Estimating the Effects of Globalization
Lecture 1: Gains from Trade

2024 CREi Lectures in Macroeconomics
Dave Donaldson (MIT)

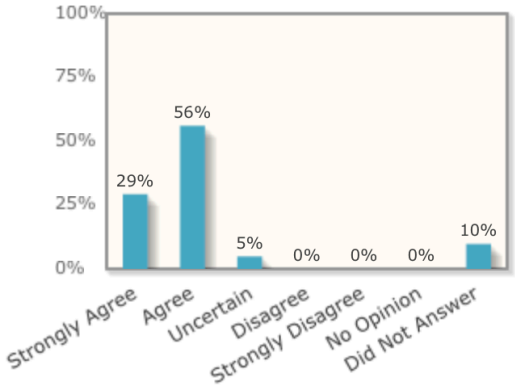
3 Lectures, 3 "What If?" Trade Questions

- **Lecture #1:** What would have happened to aggregate welfare if China hadn't entered global trade?
- **Lecture #2:** What would happen to inequality if trade were to disappear?
- **Lecture #3:** What would have happened to US welfare if Trump hadn't started his trade war?

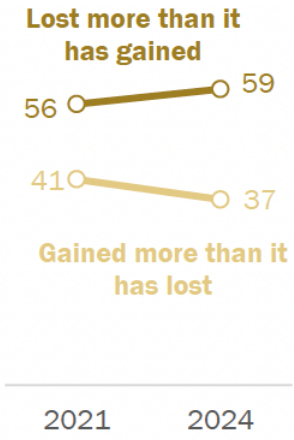
- But major focus on methodology: what can economists do to improve their answers to questions like these?
- 100% joint work with Rodrigo Adao (Chicago) and Arnaud Costinot (MIT)

Effects of Globalization—A Debate

"Freer trade improves productive efficiency and offers consumers better choices, and in the long run these gains are much larger than any effects on employment."



"All in all, would you say that the U.S. has [...] from increased trade with other nations?"



Answering Causal Questions

- **Consider reduced-form of *true model*:**

$$y_{n,t} = g_n^*(\tau_t, \epsilon_t^*)$$

  - $y_{n,t}$: endogenous outcome of interest $n \in \mathcal{N}$
  - $\tau_t = \{\tau_{kt}\}$: vector of all "policy" (etc.) variables of interest
  - ϵ_t^*: vector of all time-varying parameters—"other shocks"

- **Goal is to answer question about causal effect of policy change:**

$$\text{Causal effect:} \quad \Delta x_n^* \equiv \underbrace{g_n^*(\tau_{t+1}, \epsilon_{t+1}^*)}_{\text{“}Y_n(1)\text{”}} - \underbrace{g_n^*(\tau_t, \epsilon_{t+1}^*)}_{\text{“}Y_n(0)\text{”}}$$

$$\text{Summary of causal effects:} \quad W(\Delta x^*) \equiv \sum_n \omega_n \Delta x_n^*, \quad \text{with } \{\omega_n\}_n \text{ observed}$$

Answering Causal Questions ... With Program Evaluation

- Sometimes a "program evaluation" (a la Imbens and Rubin, 2015) approach may be available.

For example, $W(\Delta x^*)$ is identified if:

1. Have data on Δy_n
2. Have data on $\Delta \tau$
3. Policy change is exogenous: $\Delta \tau \perp\!\!\!\perp \epsilon^*_{t+1} | (\epsilon^*_t, \tau_t)$
4. True causal effects exhibit no spillovers across n (e.g. $\Delta x^*_n = \beta_n \Delta \tau_n$, with β_n unknown)

- However, for many important questions these assumptions are not plausible
  - e.g. #2 violated if policy of interest hasn't happened
  - e.g. #4 violated if interactions wide-reaching (no pure control group)

Answering Causal Questions ... With Structural Estimation

- For this reason, much research draws on "structural"/"quantitative" modeling

In some idealized form, this might look like:

