Frontier Topics in Empirical Economics: Week 7
Bartik Instruments

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Introduction

- We have already learned some basic IV methods and their extensions
- Today we will investigate a particular type of IV
- Bartik instrument, or shift-share instrument (SSIV)
- It is widely used in different contexts
- Especially trade and migration (spatial economics)
- How should we use it? What is its regression assumption?

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  - Goldsmith-Pinkham, Sorkin, and Swift (2020) consider share as IV, shift as weight
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Motivating Example: Card (2009)

- Let's start with an example from Card (2009)
- What is the impact of immigrant ratio on native-immigrant wage gap?

$$y_l = \beta_0 + \beta ln x_l + \beta_2 C_l + \epsilon_l \quad (1)$$

- l is location, y is log wage gap between immigrants and natives, x is ratio of immigrant labor to native labor, C is location-level control
- x is endogenous: Some positive productivity local shock affects both x and y

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- Let's use an IV for x
- We have data for 1980,1990, and 2000
- We construct a shift-share IV B_l as follows:

$$B_l = \sum_k Z_{lk,1980} \cdot g_k \quad (2)$$

$$Z_{lk,1980} = (N_{lk,1980}/N_{k,1980}) \times (1/P_{l,2000}) \quad (3)$$

- k is home country, $N_{lk,1980}$ is the number of immigrants in l from k in 1980, $P_{l,2000}$ is population in l in 2000
- $Z_{lk,1980}$ evaluates the base year share of immigrants from k in l
- g_k is the number of people arriving the US from 1990 to 2000 from k

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- What is the basic idea of this IV?
  - (1) Relevance: Clustering of immigrants from the same country (Chinese in SF)
  - (2) Exclusion: The local exposure of the national shock is not related to other local shocks
- It decomposes local immigrant into local-origin country
- This is an instrument with "Local Share" × "National Growth"
- We call this shift-share/Bartik instrument

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Motivating Example: Autor, Dorn, and Hanson (2013)

- Another important example is Autor, Dorn, and Hanson (2013) on China shock
- What is the impact of China's import on local labor market in the U.S.?
- They construct a shift-share variable as follows:

$$\Delta IPW_{it} = \sum_j \frac{L_{ijt}}{L_{jt} \cdot L_{it}} \Delta M_{jt}$$

- i is region, j is industry, t is year
- L_{ijt} is employment in region i industry j
- L_{jt} is total employment in industry j in the U.S.
- L_{it} is total employment in region i
- ΔM_{jt} is import growth from China to the U.S. in industry j

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Goldsmith-Pinkham, Sorkin, and Swift (2020): Definition of Bartik IV

- Let's define Bartik IV generally
- We have the following equation

$$y_{lt} = D_{lt}^{'}\rho + x_{lt}\beta_0 + \epsilon_{lt} \quad (4)$$

- l is location; t is time; D are controls; β_0 is parameter of interest
- x_{lt} is some (employment) growth rate
- y_{lt} is some (wage) outcome growth rate
- x and y can also be level variables when location FE is controlled
- We assume that $x_{lt} \not\perp \epsilon_{lt}$, need an IV
- Bartik IV comes from two identities

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Goldsmith-Pinkham, Sorkin, and Swift (2020): Definition of Bartik IV

- Identity 1: Decompose Location-level growth variable to location-industry-level variable and its growth
- Usually location-industry level, or in Card (2009), location-origin country level

$$x_{lt} = Z_{lt} G_{lt} = \sum_{k=1}^{K} z_{lkt} g_{lkt}$$

z_{lkt} is the location-industry share at t, g_{lkt} is the location-industry growth at t

- Identity 2: Decompose location-industry growth into national and local components

$$g_{lkt} = g_{kt} + \tilde{g}_{lkt}$$

g_{kt} is the national industry growth, $\tilde{g}_{lkt}$ is the location-industry growth shock

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z_{lkt} is the location-industry share at t, g_{lkt} is the location-industry growth at t

- Identity 2: Decompose location-industry growth into national and local components

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- Fix z at 0 and drop $\tilde{g}_{lkt}$ from the identity $\Rightarrow$ Bartik IV
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- Case 1: Two industries and One period
- Shares sum to 1: $z_{l2} = 1 - z_{l1}$

$$B_l = z_{l1}g_1 + z_{l2}g_2 = g_2 + (g_1 - g_2)z_{l1}$$

- We have the first stage:

$$x_l = \gamma_0 + \gamma B_l + \eta_l = \underbrace{(\gamma_0 + \gamma g_2)}_{constant} + \underbrace{\gamma(g_1 - g_2)}_{coefficient} z_{l1} + \eta_l$$

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- What is the underlying research design here?

