Lecture 2: Cross-Sectional inference on the determinants of inflation

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Outline

- Short refresher on the Phillips Curve (what it is vs. what it is not)
- McLeay and Tenreyro (2019)
- Hazell, Herreño, Nakamura, Steinsson (2022)
- Herreño, Pedemonte (2025)
- Chodorow-Reich, Gopinath, Mishra, Naraynan (2020)
- Herreño, Pinardon-Toauti, Thie (2025) - time permitting

The Phillips curve

- In models with nominal rigidities, the Phillips curve plays the role of an Aggregate Supply (AS) curve
- What happens with prices if *demand* changes
- Fundamental idea in economics. To trace an inverse supply curve, you must ensure variation in Q is driven by a demand shock
- Macroeconomics does not escape the laws of economics, you need the same
- Different formulations of price rigidity may or may not change the shape of the Phillips curve compared to the textbook model
- Some references for you to check: Gali Gertler (1997), Mankiw Reis (2003), Gertler Leahy (2008), Auclert, Rigato, Rognlie, Straub (2023)

Usual and Special features of supply curve estimation

$$\pi_t = \beta \mathbb{E}_t \pi_{t+1} + \kappa(y_t - y_t^n) + u_t$$

- π_t inflation, $\mathbb{E}_t \pi_{t+1}$ infl. expect., y_t output, y_t^n the natural rate of output, u cost-push shocks.
- $y_t^n, \mathbb{E}_t \pi_{t+1}, u_t$ in principle unobservable
- Usual supply curve estimation challenges:
  - To estimate κ must ensure that variation in y_t is uncorrelated with y_t^n and u_t, or should control for them
  - If cannot control, need an instrument
- Challenges specific to *dynamic* supply curves
  - To estimate κ must ensure that variation in y_t is uncorrelated with $\mathbb{E}_t \pi_{t+1}$, or should control for it

The Issue of Inflation Expectations

- Under rational expectations

$$\mathbb{E}_t\pi_{t+1} = \beta\mathbb{E}_t\pi_{t+2} + \kappa\mathbb{E}_t(y_{t+1} - y^n_{t+1}) + \mathbb{E}_t u_{t+1}$$

- Inflation expectations are nothing else infl exp about $t+2$ plus expected output gap and cost push shocks
- Without controlling for inflation expectations, you need to control for expected future unobservables, which may be correlated with y.

What the Phillips curve is not

The Phillips curve is not

- A tool for forecasting inflation
- A curve with a slope that can be estimated by tracing points on a scatterplot

The Phillips curve is

- A structural equation with a slope that depends on micro elasticities
- A structural equation that can shift up or down

Consequences

Estimating the Phillips curve is hard.

Mcleay and Tenreyro (2019)

Optimal Policy

- Optimal policy under discretion

$$L_t = \pi_t^2 + \lambda \tilde{y}_t^2$$

- Minimize L subject to the Phillips curve. (for you to think about: why only subject to the PC and not the PC + Euler?)

$$\pi_t = F_t + \kappa \tilde{y}_t + u_t$$

- Optimal solution

$$\pi_t = -\frac{\lambda}{\kappa} \tilde{y}_t$$

- Substitute for $\tilde{y}_t$ in the Phillips curve, and impose that u is AR(1)

$$\pi_t = \frac{\lambda}{\kappa^2 + \lambda(1 - \beta\rho)} u_t$$

- If π is driven by u, then "lean against the wind", depressing output partially
- A regression of π on $\tilde{y}$ recovers $-\frac{\lambda}{\kappa}$, not κ! (wrong sign, wrong magnitude!!)

