Regional Aggregation I

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Outline

Outline

META MESSAGES (SUPPOSED TO BE REPETITIVE)

- I expect you to do a lot of talking
- Try to formulate questions in real time. In class and in seminars
- After each question: What lead this person to ask this?
  - It will teach you how to anticipate questions and prepare in advance
- Take notes on other presentations. What worked? What did not work?
- Writing/presenting core to your craft. Take them seriously

Objectives of this section

- We will go over the determinants of the multiplier in closed economy
  Follow Woodford (2011) “simple analytics” paper

- Learn to bridge the aggregate and open-economy multipliers
  Use Chodorow-Reich (2019), Nakamura Steinsson (2014), Farhi Werning (2016)

- Core question: Can we learn something from geographic cross-sectional fiscal spending multipliers?

Of Multipliers and Parameters

- Macroeconomists oftentimes interested in two types of objects
  - Invariant structural parameters (there can be heterogeneity in these)
  - Elasticities: functions of parameters, prices, equilibrium outcomes
- Caveat: Complicate models: structural parameter $\rightarrow$ elasticities
- Caveat II: Simplify models: elasticities $\rightarrow$ structural parameter

Of Multipliers and Parameters

- In our models the multiplier is **NOT** an structural parameter
- Implications of that: In principle
  - Depend on policy regimes (lean against the wind)
  - Depend on how is financed (taxes vs. transfers from abroad)
  - Depend on the real interest rate (crowding out)
- There is not **ONE** multiplier
- Need to be more precise in what you are estimating *I am estimating the no-monetary policy response, transfer-financed spending multiplier*

Multipliers in the Neoclassical Model

- Suppose

$$\max_{C_t, H_t} \sum_{t=0}^{\infty} [u(C_t) - v(H_t) + \Gamma(G_t)]$$

$$Y = f(H_t)$$

$$Y_t = C_t + G_t$$

- All prices flexible. All markets competitive
- No capital. No durables. No assets in net supply
- Taxation in lump-sum taxes
- What is the effect of increases in G_t on Y_t

Multipliers in the Neoclassical Model

Intratemporal optimization yields

$$\frac{v'(H_t)}{u'(C_t)} = \frac{W_t}{P_t}$$

Profit maximization yields

$$f'(H_t) = \frac{W_t}{P_t}$$

Combined yield

$$\frac{v'(H_t)}{u'(C_t)} = f'(H_t)$$

Multipliers in the Neoclassical Model

Rearrange

$$\frac{v'(H_t)}{f'(H_t)} = u'(C_t)$$

- LHS: marginal utility of consumption
- RHS: Marginal disutility of producing output.

Use the production function and the resource constraint $Y = C + G$ And the production function $Y = f(H)$

$$u'(Y_t - G_t) = \tilde{v}'(Y_t)$$

Multipliers in the Neoclassical Model

$$u'(Y_t - G_t) = \tilde{v}'(Y_t)$$

Then the multiplier $\frac{dY}{dG}$ is given by

$$\frac{dY}{dG} = \frac{\eta_u}{\eta_u + \eta_{\tilde{v}}}$$

Where

- $\eta_u > 0$ is the negative of the elasticity of u' $(-\bar{Y}u''/u')$
- $\eta_{\tilde{v}} > 0$ is the elasticity of $\tilde{v}'$ $(\bar{Y}\tilde{v}''/\tilde{v}')$

That is, the multiplier is between zero and one.

Multipliers in the Neoclassical Model

$$\frac{dY}{dG} = \frac{\eta_u}{\eta_u + \eta_{\tilde{v}}}$$

- Multiplier between zero and one
- Government spending “crowds-out” private spending
- Government consumes some stuff
- Households are poorer
- Consume less normal goods (leisure and consumption)
- Multiplier is small iff
  - there is more crowding out
  - Disutility of producing more output rises fast
  - Households have large elasticity of intertemporal substitution

Multipliers in the Neoclassical Model

- Suppose G is temporarily high today. What happens to the real rate?

$$u'(C_t) = \beta R_t u'(C_{t+1})$$

- There is crowding out, R_t must be high today. (notional interest rate).