1. Have data on Δy_n
2. Have data on $\Delta \tau$
3. Policy change is exogenous: $\Delta \tau \perp\!\!\!\perp \epsilon^*_{t+1} | (\epsilon^*_t, \tau_t)$
4. Researcher's model $g_n(\tau_t, \epsilon_t; \theta)$ has causal effects known up to parameters θ
5. Parameter θ_0 identified (given #1-#4)
6. True and researcher's model agree on causal effects: $\Delta x(\theta_0) = \Delta x^*$

- However, many audiences may be skeptical of these assumptions
  - e.g. #6 may be implausible if researcher's model seems misspecified (i.e. $W \neq W^*$)
- **What can be done to mitigate audience skepticism?**

These Lectures: 2 Strategies for Improving Credibility of Structural Estimation

- **Strategy #1: Reduce what needs to be estimated**
  - Power of data is limited, so use it for what matters for causal question of interest
  - Related: "Marschak's Maxim" (Heckman, 2010), "Sufficient Statistics" (Chetty, 2009)
- **Strategy #2: Guess and "verify"**
  - Tools from program evaluation may not be able to answer the desired question
  - But they can still be used to check that the model's causal responses (of interest) align with those in the data
- **Key point:** both depend intimately on the question and the available data

Today's Theme: Aggregate Welfare Effects of Trade

- Based on Adao, Costinot and Donaldson (2017).“Nonparametric counterfactual predictions in neoclassical models of international trade.” *American Economic Review*, 107(3): 633-689.

- **Question:** What would have happened to aggregate welfare (in any given country) if China hadn't entered into global trade (post-1995)?

- **Data:** “standard” international trade flows and measures of trade costs

Background (The Field of International Trade, c. 2012)

- 2 common approaches to study of aggregate effects of trade:
- **#1 (e.g.) GTAP project:** $\approx 15,000$ demand/supply parameters (as of v 6.0)
- **#2 Arkolakis, Costinot and Rodriguez-Clare (2012):** identical structural estimating equation ("gravity equation") and identical aggregate welfare effects of trade across influential set of models:
  - Eaton and Kortum (2002)
  - Armington (1969)
  - Krugman (1980)
  - Melitz (2003)
- ACR offers example of Strategy #1 ("Reduce what needs to be estimated"):
- But how did it work? And has it been reduced too far?

Start with a Standard "Neoclassical" Trade Model

- Competitive, no distortions, non-IRS technologies
- But otherwise general: trade due to broad notion of comparative advantage (Ricardo, Heckscher-Ohlin, taste heterogeneity, trade costs, etc.)

- **Key elements:**
  - Many countries (o, d), goods (v), and factors (f)
  - Homothetic preferences (of rep. consumer) in d: $u_d(\boldsymbol{q_d})$, with $\boldsymbol{q_d} \equiv \{q^v_{od}\}$
  - CRS technology of o for d: $q^v_{od} = H^v_{od}(\boldsymbol{l^v_{od}})$, with $\boldsymbol{l^v_{od}} \equiv \{l^{fv}_{od}\}$
  - Factor endowments: $\bar{L}_{of} > 0$

- (See paper for extensions: non-homothetic, DRS, global value chains, taxes...)

Competitive Equilibrium

Allocation ($\boldsymbol{q} \equiv \{\boldsymbol{q}_d\}$, $\boldsymbol{I} \equiv \{\boldsymbol{I}_d\}$) and prices ($\boldsymbol{p} \equiv \{\boldsymbol{p}_d\}$, $\boldsymbol{w} \equiv \{\boldsymbol{w}_d\}$) such that:

1. Consumers maximize their utility:

$$\boldsymbol{q}_d \in \text{argmax}_{\tilde{\boldsymbol{q}}_d} u_d(\tilde{\boldsymbol{q}}_d)$$
$$\sum_{o,v} p_{od}^v \tilde{q}_{od}^v \leqslant \sum_n w_{df} \bar{L}_{df} \text{ for all } d;$$

2. Firms maximize their profits:

$$\boldsymbol{I}_{od}^v \in \text{argmax}_{\tilde{I}_{od}^v} \{p_{od}^v H_{od}^v(\tilde{\boldsymbol{I}}_{od}^v) - \sum_f w_{of} \tilde{I}_{of}^{fv}\} \text{ for all } o,\ d,\ v;$$

