ECON G6905
Topics in Trade

Jonathan Dingel

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COLUMBIA UNIVERSITY
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Today: Multiple factors of production

With multiple factors of production, we can talk about

- factor supplies as a source of comparative advantage
- distributional consequences of trade

Outline of today's discussion:

- Heckscher-Ohlin model
- Ricardo-Viner specific-factors model
- Trade and regional outcomes

Factor proportions theory

- The law of comparative advantage establishes the relationship between relative autarky prices and trade flows
- Factor proportions theory is an account of factor endowments as the source of relative autarky prices
  1. Countries differ in terms of factor abundance (relative factor supply)
  2. Goods differ in terms of factor intensity (relative factor demand)
- The interplay between these differences governs relative autarky prices and hence trade

Factor proportions theory

- To focus on factor endowments, shut down other channels:
  - Identical production functions (no Ricardian forces)
  - Identical homothetic preferences
- Two canonical models:
  - Ricardo-Viner model with 2 goods and 3 factors (2 of which are specific to a good)
  - Heckscher-Ohlin model with 2 goods and 2 factors
- Neary (1978), among others, treats the specific-factors model as a short-run case, whereas all factors are mobile in longer run

2×2 Heckscher-Ohlin model: Environment

Production functions (HD1) using factors L and K are

$$y_g = f_g\left(L_g, K_g\right) \quad g = 1, 2$$

Unit cost functions are given by

$$c_g\left(w, r\right) = \min_{L_g, K_g} \left\{wL_g + rK_g | f_g\left(L_g, K_g\right) \geq 1\right\}$$

We write the solution in terms of unit factor demands a_{gf}

$$c_g\left(w, r\right) = w a_{gL}\left(w, r\right) + r a_{gK}\left(w, r\right)$$

From the envelope theorem, we know

$$\frac{\mathrm{d}c_g}{\mathrm{d}w} = a_{gL} \qquad \frac{\mathrm{d}c_g}{\mathrm{d}r} = a_{gK}$$

$A(w, r) \equiv [a_{gf}(w, r)]$ denotes the matrix of total factor requirements

2×2 HO: Equilibrium in SOE

- Start with "small open economy" for which p_g are exogenous
- Profit maximization:

$$p_1 \leq c_1(w, r) \quad \text{equal if produced}$$
$$p_2 \leq c_2(w, r) \quad \text{equal if produced}$$

- Factor markets clear:

$$a_{1L}y_1 + a_{2L}y_2 = L$$
$$a_{1K}y_1 + a_{2K}y_2 = K$$

- These are four nonlinear equations in four unknowns; unique solution not generally guaranteed

Four theorems

1. Factor price equalization: Can trade in goods substitute for trade in factors?
2. Stolper-Samuelson: Who wins and who loses from a change in goods prices?
3. Rybczynski: How does output mix respond to change in endowments?
4. Heckscher-Ohlin: What is the pattern of specialization and trade?

Factor price insensitivity

- Good 1 is called labor-intensive if $\frac{a_{1L}(w,r)}{a_{1K}(w,r)} > \frac{a_{2L}(w,r)}{a_{2K}(w,r)}$ and capital-intensive if $\frac{a_{1L}(w,r)}{a_{1K}(w,r)} < \frac{a_{2L}(w,r)}{a_{2K}(w,r)}$
- A factor intensity reversal (FIR) occurs if $\exists w, r, w', r'$ such that good 1 is labor-intensive for (w, r) and capital-intensive for (w', r')

Lemma

If both goods are produced, and factor intensity reversals do not occur, then factor prices $\omega \equiv (w, r)$ are uniquely determined by goods prices $p \equiv (p_1, p_2)$.

Proof: If both goods are produced in equilibrium, then $p = A(\omega)\omega$. By Gale and Nikaido (1965), this equation admits a unique solution if $a_{fg}(\omega) > 0$ for all f, g and $\det[A(\omega)] \neq 0 \ \forall \omega$, which no factor intensity reversals guarantees.

Factor intensity reversals

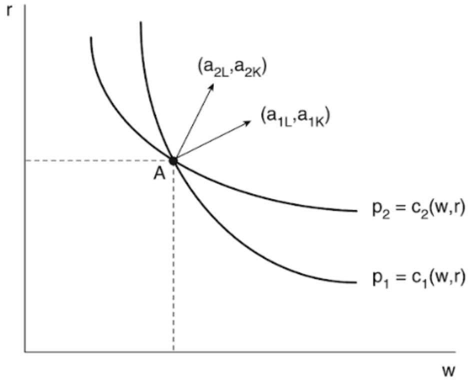


Figure 1.5

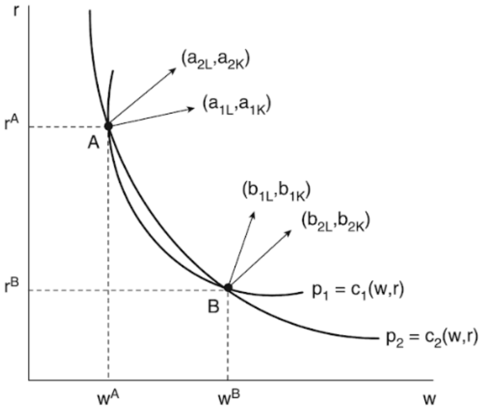


Figure 1.6

Factor price equalization

If two countries both produce both goods under free trade with the same technology and there are no factor intensity reversals, then factor prices in the two countries are the same.

- This follow directly from the previous lemma and the no-FIR diagram:
  - By free trade, goods prices are the same
  - By identical technologies, isocost lines are the same
- Hence, trade in goods is a perfect substitute for factor mobility in this model in the sense that it equalizes factor prices across countries (like factor mobility would)

Trade theory as an omitted explanation in cross-country comparisons

Stolper-Samuelson Theorem

An increase in the relative price of one good raises the real return of the factor used intensively in producing that good and lowers the real return of the other factor.