Intuition

$$\pi_t = \beta \mathbb{E}_t \pi_{t+1} + \kappa \tilde{y}_t + u_t$$

- Imagine there are no u shocks
- The IS curve is
$$\tilde{y}_t = \mathbb{E}_t \tilde{y}_{t+1} - \sigma(i_t - \mathbb{E}_t \pi_{t+1} - r_t^n)$$
- Optimal policy requires $i_t = r_t^n$, and implements $\pi_t = \tilde{y}_t = 0 \; \forall t$ (divine coincidence)
- Monetary policy offsets any demand shifts: no variation to estimate κ in this case
- Now introduce u shocks
- u shocks increase inflation directly. The central bank tightens to partially offset inflation
- Note that $\tilde{y}_t$ is correlated (caused by!) u_t ($\mathbb{E}(\tilde{y}_t u_t) \neq 0$)
- i_t is not a good instrument in this case: exclusion restriction does not hold ($\mathbb{E}(u_t i_t) \neq 0$)

Empirical idea

- The issue is that movements in i_t are caused by shifts in u_t, both aggregate variables
- Use more disaggregated data and include time fixed effects to soak the effect of i_t and u_t
- Need to write the structural equations for a particular region i.
- hat variables are deviations from aggregates (differencing away the aggregate)

$$\hat{\pi}_t^i = \beta \mathbb{E}_t \hat{\pi}_{t+1}^i + \kappa \hat{x}_t^i + \hat{u}_t^i$$

$$\hat{x}_t^i = \mathbb{E}_t \hat{x}_t^i + \sigma^{-1} (\mathbb{E}_t \hat{\pi}_{t+1}^i + \hat{r}_t^i)$$

- i_t does not appear there.
- This looks **exactly** as an aggregate model with a constant interest rate, so that $\hat{i}_t = 0$. Problems?

Estimation strategy

- Include time and city fixed effects
- $\mathbb{E}_t\hat{\pi}^i_{t+1}$ not observable, use instead census area expectations from the Michigan survey.
- Problems? Effects of measurement error? Only attenuation of estimation of γ_1?
- Specification

$$\pi_{it} = \alpha_i + \gamma_t + \gamma_1 \mathbb{E}_t \pi_{j(i),t+1} + \gamma_2 u_{it} + \epsilon_{it}$$

- Identifying assumption?
- Thoughts?

OLS estimation

Table 3: *US Metro area Phillips curve: 1990-2017*

Regression	(1) Pooled OLS	(2) Metro area FE only	(3) Year FE only	(4) Year and Metro area FE
Unemployment rate	-0.150***	-0.162***	-0.272***	-0.379***
	[0.016]	[0.019]	[0.036]	[0.052]
Inflation expectations	0.598***	0.589***	0.259*	0.225
	[0.058]	[0.059]	[0.147]	[0.141]
Core CPI inflation				
First lag	0.362***	0.371***	0.122***	0.105***
	[0.035]	[0.036]	[0.035]	[0.034]
Observations	1,525	1,525	1,525	1,525
R-squared	0.321	0.350	0.450	0.487
Metro area FE	No	Yes	No	Yes
Year FE	No	No	Yes	Yes
Seasonal dummies	Yes	Yes	Yes	Yes

Robust standard errors (clustered by metro area) in brackets
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Notes: The table shows coefficients and standard errors estimated from four regional Phillips curve specifications. Core CPI inflation is the dependent variable in each case. Specification (1) estimates equation 23 (plus controls) by pooled OLS. Specification (2) estimates equation 24 (plus controls) using group (area) fixed effects. Specification (3) is identical to (1) apart from the inclusion of a set of year dummy variables. Specification (4) is identical to (2) apart from the inclusion of a set of year dummy variables. The additional controls are one lag of core CPI inflation and a seasonal dummy variable for each metropolitan area that takes the value of 1 in H2 and 0 in H1. All specifications contain a constant. Data are semiannual non-seasonally adjusted measures from 1990 H1 to 2017 H2.

Source: McLeay and Tenreyro (2019)

Interpretation

- What is the interpretation of $\hat{\gamma}_2 = -0.38$?
- Is it $\hat{\kappa} = \hat{\gamma}_2$?
- Tension.
  - Cross-sectional studies estimate “large” slopes (-0.38)
  - Structural estimations using aggregate data (i.e., Rotemberg Woodford, 1997), estimate “small” slopes (-0.019)

Hazell, Herreño, Nakamura, Steinsson (2022)

