: specialization patterns



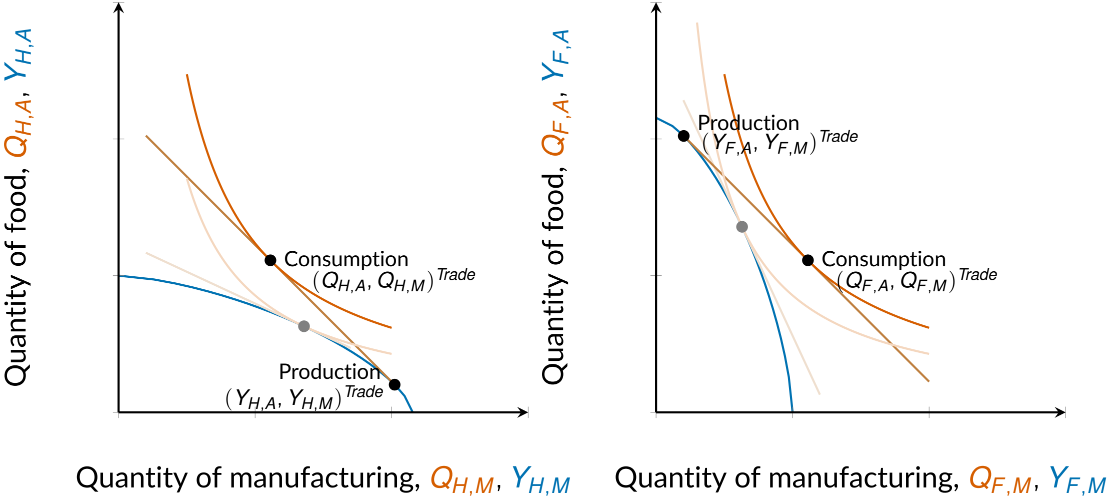
Graphical representation: gains from trade



Key STM objects and notation

- Two goods: M (manufacturing) and A (agriculture/food). Relative price: $p \equiv P_M / P_A$
- Domestic relative supply: $RS(p) \equiv \frac{Y_M(p)}{Y_A(p)}$
- Domestic relative demand: $RD(p) \equiv \frac{Q_M(p,Y)}{Q_A(p,Y)}$
- World equilibrium: p^w s.t. $RS^{\text{world}}(p^w) = RD^{\text{world}}(p^w)$
- Terms of Trade: $\text{ToT} = \frac{P_{\text{exports}}}{P_{\text{imports}}}$
  - Do ToT of either country increase or decrease after they open up to trade in the STM?

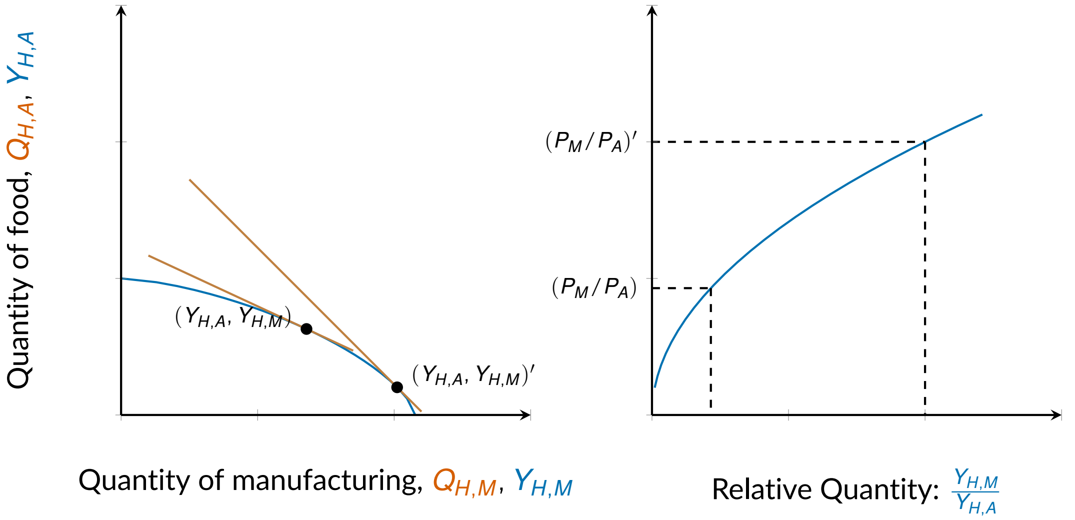
Graphical representation: trade equilibrium



