A Nominal Demand Augmented Phillips Curve

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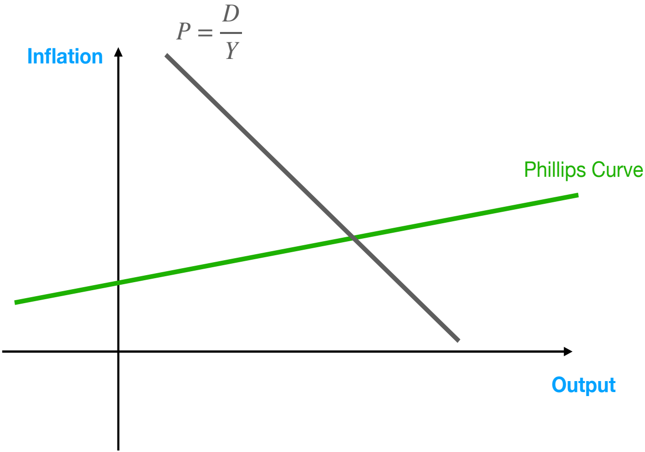
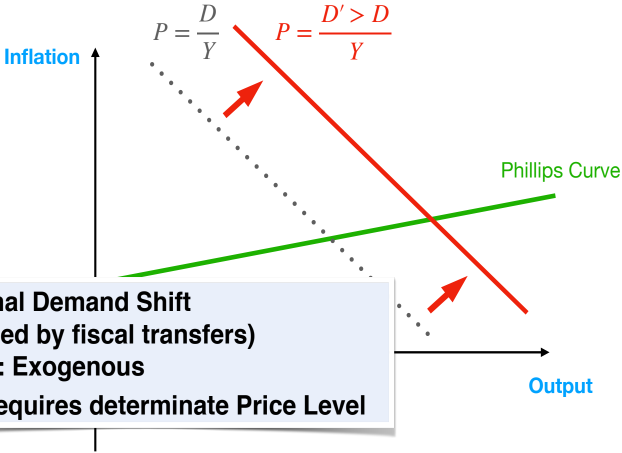
New Keynesian Phillips Curve

One Period Version

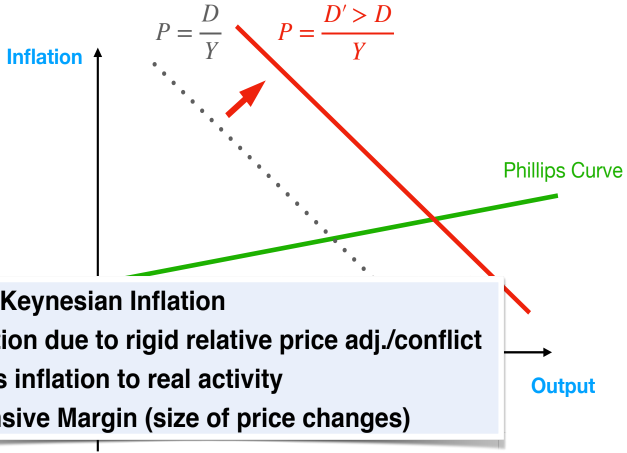


Demand Curve Shift



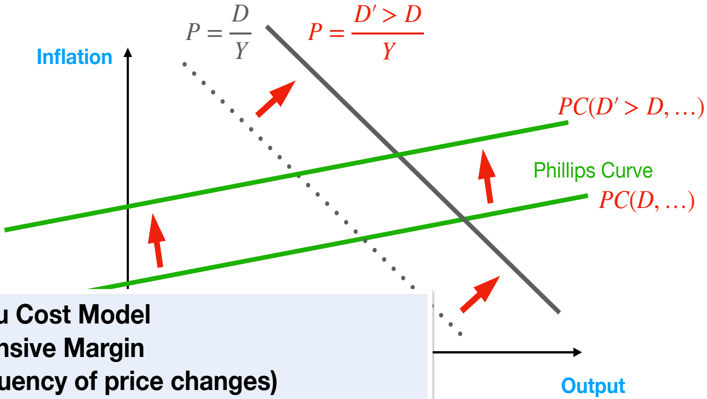
- Nominal Demand Shift
  (induced by fiscal transfers)
- Today: Exogenous
- GE: Requires determinate Price Level

