Quasi-Experimental Shift-Share Research Designs

Kirill Borusyak, Peter Hull, and Xavier Jaravel
(2022, REStud)

January 23, 2025

Presented by
Seulkichan Bang and Seho Son

Key Findings of Borusyak, Hull, and Jaravel (2022, REStud; hereafter BHJ)

- When using shift-share IVs, one has to take an *a priori* stand whether shares or shocks are exogenous. (c.f. "framework")
- BHJ propose a formal framework for the exogenous shocks view. (Exposure shares may be endogenous)
- This approach has practical implications for choosing controls (especially when shares do not add up to one - the "Incomplete Shares" issue).
  - Application to Autor, Dorn, and Hanson (2013, AER; hereafter ADH)

Intro to SSIV

- We are interested in β from a causal or structural relationship:

$$y_l = \beta x_l + \gamma' w_l + \varepsilon_l$$

- Application 1: (inverse) elasticity of labor supply
  - β: (inverse) elasticity of labor supply
  - y_l: wage growth in region l
  - x_l: employment growth in region l
- Application 2(ADH, 2013): China effect on employment growth in the U.S(manuf.).
  - β: the china effect
  - y_l: employment growth in region l
  - x_l: local labor market exposure to increased competition by china.
- Why do we need IV?

Intro to SSIV

- The structure of SSIV:
$$z_l = \Sigma_n s_{ln} g_n,$$
where $s_{ln} \in [0,1]$ are exposure shares and g_n are shocks. In simple setting $\Sigma_n s_{ln} = 1, \forall l$.
- And the first stage:
$$x_l = \alpha_0 + \alpha z_l + \eta_l.$$
- Application 1: (inverse) elasticity of labor supply
  - g_n: national growth of industry n
  - s_{ln}: lagged employment shares of industry n in a region l
  - z_l: predicted employment growth due to national industry trends
- Application 2: China effect on employment growth in the U.S(manuf.).
  - g_n: growth of China exports in manuf. industry n to 8 other countries
  - s_{ln} 10-year lagged employment shares (over total employment)
  - z_l: predicted growth of import competition

Intro to SSIV

- Compare in Application 1:

$$z_l = \Sigma_n s_{ln} g_n \text{ vs } \Sigma_n s_{ln} g_{ln},$$

  where g_{ln} is the local growth of industry n.
- By using g_n instead of g_{ln}, we can get rid of the endogeneity coming from a local-specific amenity shock, which can directly affect(through ε_l) the local wage growth.
- Note:
  - 2nd stage: $y_l = \beta x_l + \gamma' w_l + \varepsilon_l$
  - y_l and x_l: the wage growth and employment growth in region l
  - g_n: national growth of industry n
  - s_{ln} lagged employment shares of industry n in a region l
  - z_l: predicted employment growth due to national industry trends

Intro to SSIV

- Compare in Application 2:

$$z_l = \Sigma_n s_{ln} g_n \text{ vs } \Sigma_n s_{ln} g'_n,$$

  where g'_n is simply calculated from the U.S, not from the comparable countries.
- By using g_n instead of g_{ln}, we can get rid of the endogeneity coming from the dynamics in the U.S-specific economy.
- Note:
  - 2nd stage: $y_l = \beta x_l + \gamma' w_l + \varepsilon_l$
  - y_l and x_l are the employment growth in region l and the local labor market exposure to increased competition by china.
  - g_n: growth of China exports in manuf. industry n to 8 other countries
  - s_{ln} 10-year lagged employment shares (over total employment)
  - z_l: predicted growth of import competition

Intro to SSIV

- Notice that the SSIV is formed by interacting(inner product of) local shares and common shocks. Here, we can think of the appropriate setting to which SSIV can be applied:

$$z_l = \Sigma_n s_{ln} g_n,$$

- (Other example applications?)

