Estimating the Effects of Globalization
Lecture 3: How (Not) to Win a Trade War

2014 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)

Today's Theme: Trade Wars

- Based on Adao, Rodrigo, Arnaud Costinot, and Dave Donaldson "Putting quantitative models to the test: An application to the US-China trade war." *Quarterly Journal of Economics*, forthcoming.
- Context:
  - **Question:** What would have happened to US welfare if Trump hadn't started his trade war?
  - **Data:** Prices and quantities of the goods that enter and exit the US

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

FAQs About Approach to Testing Models Developed Here

1. **Why test models? (All models are wrong!)**
    - Yes but some are hopefully useful. Design test around the use in mind
2. **What's the use of a p-value? (A fancy measure of N?)**
    - Use test statistic (and hence CI) with interpretability under some misspecification
3. **What's wrong with an "untargeted moment"/over-identification test?**
    - Not clear how such moments relate to the causal question of interest
4. **Isn't it an old idea to compare causal responses in model and data?**
    - Yes. E.g. "Lucas program" of Christiano et al (1999). Here: use-driven test.
5. **Where do I get exogenous variation from?**
    - Can "re-use" exogeneity beliefs used for estimation if screen for "mechanical" fit.
6. **How can I test my model when it (by design) fits the data exactly?**
    - Can still test whether exactly-fitting residuals are orthogonal to exog. variation.
7. **There is only one economy (i.e. "N"$= 1$). How can I test anything?**
    - Can still test on disaggregated data if inference adjusted for GE dependence.
8. **Is this thing hard to use?**
    - No, only new ingredient is model's Jacobian. User's guide on our websites.

Answering Causal Questions (Recap from Lecture #1)

- **Consider reduced-form of *researcher's model*:**

$$y_{n,t} = g_n(\tau_t, \epsilon_t; \theta)$$

  - $y_{n,t}$: 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"
  - $g_n(\cdot)$: mapping implied by market structure, preferences, technology, etc.
  - θ = time-invariant parameters of $g(\cdot)$ to be estimated (often suppressed)

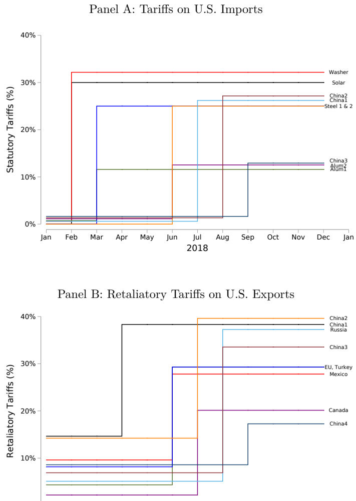
- **Goal is to answer counterfactual question about causal impact of policy change:**

$$W(\Delta x) \equiv \sum_n \omega_n \Delta x_n, \quad \text{with } \{\omega_n\}_n \text{ observed}$$

$$\text{where} \quad \Delta x_n \equiv g_n(\tau_{t+1}, \epsilon_{t+1}) - g_n(\tau_t, \epsilon_{t+1})$$

- **Essentially WLOG to write it this way**

Running Application: Fajgelbaum, Goldberg, Kennedy and Khandelwal (2020)



- What was impact of "Trump's trade war" (2018/19 tariff rise in US and abroad) on US welfare?
- From abstract: *"The aggregate [US] real income loss was \$7.2 billion, or 0.04% of GDP"*

1. Have data on Δy_n and $\Delta\tau$
2. Believe $\Delta\tau \perp\!\!\!\perp \epsilon^*_{t+1} | (\epsilon^*_t, \tau_t)$
3. $g_n(\tau_t, \epsilon_t; \theta)$ has causal effects $\Delta x_n(\theta)$
4. θ is identified (given #1-#4)
5. Report $W(\Delta x) = \sum_n \omega_n \Delta x_n(\widehat{\theta})$
6. ... "add-on" that would enhance credibility?

FGKK: Idea Behind Estimation of Parameters θ

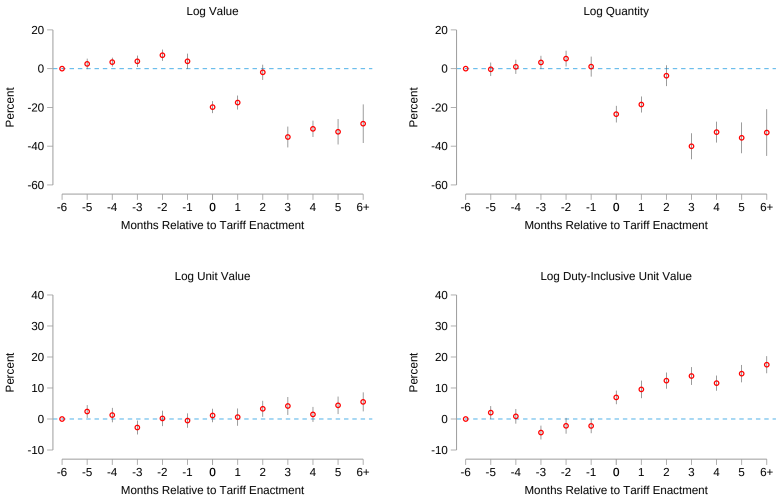
- FGKK start with event studies (for various outcomes y):

$$\begin{aligned}\Delta \ln y_{cgt} &= \eta_{ig} + \eta_{gt} + \eta_{ct}^{m} + \sum_{j=-6,6} \beta_{0j} \mathbf{I}(event_{cgt} = j) \\ &+ \sum_{j=-6,6} \beta_{1j} \mathbf{I}(event_{cgt} = j) \times target_{cg} + \varepsilon_{cgt}\end{aligned}$$

- Where c is the foreign country, g is the product, t is time (month), and $target_{cg}$ denotes products that were targeted (for tariff changes during the trade war) for/by the country c.