Demand Curve Shift



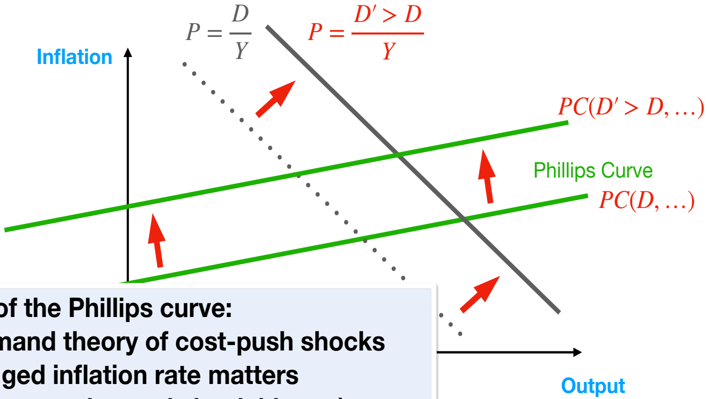
- New Keynesian Inflation
- Inflation due to rigid relative price adj./conflict
- Links inflation to real activity
- Intensive Margin (size of price changes)

Phillips curve shift



- Menu Cost Model
- Extensive Margin
  (frequency of price changes)
- Nominal demand
  -> Inflation and real activity decoupled

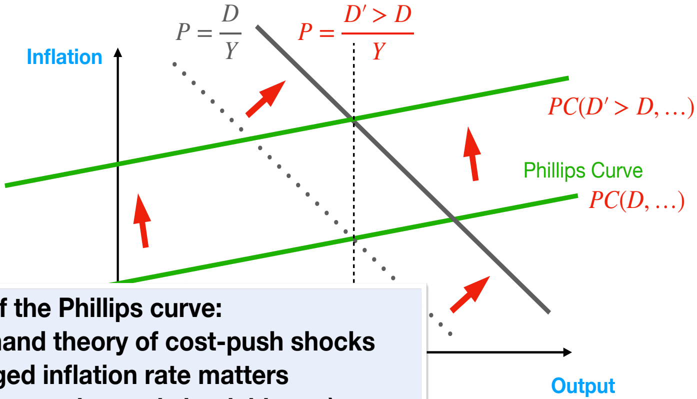
Phillips curve shift



Shift of the Phillips curve:

- **Demand theory of cost-push shocks**
- **Lagged inflation rate matters (captures demand shock history)**
- **History matters -> persistent inflation**

Phillips curve shift



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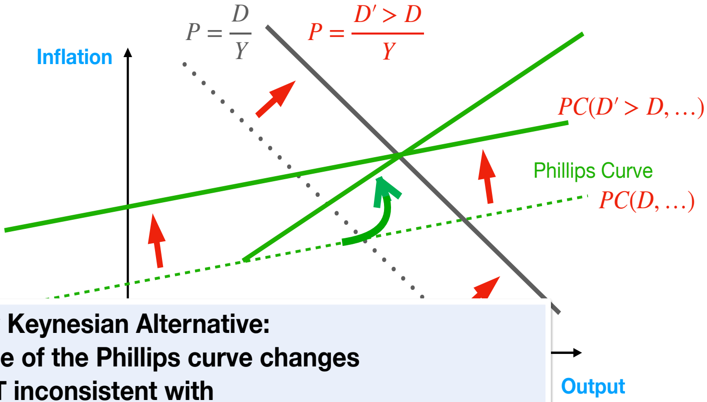
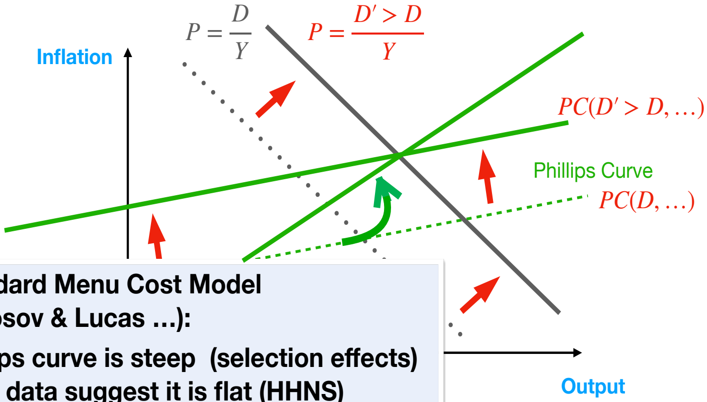


New Keynesian Alternative:
Slope of the Phillips curve changes
[BUT inconsistent with
- Hazell, Herreno, Nakamura and Steinsson (2022)
- Price change frequency]