Multipliers in the Neoclassical Model

- No mention so far of whether taxes occur today or the future
- Irrelevant. Ricardian equivalence
- Depends on lots of assumptions
- What it says: Variation in the timing of lump-sum taxes do not matter under certain conditions
- What it does not say: Government spending does not matter for output

Multipliers in the Neoclassical Model

For you to discuss among you in the break

- What happens after a news shock of G
- Permanent vs. transitory G
- Multiplier when you have capital
- News shock when you have capital
- Complementarity in preferences between C and G

Multipliers in the NK Model

- Let's move to the NK model
- No capital. Sticky prices. Flexible wages
- Firms set prices. Commit to meet demand

$$f'(H_t) \neq \frac{W_t}{P_t}$$

- What determines labor demand?
- Product demand!
- Pump up wages since households **are** on their labor supply schedule
- Not true with sticky wages (modeled in the EHL at least)

Multipliers in the NK Model

Mechanics of the NK model multipliers

- Total demand must hold $Y_t = C_t + G_t$
- G_t is exogenous
- Dynamics of Y depend on the dynamics of C.
- What determines C?

$$u'(C_t) = \beta R_t u'(C_{t+1})$$

- Key variable: the real interest rate

Multipliers in the NK Model

$$u'(C_t) = \beta R_t u'(C_{t+1})$$

- What determines the real interest rate?
- Monetary policy and price setting behavior
- The response of monetary policy is a crucial determinant of NK multiplier
- Imagine a policy $R_t = R$ (can be implemented?)
- Then $C_t = C_{t+1}$. So $\frac{dY}{dG} = 1$

Multipliers in the NK Model

$$u'(C_t) = \beta R_t u'(C_{t+1})$$

- Imagine now a Taylor rule
- Fiscal stimulus is inflationary
- interest rates go up
- Consumption today goes down
- Multiplier is less than one

Multipliers in the NK Model

- What happens in the ZLB?
- Inflationary
- nominal interest rates do not react
- real rates **decrease**
- $\frac{dC}{dG} > 0$. so $\frac{dY}{dG} > 1$

For you to think in the break

- What happens with GHH preferences?

- What happens with hand-to-mouth consumers?

Farhi and Werning (2016)

- Consider a model where $i_t = \bar{i}$ for $t \leq T$, then $i_t = \bar{r}_t$
- Suppose the economy goes back to steady state

$$c_t = \int_t^T (i_{t+s} - \pi_{t+s} - \bar{r}_{t+s}) ds$$

- Again: In the NK model g affects c via its effects on π and i. Not directly.

Farhi and Werning (2016) On null hypotheses

For a sequence of log-deviations g_{t+s}, can write the solution of the model as

$$c_t = \tilde{c}_t + \int_0^\infty \alpha_s^c g_{t+s}$$

$$\pi_t = \tilde{c}_t + \int_0^\infty \alpha_s^\pi g_{t+s}$$

$$y_t = \tilde{y}_t + g_t + \int_0^\infty \alpha_s^c g_{t+s}$$

The relevant null hypothesis changes on what you are testing.

- Consumption multipliers equal to zero
- Output multipliers equal to one

Summary

In closed economy:

- In the RBC, the closed economy, lump-sum tax, no capital multiplier $\in [0,1]$
- Depends on preference elasticities.
- In the NK model: Monetary policy conduct is key.
- The closed economy, OMP, lump-sum tax, out of the ZLB, no capital multiplier in the NK $\in [0,1]$
- Can have the same multiplier in both models
- Cannot tell if the world is Keynesian just by looking at this multiplier

Outline

Results from the Open Economy Model

Table 6—Government Spending Multiplier in Separable Preferences Model

	Closed economy aggregate multiplier	Open economy relative multiplier
Panel A. Sticky prices		
Volcker-Greenspan monetary policy	0.20	0.83
Constant real rate	1.00	0.83
Constant nominal rate	∞	0.83
Constant nominal rate ($\rho_g = 0.85$)	1.70	0.90
Panel B. Flexible prices		
Constant income tax rates	0.39	0.43
Balanced budget	0.32	0.43

Notes: The table reports the government spending multiplier for output deflated by the regional CPI for the model presented in the text with the separable preferences specification. Panel A presents results for the model with sticky prices, while panel B presents results for the model with flexible prices. The first three rows differ only in the monetary policy being assumed. The fourth row varies the persistence of the government spending shock relative to the baseline parameter values. The fifth and sixth rows differ only in the tax policy being assumed.