Proof: WLOG, let $\frac{a_{1L}(\omega)}{a_{1K}(\omega)} > \frac{a_{2L}(\omega)}{a_{2K}(\omega)}$ and $\hat{p}_1 > \hat{p}_2$, where $\hat{x} \equiv \frac{\mathrm{d}x}{x}$.
Differentiating the zero-profit conditions yields (by envelope theorem)

$$\mathrm{d}p_g = a_{gL}\mathrm{d}w + a_{gK}\mathrm{d}r$$

Define the cost share $\theta_{gL} = \frac{wa_{gL}}{c_g}$ to obtain

$$\hat{p}_g = \theta_{gL}\hat{w} + (1 - \theta_{gL})\,\hat{r}$$

Goods price changes are weighted averages of factor price changes (2 equations in $\hat{r}, \hat{w}$). $\frac{a_{1L}}{a_{1K}} > \frac{a_{2L}}{a_{2K}} \Rightarrow \theta_{1L} > \theta_{2L}$ so $\hat{r} < \hat{p}_2 < \hat{p}_1 < \hat{w}$

Notes on 2 × 2 Stolper-Samuelson Theorem

- A change in product prices has a magnified effect on factor prices
- Jones (1965) referred to these inequalities as "magnification effect" (This is the original "hat algebra")
- Trade liberalization that alters goods prices will thus produce winners and losers across factors
- Like FPI and FPE, Stolper-Samuelson result follows from zero-profit condition (+ "no joint production")

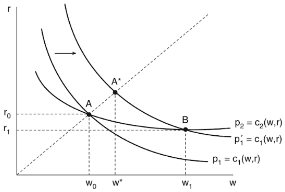


Figure 1.7

Rybczynski Theorem

For given goods prices, an increase in the endowment of one factor causes a more-than-proportionate increase in the output of the good using this factor intensively and a decrease in the output of the other good.

Differentiating the factor market clearing conditions yields,

$$\mathrm{d}L = a_{1L}\mathrm{d}y_1 + a_{2L}\mathrm{d}y_2 \text{ and } \mathrm{d}K = a_{1K}\mathrm{d}y_1 + a_{2K}\mathrm{d}y_2$$

Defining $\lambda_{gL} = \frac{a_{gL}y_g}{L}$ and $\lambda_{gK} = \frac{a_{gK}y_g}{K}$, this implies

$$\hat{L} = \lambda_{1L}\hat{y}_1 + (1 - \lambda_{1L})\,\hat{y}_2 \text{ and } \hat{K} = \lambda_{1K}\hat{y}_1 + (1 - \lambda_{1K})\,\hat{y}_2$$

If (w.l.o.g.) $\frac{a_{1L}}{a_{1K}} > \frac{a_{2L}}{a_{2K}}$, then $\lambda_{1L} > \lambda_{1K}$ so that,

$$\hat{y}_1 > \hat{L} > \hat{K} > \hat{y}_2 \text{ or } \hat{y}_1 < \hat{L} < \hat{K} < \hat{y}_2$$

Hence, if also (w.l.o.g.) $\hat{K} > \hat{L}$, we obtain,

$$\hat{y}_1 < \hat{L} < \hat{K} < \hat{y}_2$$

Rybczynski Theorem and cone of diversification

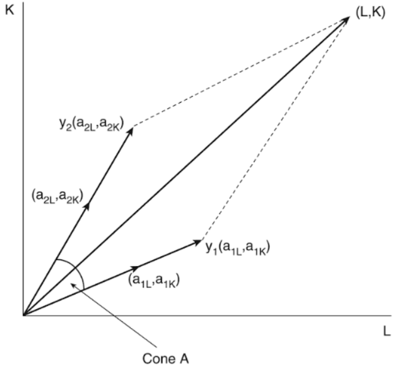


Figure 1.8

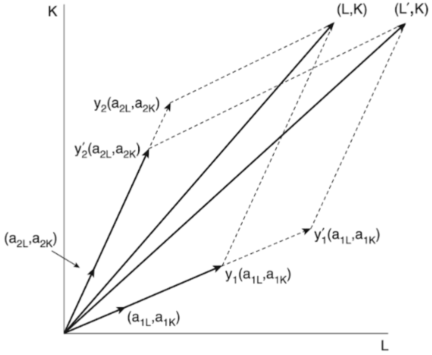


Figure 1.9

- Produce both goods iff (L, K) lies between factor requirements vectors (a_{2L}, a_{2K}) and (a_{1L}, a_{1K}), the "cone of diversification"
- Changes in endowment can be absorbed by changes in production composition given factor prices (and thus factor intensity)
- E.g., increase in labor necessitates decrease in output of capital-intensive good

Factor demand and factor prices: autarky vs free trade

- Factor demand is perfectly elastic inside the cone of diversification (given goods prices)
- Autarky factor demand slopes down
- The impact of a factor supply shock depends on openness
- Burstein, Hanson, Tian, Vogel (2020): "a local influx of immigrants crowds out employment of native-born workers in more relative to less immigrant-intensive nontradable jobs, but has no such effect across tradable occupations. Further analysis of occupation labor payments is consistent with adjustment to immigration within tradables occurring more through changes in output (versus changes in prices) when compared to adjustment within nontradables"

Heckscher-Ohlin theorem

- We now consider world economy with two countries and free trade (prior results derived for small open economies)
- This is a $2 \times 2 \times 2$ model
- Identical technologies and homothetic preferences
- What is the pattern of trade in this global economy?
  - Rather than starting from autarky, let's start from the integrated equilibrium
  - Integrated world economy with world endowment of factors yields integrated equilibrium (good prices, factor prices, resource allocations, etc)

The FPE set

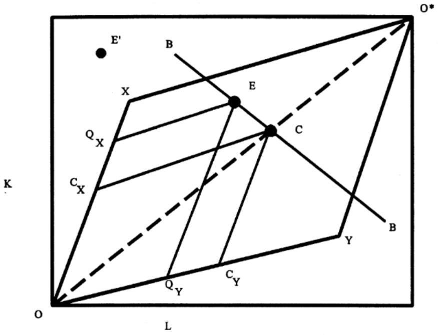


Figure 1.1.

- World endowed with K and L
- Integrated factor allocations OX and OY
- Samuelson's angel fragments world into two countries by endowments E or E'
- Can trade reproduce the integrated equilibrium? If FPE holds!

Heckscher-Ohlin theorem

In the free-trade equilibrium, each country exports the good that uses its abundant factor intensively.