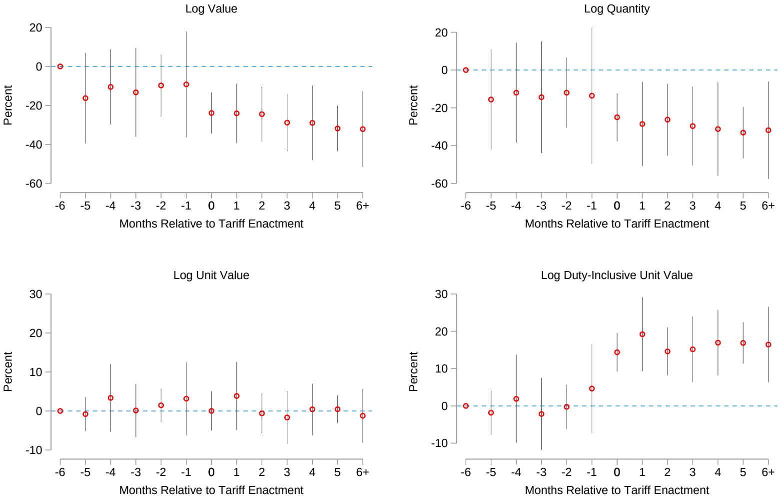
FGKK: Idea Behind Estimation of Parameters θ

Figure II: Variety Event Study: Imports



FGKK: Idea Behind Estimation of Parameters θ

Figure III: Variety Event Study: Exports



What Do We Expect a Trade War to Do? General Setup

- Setup/notation follows Adao, Costinot, Donaldson and Sturm (2023)
- **Domestic technology:** firm v produces net output $\tilde{q}(v) \in \Upsilon(v)$
- **Domestic preferences:** individual i has utility $u(i) = u(c(i); i)$
- **Domestic ownership:** individual i owns share $\phi(v, i)$ of firm v (and endowments of factors are just simple "firms")
- **Domestic competition:** high-level conditions such that any change results in (even at the firm's max) $d\pi(v) = q(v) \cdot dp + p \cdot dq(v)$
- **Foreign offer curve:** net imports m are feasible if $m \in \Omega(p^w)$
- **Domestic taxes and transfers:**
  - Specific trade taxes on each good: $p = p^w + t$
  - Production/sales taxes t^q, income tax schedule with marginal rate $T(i)$
  - Potential transfers
- **Domestic externalities:** let $\Upsilon(v)$, $u(i)$, $\Omega(\cdot)$ all depend on externalities z

What Do We Expect a Trade War to Do? Counterfactuals

- Consider any change caused by a small change in trade taxes (or foreign shocks)
- If consumers and firms are optimizing, changes must satisfy:

$$\sum_i \nu(i) du(i) = \underbrace{\beta \cdot d(\omega - \bar{\omega})}_{\text{Dom. redistribution}} + \underbrace{t \cdot dm}_{\text{Fiscal ext.: trade taxes}} - \underbrace{m \cdot dp^w}_{\text{Redistribn. from abroad}}$$

$$+ \underbrace{\sum_v t^q \cdot dq(v)}_{\text{Fiscal ext.: other taxes}} + \underbrace{\sum_i \sum_v \beta(i)\phi(v,i)(p \cdot dq(v))}_{\text{“Markup/down" } \times \ \Delta\text{allocation}}$$

$$+ \underbrace{\left(\sum_i \sum_v \beta(i)(\phi(v,i)\pi_z(v) - e_z(i)\right) \cdot dz}_{\text{Effect on un-internalized externalities}}$$

- Where $\nu(i)$ is arbitrary set of marginal “SWF” weights, $\mu(i)$ is MU of income, $\beta(i) \equiv \frac{\mu(i)\nu(i)}{\sum_i' \mu(i')\nu(i')}$, and $d\omega(i) \equiv (1 - T(i))(\sum_v \phi(v,i) d\pi(v)) - c(i) \cdot dp$

What Do We Expect a Trade War to Do? Counterfactuals

- So if we let $W \equiv \sum_i \nu(i) du(i)$ then previous expression describes how the researcher's model delivers the answer $W = \sum_n \omega_n \Delta x_n$
- For example, FGKK's model starts with high-level assumptions:
  1. Transfers and uniform SWF: no value to domestic redistribution
  2. No domestic tax, market power, or uninternalized externality effects
- Then left with:

$$W = \underbrace{t \cdot dm}_{\text{Fiscal ext.: trade taxes}} - \underbrace{m \cdot dp^w}_{\text{Redistribn. from abroad}}$$

- So remainder of FGKK's model $g(\cdot)$ provides a GE theory of how the 2018 trade war affected these two terms

FGKK's Model: Domestic (US) Households

- Household in region r and sector s has endowment of $L_{rs,t}$ units of labor

- All households have common nested CES preferences:

$$U_t = (C_{NT,t})^{\beta_{NT,t}} (C_{T,t})^{\beta_{T,t}}$$

$$C_{T,t} = \prod_{s \in \mathcal{S}} (C_{Ts,t})^{\beta_{s,t}}, \qquad C_{Ts,t} = \left[(A_{Ds,t})^{\frac{1}{\kappa}} (D_{s,t})^{\frac{\kappa-1}{\kappa}} + (A_{Ms,t})^{\frac{1}{\kappa}} (M_{s,t})^{\frac{\kappa-1}{\kappa}} \right]^{\frac{\kappa}{\kappa-1}}$$

$$D_{s,t} = \left[\sum_{g \in \mathcal{G}_s} (a_{Dg,t})^{\frac{1}{\eta}} (d_{g,t})^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}}, \qquad M_{s,t} = \left[\sum_{g \in \mathcal{G}_s} (a_{Mg,t})^{\frac{1}{\eta}} (m_{g,t})^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}}$$

$$m_{g,t} = \left[\sum_{o} (a_{og,t})^{\frac{1}{\sigma}} (m_{og,t})^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}}$$