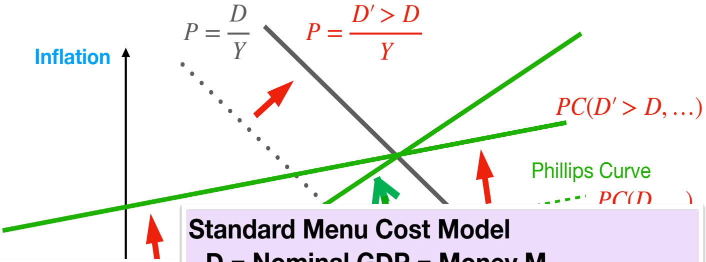
Phillips curve shift



Standard Menu Cost Model (Golosov & Lucas ...):

Phillips curve is steep (selection effects)
[BUT data suggest it is flat (HHNS)
(missing disinflation/reinflation)]
AND slope not changing much

Phillips curve shift



Standard Menu Cost Model
- **D = Nominal GDP = Money M**
- **Monetary policy sets M:**
  -> Controls Nom. GDP D
- **More General:**
  D(Nom. Rate, Fiscal Policy, Shocks, …)

Standard Menu Cost
(Golosov & Lucas …)

Phillips curve is stee
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Nominal Demand Augmented Phillips Curve

Summarizing:

Menu-cost model:	Intensive Margin	& Extensive Margin
Phillips curve:	Moving along the PC	& Shift of the PC
Integrating:	New Keynesian	& "Helicopter" Inflation

Nominal Demand Augmented Phillips Curve

Summarizing:

Menu-cost model:	Intensive Margin	& Extensive Margin
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Today:

Empirical Evidence [building on Hazell et. al.] and Theory

1. Nominal Demand Augmented Phillips Curve
   - New Keynesian real activity component
   - Nominal demand component
2. Lagged Inflation

State-dependent Price Setting

- Firms indexed by $i \in [0,1]$ set price $p_t(i)$.
- Idiosyncratic price adjustment costs.
- Nominal demand D_t and price level $P_t = \left[\int_0^1 p_t(i)^{1-\epsilon} \right]^{\frac{1}{1-\epsilon}}$
- Prob. of adjusting its price $p_{t-1}(i)$ prior to knowing adj. cost:

$$\Lambda_t(p_{t-1}(i), P_t, D_t)$$

- Aggregate price dynamics:

$$\Pi_t^{1-\epsilon} - 1 = \frac{\left[\int_0^1 [p_t^*(i)^{1-\epsilon} - p_{t-1}(i)^{1-\epsilon}] \Lambda(p_{t-1}(i), P_t, D_t) di \right.}{P_{t-1}^{1-\epsilon}}$$

Price Setting Model

Nominal Demand Augmented Phillips Curve (NDPC)

- Log-linearizing [Caballero & Engel 2007]

$$\pi_t \;=\; (\hat{p}_t^* - \hat{P}_{t-1}) \underbrace{\int_0^1 \Lambda(p_{t-1}(i), P_{t-1}, D_{t-1}) di}_{=:\bar{\Lambda}} \quad \text{[Intensive Margin]}$$

$$+ \underbrace{\int_0^1 \frac{1 - \left(\frac{p_{t-1}(i)}{P_{t-1}}\right)^{1-\epsilon}}{1-\epsilon} \hat{\Lambda}(i) di}_{=:\phi} \quad \text{[Extensive Margin]}$$

- Linearizing extensive margin ($\phi^D \geq 0,\ \phi^P \leq 0$)

$$\phi = \phi^D \Delta D_t + \phi^P \pi_t.$$

- The optimal price [One Period model]:

$$\hat{p}_t^* - \hat{P}_{t-1} = \hat{mc}_t + \hat{P}_t - \hat{P}_{t-1},$$

- Solving for the inflation rate π_t:

$$\pi_t \;=\; \underbrace{\zeta}_{\geq 0} \hat{mc}_t + \underbrace{\Phi^D}_{\geq 0} \Delta D_t.$$

Price Setting Model
NDPC - Infinite Horizon

- Optimal Price [Dotsey, King & Wolman 1999]

$$(\hat{p}_t^* - \hat{P}_{t-1}) = \Xi E_t \sum_{k=0}^{\infty} \beta^k \lambda_{k,t} [\hat{mc}_{t+k} + (\hat{P}_{t+k} - \hat{P}_{t-1})]$$

- Using this in $\pi_t = (\hat{p}_t^* - \hat{P}_{t-1})\bar{\Lambda} + \phi_t$ and rearranging:

$$\pi_t = \frac{(\bar{\Lambda}\ \Xi)}{1 - \bar{\Lambda}} E_t \sum_{k=0}^{\infty} \beta^k \hat{mc}_{t+k} + \frac{\Phi_t}{1 - \bar{\Lambda}}$$

- Φ_t depends on $\Delta D_t, \Delta D_{t-1}, \Delta D_{t-2}, \ldots$.