- If endowments are in the FPE set, this is a simple corollary of the Rybczynski theorem and homothetic preferences (no assumption on FIRs required).
- Outside the FPE set, need to also consider FIRs.
- To state the prediction in terms of autarky relative factor prices, return to general theorem of Deardorff (1980)
- Is the autarky relative price of the labor-intensive good lower in the labor-abundant country?
- See Feenstra Figure 2.1 and Jones and Neary equation (2.10)

Higher dimensions

What if there are C countries, G goods, and F factors?

- If $F = G$ ("even case"), situation is qualitatively similar
- Integrated equilibrium and FPE set are helpful devices here
- If $F > G$, then FPE set is "measure zero" ($F = 2, G = 1$ on diagonal of Samuelson's angel diagram)
- If $G > F$, then production and trade are indeterminate, but factor content of trade known

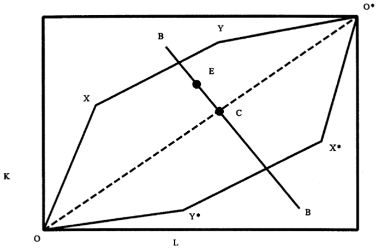


Figure 1.2.

High-dimensional predictions

- High-dimensional predictions are not much loved, since they are either weak or unintuitive.
- See Ethier (1984) survey. Comparative statics depend on whether F or G is greater.

Stolper-Samuelson in higher dimensions is Jones and Scheinkman (JPE 1977)

"friends" and "enemies" results:

- SS theorem follows from differentiating zero-profit condition
- With arbitrary F and G, still true that (no joint production)

$$\hat{p}_g = \sum_f \theta_{fg} \hat{w}_f$$

- Suppose $\hat{p}_1 \leq \cdots < \hat{p}_G$. Then there exist f_1 and f_2 such that

$$\hat{w}_{f_1} < \hat{p}_1 \leq \cdots < \hat{p}_G < \hat{w}_{f_2}$$

- In even case ($F = G$), each factor has at least one "enemy"
- In uneven cases ($F > G$), cannot always identify a natural enemy
  E.g., in Ricardo-Viner, labor is intermediate, $\hat{p}_1 < \hat{w} < \hat{p}_2$

Heckscher-Ohlin-Vanek Theorem

- Without $G = F$, we have results about factor content of trade rather than goods trade
- Define net exports of factor by the vector $T_F^c = AT^c$, where A is the $F \times G$ matrix of unit factor requirements and T^c is net exports of goods by c
- Heckscher-Ohlin-Vanek theorem: In any country c, net exports of factors satisfy $T_F^c = V^c - s^c V^{\text{world}}$ where s^c is c's share of world income
- Countries export factors in which they are relatively abundant: $V^c > s^c V^{\text{world}}$
- This prediction derives from identical technology, FPE, and homothetic preferences. Good luck.

Vast empirical literature: Davis and Weinstein (2001), Davis (2008) survey, Trefler and Zhu (2010), Morrow and Trefler (2022)

Trade and regional outcomes

- Recent work looking at trade's effects on regional labor markets can be interpreted as using a Ricardo-Viner view
- Cross-sectional regressions testing HO model take long-run view, but recent labor literature exploiting panel data lets us take factor specificity more seriously
- Suppose a trade-policy change affects p (nationwide goods prices)
- What happens to economic outcome in different regions?
- Topalova (2010) on India, Kovak (2013) on Brazil, Autor, Dorn, and Hanson (2013) on US

Ricardo-Viner model: Environment

- Two goods ($g = 1, 2$) with exogenous prices p_1, p_2 ("small open economy")
- Three factors with endowments L, K_1, K_2 and prices w, r_1, r_2
- Output of good g is

$$y_g = f^g\left(L_g, k_g\right)$$

  where L_g is (endogenous) labor working in g and f^g is HD1 (payments to specific factors under CRS are profits in DRS)
- Profit maximization (where $f_L^g \equiv \frac{\partial f^g}{\partial L_g}$):

$$p_g f_L^g\left(L_g, K_g\right) = w \qquad p_g f_{K_g}^g\left(L_g, K_g\right) = r_g$$

- Labor demand decreasing in w/p_g:

$$L_g = (f_L^g)^{-1}(w/p_g; K_g)$$

- Labor market clearing: $L = L_1(w/p_1) + L_2(w/p_2)$

Ricardo-Viner model: Equilibrium

Combine the expressions for MRPL and $L = L_1 + L_2$ to solve:

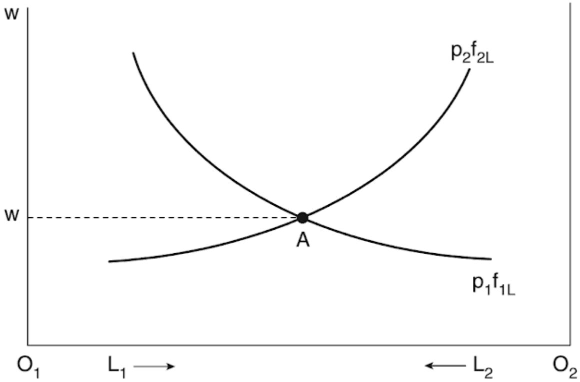


Figure 3.2

See pages 71-75 of Feenstra textbook (first edition)

Ricardo-Viner model: Comparative static: $\uparrow p_1 \rightarrow \uparrow w, \uparrow L_1/L_2$

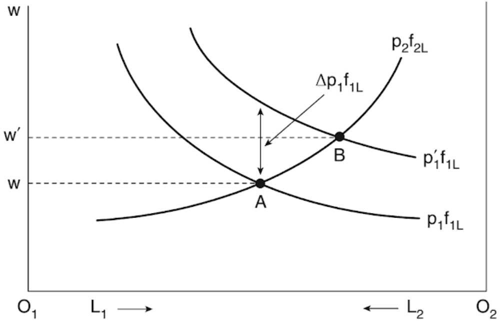


Figure 3.3

Let $\hat{w} \equiv \mathrm{d} \ln w$.