FGKK's Model: Domestic (US) Firms

- Competitive firms in each region r and sector s take good and factor prices as given
- Nested CES technologies:

$$Q_{NTr,t} = \widetilde{A}_{NTr,t} L_{NTr,t}$$

$$Q_{sr,t} = \widetilde{A}_{sr,t} \left(I_{sr,t}\right)^{\alpha_{Is,t}} \left(L_{sr,t}\right)^{\alpha_{Ls,t}}, \qquad \alpha_{Is,t} + \alpha_{Ls,t} < 1$$

$$I_{sr,t} = \prod_{k \in \mathcal{S}} (I_{ksr,t})^{\alpha_{ks,t}}, \qquad \sum_{k \in \mathcal{S}} \alpha_{ks,t} = 1$$

$$\sum_{g \in \mathcal{G}_s} \frac{q_{gs,t}}{\widetilde{a}_{gs,t}} = \sum_r Q_{sr,t}$$

FGKK's Model: Foreign Import Demand and Export Supply

- Given export price $p^{x}_{dk,t}$, exports (given by foreign import demand):

$$x_{dg,t} = a^{F}_{dg,t} \left((1 + \tau^{F}_{dg,t}) p^{X}_{dg,t} \right)^{-\sigma^{F}}$$

- Given (pre-tariff) import price $p^{F}_{og,t}$, foreign export supply is

$$m_{og,t} = (p^{F}_{og,t})^{\frac{1}{\omega^{F}}} (b^{F}_{og,t})^{\frac{1}{\omega^{F}}}$$

- US government imposes import tariffs so that import price is

$$p_{og,t} = (1 + \tau^{H}_{og,t}) p^{F}_{og,t}$$

- Government uses a lump-sum transfer $\widetilde{T}_t$ to rebate tariff revenue and foreign transfer D_t

FGKK's model $y_t = g(\tau_t, \epsilon_t; \theta)$

- Time-varying shocks to preferences, technology, and endowments:

$$\epsilon_t \equiv \{\beta_{NT,t}, \beta_{s,t}, A_{Ms,t}, a_{Dg,t}, a_{Mg,t}, a_{og,t}, \widetilde{A}_{NTr,t}, \widetilde{A}_{sr,t}, \alpha_{ls,t}, \alpha_{Ls,t}, \alpha_{ksr,t}, a^F_{dg,t}, b^F_{og,t}, D_t, L_{sr,t}\}$$

- Governments' policy vector:

$$\tau_t \equiv \{\tau^H_{og,t}, \tau^F_{dg,t}\}$$

- UMP + PMP + GMC + LMC + GBC $\Longrightarrow$ **reduced-form** $y_t = g(\tau_t, \epsilon_t; \theta)$

- In practice:
  - Foreign countries o, d: 71 partner countries
  - Sectors s: 88 tradable. Products g: 10,228 tradable (10-digit HS)
  - Estimate $\widehat{\theta}$ from previous event study regressions (for outcomes: tariffs, export/import prices and export/import quantities)
  - $\widehat{\theta}$: $\widehat{\kappa} = 1.19, \widehat{\eta} = 1.53, \widehat{\sigma} = 2.53, \widehat{\sigma}^F = 1.04, \widehat{\omega}^F = -0.002$

FGKK's Causal Effect of Interest

- Then use model to compute:

$$W(\Delta x) = \sum_{d,g} \omega_{dg}^{PX}(\Delta x_{dg}^{PX}) - \sum_{o,g} \omega_{og}^{PM}(\Delta x_{og}^{PM}) + \sum_{o,g} \omega_{og}^{TR}(\Delta x_{og}^{TR})$$

where:

- $\Delta x_{dg}^{PX} \equiv$ change in the log of US *export price* of good g in country d
- $\Delta x_{og}^{PM} \equiv$ change in the log of US *import price* of good g from country o
- $\Delta x_{og}^{TR} \equiv$ change in US *tariff revenues* on g from o (as share of import spending)
- $\omega_{dg}^{PX} \equiv$ share of export revenues in 2016 US GDP accounted by d and g
- $\omega_{og}^{PM} = \omega_{og}^{TR} \equiv$ share of import spending in 2016 US GDP accounted by o and g

Numbers We Can Believe In?

- **Data generated by <u>true</u> model:**

$$y_{n,t}{=}g_n^*(\tau_t,\epsilon_t^*), \qquad \Delta x_n^* \equiv g_n^*(\tau_{t+1}, \epsilon_{t+1}^*) - g_n^*(\tau_t, \epsilon_{t+1}^*)$$

- **For simplicity, suppose true and researcher's model agree on weights $\{\omega_n\}_n$:**

$$W(\Delta x) \equiv \sum_n \omega_n \Delta x_n \qquad \text{vs.} \qquad W(\Delta x^*) \equiv \sum_n \omega_n \Delta x_n^*$$

- That is, agree on what I previously called the "high-level" assumptions in FGKK
- But of course still room for much disagreement about Δx_n and hence $W(\Delta x_n)$