Source: Nakamura Steinsson (2014)

Results from the Open Economy Model

Table 7–Government Spending Multiplier in GHH Model

	Closed economy aggregate multiplier	Open economy relative multiplier
Panel A. Sticky prices		
Volcker-Greenspan monetary policy	0.12	1.42
Constant real rate	7.00	1.42
Constant nominal rate	∞	1.42
Constant nominal rate ($\rho_g = 0.50$)	8.73	2.04
Panel B. Flexible prices		
Constant income tax rates	0.00	0.30
Balanced budget	-0.18	0.30

Notes: The table reports the government spending multiplier for output deflated by the regional CPI for the model presented in the text with the GHH preferences specification. Panel A presents results for the model with sticky prices, while panel B presents results for the model with flexible prices. The first three rows differ only in the monetary policy being assumed. The fourth row varies the persistence of the government spending shock relative to the baseline parameter values. The fifth and sixth rows differ only in the tax policy being assumed.

Source: Nakamura Steinsson (2014). Question: Why is the multiplier $= \infty$

Results from the Open Economy Model

Table 8—Government Spending Multipliers in Incomplete Markets Model

	Closed economy aggregate multiplier	Open economy relative multiplier
Panel A. Sticky prices		
Baseline model (complete markets)	0.20	0.83
Incomplete markets, locally financed	0.18	0.84
Incomplete markets, federally financed	0.18	0.90
Panel B. Flexible prices		
Baseline model (complete markets)	0.39	0.43
Incomplete markets, locally financed	0.39	0.41
Incomplete markets, federally financed	0.39	0.40

Notes: The table reports the government spending multiplier for output deflated by the regional CPI for a version of the model presented in the text with separable utility in which the only financial asset traded across regions is a noncontingent bond. Panel A presents results for the model with sticky prices, while panel B presents results for the model with flexible prices.

Source: Nakamura Steinsson (2014)

QUESTION

- The open-economy relative multiplier is 2.04 with GHH preferences

- The closed-economy constant-nominal rate multiplier is 8.73

- Both experiments keep rates constant (time-series vs. cross-section)

Why are they not equal?

Question

How can you have a constant nominal rate policy?

How about Sargent and Wallace?

Nakamura and Steinsson 2014

- The open-economy multiplier is a useful moment
- Lets us to reject subsets of the model space
- Cannot reject some others. That's how progress looks like.
    - My thoughts: *We learned about the structure of the economy using the geographic cross-sectional multiplier in ways is not possible to do with the aggregate multiplier. In that dimension the cross-regional multiplier is a better moment than the aggregate multiplier.*
- It seems however that the answer to the question:
    - *What can we learn about the aggregate multiplier when we see the geograhic cross-sectional multiplier.*
- is "it depends" on what you mean by **the** aggregate multiplier.

SUTVA Violation: Financing

- Who pays for spending
- In closed economy, it is always locally-financed
- In open economy model (OEM), it depends
  - Financed locally (taxes vs. deficit)
  - ROW transfer
- OEM with complete markets: completely irrelevant
  - For any set of transfers devised by the government, there is an insurance transfer that undoes it.
- With incomplete markets: now we are talking. It matters who pays

$$\text{Locally financed } \mathscr{M}^G = \text{Transfer-financed } \mathscr{M}^G - \mathscr{M}^T$$

SUTVA Violations: Financing

- Foreign transfer financing is the empirically relevant case
  Spending happens locally, but financed at the federal level *OEM – PF*
- How much of the effect happens through the transfer?
  Size of the transfer is key. Increasing on ρ_g
- Two effects in NK models (you know these from before)
  1. SR: sticky prices, transfers increase demand-determined output
     - ★ How much in relative terms? Decreasing in openess α. Less open economies concentrate demand locally
  2. In the LR prices adjust, world looks neoclassical. Effects given by wealth effects
     - ★ H relatively wealthier, works less. Increasing in elasticity of labor supply $1/\phi$
  3. How to weight these effects?
     - ★ Parameters that dictate speed of price adjustment. Mainly the slope of the Phillips curve κ