From PPF to RS

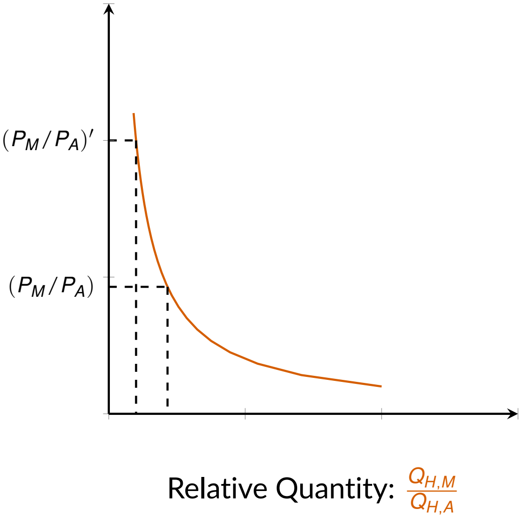
- Relative prices and other underlying forces (factor mobility, diminishing product) characterize production
- At optimum: $MRT_{A,,} = \frac{dY_A}{dY_M} = -\frac{P_M}{P_A} = -p$
- As p rises, production tilts to M:
  - RS is upward sloping

Relative Supply



From preferences to RD

- Consumer maximize $Q_M^{\alpha_i} Q_A^{1-\alpha_i}$ s.t. $P_M Q_M + P_A Q_M = I_i$



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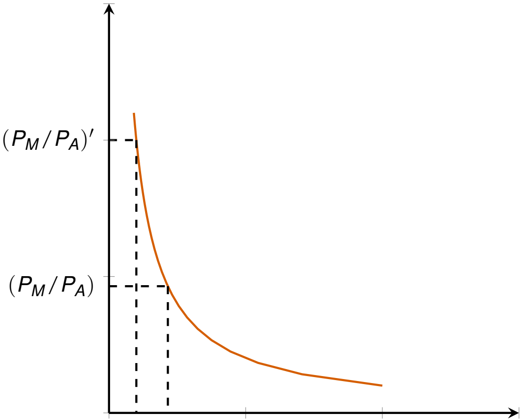

Relative Quantity: $\frac{Q_{H,M}}{Q_{H,A}}$

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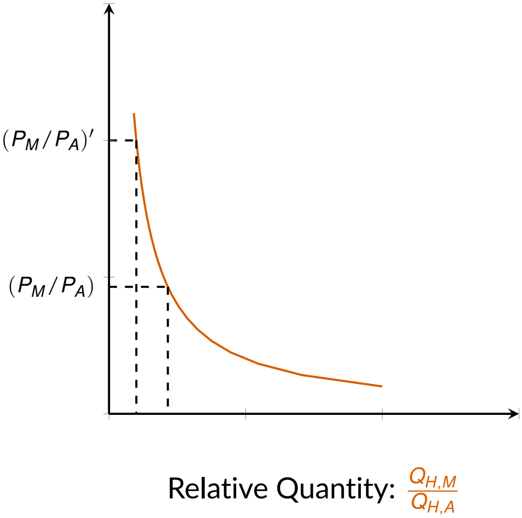
- Recall optimal demand functions are:

$$Q_M = \alpha_H \frac{I_H}{P_M}, \qquad Q_A = (1 - \alpha_H) \frac{I_H}{P_A}$$



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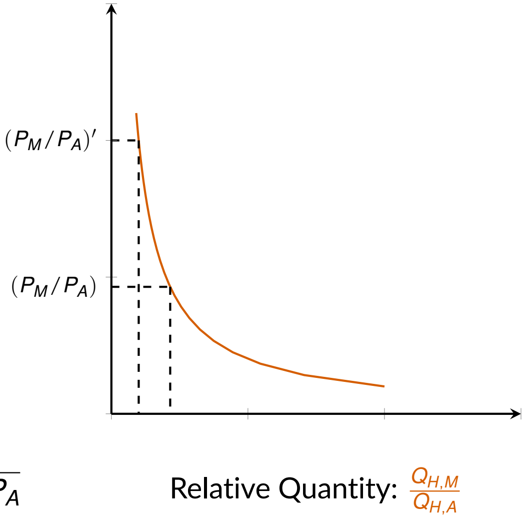
- Therefore:

$$\frac{Q_M}{Q_A}(p) = \frac{\alpha_H}{1-\alpha_H} \frac{I_H / P_M}{I_H / P_A} = \frac{\alpha_H}{1-\alpha_H} \frac{1}{P_M / P_A}$$
$$= \frac{\alpha_H}{1-\alpha_H} \frac{1}{p}$$



Domestic equilibrium and gains from trade

- Autarky: p^A at $RS(p^A) = RD(p^A)$

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- With trade: p^w at $RS(p^w) = RD(p^w)$