$$\pi_t \quad = \quad \zeta E_t \sum_{k=0}^{\infty} \beta^k \hat{mc}_{t+k} + \Phi_D^0 \Delta D_t + \sum_{k=1}^{\infty} \Phi_D^k \Delta D_{t-k}$$

Regional NDPC

Regional NDPC for Non-Tradables:

$$\pi^N_{r,t} \;=\; E_t \sum_{k=0}^{\infty} \beta^k (\zeta \hat{mc}^N_{r,t+k}) + \Phi^0_D \Delta D^N_{r,t} + \sum_{k=1}^{\infty} \Phi^k_D \Delta D^N_{r,t-k}$$

- $\pi^N_{r,t}$ - non-tradable inflation in region r.
- D^N_r - nominal demand for non-tradables in region r.
- $\hat{mc}^N_{r,t+k} = -\varphi^{-1}\hat{u}_{r,t} - \hat{p}^N_{r,t} \quad [mc^N = w/P^N; u \approx -w/P]$
  - $\hat{u}_{r,t}$ - unemployment rate in region r
  - $\hat{p}^N_{r,t}$ - relative price of non-tradables

Regional NDPC

Regional NDPC for Non-Tradables:

$$\pi_{r,t}^{N} = E_t \sum_{k=0}^{\infty} \beta^k (\zeta \hat{mc}_{r,t+k}^{N}) + \Phi_D^0 \Delta D_{r,t}^{N} + \sum_{k=1}^{\infty} \Phi_D^k \Delta D_{r,t-k}^{N}$$

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  - $\hat{u}_{r,t}$ - unemployment rate in region r
  - $\hat{p}_{r,t}^{N}$ - relative price of non-tradables
- Incomplete markets:

  Nominal transfers $\rightarrow$ Nominal Demand.

Regional NDPC

Regional NDPC for Non-Tradables:

$$\pi^N_{r,t} \quad = \quad E_t \sum_{k=0}^{\infty} \beta^k (\zeta \hat{mc}^N_{r,t+k}) + \Phi^0_T \Delta T_{r,t} + \sum_{k=1}^{\infty} \Phi^k_T \Delta T_{r,t-k}$$

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  - $\hat{u}_{r,t}$ - unemployment rate in region r
  - $\hat{p}^N_{r,t}$ - relative price of non-tradables
- Incomplete markets:

  Nominal transfers $\rightarrow$ Nominal Demand.
- T_r - nominal transfer to region r households.

Data

- Regional Transfers
  - BEA- Personal Current Transfer Receipts (SQINC35)
  - "State unemployment insurance compensation" + "All other personal current transfer receipts"
  - Includes income maintenance benefits (SSI, EITC, SNAP), Alaska Permanent Fund benefits and ARRA transfers
- State-Level Inflation Rates and Price Indices
  - Data from Hazell, Herreño, Nakamura and Steinsson (2022)
  - Use CPI Research Database provided by BLS
  - Non-shelter state inflation rates
  - Non-tradables: education, telephone, medical and recreational services, …
- Labor market data
  - State-level unemployment rates from LAUS.
  - State-industry level employment data from QCEW.

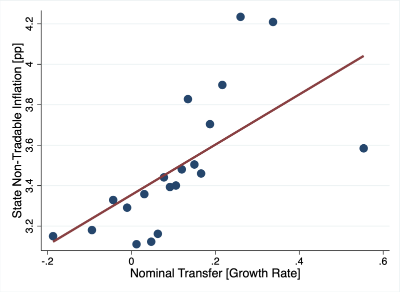
Visualisation

Binned Scatterplots

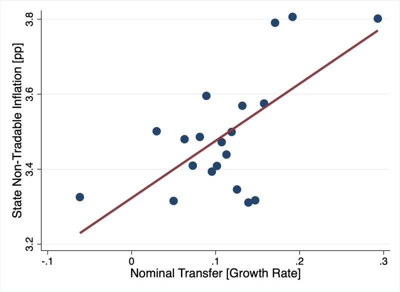
State Nominal transfer growth rate

$\leftrightarrow$

State Non-Tradable Inflation



No State and Time Fixed Effects



State and Time Fixed Effects

Empirical Specification

$$\pi^N_{r,t} \quad = \quad \kappa E_t \sum_{k=0}^{K} \beta^k \hat{mc}^N_{r,t+k} + \Phi \Delta T_{r,t-4} + \gamma \pi^N_{r,t-4} + \alpha_r + \gamma_t + \epsilon_{r,t}$$

- $\pi^N_{r,t} = \log(P^N_{r,t}) - \log(P^N_{r,t-4})$ [Non-tradable inflation]
- $\Delta T_{r,t-4} = \log(T_{r,t-4}) - \log(T_{r,t-8})$ [State Transfer]
- $\sum_{k=0}^{K} \beta^k \hat{mc}^N_{r,t+k}$ truncated at $K = 20$ quarters
- $\pi^N_{r,t-4}$ - Lagged non-tradable inflation rate
- α_r, γ_t: State and time fixed effects.