3. Goods markets clear:

$$q_{od}^v = H_{od}^v(\boldsymbol{I}_{od}^v) \text{ for all } o,\ d, \text{ and } v;$$

4. Factor markets clear:

$$\sum_{d,v} I_{od}^{fv} = \bar{L}_{of} \text{ for all } o \text{ and } f.$$

Reduced Exchange Model

- Now draw on concept from GE theory: a "reduced exchange model"

- This is a fictitious endowment economy in which consumers directly exchange factor services
  - Taylor (1938), Rader (1972), Wilson (1980), Mas-Colell (1991)
  - Also a (weaker) connection with Vanek's approach to H-O trade model

- *Reduced preferences* over primary factors of production defined by:

$$
\begin{aligned}
U_d(\boldsymbol{L}_d) \equiv \max_{\tilde{\boldsymbol{q}}_d, \tilde{\boldsymbol{l}}_d} & u_d(\tilde{\boldsymbol{q}}_d) \\
\text{s.t. } & \tilde{q}^v_{od} \leqslant H^v_{od}(\tilde{\boldsymbol{l}}^v_{od}) \text{ for all } o \text{ and } v, \\
\text{and } & \sum_v \tilde{l}^{fv}_{od} \leqslant L^f_{od} \text{ for all } o \text{ and } f
\end{aligned}
$$

Reduced Equilibrium

Allocation $\boldsymbol{L} \equiv \{\boldsymbol{L_d}\}$ and prices $\boldsymbol{w} \equiv \{\boldsymbol{w_d}\}$ such that:

1. Consumers maximize their reduced utility:

$$\begin{aligned} \boldsymbol{L}_d \in \text{argmax}_{\tilde{\boldsymbol{L}}_d} & U_d(\tilde{\boldsymbol{L}}_d) \\ \text{s.t.} & \sum_{o,f} w_{of} \tilde{L}^f_{od} \leqslant \sum_f w_{df} \bar{L}_{df} \text{ for all } d; \end{aligned}$$

2. Factor markets clear:

$$\sum_d L^f_{od} = \bar{L}_{of} \text{ for all } o \text{ and } f.$$

Equivalence Between CEs and REs

Proposition 1 (Equivalence)

For any competitive equilibrium, $(\boldsymbol{q}, \boldsymbol{l}, \boldsymbol{p}, \boldsymbol{w})$*, there exists a reduced equilibrium,* $(\boldsymbol{L}, \boldsymbol{w})$*, with:*

1. *the same factor prices,* $\boldsymbol{w}$*;*
2. *the same factor content of trade,* $L_{od}^{f} = \sum_{v} l_{od}^{fv}$ *for all* o*,* d*, and* f*;*
3. *the same welfare levels,* $U_d(\boldsymbol{L}_d) = u_d(\boldsymbol{q}_d)$ *for all* d*.*

Conversely, for any reduced equilibrium, $(\boldsymbol{L}, \boldsymbol{w})$*, there exists a competitive equilibrium,* $(\boldsymbol{q}, \boldsymbol{l}, \boldsymbol{p}, \boldsymbol{w})$*, such that 1-3 hold.*

Reduced Counterfactuals

- The reduced equilibrium approach is useful whenever (as is common) counterfactual questions have an "aggregate" structure (effect of somewhat aggregate primitive on somewhat aggregate outcomes)

- Suppose that the reduced utility function over primary factors in this economy can be parametrized as

$$U_d(\boldsymbol{L}_d) \equiv V_d(\{L^f_{od}/\tau^f_{od}\}),$$

where $\tau^f_{od} > 0$ are exogenous shocks to reduced preferences
  - What then matters is *effective factor prices* $\boldsymbol{\omega}_d \equiv \{w_{of}\ \tau^f_{od}\}$
  - Will write demand in terms of expenditure shares: $\boldsymbol{s}_d = \boldsymbol{\chi}_d(\boldsymbol{\omega}_d)$

- **Counterfactual question:** *What are the effects of a change from* $\boldsymbol{\tau}$ *to* $\boldsymbol{\tau}'$ *(holding all else constant) on trade flows, factor prices, and welfare?*

Counterfactual Trade Flows, Factor Prices, and Welfare

Proposition 2 ("Exact-hat algebra")