Identification Challenges

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

- 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)
- 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

$$\pi_{Ht}^{N} = \beta E_t \pi_{H,t+1}^{N} + \lambda \hat{mc}_{Ht}^{N}$$

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

$$\pi_{Ht}^{T} = \beta E_t \pi_{H,t+1}^{T} + \lambda \hat{mc}_{Ht}^{T}$$

- Phillips curve for foreign-produced tradeables

$$\pi_{Ft}^{T} = \beta E_t \pi_{F,t+1}^{T} + \lambda \hat{mc}_{Ft}^{T}$$

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

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

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

- 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:

- 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

- 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

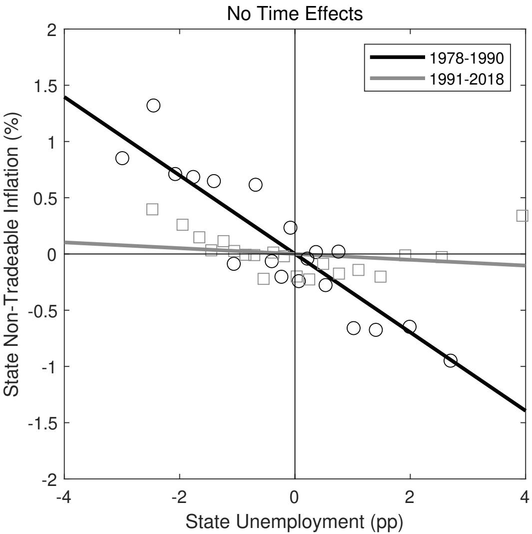
Full Sample

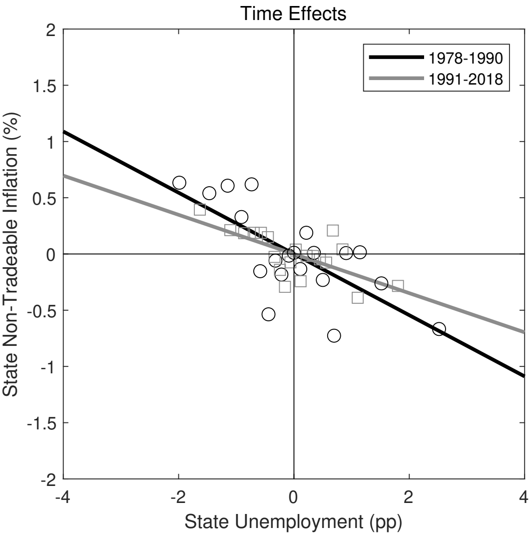
	No Time Effects	Lagged u IV	Tradeable Demand IV
	(1)	(2)	(3)
κ	0.0003	0.0062	0.0062
	(0.0019)	(0.0028)	(0.0025)
ψ	0.017	0.112	0.339
	(0.027)	(0.057)	(0.126)
State Effects	✓	✓	✓
Time Effects		✓	✓

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

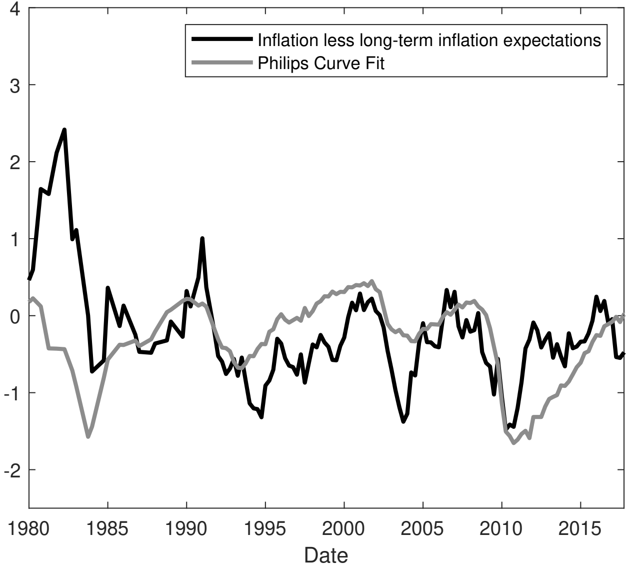




Scatterplots—Non-Tradeable Inflation and Unemployment

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


Inflation less long-term inflation expectations
Philips Curve Fit
4
3
2
1
0
-1
-2
1980
1985
1990
1995
2000
2005
2010
2015
Date