SUTVA Violations: Financing

- Chodorow-Reich 2019: Illustrative case in the Cole-Obstfeld case $\sigma = \eta = \gamma = 1$
- In that case:

$$\text{(7)} \qquad \beta_h^{transfer, nominal} V = \left(\frac{1-\alpha}{\alpha}\right)\left(\frac{r}{r+\rho}\right)\Delta G_{s,t},$$

- For $\alpha = 0.3$, $\rho = 0.8$, $r = 0.03$, then $\beta_h^{transfer,nominal} = 0.07$
- OEM - PF multipliers ≈ 1.5. So SUTVA violation is small.
- Nominal expenditure jumps but prices do not. so $\beta_h^{transfer,nominal} = \beta_h^{transfer,output}$ on impact.
- Going forward: prices adjust, transfer buys less goods. wealth effects impose negative pressure
  SUTVA violation less than 0.07

SUTVA violations: Financing

- Now let's consider deviations from Ricardian Equivalence
  - Let's say failure of Ricardian Equivalence comes > 0 share of HtM hh's
- Away from Ricardian Equivalence, the form of local financing matters
  1. Higher taxes today
  2. Higher debt today
- SUTVA violations are zero if deficit-financed
- SUTVA violations are larger if tax financed

  CR 2019: *For non-Ricardian agents, there is an exact analog between having agents in future periods pay for current spending and having agents in other areas pay for current spending.*

SUTVA violations: Expenditure Switching

- The case of financing convered most of this.
- In open regions, increases in local demand create relative price differences
- Diminished demand for local varieties
- Decreases the value of the OEM

SUTVA violations: Migration + Investment

- Migration pumps up OEM multipliers

- Migration concerns rise with the persistence of spending

- Same can be said about K, not only L

- SUTVA + external validity concerns

Outline

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Identification Challenges

$$\pi_t = \beta E_t \pi_{t+1} - \kappa(u_t - u_t^n) + \nu_t$$

1. Inflation expectations may covary with unemployment
   - For example: Imperfectly credible regime change
   - Literature seeks to control for inflation expectations
   - Results sensitive to details / weak instruments (Mavroeidis, Plagborg-Møller and Stock 2014)
2. Supply shocks (u_t^n and ν_t)
   - Lead to positive comovement between inflation and unemployment (stagflation)
   - Good monetary policy compounds with by counteracting demand variation, leaving only supply variation (Fitzgerald-Nicolini, 2014, McLeay-Tenreyro 2019)

The Role of the Long-Run Inflation Target

$$\pi_t = -\psi \tilde{u}_t + E_t \pi_{t+\infty} + \omega_t$$

- Long-run inflation target major determinant of current inflation
  - Has a coefficient of one
  - Current inflation moves one-for-one with beliefs about long-run inflation target
- Inflation can vary without **any** variation in $\tilde{u}_t$
  - Purely due to changes in $E_t \pi_{t+\infty}$
- Correlation between $E_t \pi_{t+\infty}$ and $\tilde{u}_t$ potentially a source of severe omitted variables bias

Advice

- Not writing your models from first principles is really tempting
- In this case, that would amount to take the aggregate PC:

$$\pi_t = \beta E_t \pi_{t+1} - \kappa(u_t - u_t^n) + \nu_t$$

- And just replace t with Ht (H for Home)

$$\pi_{Ht} = \beta E_t \pi_{H,t+1} - \kappa \hat{u}_{Ht} + \nu_{Ht}$$

- This equation raises conceptual concerns
  - Effects of Tradeables?
  - Permanent deviations from PPP?