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- Growth rate: policy effect size;
- Initial share: Exposure to some policy
- Whether locations with more industry 1, experience different changes in x following shocks whose effect depends on industry sizes
- More clear if we set $g_{11} - g_{21} = 0$: Before policy/after policy
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- Assume that we have K industries and one period, stack all variables to matrix
- Let $M_D = I - D(D'D)^{-1}D'$ be the annihilator matrix, $X^{\perp} = M_D X$
- Z is share and G is shock

Proposition 1 in PSS(2020)

We define Bartik and GMM esimator using industry shares as instruments:

$$\hat{\beta}_{Bartik} = \frac{B'Y^{\perp}}{B'X^{\perp}}, \hat{\beta}_{GMM} = \frac{X^{\perp\prime} Z W Z' Y^{\perp}}{X^{\perp\prime} Z W Z' X^{\perp}}$$

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Given assumption 1 and 2,

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- Initial industry share is mean independent of shocks on outcome levels
  Wrong!
- Initial industry share is mean independent of shocks on outcome changes
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- Keep in mind, when using Bartik IV
  Either control for location+time FE, or use growth variable as y!

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When is Assumption 2 plausible?

- This is an "exposure design" (similar to DID)
- Different exposures of locations to national industry-level shocks affect outcomes only through changing x
- There is no systematic difference in terms of unobserved local shocks for places with different exposures (parallel trend)
- Think of Shanghai, Hong Kong and Shenyang, Wuhan
  - SH, HK are more involved in finance industry than SY, WH
  - If a financial crisis happens, SH, HK are more exposed
  - We have to assume that there is no other unobserved shocks hitting SH, HK and SY, WH differently
  - The trend of economic situations (without crisis shock) should be parallel

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When is Assumption 2 plausible?

- This is an "exposure design" (similar to DID)
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- Think of Shanghai, Hong Kong and Shenyang, Wuhan
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We can write

$$\hat{\beta}_{Bartik} = \sum_k \hat{\alpha}_k \hat{\beta}_k$$

where

$$\hat{\beta}_k = (Z_k' X^{\perp})^{-1} Z_k' Y^{\perp}, \hat{\alpha}_k = \frac{g_k Z_k' X^{\perp}}{\sum_{k'} g_{k'} Z_{k'}' X^{\perp}}$$

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- We construct a single instrument for each industry $B_k = z_{lk0} g_k$
- $\hat{\beta}_k$ is IV estimator for each instrument k
- $\hat{\alpha}_k$ is called Rotemberg weight
- The Rotemberg weight means how important this single industry is
- If $\hat{\alpha}_k$ is large, misspecification on this industry is dangerous
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Tips

- This decomposition is different from the main GMM interpretation
- Bartik IV and GMM equivalence is discussed in a joint estimation context
- Bartik IV is equivalent to a joint GMM with shares as IVs (in one regression)
- Bartik IV decomposition means Bartik IV can be decomposed to a combination of K separately estimated IV estimators
- We run these IV regs one by one (for each industry share), then take weighted average of each regression coefficient $\hat{\beta}_k$

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- In a restricted heterogeneous effect case: Bartik IV is a combination of location level treatment effect
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- When treatment effect patterns become more and more complicated
- For instance dynamic, heterogeneous...
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- No. This is an intrinsically problem. Think about why

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Some tests you can implement

- Test 1: Correlations of controls and industry compositions
- Assume that there are some covariates predicting changes in y not through x
- Test whether these location covariates are correlated with the industry shares
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- This is a balance test
- Example: y is employment; x is wage; z is manufacturing share; covariate d is immigrant share
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- In specification with pre-period, you are doing DID
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- Whether locations with high shares of a main industry is different to locations with low shares in trends

Goldsmith-Pinkham, Sorkin, and Swift (2020): Empirical Suggestions

- Test 2: Test for pre-trends if you have pre-shock period
- In specification with pre-period, you are doing DID
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- Test 3: Overidentification Tests
- The main equivalence result tells us Bartik IV is an overidentified GMM
- Let's run overidentification test to check the validity of the bundle of share instruments
- If it is rejected, there are two possibilities
- Either your instruments are not exogenous (misspecification)
- Or there is heterogeneous treatment effect etc...
- This is not so recommended

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Borusyak, Hull, and Jaravel (2022): Shift as IV

- We have already investigated Goldsmith-Pinkham, Sorkin, and Swift (2020)
- They interpret the share part as IV and the shift part as weight
- Another framework is proposed by Borusyak, Hull, and Jaravel (2022)
- In contrast, they interpret the shift part as IV and the share part as weight
- The identification assumption then becomes the "random assignment of shocks"

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Borusyak, Hull, and Jaravel (2022): Settings

- Assume that we have the following shift-share IV:

$$z_l = \sum_k s_{lk} g_k, \quad k = 1, 2, ..., K$$

- s_{lk} is the share of industry k in location l
- g_k is the national shift for industry k
- We seek to estimate parameter β in the following regression:

$$y_l = \beta x_l + w_l^{'} \gamma + \epsilon_l$$

- w is the set of controls
- A valid instrument satisfies moment condition: $E[\sum_l z_l \epsilon_l] = 0$

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- Now we derive the equivalence between the original regression and a shock-level regression
- Plug the definition of SSIV into the moment condition:

$$E[\sum_l z_l \epsilon_l] = E[\sum_l \sum_k s_{lk} g_k \epsilon_l]$$

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- We exchange the order of the summation and have:

$$E[\sum_l z_l \epsilon_l] = E[\sum_k \sum_l s_{lk} g_k \epsilon_l] = E[\sum_k g_k \sum_l s_{lk} \epsilon_l]$$
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- $s_k = \sum_l s_{lk}$ is the sum of shares of industry k for all locations
- $s_k = 1$ in many common examples
- $\bar{\epsilon}_k = \frac{\sum_l s_{lk} \epsilon_l}{\sum_l s_{lk}}$ is a weighted average of unobserved terms
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- Therefore, it transforms the identification assumption from l level to k level
- Now assume that we want to identify the effect of U.S. tariff on employment in China
- What is the research design here?
- Can you interpret the identification assumption at k level?