Herreño, Pedemonte (2025)

Motivation

- Widely used assumption that changes in i_t transmit equally across regions
- Implies you can remove their effects from cross-regional regressions using time-fixed effects
- Not true of course if regions are differentially sensitive to aggregate movements in i_t. Two main possibilities:
  - Demand heterogeneity: Local consumption growth reacts differentially to i_t
  - Supply heterogeneity: Local prices react differentially to local demand changes (caused by i_t)
- Examples of each possibility:
  - Demand heterogeneity: durability of consumption goods, financial constraints, myopia, ...
  - Supply heterogeneity: labor supply elasticities, differences in consumption baskets towards more flexible prices, differences in production functions,

Approach

- Evaluate non-parametrically the importance and family of models that can explain heterogeneity
- Very simple testable implication, covariance of dynamic causal effects of p and q in the cross-section
  - Every margin that enters the problem in the slope of the Phillips curve generates a negative covariance.
  - Every margin that enters the problem in the Euler equation generates a positive covariance
  - Not possible to differentiate among stories that enter in the same block (set identification)
- How large are these heterogeneous treatment effects?
- Is the heterogeneity important to understand national effects?

Approach

Quantity and price local projections for region i

$$\pi_{i,t+h,t-1} = \alpha_{i,p} + \sum_{j=0}^{J} \beta_{i,p}^{h,j} RR_{t-j} + \sum_{k=0}^{K} \gamma_{i,p}^{h,k} \pi_{i,t-1,t-1-k} + \varepsilon_{p,i,t+h}^{h} \quad \forall h \in [0, H], i \in \mathcal{I},$$

$$g_{i,t+h,t-1}^{e} = \alpha_{i,e} + \sum_{j=0}^{J} \beta_{i,e}^{h,j} RR_{t-j} + \sum_{k=0}^{K} \gamma_{i,e}^{h,k} g_{i,t,t-k}^{e} + \varepsilon_{e,i,t+h}^{h} \quad \forall h \in [0, H], i \in \mathcal{I},$$

$\beta_{i,p}^{h,0}$, and $\beta_{i,e}^{h,0}$ trace the CIRF for inflation, and the IRF for employment growth. Identifying assumption? Thoughts?

Non-Parametric Heterogeneous Effects

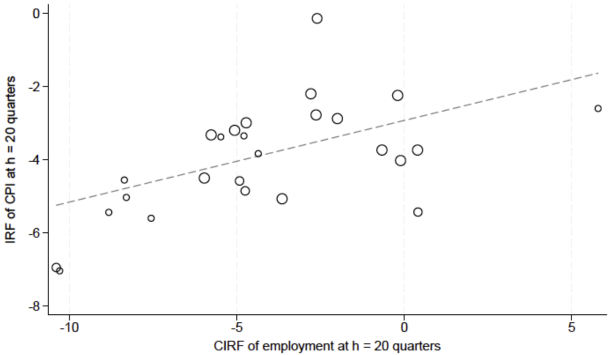


Figure 3: Effect of a Monetary Policy Shock in Employment and Prices for Each City

Note: This figure plots on the y-axis the local projection on local consumer prices of an exogenous monetary policy tightening of 100 basis points 20 quarters after the shock. The x-axis plots the cumulative effect (area under the curve) of local employment 20 quarters after a monetary policy shock of 100 basis points. The units of both axes are percentage points. Each bubble in the scatter plot corresponds to a metropolitan area. The size of each bubble represents the average income per capita of each metropolitan area.

Model

- Two Regions: Home and Foreign
- Tradeable sector in each region
- Home bias
- No labor mobility between regions
- A fraction of hand-to-mouth households in each region

Extension of TANK of Bilbiie (2008) to a monetary union

Households and Firms

- Households:
  - Consume and supply labor
  - Ricardian households: On their Euler equation
  - Hand-to-Mouth households: Out of their Euler equation
  - Standard separable preferences
- Firms:
  - Linear production function on labor
  - Calvo (1983) type price rigidity