Identification

Bartik-type Instrument

Tradable Bartik type instrument in region r in period t:

$$\mathcal{B}_{r,t} := \sum_{l} \bar{z}_{l,r} \times g_{-r,l,t},$$

- $\bar{z}_{l,r}$ is the time-average employment share of industry l in the tradable sector in region r
- $g_{-r,l,t}$ is the Period t three-year growth of industry r national employment leaving out region r

Idea:

- $g_{-r,l,t} \rightarrow$ differential impact on NT-demand in Sector r depending on $\bar{z}_{l,r}$
- Example [HHNS]: Oil price shock affects Texas and Illinois differently
- No time correlation with the Texas/Illinois cost-difference.

Identification

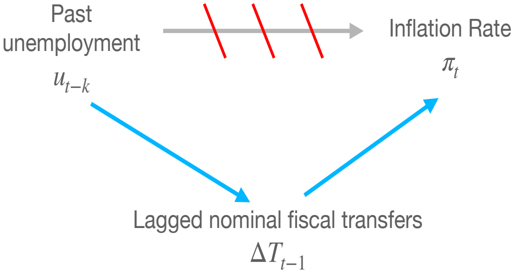
Past unemployment rates

Relevance:

$u_{r,t-k}$ triggers UI and other income maintenance programs:

Orthogonality:

$$E(u_{r,t-k}\epsilon_{r,t}) = 0, \quad k = \underline{k}, \underline{k}+1, \ldots, \overline{k}$$



Identification

Past unemployment rates

Orthogonality:

$$E(u_{r,t-k}\epsilon_{r,t}) = 0, \quad k = \underline{k}, \underline{k}+1, \ldots, \overline{k}$$

Is correct

- in New Keynesian model if $\hat{mc}_t = u_t$:

$$\pi^N_{r,t} = \kappa \sum_{k=0}^{\infty} \beta^k \hat{mc}^N_{r,t+k}$$

- in menu cost model if $\hat{mc}_t = u_t$ and control for ΔD_{t-k}

$\Rightarrow$ I impose this theoretical identifying assumption

$$[\hat{mc}_t = u_t] + [\text{control } \Delta D_{t-k}] \rightarrow E(u_{r,t-k}\epsilon_{r,t}) = 0$$

Identification

Past unemployment rates

Orthogonality:

$$E(u_{r,t-k}\epsilon_{r,t}) = 0, \quad k = \underline{k}, \underline{k}+1, \dots, \overline{k}$$

BUT:

- Unemployment $\neq$ Marginal cost gap $\Rightarrow$ Residual

$$\hat{mc}^N_{r,t} = u_{r,t} + mc^{res}_{r,t}, \qquad E(u_{r,t} mc^{res}_{r,t}) = 0.$$

- Inflation:

$$\pi^N_{r,t} = \sum_{k=0}^{\infty} \beta^k u_{r,t+k} + \underbrace{\sum_{k=0}^{\infty} \beta^k mc^{res}_{r,t+k}}_{\hookrightarrow \epsilon_{r,t}}$$

- Orthogonality condition then reads:

$$E(u_{r,t-k} mc^{res}_{r,t}) = 0, \quad k = \underline{k}, \underline{k}+1, \dots, \overline{k}.$$

- Overidentifying assumptions are tested.

Results

	ΔT	$\sum$ mc	π_{t-4}
Benchmark	0.115 (0.037)	0.049 (0.020)	0.081 (0.111)

Specification Tests

Identification	Under-I.	Weak-I. (F-Test)	Over-I.
Benchmark	0.019 ✓	47.851 ✓	0.287 ✓

Clustered P-values in parentheses.

Results

	ΔT	$\sum$ mc	π_{t-4}	ΔT_{t-4}
Benchmark	0.115	0.049	0.081	
	(0.037)	(0.020)	(0.111)	
Lagged Transfer	0.145	0.067	0.058	0.115
	(0.017)	(0.015)	(0.268)	(0.036)

Specification Tests

Identification	Under-I.	Weak-I. (F-Test)	Over-I.
Benchmark	0.019 ✓	47.851 ✓	0.287 ✓
Lagged Transfer	0.007 ✓	21.801 ✓	0.912 ✓✓

Clustered P-values in parentheses.