Totally differentiate labor market clearing:

$$-\sum_g l_g^0 \sigma_g^0 (\hat{w} - \hat{p}_g) = \hat{\bar{L}}$$

$$\Rightarrow \hat{w} = \sum_g \left(\frac{l_g^0 \sigma_g^0}{\sum_k l_k^0 \sigma_k^0} \right) \hat{p}_g + \frac{-\hat{\bar{L}}}{\sum_k l_k^0 \sigma_k^0}$$

$l_g^0 = L_g^0 / \bar{L}$ is initial g share of labor,

$\sigma_g^0 \equiv -\frac{\partial \log L_g(w^0/p_g^0)}{\partial \log w/p_g}$ is labor demand elasticity in g (at initial eq.)

- **Dutch disease**: $\hat{w} < \hat{p}_1$ and $\hat{r}_2 < \hat{p}_1$, but $\hat{r}_1 > \hat{p}_1$

One can do similar exercises for changes in endowments, etc. See Feenstra textbook.

Towards an empirical specification across regional SOEs

- Consider regional SOEs $i = 1, ..., J$, with sectors $s = 1, ..., S$.
- Sectoral labor demand ($\sigma > 0$ from DRS production or imperfect substitution in preferences):

$$\log L_{is}^D = -\sigma \log w_i + \log D_{is} \quad (\sigma > 0)$$

$$\log D_{is} = \rho \log \chi_s + \log \mu_s + \log \eta_{is}$$

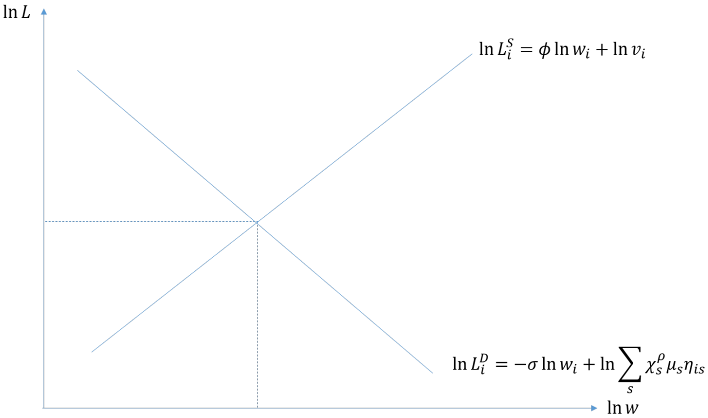
- χ_s is sector-level trade shock; μ_s and η_{is} are other labor demand shifters
- For simplicity, elasticities are the same for all sectors and regions.
- Labor is freely mobile across s but immobile across i. Supply is

$$\log L_i^S = \phi \log w_i + \log v_i \quad (\phi > 0)$$

- Labor market clearing in each regional market i:

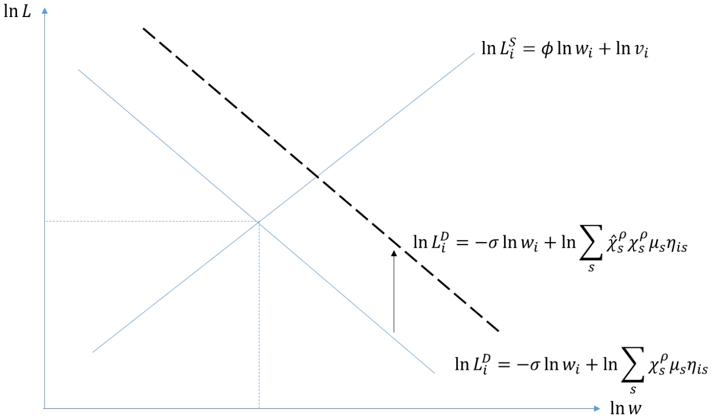
$$L_i^S(w_i) = \sum_s L_{is}^D(w_i, \chi_s, \mu_s, \eta_{is})$$

Impact of a sectoral trade shock



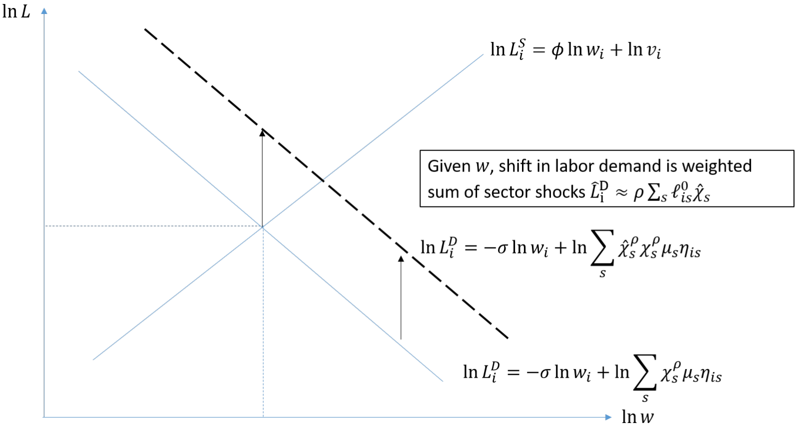
Since labor demand and supply only depends on local wage, graph represents labor market clearing for each i

Impact of a sectoral trade shock



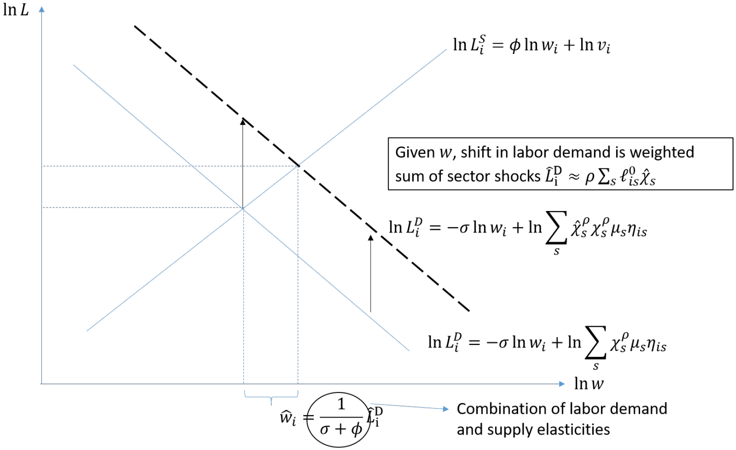
Consider common shocks to the sector demand in all regions $\hat{\chi}_s$

Impact of a sectoral trade shock



Labor demand shift in i: average sectoral shock weighted by i's initial employment shares