Intro to SSIV

- So... how can SSIV be valid instrument?
  - Literature uses the exogeneity of either the shares(s_{ln}) or the shocks(g_n), to show the possible identification and consistency for β.
  - Goldsmith-Pinkham, Sorkin and swift (2020, AER; hereafter GPSS) discuss the validity of SSIV coming from the exogeneity of the shares. Specifically, they show that the SSIV is equivalent to using the local industry shares as instruments. (They also decompose the SSIV estimator into a weighted sum of the just-id IV estimator that use each industry share as a separate instrument)
- In contrast, this paper we now introduce uses the exogeneity of the shocks, allowing the exposure shares to be endogenous.

Sketch of Proof: Setting

- Consider SSIV estimator of

$$y_l = \beta x_l + \gamma' w_l + \epsilon_l$$

instrumented by $z_l = \sum_n s_{ln} g_n$.

- By the FWL theorem for IV, this estimator can be written:

$$\hat{\beta} = \frac{\sum_l z_l y_l^{\perp}}{\sum_l z_l x_l^{\perp}} = \frac{\sum_l \sum_n s_{ln} g_n y_l^{\perp}}{\sum_l \sum_n s_{ln} g_n x_l^{\perp}}$$

where $v_l^{\perp}$ denotes sample residuals from regressing v_l on w_l.

Sketch of Proof: Numerical Equivalence

- $\hat{\beta}$ can be obtained from a just-identified shock-level IV procedure that uses g_n to instrument for a shock-level "aggregate" of the treatment:

$$\hat{\beta} = \frac{\frac{1}{L}\sum_l z_l y_l^{\perp}}{\frac{1}{L}\sum_l z_l x_l^{\perp}} = \frac{\frac{1}{L}\sum_l \sum_n s_{ln} g_n y_l^{\perp}}{\frac{1}{L}\sum_l \sum_n s_{ln} g_n x_l^{\perp}} = \frac{\sum_n g_n \sum_l \frac{1}{L} s_{ln} y_l^{\perp}}{\sum_n g_n \sum_l \frac{1}{L} s_{ln} x_l^{\perp}} = \frac{\sum_n s_n g_n \bar{y}_n^{\perp}}{\sum_n s_n g_n \bar{x}_n^{\perp}}$$

where $s_n = \frac{1}{L}\sum_l s_{ln}$ are weights capturing the average importance of shock n, $\bar{v}_n = \frac{\sum_l s_{ln} v_l}{\sum_l s_{ln}}$ is an exposure-weighted average of v_l.

Sketch of Proof: Baseline Assumptions

- **A1** (Quasi-random shock assignment): $\mathbb{E}[g_n \mid \bar{\epsilon}, s] = \mu, \ \forall n$
  - Each shock has the same expected value, conditional on the shock-level unobservable $\bar{\epsilon} = (\bar{\epsilon}_1, ..., \bar{\epsilon}_N)$ and average exposure $s = (s_1, ..., s_N)$
  - Implies SSIV validity, as

$$z_l = \mu + \sum_n s_{ln}(g_n - \mu) \ \text{ and } \ \mathbb{E}[\sum_n s_n g_n \bar{\epsilon}_n] = 0$$

  - In App. 1, it requires that the demand shocks g_n(growth, import tariffs in industry n) should not have been chosen strategically, based on labor supply trends, or in a way that is correlated with such trends.
  - This assumption makes it possible to allow for the endogeneity of the shares s_{ln} to ϵ_l.