Proportional changes in expenditure shares and factor prices, $\hat{\mathbf{s}}$ and $\hat{\mathbf{w}}$, caused by proportional changes in reduced-demand preferences $\hat{\boldsymbol{\tau}}$ solve

$$\{\hat{s}^f_{od} s^f_{od}\} = \boldsymbol{\chi}_d(\{\hat{w}_{of}\hat{\tau}^f_{od}\}) \;\forall\; d,$$

$$\sum_d \hat{s}^f_{od} s^f_{od} \left[\sum_f \hat{w}_{df} w_{df} \bar{L}_{df}\right] = \hat{w}_{of} w_{of} \bar{L}_{of} \;\forall\; o \text{ and } f.$$

Proposition 3 (Welfare)

EV for change from $\boldsymbol{\tau}$ to $\boldsymbol{\tau}'$ can be calculated in the usual manner: "integrate below demand curve" using demand system $\boldsymbol{\chi}_d(\cdot)$ between $\boldsymbol{\omega}_d$ and $\boldsymbol{\omega}'_d$.

What Do We Know About Reduced Factor Demand Systems?

- Not very much!
- But one important case is where reduced factor demand is CES:

Gravity model (i.e. ACR) $\iff$ $\chi_{od}(\boldsymbol{\omega}_d) = \dfrac{\alpha_{od}(\omega_{od})^{-\theta}}{\sum_l \alpha_{ld}(\omega_{ld})^{-\theta}}$

- So the reason behind ACR's result is that all models in their class are CEs that have the same RE
- But this is clearly a very simplistic RE. Could the data tell us more?

Identification of Reduced Factor Demand Systems

- Now assume data generated by neoclassical trade model at different dates t
- And introduce time-varying heterogeneity via:

$$u_{d,t}(\boldsymbol{q_{d,t}}) = \bar{u}_d(\{q^v_{od,t}\}), \text{ for all } d,$$
$$H^v_{od,t}(\boldsymbol{l^v_{od,t}}) = \bar{H}^v_{od}(\{l^{fv}_{od,t}/\tau^f_{od,t}\}), \text{ for all } o,\ d, \text{ and } v.$$

- And available data is "standard":
  1. $s^f_{od,t}$: factor expenditure shares ("factor content of trade", a la Leontief/Vanek)
  2. $w_{of,t}\bar{L}_{of,t}$: factor payments
  3. $(z^\tau)^f_{od,t}$: shifters of effective factor prices (e.g. shifters of trade costs: tariffs/freight)

Identification Assumptions: Exogeneity

- **A1. [Exogeneity]** *Effective factor prices* $\omega^f_{od,t}$ *are related to* $(z^\tau)^f_{od,t}$ *via:*

$$\ln\omega^f_{od,t} = \ln(z^\tau)^f_{od,t} + \varphi^f_{od} + \xi^f_{d,t} + \eta^f_{od,t}, \text{ for all } o,\ d,\ f, \text{ and } t,$$

  with fixed effects φ^f_{od} *and* $\xi^f_{d,t}$*, and with* $E[\boldsymbol{\eta}^f_{od,t}|\boldsymbol{z}^\tau_t] = 0$.

- **A2. [Completeness]** *For any importer pair* (d_1, d_2)*, and any function* $h(\boldsymbol{s}_{d_1,t}, \boldsymbol{s}_{d_2,t})$ *with finite expectation,* $E[h(\boldsymbol{s}_{d_1,t}, \boldsymbol{s}_{d_2,t})|\boldsymbol{z}^\tau_t] = 0$ *implies* $h(\boldsymbol{s}_{d_1,t}, \boldsymbol{s}_{d_2,t}) = 0$.

- (Following Newey and Powell (2003), completeness is nonparametric analog of rank condition in parametric models.)

Identification of Factor Demand

- Argument can then follow Berry and Haile (2014)...