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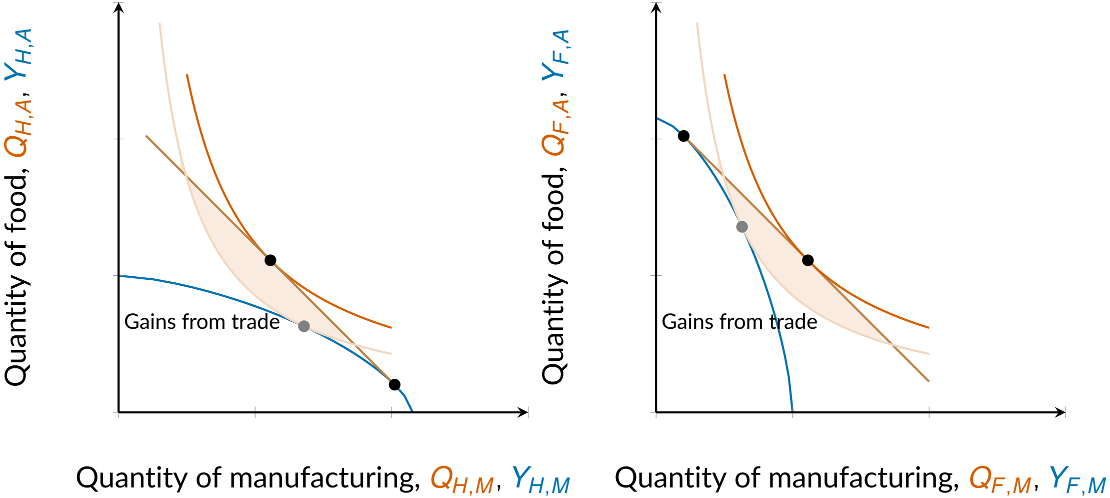
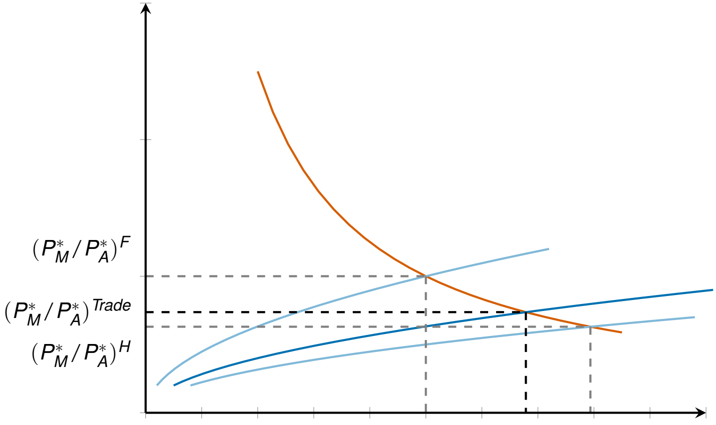
- Production after trade: price p^w pins production with slope $-p^w$
- Gains from trade: higher affordable indifference curve if $p^w \neq p^A$

Graphical representation: gains from trade



STM: World Equilibrium



Relative Quantity: $\frac{Q_{H,M}+Q_{F,M}}{Q_{H,A}+Q_{F,A}}$, $\frac{Y_{H,M}+Y_{F,M}}{Y_{H,A}+Y_{F,A}}$

Figure: World Trade Equilibrium

From the Standard Trade Model to Trade Flows

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- Demand side: Cobb–Douglas preferences, as usual:

$$U_i = Q_{i,M}^{\alpha_i} Q_{i,A}^{1-\alpha_i}, \quad Q_{i,M} = \alpha_i \frac{w_i L_i}{P_{i,A}}.$$

Each country spends a fixed share α_i of income on computers and $1 - \alpha_i$ on roses.

Iceberg Trade Costs

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- Delivered price in the destination:

$$\underbrace{P_{sd,M}}_{\text{price at destination}} = \underbrace{\tau_{s \to d}}_{\text{trade cost} \geq 1} \times \underbrace{P_{s,M}}_{\text{price at source}} = \tau_{s \to d} \times a_{M,s} w_s$$

From Quantities to the Gravity Equation

- Resulting import demand (quantities)

$$Q_{M,s\to d} = \alpha_d \frac{w_d L_d}{\tau_{s\to d}\, a_{C,s}\, w_s} = \underbrace{\frac{1}{a_{M,s}\, w_s}}_{\text{source factors}} \times \underbrace{\alpha_d w_d L_d}_{\text{destination factors}} \times \underbrace{\frac{1}{\tau_{s\to d}}}_{\text{bilateral trade costs}}$$