Testing With an IV-Based Test Statistic

- Want to test $W(\Delta x) = W(\Delta x^*)$—not $g = g^*$!
- Empirical challenge: don't observe Δx_n^* (obviously)
- But suppose we observe change in outcomes before and after the policy change

$$\Delta y_n = g_n^*(\tau_{t+1}, \epsilon_{t+1}^*) - g_n^*(\tau_t, \epsilon_t^*) = \Delta x_n^* + \Delta \eta_n^*$$

where $\Delta \eta_n^* \equiv g_n^*(\tau_t, \epsilon_{t+1}^*) - g_n^*(\tau_t, \epsilon_t^*)$ is the causal impact of the other shocks

Definition: IV-based test statistic

Suppose we have some "instrument" z. Then IV-based test statistic *is*

$$\hat{\beta}_z \equiv \frac{1}{N_W} \sum_{n \in \mathcal{N}_W} z_n (\Delta y_n - \Delta x_n)$$

where N_W denotes the number of observations in $\mathcal{N}_W \equiv \{n : \omega_n \neq 0\}$.

An IV-Based Test: Moment Restriction

A3: No misspecification of causal effects

For any $n \in \mathcal{N}_W$, $\Delta x_n^* = \Delta x_n$.

Proposition 1: expected value of IV-based test statistic

Take any IV z *that satisfies* $E_t[\sum_{n\in\mathcal{N}_W} z_n \Delta\eta_n^*] = 0$. *If A3 holds, then* $E_t[\hat{\beta}_z] = 0$.

- **Proof:** Substitute $E_t[\sum_{n\in\mathcal{N}_W} z_n \Delta\eta_n^*] = 0$ into definition of $\hat{\beta}_z$ and use identity $\Delta y_n = \Delta x_n^* + \Delta\eta_n^*$. Then A3 implies

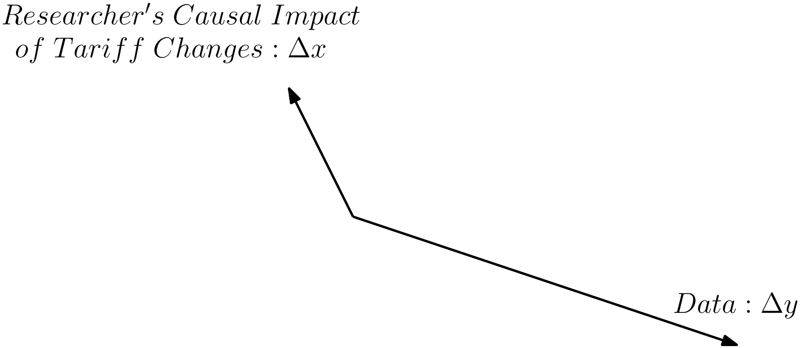
$$E_t[\hat{\beta}_z] = \frac{1}{N_W} E_t[\sum_{n\in\mathcal{N}_W} z_n(\Delta x_n^* - \Delta x_n)] = 0$$

- **NB:** Given z that satisfies $E_t[\sum_{n\in\mathcal{N}_W} z_n \Delta\eta_n^*] = 0$, $E_t[\hat{\beta}_z]$ is a weighted sum of misspecifications, $\Delta x_n^* - \Delta x_n$, along all welfare-relevant variables