Model - Households

- Local consumption aggregates C of different households

$$C_{Ht} = \lambda_H C_{HH,t} + (1 - \lambda_H) C_{HR,t}$$

- HtM consumption exp determined by local labor income

$$P_{Ht} C_{HH,t} = W_{Ht} L_{HHt}$$

- Ricardian consumption growth given by the Euler equation. In logs,

$$c_{HR,t} = \mathbb{E}_t c_{HR,t+1} - \frac{1}{\gamma_H} (i_t - \mathbb{E}_t \pi_{H,t+1})$$

- Risk sharing condition holds for Ricardian Households

$$C_{HR,t}^{\gamma_H} C_{FR,t}^{-\gamma_F} = \frac{P_{Ft}}{P_{Ht}}$$

- Labor supply curves

$$\psi L_{HR,t}^{\alpha_H} C_{HR,t}^{\gamma_H} = \frac{W_{Ht}}{P_{Ht}}, \ L_{HHt} = \left(\frac{1}{\psi}\right)^{\frac{1}{\gamma_H + \alpha_H}} \left(\frac{W_{Ht}}{P_{Ht}}\right)^{\frac{1-\gamma_H}{\gamma_H + \alpha_H}} . \tag{1}$$

Model - Firms

- Demand comes from different regions and household types

$$Y_{H,t}(z) = \lambda_H C_{HH,H,t}(z) + (1 - \lambda_H) C_{HR,H,t}(z) + C_{F,t}(z).$$

- CES bundles within and across regions
- Calvo (1983) frictions. Firms change their prices with probability $1 - \theta_H$.
- marginal-cost based Phillips curve

$$\pi_{Ht} = \beta \mathbb{E}_t \pi_{H,t+1} + \kappa_H mc_{Ht}$$

- where $\kappa_H = \frac{(1-\theta_H \beta)(1-\theta_H)}{\theta_H}$

Marginal costs and hand-to-mouth households

- In a closed economy with linear production functions and no productivity shocks, $C = Y = L$
- useful because it implies that

$$mc_t = w_t - p_t = \gamma c_t + \varphi l_t = (\alpha + \gamma) y_t$$

- Not true in an open economy,

$$mc_{Ht} = \alpha y_{Ht} + \gamma c_{Ht} - p_{Ht}$$

- With hand-to-mouth households in an open economy

$$mc_{H,t} = \frac{1}{\varphi_H} y_{Ht} + \frac{1}{\varphi_H} (1 - \lambda_H) \varphi \gamma c_{R,t} - p_{Ht} \tag{2}$$

- for $\varphi_H = \lambda_H \tilde{\varphi} + (1 - \lambda_H)\varphi$, $\tilde{\varphi} = \frac{\varphi(1-\gamma)}{1+\gamma\varphi}$, and $\varphi = 1/\alpha$
- The presence of HtM households changes the relative strength of Frisch versus wealth effects
- On top of that, non-ricardian households will change the equilibrium behavior of y and c

Model

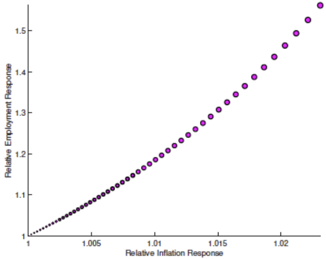


Figure 4: Relative Price and Employment Responses - Fraction of Hand-to-Mouth Consumers

Note: This figure shows the relative behavior of regional prices, on the x-axis, and employment, on the y-axis, after a national monetary policy shock. The source of regional heterogeneity is the share of hand-to-mouth households (λ). Relative inflation and employment are computed as the ratio between the discounted cumulative impulse response functions of each variable in the Home region divided by the analogous object in the Foreign region. A value of 1 means that the Home and Foreign regions have responses of the same magnitude in present value. Each point of the scatterplot represents the solution of a model with a different value of λ. The size of the marker represents how large is the heterogeneity in parameters across regions. The calibrations that underlie the figure are presented in Online Appendix A.5.