Results

	ΔT	$\sum$ mc	π_{t-4}
Benchmark	0.115	0.049	0.081
	(0.037)	(0.020)	(0.111)
No Infl. Lag	0.130	0.052	
	(0.042)	(0.025)	

	Specification Tests		
Identification	Under-I.	Weak-I. (F-Test)	Over-I.
Benchmark	0.019 ✓	47.851 ✓	0.287 ✓
No Infl. Lag	0.028 ✓	46.776 ✓	0.282 ✓

Clustered P-values in parentheses.

Results

	ΔT	$\sum$ mc	π_{t-4}
Benchmark	0.115	0.049	0.081
	(0.037)	(0.020)	(0.111)
No Marg. Cost	0.052		0.086
	(0.012)		(0.106)

Specification Tests

Identification	Under-I.	Weak-I. (F-Test)	Over-I.
Benchmark	0.019 ✓	47.851 ✓	0.287 ✓
No Marg. Cost	0.011 ✓	87.818 ✓	0.211 ✓

Clustered P-values in parentheses.

Results

	ΔT	$\sum$ mc	π_{t-4}
Benchmark	0.115	0.049	0.081
	(0.037)	(0.020)	(0.111)
No Transfer		0.021	0.080
		(0.171)	(0.107)

Specification Tests

Identification	Under-I.	Weak-I. (F-Test)	Over-I.
Benchmark	0.019 ✓	47.851 ✓	0.287 ✓
No Transfer	0.001 ✓	156.5 ✓	0.030 ✗

Clustered P-values in parentheses.

Results

Different Marginal Cost Measures

	Marg. Cost $\beta = 0.95$	Marg. Cost $\beta = 0.9$	Marg. Cost $\varphi = 1/2$	Marg. Cost $\varphi = 2$
ΔT	0.108	0.098	0.115	0.115
	(0.023)	(0.013)	(0.037)	(0.037)
$\sum mc$	-0.060	-0.074	-0.024	-0.097
	(0.010)	(0.005)	(0.020)	(0.020)
		Specification Tests		
Under-I.	0.009 ✓	0.006 ✓	0.019 ✓	0.019 ✓
Weak-I.	57.070 ✓	66.903 ✓	47.834 ✓	47.877 ✓
Over-I.	0.309 ✓	0.317 ✓	0.287 ✓	0.288 ✓

Results

REAL Demand Phillips Curve Estimates

	Inflation	Inflation
Real Transfer Growth	0.164	
	(0.938)	
Real Transfer Level		-39.075
		(0.454)
$\sum$ Marginal Cost	-0.023	0.180
	(0.292)	(0.508)

- Nominal and not real demand growth matters.
- Not proxy for real marginal cost: Real Level does not matter

Results (Aggregate U.S. Data)

Indexation

Looking under the hood of the estimated time FE:

	Estimated Time FE $\hat{\gamma}_t$	
Lag. Inflation, $\pi_{US,t-4}$	0.658	0.103
	(0.000)	(0.531)
Lag. Pers. Income gr.		28.438
		(0.017)
Lag. Social Security gr.		50.457
		(0.004)

Results (Aggregate U.S. Data)

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Year $t-1$ | Year t

$$\pi_{t-1} \xrightarrow{\text{Indexation,...}} \text{Personal Income growth}_{t-1} \overset{\textbf{NDPC}}{\Longrightarrow} \pi_t$$

Results (Aggregate U.S. Data)

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Year $t-1$ | Year t

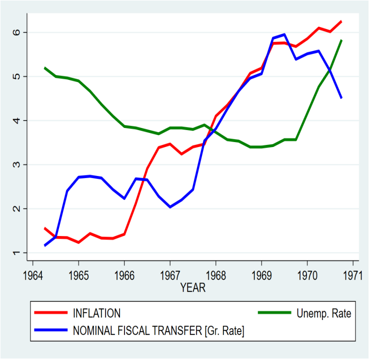
$$\pi_{t-1} \xrightarrow{\text{Indexation,...}} \text{Personal Income growth}_{t-1} \xRightarrow{\textbf{NDPC}} \pi_t$$

“Aggregate Implications”

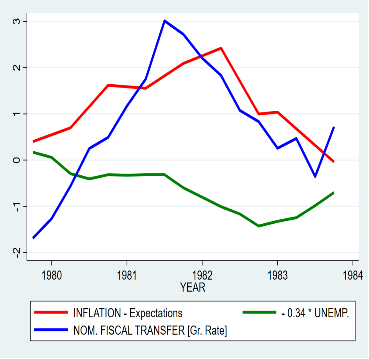
Predicted inflation using U.S. Aggregate Personal Transfers

$$\pi_t^{pred} = const + 0.145 \Delta T_{t-4}^{U.S.} + 0.115 \Delta T_{t-8}^{U.S.}$$