Model

- Two regions: Home and Foreign
- Tradeable and non-tradeable sector in each region
- No labor mobility between regions
- Perfect labor mobility between sectors within region
- Monetary union

Households and Firms

- Households:
  - Consume and supply labor
  - Nested CES demand over varieties of traded and non-traded goods
  - GHH preferences
- Firms:
  - Linear production function in labor
  - Calvo (1983) type price rigidity

Model environment

- Phillips curve for local non-tradeables

$$\pi^N_{Ht} = \beta E_t \pi^N_{H,t+1} + \lambda \hat{mc}^N_{Ht}$$

- λ is summarizes price rigidity: $\lambda = \frac{(1-\alpha)(1-\alpha\beta)}{\alpha}$
- Phillips curve for locally-produced tradeables

$$\pi^T_{Ht} = \beta E_t \pi^T_{H,t+1} + \lambda \hat{mc}^T_{Ht}$$

- Phillips curve for foreign-produced tradeables

$$\pi^T_{Ft} = \beta E_t \pi^T_{F,t+1} + \lambda \hat{mc}^T_{Ft}$$

Model environment

- In log-linear terms marginal costs are given by (producer-priced) real wages and productivity. For example:

$$\hat{mc}^N_{Ht} = \hat{w}_{Ht} - p^N_{Ht} - z^N_{Ht}$$

- And (cpi-deflated) real wages relate to labor

$$\hat{w}_{Ht} - p_{Ht} = \varphi^{-1}\hat{n}_{Ht}$$

- So we can express the local-NT Phillips curve as

$$\pi^N_{Ht} = \beta E_t \pi^N_{H,t+1} + \kappa n_{Ht} - \lambda \hat{p}^N_{Ht} + \nu^N_{Ht}$$

Outline

Aggregate and Regional Phillips Curves

- In the aggregate

$$\pi_t = \beta E_t \pi_{t+1} - \kappa \hat{u}_t + \nu_t$$

- In a region, for non-tradeables

$$\pi^N_{Ht} = \beta E_t \pi^N_{H,t+1} - \kappa u_{Ht} - \lambda \hat{p}^N_{Ht} + \nu^N_{Ht}$$

- Same slope in the model. Extra term.

Relative Price of Non-Tradeables

$$\pi_{Ht}^{N} = \beta E_t \pi_{H,t+1}^{N} + \kappa n_{Ht} - \lambda \hat{p}_{Ht}^{N} + \nu_{Ht}^{N}$$

- Mechanical reason: labor supply depends on cpi-deflated real wages. marginal cost depends on sectoral-ppi-deflated wages.
- Conceptual reason. Imagine κ is "high"
  - Imagine a local demand boom $n_{Ht} \uparrow$
  - Inflation of non-tradeables increases. A lot.
  - More than the price of tradeables
  - Relative prices in the non-traded sector increase
  - Downward pressure on the relative demand for non-tradeables
  - And an non-tradeable inflation as a consequence
  - The extra term brings the economy back to PPP

Importance of non-tradeable inflation

- Geographic cross-sectional Phillips curve similar to difference in the PC across two regions
- We can compute that object for overall CPI inflation

$$\pi_{Ht} - \pi_{Ft} = \beta E_t(\pi_{H,t+1} - \pi_{F,t+1}) - \phi_N \kappa (n_{Ht} - n_{Ft}) - \lambda \phi_N (\hat{p}^N_{Ht} - \hat{p}^N_{Ft})$$

- Attenuation bias due to tradeability
- Can think of it as a SUTVA violation
- Higher demand locally spillovers the foreign region
- Focusing on NT inflation solves this particular issue

Wealth Effects

- With separable preferences the aggregate Phillips curve is

$$\pi_t = \beta E_t \pi_{t+1} - \kappa \hat{u}_t + \lambda \sigma^{-1} \hat{c}_t + \nu_t$$

- And the analog at for NT goods at the local level

$$\pi^N_{Ht} = \beta E_t \pi^N_{H,t+1} - \kappa \hat{u}_{Ht} + \lambda \sigma^{-1} \hat{c_{Ht}} - \lambda \hat{p}^N_{Ht} + \nu_t$$

- However, at the aggregate level $\hat{c}_t = \hat{y}_t = \hat{n}_t + \hat{z}_t = -\hat{u}_t + \hat{z}_t$

- Aggregate PC in terms of u with a slope $\tilde{\kappa} = \lambda(\varphi + \sigma^{-1})$

- Not true at the local level. $\hat{y}_{Ht} = -\hat{u}_{Ht} + \hat{z}_{Ht} = \hat{c}_{Ht} + \hat{nx}_{Ht}$, where nx are net exports.