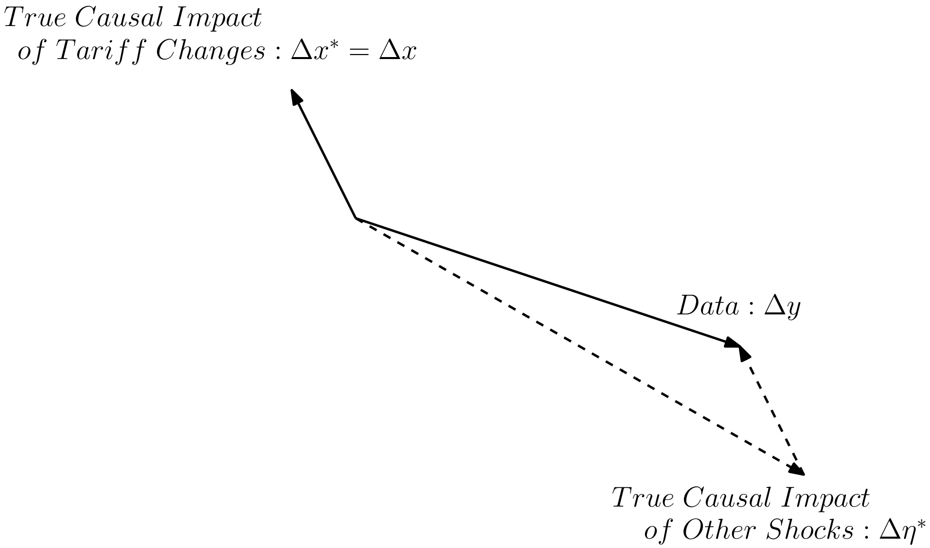
Intuition behind IV-Based Test

$Researcher's\ Causal\ Impact$
$of\ Tariff\ Changes: \Delta x$

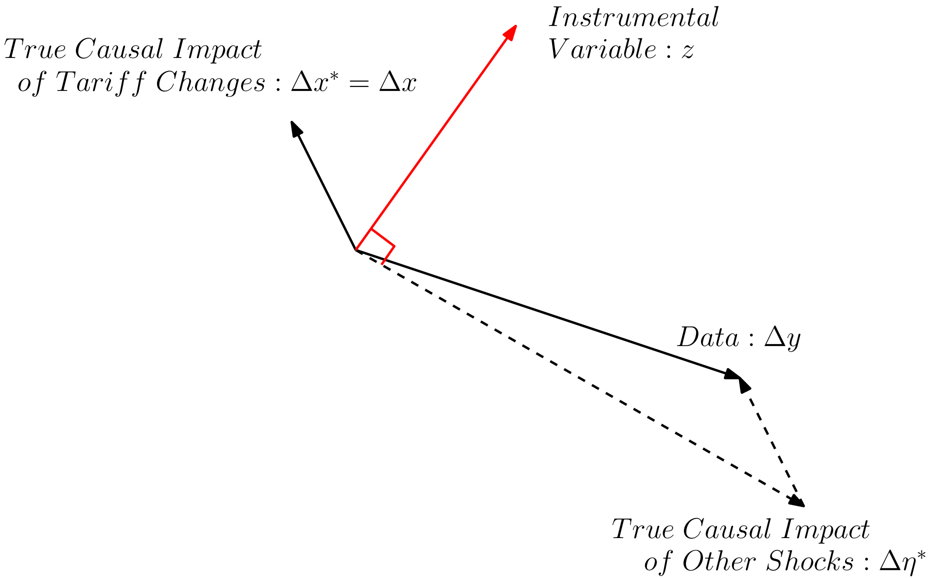
Intuition behind IV-Based Test



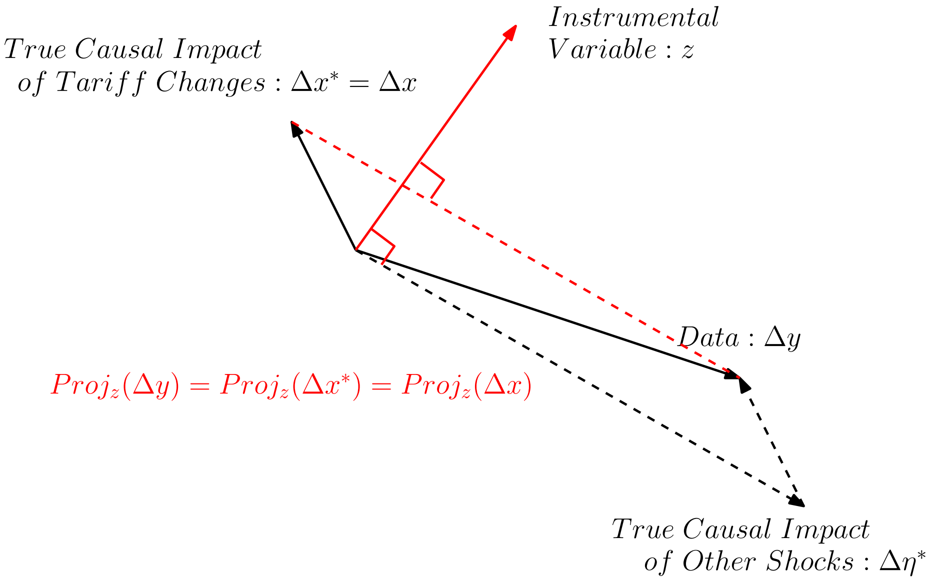
Intuition behind IV-Based Test



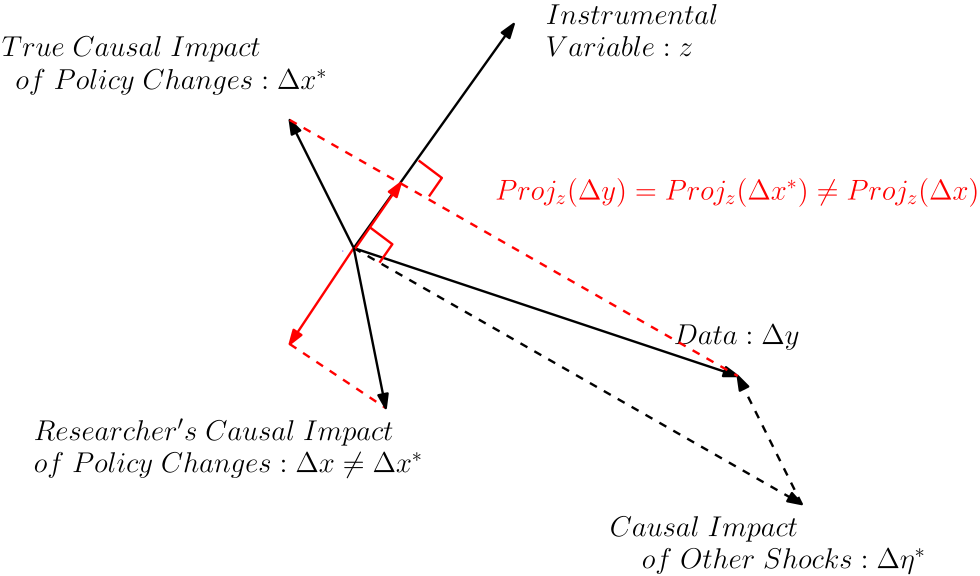
Intuition behind IV-Based Test



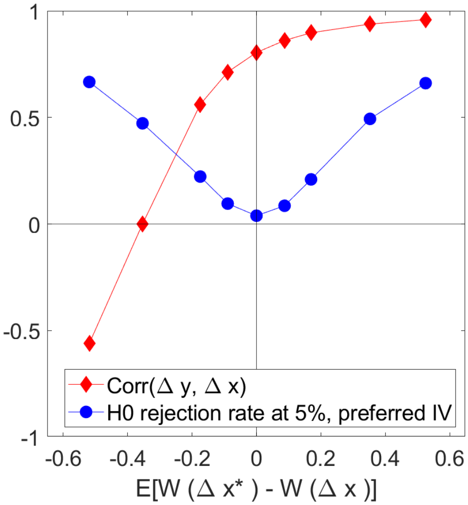
IV-Based Test (when does not reject)