Impact of a sectoral trade shock



Wage response is given by labor demand shift adjusted by wage elasticity of excess labor demand $(\sigma + \phi)$

National sectoral shocks affect regional outcomes

- For any variable z, we define $\hat{z} = \log\left(z^t/z^0\right)$. Each time period has different potential shifter realizations:

$$(\{\hat{\chi}_s, \hat{\mu}_s\}_s, \{\hat{\eta}_{is}\}_{i,s}, \{\hat{v}_i\}_i) \sim F(\cdot)$$

- Up to a first-order approximation around the initial equilibrium,

$$\hat{L}_i^S = \sum_s \frac{L_{is}^{D,0}}{\sum_k L_{ik}^{D,0}} \hat{L}_{is}^D$$

- Denote $l_{is}^0 \equiv L_{is}^0/L_i^0$ as the sectoral employment share in initial equilibrium.
- Substituting for supply and demand yields:

$$\phi\hat{w}_i + \hat{v}_i = \sum_s l_{is}^0(-\sigma\hat{w}_i + \rho\hat{\chi}_s + \hat{\mu}_s + \hat{\eta}_{is})$$

- Therefore

$$\hat{w}_i = \frac{1}{\phi+\sigma}\sum_s l_{is}^0(\rho\hat{\chi}_s + \hat{\mu}_s + \hat{\eta}_{is}) - \frac{1}{\phi+\sigma}\hat{v}_i$$

Simple environment yields shift-share exposure measure

$$\hat{w}_i = \alpha^w + \beta^w \sum_s l_{is}^0 \hat{\chi}_s + \epsilon_{wi} \qquad \hat{L}_i = \alpha^L + \beta^L \sum_s l_{is}^0 \hat{\chi}_s + \epsilon_{Li}$$

- Shift in labor demand, $\sum_s l_{is}^0 \hat{\chi}_s$, is greater in i with higher l_{is}^0 in sectors with greater shock $\hat{\chi}_s$.
- $\beta^w \equiv \rho/(\phi + \sigma)$ and $\beta^L \equiv \phi\beta^w$ control how much a higher $\hat{\chi}_s$ affects outcomes in regions specialized in sector s.
- The constant and residual capture other shocks: $\alpha^w = E[\tilde{\epsilon}_{wi}]$ and $\epsilon_{wi} = \tilde{\epsilon}_{wi} - \alpha^w$ with

$$\tilde{\epsilon}_{wi} \equiv \frac{1}{\phi + \sigma}\left[-\hat{v}_i + \sum_s l_{is}^0(\hat{\mu}_s + \hat{\eta}_{is})\right]$$

- Exposure to other sectoral shocks (eg, productivity): $\sum_s l_{is}^0 \hat{\mu}_s$
- Local supply and demand shocks: $\hat{v}_i$ and $\hat{\eta}_{is}$
- See Adao, Kolesar, Morales (2019) on econometrics of shift-share designs

Indian tariff cuts and district-level poverty (Topalova 2010)

Regression for outcome y in district d in year t

$$y_{dt} = \alpha_d^D + \alpha_t^T + \beta \text{tariff}_{dt} + \epsilon_{dt}$$

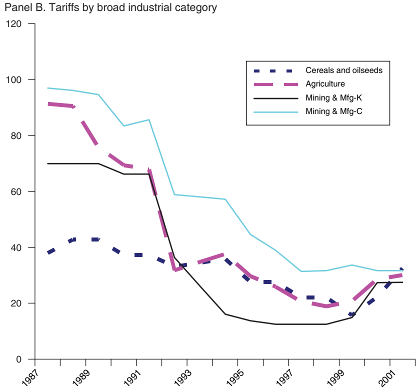


FIGURE 1. EVOLUTION OF INDIA'S TARIFF AND NTBS (*Continued*)

- y is poverty rate and tariff is employment-weighted average of national industry import tariffs
- India has long-running poverty surveys, many districts, and a large trade liberalization in 1991
- IV for tariffs: initial level, because tariff harmonization meant "the higher the tariff, the bigger the cut"

Table 3A—Trade Liberalization, Poverty, and Average Consumption in Rural India

Data	Pre & post (1)	Pre & post (2)	Pre & post (3)	Pre & post (4)	Pre only (5)	Pre & post (6)	Pre & post (7)	Pre & post (8)
Panel A. Dependent variable: poverty rate								
Tariff	−0.242*		−0.710***	−0.467*	0.038	−0.479**	−0.424*	−0.381***
	[0.122]		[0.250]	[0.247]	[1.000]	[0.236]	[0.229]	[0.139]
Traded tariff		−0.223**						
		[0.084]						
NTB (share of free HS codes)						0.073		
						[0.202]		
Panel B. Dependent variable: log average per capita consumption								
Tariff	−0.055		0.512	0.677*	−0.085	0.683*	0.657*	0.583**
	[0.353]		[0.639]	[0.400]	[0.463]	[0.373]	[0.333]	[0.216]
Traded tariff		0.161						
		[0.207]						
NTB (share of free HS codes)						−0.036		
						[0.248]		
IV with traded tariff	No	No	Yes	Yes	Yes	Yes	Yes	Yes
IV with traded tariff and initial traded tariff	No	No	No	No	No	No	No	Yes
District indicators	Yes	Yes	Yes	Yes	NA	Yes	Yes	Yes
Initial district conditions × post	No	No	No	Yes	NA	Yes	Yes	Yes
Region indicators	NA	NA	NA	NA	Yes	NA	NA	NA
Initial region indicators × post	NA	NA	NA	NA	Yes	NA	NA	NA
Other reforms controls	No	No	No	No	No	No	Yes	Yes
N	728	728	728	728	128	728	728	728

Notes: Standard errors (in brackets) are clustered at the state-year level. Regressions are weighted by the number of households in a district. All specifications include a post-reform indicator. Initial district conditions that are interacted with the post-reform indicator include percentage of workers in a district employed in agriculture, employed in mining, employed in manufacturing, employed in trade, employed in transport, and employed in services (construction is the omitted category), as well as the share of district's population that is schedule caste/tribe, the percentage of literate population, and state labor laws indicators. Other reform controls include controls for industry licensing, foreign direct investment, and number of banks per 1,000 people. Regressions in column 5 replace all district-level variables with their equivalents at the regional level and use only pre-reform data for the outcomes of interest.