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  - increasing in the importing country's income ($w_d L_d$),
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- In general, exports from the s to d will satisfy:

$$\underbrace{X_{sd}}_{\substack{\text{trade flows}\\ \text{from s to d}}} \propto \frac{\underbrace{\omega_s}_{\text{source factors}} \times \underbrace{\gamma_d}_{\text{destination factors}}}{\underbrace{\tau_{sd}^{\theta}}_{\text{bilateral trade costs}}}$$

Gravity: Physics vs. Economics

Newton's Law of Gravitation

$$F_{ij} = G \frac{m_i \, m_j}{r_{ij}^2}$$

- m_i, m_j: physical masses
- r_{ij}: distance between objects
- G: universal gravitational constant

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Trade Gravity (reduced form)

$$X_{ij} = K \frac{Y_i \, Y_j}{d_{ij}^{\theta}}$$

- Y_i, Y_j: *economic masses* (GDP/total expenditure)
- d_{ij}: bilateral distance (proxy for trade costs)
- $\theta > 0$: trade-cost elasticity (empirical)
- K: scaling constant / fixed effects

Gravity in international trade

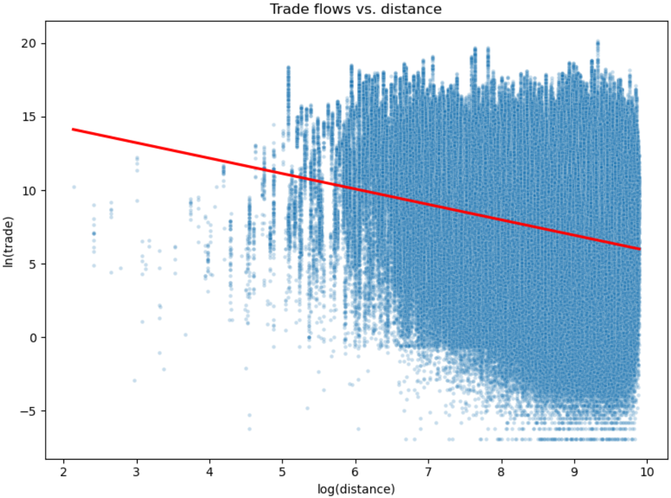

Figure: Estimated as $\ln X_{sd,t} = 16.37 - 1.05 \ln \mathit{distance}_{sd} + e_{sd,t}$; $N = 840,165$.

Gravity Regression Results

Dep variable: $\ln(\text{trade})$.	**Coef.**	**Std. Err.**	t	$P >\| \|t\| \|$	**[95% Conf. Int.]**
Intercept	16.3673	0.046	354.512	0.000	[16.277, 16.458]
$\ln(\text{distance})$	-1.0480	0.005	-197.465	0.000	[-1.058, -1.038]
Observations			840,167		
R-squared			0.044		
Adj. R-squared			0.044		
F-statistic			38,990 (p = 0.000)		
Log-Likelihood			-2,350,900		
AIC / BIC			4,702,000 / 4,702,000		

Notes: Standard errors assume correctly specified covariance matrix.

Why gravity?

- Connects trade flows to economic size and trade costs

- Workhorse for counterfactuals (tariffs, borders, infrastructure) and for mapping STM shocks to data

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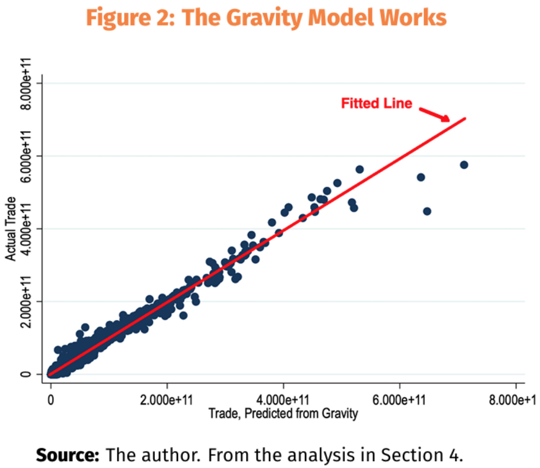

Figure: (Yotov, 2025)

Trade Gravity: Generalizing

- Note that:

$$X_{ij} = K \frac{Y_i \, Y_j}{d_{ij}^{\theta}}$$

  is a special case of:

$$X_{ij} \propto \frac{\underbrace{\omega_i}_{\text{source factors}} \times \underbrace{\gamma_j}_{\text{destination factors}}}{\underbrace{\tau_{ij}^{\theta}}_{\text{bilateral trade costs}}}$$

- So the Standard Trade Models (and most trade models we use) satisfy the gravity equation

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  - Common/different language
  - Shared colonial history
  - Shared border
  - Geographical features
  - Transportation methods
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- We will explore these more during one of the data labs. For now, will give you some flavor on why trade costs matter.