- In general the two slopes will not be the same

Possible extensions

One example among many

- The assumption of integrated labor markets is important
- Imagine they are not, and there is a demand boom in the tradeable sector at the local level
- u_{Ht} would go down
- But marginal costs in the non-tradeable sector would not react
- Slope for non-tradeables would be small, regardless of aggregate κ

Big picture

- In a standard textbook model $\kappa_H^N = \kappa$
- In more general settings this may not be true
- But can still write a model, and set (κ, Θ) such that the model recovers κ_H^N

Phillips Curve Slope

- Choice that seems to be a plain specification choice
  - Aggregate: slope when using one-year ahead inflation expectations

$$\pi_t = \beta E_t \pi_{t+1} - \kappa \hat{u}_t + \nu_t$$

  - Cross-sectional: slope when using time and region fixed effects

$$\pi_{Ht} = -\psi \hat{u}_{jt} + \alpha_t - \gamma_j + \xi_{jt}$$

  - $\hat{\kappa} < \hat{\psi}$
- The natural outcome of a conceptual difference in these equations

Estimation of κ

- Take our Phillips curve and iterate it forward

$$\pi_{it}^N = \alpha_i + \gamma_t - \kappa E_t \sum_{j=0}^{\infty} \beta^j u_{i,t+j} - \lambda E_t \sum_{j=0}^{\infty} \beta^j \hat{p}_{i,t+j}^N + \omega_{it}$$

- Replace expectations with realized values and expectation error and truncate the infinite sums:

$$\pi_{it}^N = \alpha_i + \gamma_t - \kappa \sum_{j=0}^{T} \beta^j u_{i,t+j} - \lambda \sum_{j=0}^{T} \beta^j \hat{p}_{i,t+j}^N + \omega_{it} + \eta_{it}$$

where η_{it} is an expectations error (and truncation error)

- We can now estimate κ using an IV regression

- Calibrate $\beta = 0.99$

Illustrative example

$$\pi_{it}^{N} = \alpha_i + \gamma_t - \kappa E_t \sum_{j=0}^{\infty} \beta^j u_{i,t+j} - \lambda E_t \sum_{j=0}^{\infty} \beta^j \hat{p}_{i,t+j}^{N} + \omega_{it}$$

- Assume that u and $\hat{p}^N$ follow AR(1) processes

$$\pi_{it}^{N} = \alpha_i + \gamma_t - \psi u_{it} - \delta \hat{p}_{i,t}^{N} + \omega_{it}$$

- where for example $\psi = \kappa/(1-\beta\rho_u)$

- Since β is close to 1, and unemployment is highly persistent, then ψ can be substantially larger than κ

Identification

Two Approaches:

1. Use lagged unemployment and relative prices as instruments
    - Unemployment may reflect supply shocks
    - Time fixed effects capture national supply shocks
    - Identifying assumption: No relative change in restaurant technology in Texas vs. Illinois when Texas experiences a recession relative to Illinois
2. Tradeable demand instrument

Tradeable Demand Spillover Instrument

$$\text{Tradable Demand}_{i,t} = \sum_{x \in T} \bar{S}_{x,i} \times \Delta \log S_{-i,x,t}$$

- $\bar{S}_{x,i}$: Average employment share of industry x in state i over time
- $\log S_{-i,x,t}$: National employment share of industry x at time t
- Identifying assumption: supply shocks not simultaneously correlated with **both** shifts $\Delta \log S_{-i,x,t}$ **and** shares $\bar{S}_{x,i}$
- Intuition:
  - Oil boom increases labor demand and wages in Texas
  - "Demand shock" for Texan restaurants
  - Oil boom does not differentially affect production technology for restaurants in Texas