U.S. 1964-1970



U.S. 1980 - 1984



Conclusion

Theoretical Contribution:

- Derived nominal demand augmented Phillips curve (NDPC)
- Two determinants of inflation:
  Real marginal costs and nominal demand growth
- NDPC $\neq$ NKPC (without strong assumptions)

Empirical Contribution:

- Estimate NDPC in cross-section of U.S. states
- Confirm theoretical predictions: Nominal not real demand growth matters; not a proxy for marg. cost, looks like cost-push shock from NKPC perspective

More Slides

High level modeling choices

- Follow Midrigan (ECMA 2011)
- Introduce idiosyncratic firm productivity shocks
- Stochastic (exponential) adjustment costs
- No mass points
- Weekly and quarterly versions

Match key steady state targets:

- Frequency of (regular) weekly price changes: 2.9%.
- Distribution of size of (regular) price changes
- Replicates evidence on intensive and extensive margin in Alvarez, Beraja, Gonzalez-Rozada and Neumeyer (QJE 19): "From hyperinflation to stable prices: Argentina's evidence on menu cost models"

Experiments

- Study response of model to shocks to nominal demand growth ΔD_t
- Linearize model with small MIT-shocks in sequence space (Boppart, Krusell & Mitman 2018, Auclert et al 2021)
- Consider two processes for demand growth:
  - Quarterly autocorrelation $\rho_D = 0.5$ (as in the data)
  - Quarterly autocorrelation $\rho_D = 0$ ($\equiv$ permanent level shock)
- Simulate to obtain weekly model generated data
- Implement quarterly Phillips curve regressions:

$$\pi_t = \alpha \sum \mathbb{E}[\beta^k mc_{t+k}] + \gamma \pi_{t-1} + \delta \Delta D_{t-1} + \epsilon_t$$

Results: $\rho_D = 0.5$

New Keynesian Calvo Specifications:

	$\sum$ mc	π_{t-1}
Calvo	0.0150	
	(0.0001)	
+ Lagged Inflation	0.0116	0.4118
	(0.0001)	(0.0052)

Standard errors in parentheses.

Results: $\rho_D = 0.5$

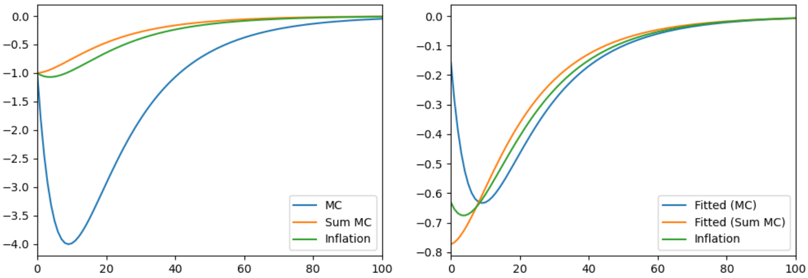
Full specification:

	$\sum$ mc	π_{t-1}	ΔD
Calvo	0.0116	0.4118	
	(0.0001)	(0.0043)	
Full Specification	0.0080	-0.0271	0.5862
	(0.0000)	(0.0036)	(0.0039)

Standard errors in parentheses.

Understanding the results: Weekly IRFs $\rho_D = 0.5$

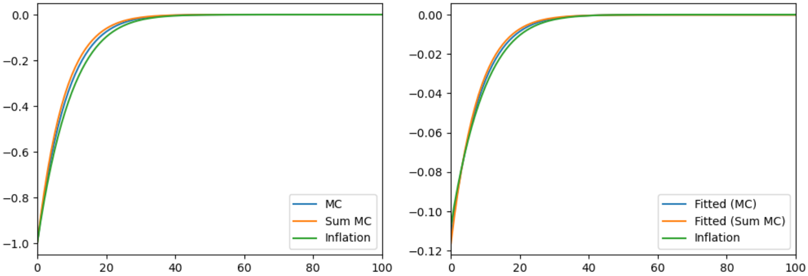
(Expected discounted) Output gaps don't coincide with inflation



Fitted (MC): Coefficient $\pi_{t-1} = 0.7828$
Fitted (Sum MC): Coefficient $\pi_{t-1} = 0.2907$

Understanding the results: Weekly IRFs $\rho_D = 0$

Nature of shock matters. With level shocks, (expected discounted) output gaps much closer to inflation