IV-Based Test (when rejects)



FGKK (2020): Monte Carlo simulation



From Exogenous Policy Shifters to a Candidate IV

- So far, taken as given a z that satisfies $E_t[\sum_{n\in\mathcal{N}_W} z_n \Delta\eta_n^*] = 0$
- Empirical literature offers vector of exogenous policy shifters $\Delta\tau_{IV} \equiv \{\Delta\tau_{IV,k}\}_k$:
  - Could just be observed policy change (as in FGKK)
- We confine attention to instruments z that take form:

A1: Shift-share structure

For any $n \in \mathcal{N}_W$, the IV takes the form $z_n = \sum_k s_{nk}\Delta\tau_{IV,k}$, where the vector of "shares" $\{s_{nk}\}$ may be a function of, and only of, (ϵ_t^*, τ_t).

A2: Exogeneity of the shifters

$E_t[\Delta\tau_{IV}|(\epsilon_t^*, \tau_t)] = 0$ *and* $\Delta\tau_{IV} \perp\!\!\!\perp \epsilon_{t+1}^*|(\epsilon_t^*, \tau_t)$.

- Then trivial to show that A1 and A2 $\Rightarrow E_t[\sum_{n\in\mathcal{N}_W} z_n \Delta\eta_n^*] = 0$

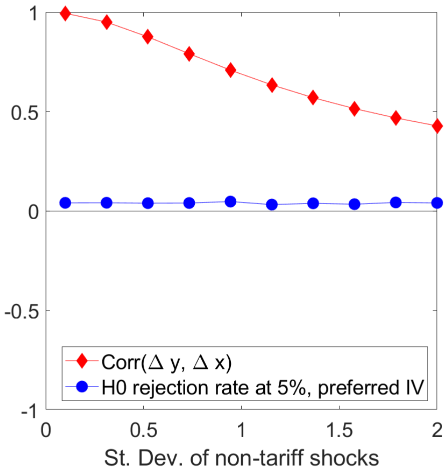
Asymptotic Null Distribution of Test Statistic

- How to do inference? Haven't yet taken any stand on distribution of shocks ϵ_{t+1} (and hence of the data Δy under the null
- Can apply "design-based" results on consistency (Borusyak et al., 2022) and inference (Adao et al., 2019) of shift-share IV

Proposition 2: asymptotic behavior of test statistic

Take IV z that satisfies A1 and A2. If A3 holds and (i) $\Delta\tau_{IV,k}$ are i.i.d., (ii) $\frac{1}{N_W^2}\sum_k (S_k)^2 \to 0$ with $S_k \equiv \sum_n |s_{nk}|$, and (iii) $Var_t[\Delta\tau_{IV,k}]$ and $\Delta\eta_n^*$ are uniformly bounded, then $\hat{\beta}_z \to_p 0$. If, in addition, (iv) $\frac{\max_k(S_{k,t})}{\sum_k S_{k,t}^2} \to 0$; (v) $E_t[(\Delta\tau_{IV,k})^4]$ is uniformly bounded; and (vi) $\frac{1}{\sum_k S_k^2} Var_t[\sum_{n\in\mathcal{N}_W} z_n \Delta\eta_n^* | \epsilon_{t+1}^*] \to_p V_\beta > 0$, then $r_\beta \hat{\beta}_z \to_d \mathcal{N}(0, V_\beta)$ with $r_\beta \equiv N_W/\sqrt{\sum_k S_k^2}$.

FGKK (2020): In Monte Carlo, coverage of test statistic when no misspecification



Extensions

- **Estimation uncertainty:**
  - If g is known up to estimation of structural parameter θ, then can compute asymptotic distribution of $\hat{\beta}_z(\hat{\theta})$ whenever
    - $\hat{\theta}$ is independent of $\hat{\beta}_z(\theta)$ (e.g. when estimation on a different sample)
    - $\hat{\theta}$ is an IV estimator, potentially based on the same policy shifters (as in FGKK)
- **Clustering:**
  - Weaken such that $\Delta\tau_{IV,k}$ is only i.i.d across *groups* of observations
- **Controls:**
  - Weaken A2 such that indep. of $\Delta\tau_{IV}$ holds only after controlling for linear determinants of $\Delta\eta^*$
  - Need to then residualize shares $\{s_{nk}\}$ w.r.t. those controls

Economic Interpretation of Test Statistic $\hat{\beta}_z$

- **Question:** How should we interpret any value of the test statistic? Ideally, we would like it to measure, at least on average, misspecification in the counterfactual of interest, i.e.,

$$E_t[W(\Delta x^*) - W(\Delta x)] = E_t[\sum_n \omega_n(\Delta x_n^* - \Delta x_n)]$$

- **Challenge:** $E_t[\hat{\beta}_z] = \frac{1}{N_W} E_t[\sum_n z_n(\Delta x_n^* - \Delta x_n)] \neq E_t[\sum_n \omega_n(\Delta x_n^* - \Delta x_n)]$ for arbitrary z
    - LATE logic with $\Delta x_n^* - \Delta x_n$ playing the role of the heterogeneous treatment

- **But, lots of freedom to choose shares in shift-share IV z...**

Economic Interpretation of Test Statistic $\hat{\beta}_z$

- **Question:** How should we interpret goodness of fit measure? Ideally, we would like it to measure, at least on average, misspecification in the counterfactual of interest, i.e.,

$$E_t[W(\Delta x^*) - W(\Delta x)] = E_t[\sum_n \omega_n(\Delta x_n^* - \Delta x_n)]$$

A3': Misspecification of causal impacts

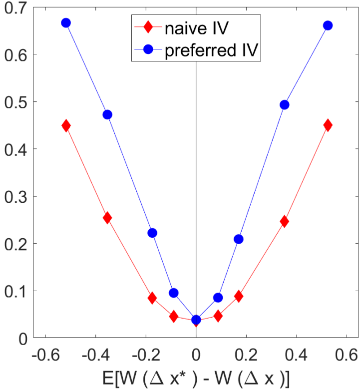
For any $n \in \mathcal{N}_W$, $\Delta x_n^* = \alpha_n \Delta x_n$, with the misspecification parameter α_n a function of $(\epsilon_t^*, \epsilon_t, \tau_t)$, but not τ_{t+1}.