***Significant at the 1 percent level.

Kovak (2013)

Look at Brazil's import liberalization

- Topalova finds little geographical or intersectoral migration
- In Brazil, substantial migratory responses

Estimating equation explicitly derived from a specific-factors model

- Good i with specific factor K_i and labor L
- Factor market clearing:

$$a_{K_i} Y_i = K_i \qquad \sum_i a_{Li} Y_i = L$$

- Differentiating, $\hat{L} = \sum_i \lambda_i (\hat{a}_{Li} - \hat{a}_{K_i})$ where $\lambda_i \equiv L_i / L$
- $\hat{p}_i = (1 - \theta_i)\hat{w} + \theta_i \hat{r}_i$, where $\theta_i \equiv \frac{r_i K_i}{p_i Y_i}$ is specific factor's cost share

Kovak (2013): Model, continued

If σ_i is elasticity of substitution btw K_i and L then

$$\hat{a}_{K_i} - \hat{a}_{Li} = \sigma_i \left(\hat{w} - \hat{r}_i \right)$$

Combining with expression for $\hat{L}$, we get

$$\hat{L} = \sum_i \lambda_i \sigma_i \left(\hat{r}_i - \hat{w} \right)$$

Solve for $\hat{w}$ using some matrix algebra

$$\hat{w} = -\frac{1}{\sum_{i'} \lambda_{i'} \frac{\sigma_{i'}}{\theta_{i'}}} \hat{L} + \sum_i \frac{\lambda_i \frac{\sigma_i}{\theta_i}}{\sum_{i'} \lambda_{i'} \frac{\sigma_{i'}}{\theta_{i'}}} \hat{p}_i$$

- In baseline, no migration, so $\hat{L} = 0$
- Idiot's law of elasticities says $\sigma_i = 1 \; \forall i$
- Extend to address non-traded goods

Estimate using region's tariff change assuming full passthrough

Kovak (2013): Identifying variation

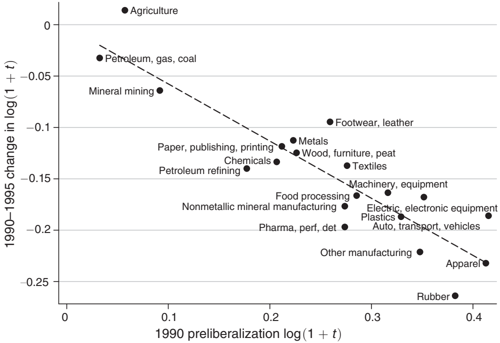


Figure 1. Relationship between Tariff Changes and Preliberalization Tariff Levels

Note: Correlation: −0.899; regression coefficient: −0.556; standard error: 0.064; *t*: −8.73.
Source: Author's calculations based on data from Kume, Piani, and de Souza (2003).

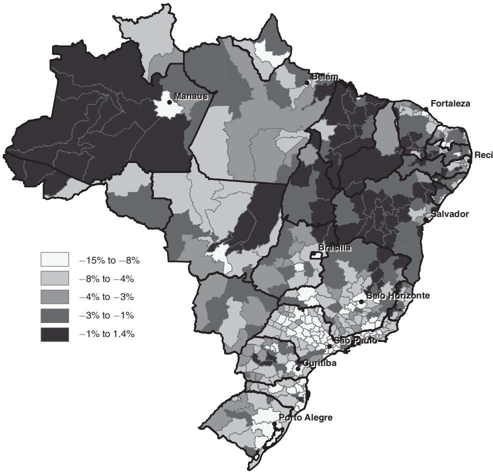


Figure 3. Region-Level Tariff Changes

Notes: Weighted average of tariff changes. See text for details.

Kovak (2013): Empirical estimates

TABLE 1—THE EFFECT OF LIBERALIZATION ON LOCAL WAGES

	Main		No labor share adjustment		Nontraded price change set to zero		Nontraded sector workers' wages	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Regional tariff change	0.404	0.439	0.409	0.439	2.715	1.965	0.417	0.482
Standard error	(0.502)	(0.146)***	(0.475)	(0.136)***	(1.669)	(0.777)**	(0.497)	(0.140)***
State indicators (27)	—	X	—	X	—	X	—	X
Nontraded sector								
Omitted	X	X	X	X	—	—	X	X
Zero price change	—	—	—	—	X	X	—	—
Labor share adjustment	X	X	—	—	X	X	X	X
R^2	0.034	0.707	0.040	0.711	0.112	0.710	0.037	0.763

Notes: 493 microregion observations (Manaus omitted). Standard errors adjusted for 27 state clusters (in parentheses). Weighted by the inverse of the squared standard error of the estimated change in log microregion wage, calculated using the procedure in Haisken-DeNew, and Schmidt (1997).

Estimates lie between immobile labor ($\beta = 1$) and perfectly mobile labor ($\beta = 0$), suggesting mobility frictions (or incomplete passthrough)

Dix-Carneiro and Kovak (2017) estimate dynamic version:

$$w_{r,t} - w_{r,1991} = \alpha_{st} + \beta_t \cdot \mathrm{RTC}_r + \gamma_t (w_{r,1990} - w_{r,1986}) + \epsilon_{rt}$$

Autor, Dorn, Hanson (2013)

- Use of trade quantities (China shock) rather than prices, so a gravity-based model rather than specific-factor SOE
- Exogenous Chinese export supply shock in industry j is $\hat{A}_{Cj}$
- Look at region i's outcomes for wages $\hat{w}_i$, employment in traded goods $\hat{L}_i^T$, and employment in non-traded goods $\hat{L}_i^N$
- Treatment is exposure to import competition (shift-share design):

$$\Delta \text{IPW}_{Uit} = \sum_j \frac{L_{ijt}}{L_{Ujt}} \frac{\Delta M_{UCjt}}{L_{it}}$$

- Instrument using non-US exposure ("other" o):

$$\Delta \text{IPW}_{oit} = \sum_j \frac{L_{ijt-1}}{L_{ujt-1}} \frac{\Delta M_{oCjt}}{L_{it-1}}$$

