Frontier Topics in Empirical Economics: Chapter 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 identification assumption?

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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?

$$y_l = \beta_0 + \beta_1 \ln x_l + \beta_2 C_l + \epsilon_l \tag{1}$$

- 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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- We have data for 1980,1990, and 2000
- We construct a shift-share IV B_l as follows:

$$B_l = \sum_k \underbrace{Z_{lk,1980}}_{share} \cdot \underbrace{g_k}_{shift} \tag{2}$$

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

- 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
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- What is the basic idea of this IV?
- It decomposes the local immigrant inflow into location by origin country components
- This is an instrument with "Local Share" $\times$ "National Growth (Shift)"
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  - (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 unobserved local shocks
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- Another important example is Autor, Dorn, and Hanson (2013) on China shock
- What is the impact of Chinese imports on local labor markets 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
- Share and shift reading: share = L_{ijt}/L_{it} (local industry composition); shift = $\Delta M_{jt}/L_{jt}$ (national import growth per worker)

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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

$$y_{lt} = D_{lt}'p + x_{lt}\beta_0 + \epsilon_{lt} \tag{4}$$

- 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 and time FE are controlled
- We assume that $x_{lt} \not\perp\!\!\!\perp \epsilon_{lt}$, need an IV
- Bartik IV comes from two identities

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

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

$$y_{lt} = D'_{lt}\rho + x_{lt}\beta_0 + \epsilon_{lt} \tag{4}$$

- 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 and time FE are controlled
- We assume that $x_{lt} \not\perp\!\!\!\perp \epsilon_{lt}$, need an IV
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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

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

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- We construct Bartik IV B_{lt} as:

$$B_{lt} = Z_{l0} G_t = \sum_k \underbrace{z_{lk0}}_{Share} \underbrace{g_{kt}}_{Shift} \tag{5}$$

- The first part is the initial share of industry k in location l
- The second part is the national growth of industry k
- We can also use leave-one-out growth rate excluding location l itself, strengthening exogeneity
- Fix z at 0 and drop $\tilde{g}_{lkt}$ from the identity $\Longrightarrow$ Bartik IV
- Before we formally establish the equivalence between Bartik IV and GMM
- Let's consider two special cases

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

- Case 1: Two industries and One period
- Shares sum to 1: $z_{i2} = 1 - z_{i1}$

$$B_i = z_{i1}g_1 + z_{i2}g_2 = g_2 + (g_1 - g_2)z_{i1}$$

- We have the first stage:

$$x_i = \gamma_0 + \gamma B_i + \eta_i = \underbrace{(\gamma_0 + \gamma g_2)}_{constant} + \underbrace{\gamma(g_1 - g_2)}_{coefficient} z_{i1} + \eta_i$$

- Using Bartik in 2SLS is identical to using single IV, z_{i1}

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- Case 2: Two industries and Two periods

$$B_{lt} = g_{1t} z_{l10} + g_{2t} z_{l20} = g_{2t} + (g_{1t} - g_{2t}) z_{l10}$$

- Assume that we control for time FE, we have a first stage:

$$x_{lt} = \tau_t + \gamma B_{lt} + \eta_{lt} = \underbrace{(\tau_t + g_{2t}\gamma)}_{\tilde{\tau}_t} + z_{l10}(g_{1t} - g_{2t})\gamma + \eta_{lt}$$

- Now we cannot directly say only z_{l10} is the instrument
- Because with two periods, $g_{1t} - g_{2t}$ is not a constant
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- Denote indicator function as $\mathbf{1}(\cdot)$, we have:

$$g_{1t} - g_{2t} = \mathbf{1}(t = 1)(g_{11} - g_{21}) + \mathbf{1}(t = 2)(g_{12} - g_{22})$$

- Then first stage becomes:

$$x_{it} = \tilde{\tau}_t + z_{i10}\mathbf{1}(t = 1) \underbrace{(g_{11} - g_{21})\gamma}_{\text{rescaled parameter}\tilde{\gamma}_1} + z_{i10}\mathbf{1}(t = 2) \underbrace{(g_{12} - g_{22})\gamma}_{\text{rescaled parameter}\tilde{\gamma}_2} + \eta_{it}$$

- This is running x on the time FE and two interactions of z_{i10} and time dummies
- $g_{12} - g_{22}$ is the relative industry growth rate (shock)
- 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 consider period 1 as some pre-period
- Then we can set $g_{11} - g_{21} = 0$: Before policy/after policy
- DID specification! $\tilde{\gamma}_1 = 0 \implies$ parallel pre-trend

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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, $X^{\perp} = M_D X$
- By the FWL theorem, we can estimate the coefficient of interest on residualized variables (Hansen, 2022)
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Proposition 1 in GPSS (2020)

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

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

If $W = GG'$, then $\hat{\beta}_{Bartik} = \hat{\beta}_{GMM}$

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

If $W = GG'$, then $\hat{\beta}_{Bartik} = \hat{\beta}_{GMM}$

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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, $X^{\perp} = M_D X$
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- Assumption 1: Relevance
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- Initial industry share is mean independent of unobserved outcome levels
  Wrong!
- Initial industry share is mean independent of unobserved outcome changes
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We can write

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where

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- We construct a single instrument for each industry $B_k = z_{ik0} g_k$
- $\hat{\beta}_k$ is IV estimator for each instrument k
- $\hat{\alpha}_k$ is called Rotemberg weight, summing to one
- 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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- You will find similar things in the forthcoming lectures when we discuss complicated DID designs
- When treatment effect patterns become more and more complicated
- For instance dynamic, heterogeneous...
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- Now we have introduced an econometrics analysis of the Bartik IV
- What should we do in our empirical research if we want to interpret Bartik IV in the framework of Goldsmith-Pinkham, Sorkin, and Swift (2020)?
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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
- Since industry shares need to affect y only through changes in x
- This is a balance test
- Example: y is employment; x is wage; z is manufacturing share; covariate d is immigrant share
- A suggestion from GPSS: control for higher level shares

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- In specification with pre-period, you are doing DID
- Initial shares are local policy exposure; Growth rates are policy size
- Check pre-trends for both overall Bartik IV and single industry IV with high weight
- Whether locations with high shares of a main industry are different from locations with low shares in trends

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- The main equivalence result tells us Bartik IV is an over-identified 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)
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- 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
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- Assume that we have the following shift-share IV:

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

- 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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- Plug the definition of SSIV into the moment condition:

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- $s_k = \sum_l s_{lk}$ is the sum of shares of industry k for all locations
- It measures the total exposure to industry k summed across locations
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- Now assume that we want to identify the effect of U.S. tariff on employment in China
- What is the research design here?
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- Industries experiencing a rise in tariff should not face systematically different labor supply shocks in their primary markets
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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

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

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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 are common shock components g_k and ν_k in ϵ_l and z_l
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- r_l can be location level GDP, population etc...
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- Personally, I think this is more important than previous two
- Because it directly tests the main assumption

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  - Focus on shock exposure of several specific industries
  - Have some exposure shares tailored to the specific policy question
- We should consider Borusyak, Hull, and Jaravel (2022) when
  - Exogeneity comes from shift (shock)
  - We believe shocks are randomly assigned
  - Fixed small number of locations ($K \to \infty, L = L^*$)
  - Whenever the second-stage error ϵ_l has a shift-share structure
    Mechanical correlation between Bartik IV and this error: $\epsilon_l = \sum_k s_{lk} \nu_k$

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