Proposition 3: IV-based test stat measures average welfare misspecification

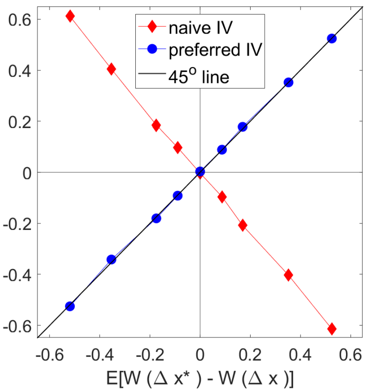
Take IV z that satisfies A1 and A2 and define z', with $z_n' \equiv z_n \omega_n E_t[\Delta x_n]/E_t[z_n \Delta x_n]$. If A3' holds, then $E_t[\hat{\beta}_{z'}] = E_t[W(\Delta x^*) - W(\Delta x)]$.

FGKK (2020): Monte Carlo Comparing IV-Based Tests

"Preferred IV" follows method in Proposition 3. "Naive IV" only uses tariff shifters on product of interest.



(a) Rejection rate



(b) Mean of $\hat{\beta}_z$

Choosing IVs to Improve Statistical Power

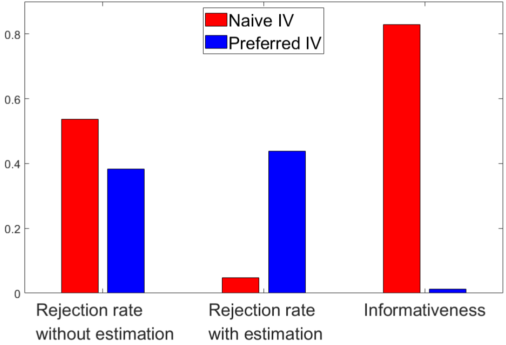
- IV in Proposition 3 still leaves lots of flexibility in choice of shares. Can use that to improve power...

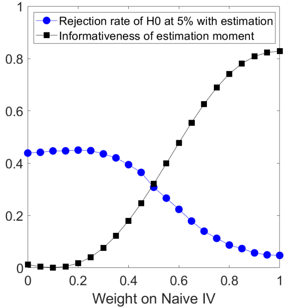
- Three potential reasons for low-power of arbitrary IV-based test:
  1. **Lack of first stage:** $E_t[z_n \Delta x_n] = E_t[z_n \Delta y_n] = 0$ because z is noise
  2. **Mechanical fit:** Estimation moments "mechanically" related to testing moments
  3. **Precision:** Too much variance in $\Delta y_n - \Delta x_n \Rightarrow$ too much variance in $\hat{\beta}_z$

- Three potential solutions:
  1. To address lack of first stage, **use** causal impact of shifters predicted by **researcher's model,** i.e. $s_{nk} = \partial f_n / \partial \tau_k \Rightarrow z_n = \sum_k (\partial f_n / \partial \tau_k) \Delta \tau_{IV,k}$
  2. To address mechanical fit, use IV z such that **estimation moments** are **less informative** about $\hat{\beta}_z$ in the sense of Andrews et al. (2020)
  3. To improve precision, project z on a vector of controls and **use residuals**

FGKK (2020): Monte Carlo for Estimation, Informativeness and Mechanical Fit

"Preferred IV" as before. "Naive IV" further residualized with respect to product-specific fixed effects. σ estimated as in FGKK using product-specific fixed effects. Import quantities are misspecified.





Related Tests

- **Testing via model "forecasts"/backcasts—e.g. correlation(data,model)=1**
  - Lai and Trefler (2002), Costinot and Donaldson (2012), Kehoe et al. (2017), Desmet et al. (2018)
  - $\hat{\beta}_{z'} = \frac{1}{N_W}\sum_n z_n'(\Delta x_n^* - \Delta x_n)$ is very different from $\text{corr}(\Delta y_n, \Delta x_n) \propto \frac{\text{var}(\Delta x_n^*)}{\text{var}(\Delta \eta_n^*)}$

- **Testing via "untargeted moments"**
  - Edmond et al. (2011); Costinot et al. (2016); Antras et al. (2017)
  - Testing $W(\Delta x^*) = W(\Delta x)$ not $g = g^*$

- **Testing via "untargeted causal responses"**
  - "Lucas (1980) Program"—Christiano et al. (1999, 2005), Todd and Wolpin (2006), Nakamura and Steinsson (2014, 2018), Ahlfeldt et al. (2015), Adao et al. (2022)
  - Tests of conduct in IO etc.: Bresnahan (1982), Berry-Haile (2014)
  - $\hat{\beta}_{z'} = \frac{1}{N_W}\sum_n z_n'(\Delta x_n^* - \Delta x_n)$ is weighted avg. of responses that matter for counterfactual
  - How to do inference (dependence, prior estimation)? How to avoid mechanical success?