ADH (2013): Manufacturing employment falls

Table 2—Imports from China and Change of Manufacturing Employment in CZs, 1970–2007: 2SLS Estimates

Dependent variable: 10 × annual change in manufacturing emp/working-age pop (in % pts)

	I. 1990–2007			II. 1970–1990 (pre-exposure)		
	1990–2000	2000–2007	1990–2007	1970–1980	1980–1990	1970–1990
	(1)	(2)	(3)	(4)	(5)	(6)
(Δ current period imports from China to US)/worker	−0.89***	−0.72***	−0.75***			
	(0.18)	(0.06)	(0.07)			
(Δ future period imports from China to US)/worker				0.43***	−0.13	0.15
				(0.15)	(0.13)	(0.09)

Notes: $N = 722$, except $N = 1{,}444$ in stacked first difference models of columns 3 and 6. The variable "future period imports" is defined as the average of the growth of a CZ's import exposure during the periods 1990–2000 and 2000–2007. All regressions include a constant and the models in columns 3 and 6 include a time dummy. Robust standard errors in parentheses are clustered on state. Models are weighted by start of period CZ share of national population.

Autor, Dorn, Hanson (2013): Population response

TABLE 4—IMPORTS FROM CHINA AND CHANGE OF WORKING-AGE POPULATION IN CZ, 1990–2007: 2SLS ESTIMATES

Dependent variables: Ten-year equivalent changes in log population counts (in log pts)

	I. By education level			II. By age group		
	All (1)	College (2)	Noncollege (3)	Age 16–34 (4)	Age 35–49 (5)	Age 50–64 (6)
Panel A. No census division dummies or other controls						
(Δ imports from China to US)/worker	−1.031**	−0.360	−1.097**	−1.299	−0.615	−1.127***
	(0.503)	(0.660)	(0.488)	(0.826)	(0.572)	(0.422)
R^2	—	0.03	0.00	0.17	0.59	0.22
Panel B. Controlling for census division dummies						
(Δ imports from China to US)/worker	−0.355	0.147	−0.240	−0.408	−0.045	−0.549
	(0.513)	(0.619)	(0.519)	(0.953)	(0.474)	(0.450)
R^2	0.36	0.29	0.45	0.42	0.68	0.46
Panel C. Full controls						
(Δ imports from China to US)/worker	−0.050	−0.026	−0.047	−0.138	0.367	−0.138
	(0.746)	(0.685)	(0.823)	(1.190)	(0.560)	(0.651)
R^2	0.42	0.35	0.52	0.44	0.75	0.60

Notes: $N = 1{,}444$ (722 CZs × two time periods). All regressions include a constant and a dummy for the 2000–2007 period. Models in panel B and C also include census division dummies while panel C adds the full vector of control variables from column 6 of Table 3. Robust standard errors in parentheses are clustered on state. Models are weighted by start of period commuting zone share of national population.

Autor, Dorn, Hanson (2013): Margins of adjustment

TABLE 5—IMPORTS FROM CHINA AND EMPLOYMENT STATUS OF WORKING-AGE POPULATION WITHIN CZS, 1990–2007: 2SLS ESTIMATES

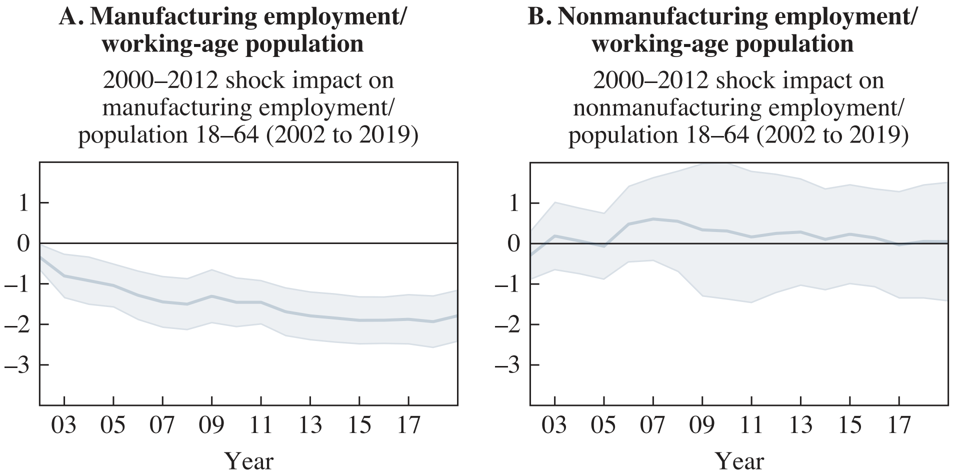
Dependent variables: Ten-year equivalent changes in log population counts and population shares by employment status

	Mfg emp (1)	Non-mfg emp (2)	Unemp (3)	NILF (4)	SSDI receipt (5)
Panel A. 100 × log change in population counts					
(Δ imports from China to US)/worker	−4.231***	−0.274	4.921***	2.058*	1.466***
	(1.047)	(0.651)	(1.128)	(1.080)	(0.557)
Panel B. Change in population shares					
All education levels					
(Δ imports from China to US)/worker	−0.596***	−0.178	0.221***	0.553***	0.076***
	(0.099)	(0.137)	(0.058)	(0.150)	(0.028)
College education					
(Δ imports from China to US)/worker	−0.592***	0.168	0.119***	0.304***	—
	(0.125)	(0.122)	(0.039)	(0.113)	
No college education					
(Δ imports from China to US)/worker	−0.581***	−0.531***	0.282***	0.831***	—
	(0.095)	(0.203)	(0.085)	(0.211)	

Notes: N = 1,444 (722 CZs × two time periods). All statistics are based on working age individuals (age 16 to 64). The effect of import exposure on the overall employment/population ratio can be computed as the sum of the coefficients for manufacturing and nonmanufacturing employment; this effect is highly statistically significant ($p \leq 0.01$) in the full sample and in all reported subsamples. All regressions include the full vector of control variables from column 6 of Table 3. Robust standard errors in parentheses are clustered on state. Models are weighted by start of period CZ share of national population.