Measuring Trade Costs: *Railroads of the Raj*

- Goal: Quantify how India's 19th–20th century railroad expansion reduced trade costs (and raised welfare).

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- Natural experiment: expansion of India's railway system during colonial times.
- Salt as a reference good: tradeable and homogeneous; limited local production.
- Intuition: expansion of railroads reduce trade costs $\rightarrow$ prices of salt should converge.

Expansion of India's railroad system

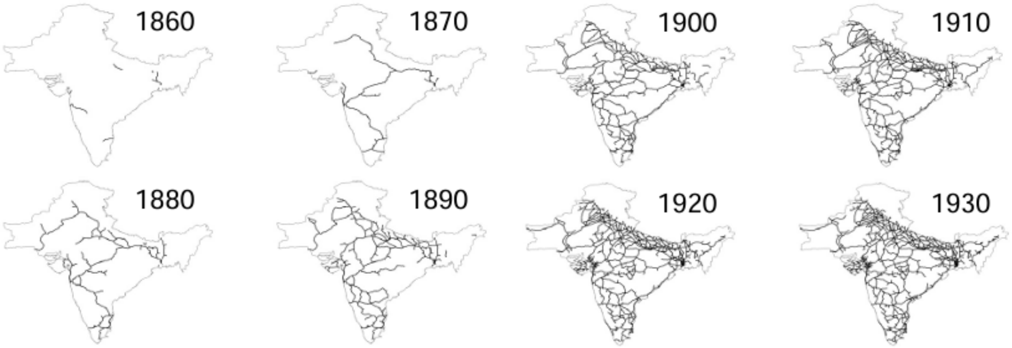

Figure 1: The evolution of India's railroad network, 1860-1930: These figures display the decadal evolution of the railroad network (railroads depicted with thick lines) in colonial India (the outline of which is depicted with thin lines). The first railroad lines were laid in 1853. This figure is based on a GIS database in which each (approximately) 20 km long railroad segment is coded with a year of opening variable. Source: Author's calculations based on official publications. See Appendix A for details.

Figure: Source: (Donaldson, 2018)

Measuring Trade Costs: *Railroads of the Raj*

- Donaldson (2018) uses price differences between district pairs as a *revealed measure* of trade frictions.
- Empirical specification:

$$\ln\left(\frac{p_{it}}{p_{jt}}\right) = \alpha + \beta \, \text{Effective Distance}_{ijt} + \gamma X_{ijt} + \varepsilon_{ijt}$$

- Effective distance:
  - shortest available travel distance, given the transport network available in a given year — taking into account which transport modes exist (rail, river, road) and their relative cost-efficiency.
- $\beta > 0 \Rightarrow$ rail connection $\Rightarrow$ smaller effective distance $\Rightarrow$ smaller price gaps $\Rightarrow$ lower trade costs.

Results

TABLE 2—RAILROADS AND TRADE COSTS: STEP 1

Dependent variable: log salt price at destination	(1)	(2)
log effective distance to source, along lowest-cost route (at historical freight rates)	0.088 (0.028)	
log effective distance to source, along lowest-cost route (at estimated mode costs)		0.169 [0.062, 0.296]
Estimated mode costs per unit distance:		
Railroad (normalized to 1)		1 N/A
Road		2.375 [1.750, 10.000]
River		2.250 [1.500, 6.250]
Coast		6.188 [5.875, 10.000]
Observations	7,345	7,345
R^2	0.946	0.946

Notes: Regressions estimating equation (12) using data on 6 types of salt (listed in online Appendix A), from 133 districts in Northern India, annually from 1861 to 1930. Column 1 and column 2 estimated by OLS and NLS respectively; both include salt type × year and salt type × destination fixed effects. "Effective distance to source, along lowest-cost route" measures the railroad-equivalent kilometers (because railroad freight rate is normalized to 1) between the salt source and the destination district, along the lowest-cost route given relative mode costs per unit distance. "Historical freight rates" used are 4.5, 3.0, and 2.25 respectively for road, river, and coastal mode costs per unit distance, all relative to rail transport. Standard errors corrected for clustering at the destination district level are reported in parentheses of column 1, and bootstrapped 95 percent confidence intervals are reported in column 2.

Figure: Source: Donaldson, 2018