Model

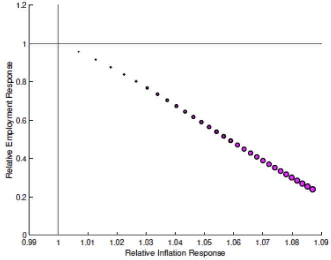


Figure 5: Relative Price and Employment Responses - Phillips curve

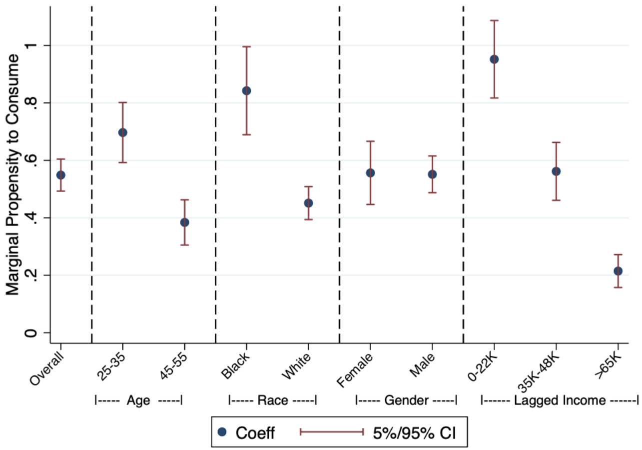
Note: This figure shows the relative behavior of regional prices, on the x-axis, and employment, on the y-axis, after a national monetary policy shock. The source of regional heterogeneity is variation in the extent of nominal rigidities. Relative inflation and employment are computed as the ratio between the discounted cumulative impulse response functions of each variable in the Home region divided by the analogous object in the Foreign region. A value of 1 means that Home and Foreign regions have responses of the same magnitude in present value. Each point of the scatterplot represents the solution of a model with different variations in the extent of nominal rigidities. The size of the marker represents how large the heterogeneity in parameters is across regions. The calibrations that underlie the figure are in Online Appendix A.6.

HtM to Income

- Many possible margins of heterogeneity would give rise to a positive covariance
- Tractability exercise. How far can you go with one channel
- We *choose* the share of HtM. Reason. HtM maps to MPCs, which are high on average and heterogeneous
- One clear challenge, λ_H not observable.
- But the model suggests a mapping $MPC_i = \lambda_i + (1 - \lambda_i) * (1 - \beta)$ or $\lambda_i = \frac{MPC_i - (1-\beta)}{\beta}$
- How to measure MPC_i for local households across MSAs?
- Nothing is perfect. We use Patterson (2019) estimates on the sensitivity of consumption to income changes across income groups
- We then use individual earnings data from the CPS and impute an MPC to each household, and aggregate at the MSA level

MPCs

Figure 2: Heterogeneity in Marginal Propensity to Consume Estimates



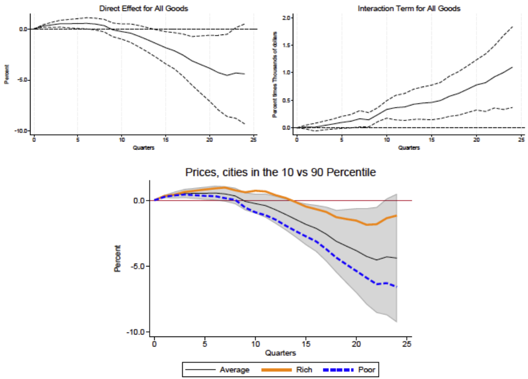
Local Projections with Heterogeneous effects

$$\pi_{i,t+h,t} = \alpha^{h}_{i,p} + \sum_{j=0}^{J} \beta^{h,j}_{p} RR_{t-j} + \sum_{j=0}^{J} \gamma^{h,j}_{p} RR_{t-j} \times RPIPC_{i,t-j-1} + \sum_{j=0}^{J} X'_{i,t-j} \theta^{h,j}_{p} + \varepsilon^{h}_{p,i,t+h}, \tag{3}$$

$\forall h \in [0, H]$ with $X_{i,t-j} = [RPIPC_{i,t-j-1} \ \ \pi_{i,t,t-j}]$, where $RPIPC_{i,t}$ is the relative personal income per capita in city i at time t