Testing vs. Estimation

- **If moment $\hat{\beta}_{z'} = \frac{1}{N_W} \sum_n z_n' (\Delta x_n^* - \Delta x_n)$ is "useful", why use it for testing rather than estimation?**
  - E.g. could impose $\hat{\beta}_{z'} = 0$ as an additional moment in GMM for estimating θ
  - Efficient! Minimizes asymptotic Var($\widehat{\theta}$) under null of no misspsecification
  - Could then also do J-test for purposes of testing A3

- **2 advantages to the testing-based approach developed here:**

  1. **Economic interpretation:**
     - J-test statistic is weighted sum of moment gaps
     - How then to assess errors in the model's counterfactual prediction?

  2. **Power:**
     - Moments used for θ are often relatively "partial equilibrium", but counterfactual is more "GE"
     - GMM: low-variance moments get more weight (for estimation and testing)
     - If GE moments are inherently noisier, this tilts power away from testing the counterfactual

FGKK (2020): Now on actual data on Trade War

Everything exactly as in previous simulations, except...

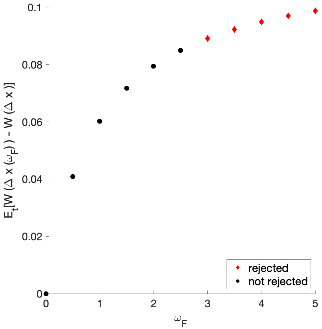
1. Use actual US and foreign tariff changes:
   - $\tau_t \equiv \{\tau^H_{og,t}, \tau^F_{dg,t}\}$: avg. Jan-Dec, 2016
   - $\tau_{t+1} \equiv \{\tau^H_{og,t+1}, \tau^F_{dg,t+1}\}$: avg. Jan-April, 2019
2. Use actual data on post-shock outcomes y_{t+1}

FGKK (2020): An IV-based test

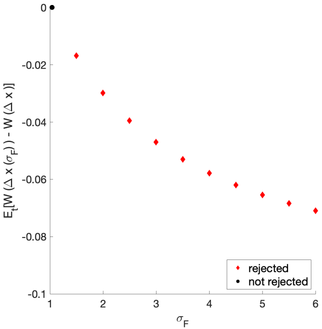
Goodness-of-fit measure:	Correlation	IV-Based Test	
		Naive IV	Preferred IV
	$Corr\left(\Delta y_n, \Delta x_n(\hat{\theta})\right)$	$\hat{\beta}_{z^{\text{naive}}}(\hat{\theta})$	$\hat{\beta}_{z^{\text{pref}}}(\hat{\theta})$
	(1)	(2)	(3)
Point estimate	0.04	0.59	0.15
Inference ignoring estimation of $\widehat{\theta}$			
Std. error		0.66	0.21
p-value of H_0: $\hat{\beta}_z = 0$		0.36	0.48
Inference accounting for estimation of $\widehat{\theta}$			
Std. error		0.67	0.23
p-value of H_0: $\hat{\beta}_z = 0$		0.37	0.52

Under A3' column (3) $\Rightarrow$ $E_t[W(\Delta x^*) - W(\Delta x)] = +0.15\%$ of GDP.
(Recall that $W(\Delta x)$ = -0.04% of GDP = –$7 B.)

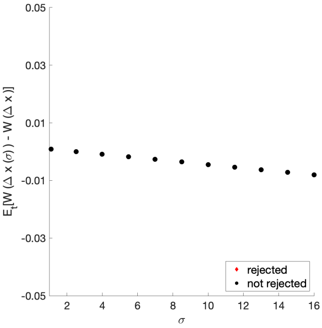
FGKK (2020): Would Alternative Models Be Rejected?



(a) Alternative values of ω_F

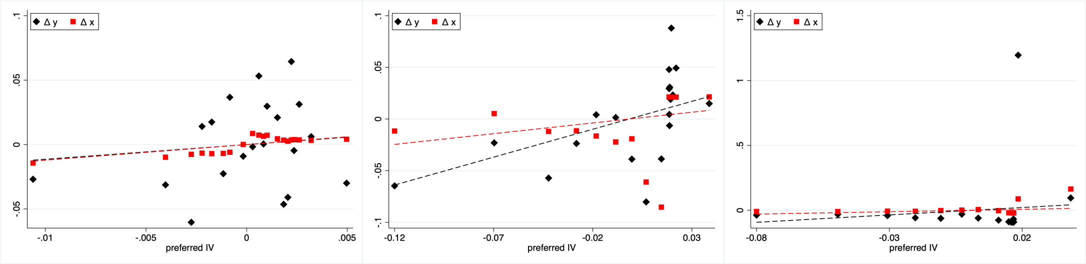


(b) Alternative values of σ_F



(c) Alternative values of σ

FGKK (2020): Other predictions



(a) Export Prices (0.15 (0.23)) (b) Import Prices (0.33 (0.08)) (c) Tariff Revenues (0.77 (0.21))

Kehoe and Prescott (1995): "... shortcomings in [counterfactual] predictions of a model would then provide motivation for further theoretical development and further testing."

Concluding Remarks

- For many important questions, structural estimation is necessary. But audience skepticism is severe!
- How can researchers make structural estimation more credible?
- **Themes from these lectures about how this might be done better:**
  - Program evaluation and structural estimation have complementary elements
  - Enhancing credibility will hinge on the causal question and the available data
  - **Strategy #1: Reduce what needs to be estimated**
  - **Strategy #2: Guess and "verify".** After guessing at a model that will deliver the right causal response, easy add-on procedure can (hopefully) verify that the data does not reject the assumption that this model does indeed do so

Thank You!