Sketch of Proof: Baseline Assumptions

- **A2** (Many uncorrelated shocks):

$$\mathbb{E}[\sum_n s_n^2] \to 0 \text{ as } L \to \infty \text{ and } Cov(g_n, g_n' \mid \bar{\epsilon}, s) = 0, \forall (n, n') \text{ with } n' \neq n,$$

  - First part: many shocks, each with sufficiently small average exposure.
  - Second part: shocks are mutually uncorrelated given the unobservables
  - Imply a shock-level law of large numbers:

$$\frac{1}{L} \sum_l z_l \epsilon_l = \sum_n s_n g_n \bar{\epsilon}_n \xrightarrow{p} 0$$

Weakened Version of Assumptions

- **Conditional Quasi-Random Assignments**: $\mathbb{E}[g_n \mid \bar{\epsilon}, q, s] = \mu' q_n$ for some observed shock-level variables q_n
  - Consistency follows when $w_l = \sum_n s_{ln} q_n$ is controlled for in the IV, as $z_l = \mu' \sum_n s_{ln} q_n + \sum_n s_{ln}(g_n - \mu' q_n)$
- **Weakly Mutually Correlated Shocks**: $g_n \mid (\bar{\epsilon}, q, s)$ are clustered or otherwise mutually independent
  - Consistency follows when mutual correlation is not too strong

Extensions

- **Estimated Shocks and the Rationale for the LOO Correction**
  - $g_n = \sum_l w_{ln} g_{ln}$ proxies for an infeasible $g_n{}^*$
  - Suppose that the demand shocks are as-good-as-randomly assigned across industries s.t. the infeasible SSIV estimator with $z_l{}^* = \sum_n s_{ln} g_n{}^*$ satisfies the BHJ framework
  - The asymptotic bias of the feasible SSIV estimator with $z_l = \sum_n s_{ln} g_n$ then depends on an aggregate of the supply shock estimation error:

$$\psi_l = z_l - z_l{}^* \propto \sum_n s_{ln} \sum_{l'} \omega_{l'n} \epsilon_{l'}$$

  - Consistency may require a "leave-one-out (LOO)" adjustment
  - In practice, the LOO correction does not matter for the SSIV estimate (BHJ, GPSS, Adão et al., 2019)

Extensions

- **Panel Data**: Have $(y_{lt}, x_{lt}, s_{lnt}, g_{nt})$ across $l = 1, ..., L,\ t = 1, ..., T$
  - Consistency can follow from either $N \to \infty$ or $T \to \infty$
  - Unit fixed effects "de-mean" the shocks, if s_{lnt} are time-invariant
- **Multiple Shocks**: Propose new overidentified SSIV procedures
- **Incomplete shares**: Detailed examination will follow in the subsequent pages

The "Incomplete Shares" Issue

- So far, the study assumed a constant sum-of-shares: $S_l = \sum_n s_{ln} = 1$
  - But in some settings, S_l varies across l
  - ADH instrument constructed with "incomplete" manufacturing (mfg.) shares: S_l is region l's share of non-mfg. employment. This is not constant across time periods.
- BHJ show that **A1/A2 are not enough for indentification in this case**
  - Now $z_l = \sum_n s_{ln}(\mu + (g_n - \mu)) = \mu S_l + \sum_n s_{ln}(g_n - \mu)$
  - The IV implicitly uses variation in S_l, which may be endogenous
- GPSS' assumption of exogenous exposure shares is likely to be *a priori* implausible in the ADH setting
- Main weakness: Is the industry share of locations constant over time? - May not
  - The possibility of other industry shocks entering ϵ_{lt} looms large.
- **Controlling for the sum-of-shares S_l isolates clean shock variation**
  - Can be seen as a case of conditional quasi-random assignment: "dummying out" the non-mfg. sector, in ADH

ADH Revisited

- ADH studies the effects of rising Chinese import competition on US commuting zones, 1991-2000 and 2000-2007
  - Treatment x_l: local growth of Chinese imports in USD 1,000/worker
  - Main outcome y_l: local change in mfg. employment share
- To address endogeneity challenge, use a SSIV $z_{lt} = \sum_n s_{lnt} g_{nt}$
  - n: 397 SIC4 mfg. industries ($\times$ 2 periods)
  - g_{nt}: growth of Chinese imports in eight **non-US economies** per US worker
  - s_{lnt}: lagged share of mfg. industry n in total employment of location l