Price Effects

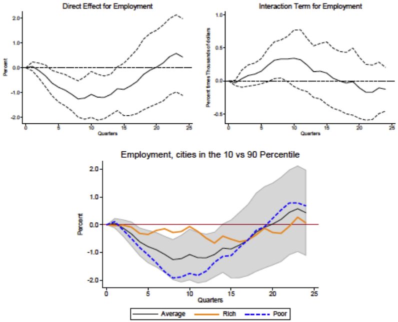
Figure 7: Effect of Monetary Policy and Income Heterogeneity



Note: The top left and right panel of the figure shows the estimated coefficient $\hat{\beta}_p^h$ and $\hat{\gamma}_p^h$ from equation 10, respectively. We use $H = 24$, $J = 8$, and $K = 8$. Relative income per capita is denominated in 2000 dollars. The dashed lines show 90 percent intervals. Standard errors are clustered at the metropolitan area and time level. The bottom panel shows the point estimates of the impulse response for notional metropolitan areas in the 10th and 90th percentiles of the income distribution, together with the average response coming from the top left panel. The 90th percentile of the distribution is USD 2,935 higher than the average annual income, and the 10th percentile is USD 1,989 lower than the average annual income.

Employment Effects

Figure 9: Effect of Monetary Policy Shock and Income Heterogeneity for Employment



Note: The top left and right panel show the estimated coefficients $\hat{\beta}^h$ and $\hat{\gamma}^h$, respectively when the left-hand side variable in equation (10) for private employment. We use $H = 24$, $J = 8$ and $K = 8$. The dashed lines show 90 percent intervals. Standard errors are clustered at the city and time level. The lower panel shows the point estimates $\beta^h + \gamma^h RPIPC_{i,t+h}$ of equation (10) for metropolitan areas in the 90th and 10th percentiles of the geographic income distribution along with the average effects from the top left panel. The 90th percentile of the employment distribution is 2,934 USD (in 2000 dollars) higher than the average annual income, while the 10th is 1,989 USD (in 2000) lower than the average annual income.

Aggregate Effects

Table 1: Simulation of Heterogeneous and Homogeneous Monetary Union

	Heterogeneity			Homogeneity		
	Region 1	Region 2	Aggregate	Region 1	Region 2	Aggregate
Share of HtM	70.2	57.9	64.0	64.0	64.0	64.0
Employment	-1.739	-0.440	-1.090	-0.799	-0.799	-0.799
Consumption	-2.174	-0.005	-1.090	-0.799	-0.799	-0.799
Real Wage	-3.334	-0.298	-1.816	-1.331	-1.331	-1.331
Inflation	-0.197	-0.097	-0.147	-0.114	-0.114	-0.114

Note: This table shows the effect on impact of a monetary policy shock of 1 percentage points on employment, inflation, consumption, and the real wage. We introduce the same experiment for economies with heterogeneity in the share of hand-to-mouth consumers, and without heterogeneity in hand-to-mouth consumers. Both economies have an average share of hand-to-mouth consumers of 64%. Columns 2 to 4 (heterogeneity) show the effect of the shock in an economy with heterogeneous values of HtM across regions. We show the results for each region (columns 2 and 3) and the aggregate economy (column 4). Columns 5 to 7 show the same effects, but for an economy where regions have the same share of hand-to-mouth consumers. All the numbers are shown in percentage points.

Chodorow-Reich, Gopinath, Mishra, Narayanan (2020)

Why is this a successful paper

- the New Keynesian synthesis has no role for cash, “the cashless limit”
- This paper studies a natural experiment where interest rates did not change, but the availability of cash did
- And finds substantial effects
- It moved my priors on the importance of cash

Research Design

- Simple specification (good thing!)

$$(y_{it} - y_{i,\text{baseline}}) = \beta_{0,t} + \beta_{1,t} z_{i,treatment} + \Gamma_t X_i + \epsilon_{it}$$

- Baseline: 2016m11 if monthly, 2016Q3 if quarterly)
- $z_{i,t} = \log Z_{i,t}$ log of the shock.
- Run local projections changing t.

Identifying assumption

Thoughts?

Aggregation

$$\beta_{1,t}\frac{\sum_{i:Z_{i,t}<1} z_{it}Y_{i,baseline}}{\sum_i Y_{i,baseline}}$$

Thoughts?

Herreño, Pinardon-Touati, Thie (2025)

Open slide deck.