- **A3. [Invertibility]** *In any country d, for any observed expenditure shares, $\boldsymbol{s} > 0$, there exists a unique vector of relative effective factor prices, $(\boldsymbol{\chi}_d)^{-1}(\boldsymbol{x})$, such that all $\boldsymbol{\omega}_d$ satisfying $\boldsymbol{s} \in \boldsymbol{\chi}_d(\boldsymbol{\omega}_d)$ also satisfy $\omega^f_{od}/\omega^1_{1d} = (\chi^f_{od})^{-1}(\boldsymbol{s})$.*

Proposition 4 (Identification)

Suppose that A1-A3 hold. Then relative effective factor prices $\{\boldsymbol{\omega}_{d,t}\}$ and the factor demand system $\boldsymbol{\chi}(\cdot)$ are identified.

Summary So Far...

- **Causal question:** What would have happened to aggregate welfare (in any given country) if China hadn't entered into global trade?
- How to answer it?
- Program evaluation approach seems challenging. Instead, use structural estimation.
- **But deploy Strategy #1 (i.e. reduce what needs to be estimated)**:
  - Question involves aggregate-level shock (i.e. hits factors, not goods) and aggregate-level impact (welfare, not e.g. pattern of goods trade)
  - Reduced factor demand approach: $\chi(\cdot)$ is a "sufficient function", and it is identified from standard data and exogeneity assumptions

Towards Estimation

- While $\chi(\cdot)$ seems a minimally sufficient function for our question of interest, it is (probably) too high-dimensional for practical datasets
- Lots of ways to start reducing dimensionality.
- One way: go in direction of ACR...
  - Within any country, all goods have same factor intensities (i.e. Ricardian model)
  - Pool: $\chi_d(\boldsymbol{\omega}_{d,t}) = \chi(\{\alpha_{od}\omega_{od,t}\})$, for all d.
- What about going as far as ACR (i.e. where $\chi(\cdot)$ is CES)?
- CES has independence of irrelevant alternatives (IIA) property. That seems particularly restrictive when question is about the rise of a substitute (i.e. China).
- **But what does the data say about IIA?**

Departures from IIA in Standard Gravity (i.e. ACR Models)

TABLE 1—REDUCED-FORM ESTIMATES AND VIOLATION OF IIA IN GRAVITY ESTIMATION

Dependent var.: $\Delta\Delta$ log(exports)	(1)	(2)	(3)	(4)
$\Delta\Delta$ log(freight cost)	−5.955	−6.239	−1.471	−1.369
	(0.995)	(1.100)	(0.408)	(0.357)
Test for joint significance of interacted competitors' freight costs ($H_0 : \gamma_l = 0$ *for all* l)				
F-stat		110.34		768.63
p-value		< 0.001		< 0.001
Disaggregation level		exporter		exporter-industry
Observations		576		8,880

Notes: Sample of exports from 37 countries to Australia and United States between 1995 and 2010 (aggregate and 2-digit industry-level). The notation $\Delta\Delta$ refers to the double-difference (first with respect to one exporting country, the United States, and second across the two importing countries). All models include a full set of dummy variables for exporter(-industry). Standard errors clustered by exporter are reported in parentheses.

A More Flexible Factor Demand System

- So IIA is rejected! But how to model departures from it?
- Inspired by IO approach to that same question—e.g. Berry (1994) and Berry, Levinsohn and Pakes (1995) mixed logit demand—introduce a "Mixed CES" system:

$$\chi_{od}(\boldsymbol{\omega}_{d,t}) = \int \frac{(\kappa_o)^{\sigma_1\delta}(\alpha_{od}\omega_{od,t})^{-(\bar{\theta}\cdot\theta^{\sigma_2})}}{\sum_{l=1}^{N}(\kappa_l)^{\sigma_1\delta}(\alpha_{ld}\omega_{ld,t})^{-(\bar{\theta}\cdot\theta^{\sigma_2})}} dF(\delta,\theta)$$

- Where:
  - κ_o = "characteristic" of exporter o (we use exporter's per-capita GDP in 1995)
  - $F(\delta,\theta)$ is a bivariate distribution of parameter heterogeneity: δ has mean zero, $\ln\theta$ mean zero, and covariance matrix is identity
  - $\boldsymbol{\alpha}_d \equiv \{\alpha_{od}\}$ is a vector of unobserved importer-exporter-specific shifters
- Departures from gravity (IIA) governed by $\sigma_1 \neq 0$ or $\sigma_2 \neq 0$