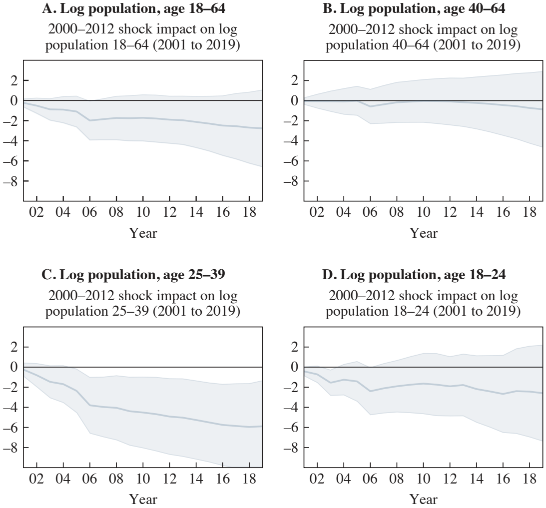
Autor, Dorn, Hanson (2021): Effects are persistent

Figure 5. Trade Shock Impact on Employment, 2001–2019



Autor, Dorn, Hanson (2021): Only young migrate away

Figure 7. Trade Shock Impact on Log Population Head Counts, 2000–2019



The "China Shock" literature

- ADH (2021) review the large literature launched by ADH (2013) investigating the impact of the China shock on different countries and outcomes (e.g., voting behavior, health outcomes, family structure)
- The regional incidence approach is not the only one.
- Studies look at sector-level variation in exposure to trade shocks (the cornerstone for regional shift-share approach), such as Autor, Dorn, Hanson, Song (2014), Acemoglu, Autor, Dorn, Hanson, Price (2016), Pierce and Schott (2016) [the NTR gap variation is roughly orthogonal to the "China shock" variation]
- Hummels, Jorgensen, Munch, Xiang (2014): Firm-level variation in exposure to trade shocks via global product-level demand shocks

Where do we stand?

- Empirical literature credibly built the case that those initially more exposed to trade shocks experience persistent effects
- However, measures of exposure are often ad-hoc or derived from simple models that ignore several adjustment channels in general equilibrium
- Difference in differences has a "missing intercept" problem (e.g., Moll and Hanney 2025)
- General-equilibrium modeling can fill in the missing intercept and other channels of adjustments, but few verify that their GE models quantitatively replicate the diff-in-diffs estimates from the empirical literature

Adao, Arkolakis, Esposito (2025): China shock and spatial links

AAE extend the empirical approach of Autor Dorn Hanson (2013) to show how spatial links shaped the response of US Commuting Zones to the China shock:

- spatial links propagated shocks in labor demand across regions: employment and wage growth were weaker in a CZ geographically close to other CZs facing higher import competition
- stronger import growth in goods consumed in a CZ did not generate relative gains in employment and wages
- population did not respond to any measure of regional shock exposure

Direct and indirect effects of local shock exposure

Again, assume labor is mobile across sectors but trapped in regions, so labor supply is

$$\log L_i^S = \phi \log w_i + \log v_i$$

Assume that labor demand features spatial links:

$$\log L_{is}^D = -\sigma \log w_i + \sum_j \sigma_{ij} \log w_j + \rho \log \chi_s + \log \eta_{is};$$

Intuition for $\sigma_{ij} > 0$ is labor demand in i increases when

- competitor market j has higher cost due to higher wage
- destination market j has higher spending due to higher wage

Market clearing in every region i still must hold: $L_i^S = \sum_s L_{is}^D$

Impact of trade shocks

- Up to a first-order approximation:

$$\phi \hat{w}_i + \hat{v}_i = -\sigma \hat{w}_i + \sum_j \sigma_{ij} \hat{w}_j + \rho \hat{X}_i \quad \forall i$$

- $\hat{X}_i$ is the shift-share variable of i's exposure to the trade shock:

$$\hat{X}_i \equiv \sum_s l^0_{is} \hat{\chi}_s$$

- One needs to solve for equilibrium in all markets together.
- Denote vectors by $\mathbf{z} = [z_i]_i$ and matrices as $\overline{\mathbf{z}} = [z_{ij}]_{ij}$

$$(\sigma + \phi)\hat{\mathbf{w}} - \overline{\sigma}\hat{\mathbf{w}} = \rho \hat{\mathbf{X}} + \hat{\mathbf{v}}$$

- Thus,

$$\underbrace{\left(\overline{\mathbf{I}} - \frac{1}{\sigma + \phi}\overline{\sigma}\right)}_{\equiv \mathbf{I} - \overline{\lambda}} \hat{\mathbf{w}} = \underbrace{\left(\frac{\rho}{\sigma + \phi}\right)}_{\equiv \kappa} \hat{\mathbf{X}} + \frac{1}{\sigma + \phi}\hat{\mathbf{v}}$$

Direct and indirect effects of trade shocks

- Assume $1 - \lambda_{ii} > \sum_{j \neq i} |\lambda_{ij}|$:

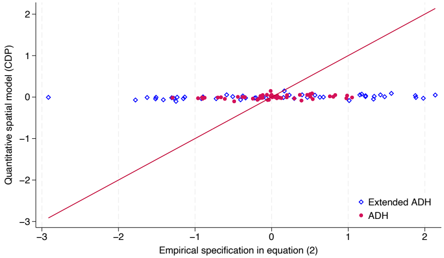
$$\overline{\beta} \equiv (\mathbf{I} - \overline{\lambda})^{-1} = \mathbf{I} + \overline{\lambda} + \sum_{d=2}^{\infty} \overline{\lambda}^{d}$$

$$\hat{w}_i = \underbrace{\kappa \beta_{ii} \hat{X}_i}_{\text{direct effect}} + \underbrace{\sum_{j \neq i} \kappa \beta_{ij} \hat{X}_j}_{\text{indirect effect}} + \hat{v}_i^{\omega}$$

- In this case, links *amplify* impact ($\sigma_{ij} > 0 \; \forall i, j \implies \beta_{ij} > 0 \; \forall i, j$).
- More generally, GE impact requires measuring indirect effects

- Diff-in-diffs regressions assume indirect effects are common across markets (and therefore in the missing intercept)
- Quantitative modelers ignore whether GE predictions match estimated directed and indirect effects at their peril

Figure 1: Differential Impact of the China Shock on Log Employment Rate



Next week:

- Trade with increasing returns
- Please read Krugman (1980) beforehand