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- The industry demand shocks g_k must be orthogonal with the industry-level unobservables $\bar{\epsilon}_k$, the average local supply shocks in different regions weighted by industry size
- Industries experiencing a rise in tariff should not face systematically different labor supply shocks in their primary markets
- Assume a U.S. tariff hits steel industry in China, which hits Hebei hard
- We should expect no labor supply shocks in Hebei, such as a change of enrollment quota in Gaokao

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- Now we have the following proposition

Proposition 1 in BHJ(2022)

The SSIV estimator $\hat{\beta}$ equals the second-stage coefficient from a s_k-weighted shock-level IV regression that uses the shocks g_k as the instrument in estimating

$$\bar{y}_k = \alpha + \beta \bar{x}_k + \bar{\varepsilon}_k$$

where $\bar{v} = \frac{\sum_l s_{lk} v_l}{\sum_l s_{lk}}$ denotes an exposure-weighted average of a variable v_l

- This proposition 1 establishes the equivalence between the original and the shock-level regressions

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- We establish the consistency of this estimator under two assumptions:
  - Assumption 1: $E[g_k|\bar{\varepsilon}, s]$, quasi-random shock assignment
  - Assumption 2: $E[\sum_k s_k^2] \to 0$, $Cov[g_k, g_{k'}|\bar{\varepsilon}, s] = 0$, many uncorrelated shocks industries should not be too concentrated

Proposition 3 in BHJ (2022)

Suppose Assumptions 1-2 and some other regularity conditions hold, we have: $\hat{\beta} \xrightarrow{p} \beta$

- Identification is valid when shocks are random

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- The first empirical suggestion is about the inference of the std err
- Adao, Kolesár, and Morales (2019) show that the traditional inference is incorrect since samples in the SSIV setting are intrinsically not i.i.d.
- Because there is common shock components g_k and ν_k in ϵ_l and z_l
- ϵ_l and z_l are mechanically correlated across observations
- The correlations are large for locations with similar industry shares

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Borusyak, Hull, and Jaravel (2022): Empirical Suggestions

- The first empirical suggestion is about the inference of the std err
- Adao, Kolesár, and Morales (2019) show that the traditional inference is incorrect since samples in the SSIV setting are intrinsically not i.i.d.
- Because there is common shock components g_k and ν_k in ϵ_l and z_l
- ϵ_l and z_l are mechanically correlated across observations
- The correlations are large for locations with similar industry shares

Borusyak, Hull, and Jaravel (2022): Empirical Suggestions

- Borusyak, Hull, and Jaravel (2022) show that the shock-level regression does not suffer from this
- You can directly use the traditional std err and CI estimated here
- A stata package can help you run this shock-level regression: *ssaggregate*

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Borusyak, Hull, and Jaravel (2022): Empirical Suggestions

- The second empirical suggestion is about the descriptive test for IV validity
- A simple balance test is to regress some pre-determined control r_l on IV z_l
- r_l can be location level GDP, population etc...
- This can be combined with the Oster bound method
- Another balance test is to start from a shock-level confounder r_k
- Then construct observation-level average $r_l = \sum_k s_{lk} r_k$
- Then run this average r_l on IV z_l

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- Another possible way to implement the balance test is to transform everything to k level
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- We have introduced two frameworks to understand Bartik IV
- The first is Goldsmith-Pinkham, Sorkin, and Swift (2020)
    - Equivalence: GMM with shares as instruments, shifts as weights
    - Research design: Exposure DiD
    - Assumption: Locations with different shares have parallel trends
- The second is Borusyak, Hull, and Jaravel (2022)
    - Equivalence: Shock-level regression, shifts as instruments, shares as weights
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- When to use which framework really depends on the setting of our research

Conclusion

- Bartik IV is constructed in a shift-share style
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Conclusion

For Goldsmith-Pinkham, Sorkin, and Swift (2020)

- Bartik IV is equivalent to GMM with shares as instruments
- We should always control for location/time FE, or use change variables
- Bartik IV is similar to a policy exposure design, with initial shares as the exposures
- We can decompose Bartik IV to be weighted averages of single share instruments
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For Borusyak, Hull, and Jaravel (2022)

- Bartik IV is equivalent to a shock-level regression with shifts as instruments
- The research design is based on the assumption of a series of randomly assigned shocks
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