Demand System Parameter Estimates (GMM)

	$\bar{\theta}$	σ_1	σ_2
CES	-5.995		
	(0.950)		
Mixed CES (restricted heterogeneity)	-6.115	2.075	
	(0.918)	(0.817)	
Mixed CES (unrestricted heterogeneity)	-6.116	2.063	0.003
	(0.948)	(0.916)	(0.248)

Implied Departures from IIA

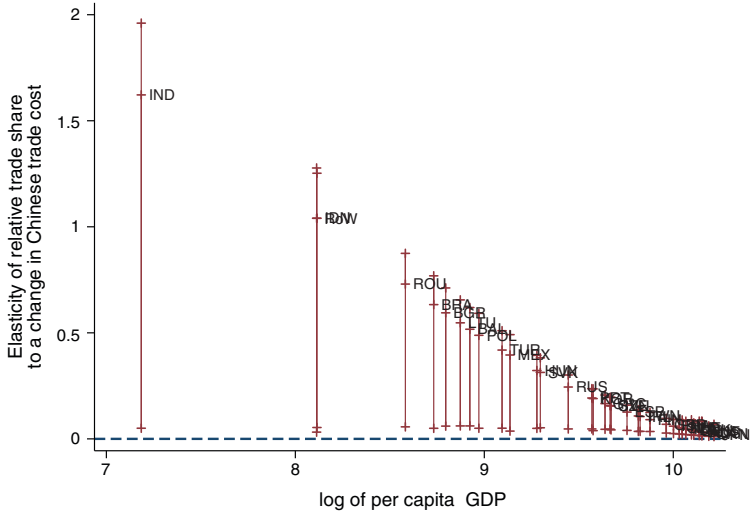


Figure 1. Elasticity of Demand Relative to the United States with Respect to Chinese Factor Price

Welfare Effects of Chinese Integration

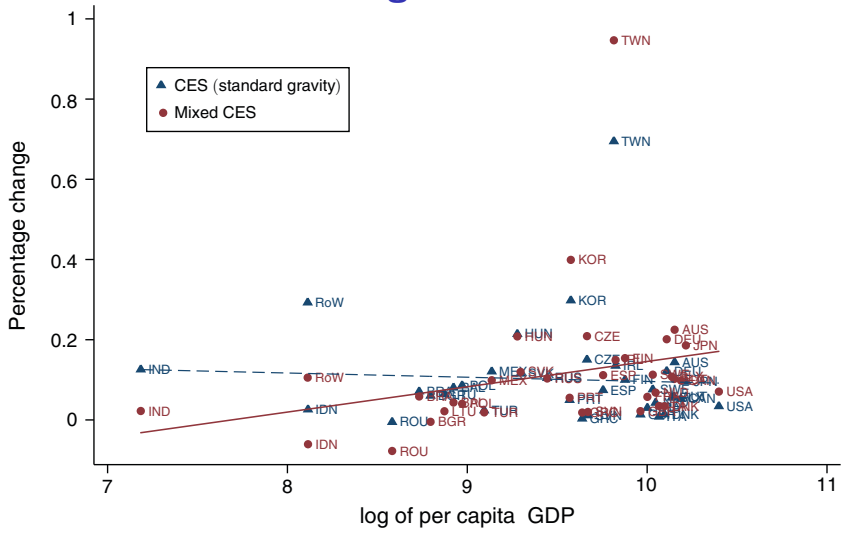


FIGURE 4. WELFARE GAINS FROM CHINESE INTEGRATION SINCE 1995: OTHER COUNTRIES, 2007

Concluding Remarks

- For many important questions, structural estimation is necessary. But audience skepticism is severe!
- How can researchers make structural estimation more credible?
- **Today's lecture:**
  - Full deployment of Strategy #1: Reduce what needs to be estimated
  - Insights from GE/Trade theory on how to get there
  - Facilitates connections with other fields (e.g. IO) in perhaps surprising ways
- **Tomorrow's lecture:**
  - Change the question: how does trade affect inequality?
  - Enrich the data: bring in administrative microdata to relax assumptions
  - Strengthen Strategy #2: Guess and Verify

Thank You!