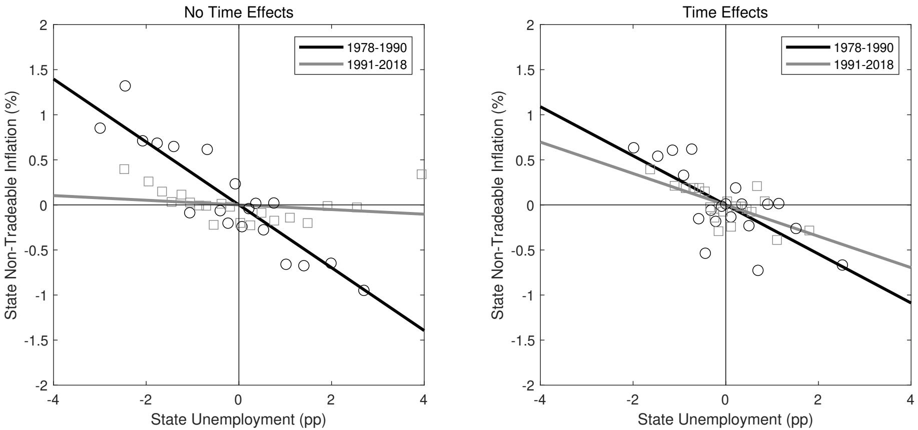
Full Sample

	No Time Effects	Lagged u IV	Tradeable Demand IV
	(1)	(2)	(3)
κ	0.0003	0.0062	0.0062
	(0.0019)	(0.0028)	(0.0025)
ψ	0.017	0.112	0.339
	(0.027)	(0.057)	(0.126)
State Effects	✓	✓	✓
Time Effects		✓	✓

Has the Phillips Curve Flattened?

	Lagged u IV No Time Fixed Effects		Lagged u IV Time Fixed Effects		Tradeable Demand IV Time Fixed Effects	
	Pre-1990 (1)	Post-1990 (2)	Pre-1990 (3)	Post-1990 (4)	Pre-1990 (5)	Post-1990 (6)
κ	0.0278	0.0002	0.0107	0.0050	0.0109	0.0055
	(0.0025)	(0.0017)	(0.0080)	(0.0038)	(0.0048)	(0.0029)
ψ	0.449	0.009	0.198	0.090	0.422	0.332
	(0.063)	(0.025)	(0.113)	(0.057)	(0.232)	(0.157)

All specifications include state fixed effects



Scatterplots—Non-Tradeable Inflation and Unemployment

Our Estimates Compared to Prior Work

Aggregate Implication

- Plot RHS and LHS of

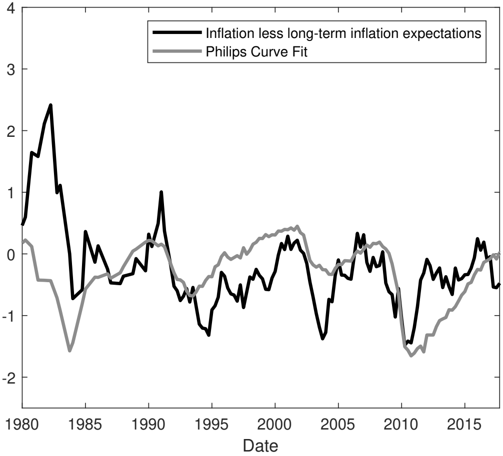
$$\pi_t - E_t \pi_{t+\infty} = -\kappa \zeta \tilde{u}_t + \omega_t$$

  assuming no supply shocks $\omega_t = 0$

- Scaling factor: $\zeta = 6.16$ (s.e. 1.80)

$$\sum_{j=0}^{T} \beta^j \tilde{u}_{t+j} = \zeta \tilde{u}_t + \alpha + \varepsilon_t.$$

- Aggregate includes housing
  - Estimate aggregate Phillips curve for shelter
  - Data from American Community Survey for 2001-2017
  - $\kappa = 0.0243$ (s.e. 0.0053) Table
  - About four time larger than for non-shelter



Aggregate Phillips Curve and Housing: Predicted vs. Fit

Outline

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