ADH Revisited

- BHJ show how ADH can be seen as leveraging quasi-random shocks
  - Variation in the g_{nt} reflects only Chinese productivity shocks and the various supply and demand shocks in the non-U.S. economies
  - Key ADH strategy: Eliminating bias from shocks that are specific to the U.S.
- Evaluate A1 by regional and industry-level balance tests
  - Industry shocks are uncorrelated with five observables considered by Acemoglu et al. (2016)
- Evaluate A2 by studying variation across industries
  - Effective sample size (1/HHI of s_n weights): 58-192
  - Shocks appear mutually uncorrelated across SIC3 sectors
- Address the incomplete shares issue by controlling for lagged manufacturing shares interacted with period indicators

Robust Coefficients; Accounting for Incomplete Shares

Table 4: Shift-Share IV Estimates of the Effect of Chinese Imports on Manufacturing Employment

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Coefficient	-0.596	-0.489	-0.267	-0.314	-0.310	-0.290	-0.432
	(0.114)	(0.100)	(0.099)	(0.107)	(0.134)	(0.129)	(0.205)
Regional controls							
Autor et al. (2013) controls	✓	✓	✓		✓	✓	✓
Start-of-period mfg. share	✓						
Lagged mfg. share		✓	✓	✓	✓	✓	✓
Period-specific lagged mfg. share			✓	✓	✓	✓	✓
Lagged 10-sector shares					✓		✓
Local Acemoglu et al. (2016) controls						✓	
Lagged industry shares							✓
SSIV first stage F-stat.	185.6	166.7	123.6	272.4	64.6	63.3	27.6
# of region-periods	1,444	1,444	1,444	1,444	1,444	1,444	1,444
# of industry-periods	796	794	794	794	794	794	794

Why Does the Coefficient Change?

- The China shock is systematically higher in the 2000s than 1990s, on average across mfg. industries (μ_t)
  - Since $z_{lt} = s_{lt}\mu_t + \ldots$, SSIV is systematically higher in the 2000s than 1990s in mfg.-heavy regions
- In the 2000s mfg. decline was generally faster—could be due to China
  - But could also be for any other reason (faster automation, innovation, etc.)
  - The BHJ specification controls for any unobserved shocks specific to the manufacturing sector overall in 2000s
- Controlling for $S_{lt} \cdot 1[t = 2000]$ isolates within-period within-mfg. variation
- Absent the control, all such shocks are attributed to China

Discussion: Different Frameworks and Different Views

- Different frameworks produce different views on ADH
  - BHJ's framework concluded that the ADH approach can be reasonably viewed
  - GPSS find the ADH exposure shares to be implausible instruments (via different balance and overidentification tests.)
- The exogeneity of industry shares is an *ex ante* implausible research design
  - Any unobserved labour demand or supply shocks across industries (may affect the error term)
- The BHJ approach relies on the **exogeneity of the specific ADH trade shocks**, allowing for **endogenous exposure shares.**

How to Choose the Appropriate Framework?

- BHJ emphasize that the decision to pursue a "shocks" vs. "shares" identification strategy must be made *ex ante*
  - The two identification strategies have different economic content
  - Undesirable to base identifying assumptions on ex post tests
- BHJ suggest thinking about whether **shares** are "tailored" to the economic question/treatment, or are "generic"
  - Generic shares (e.g. ADH): unobserved v_n are likely to enter ϵ_l via the same or similar shares, violating share exogeneity. Appropriate for the BHJ framework
  - Tailored shares: have a DID feel. Don't even need the shocks (except to possibly improve power or avoid many-IV bias). The BHJ framework cannot be applied

`ssaggregate`: a Stata Command

- `ssaggregate` converts “location-level” variables in a shift-share IV dataset to a dataset of exposure-weighted “industry-level” aggregates, as described in BHJ
- It can be used in both long and wide forms.
- The dataset in memory may be a panel or repeated cross-section, with periods indexed by `t()`.