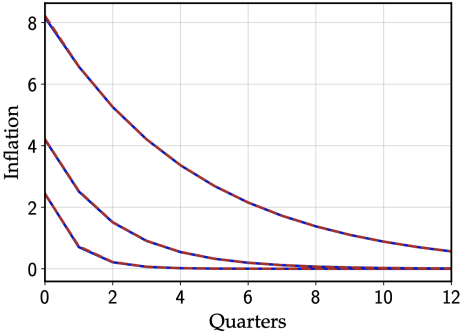


Fitted (MC): Coefficient $\pi_{t-1} = 0.1217$

Fitted (Sum MC): Coefficient $\pi_{t-1} = 0.065$

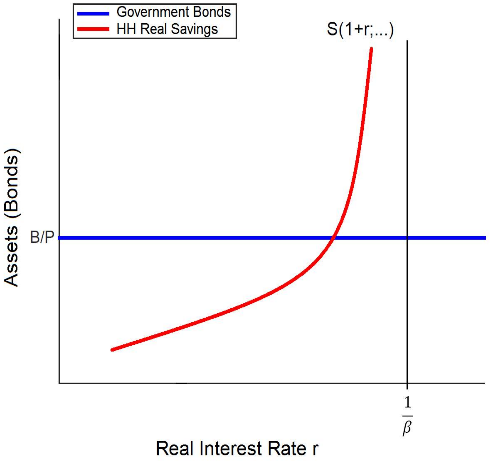
Comparison to Auclert et al 2023

With AR(1) shocks ($\rho = \{0.3, 0.6, 0.8\}$) to real marginal costs, inflation and (expected discounted) output gaps coincide



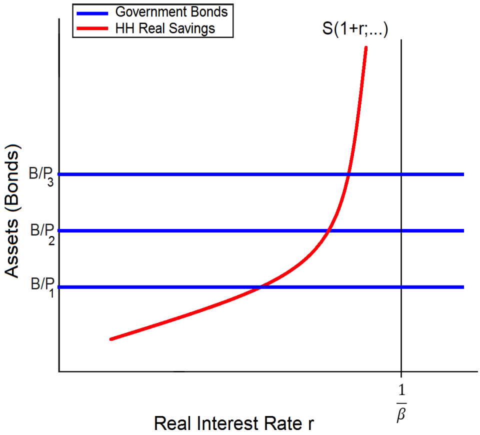
Steady State Price Level

Asset Market in Incomplete Markets Model

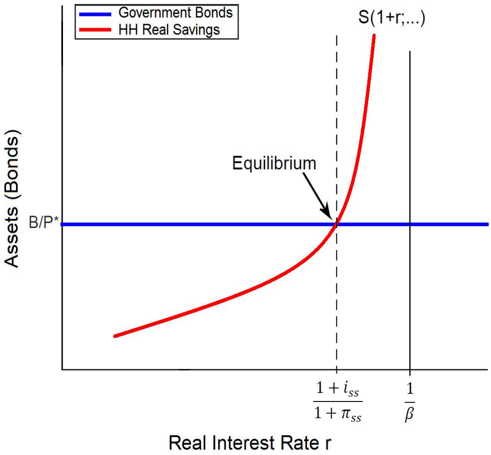


Steady State Price Level

Indeterminacy



Steady State Price Level



Real Interest Rate:

$$(1+r) = \frac{1+i}{1+\pi}$$

Monetary Policy:

Sets $1+i$

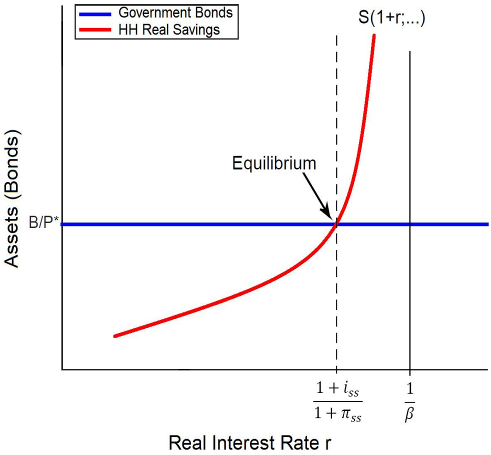
Fiscal Policy:

$$\pi = \frac{B'-B}{B} = \frac{G'-G}{G} = \frac{T'-T}{T}$$

i : nominal interest rate
r : real interest rate
π : inflation rate

B: nominal bonds
G: nominal government spending
T: nominal tax revenue

Steady State Price Level



Steady-state Conditions:

$$\frac{B}{P*} = S(\frac{1+i_{ss}}{1+\pi_{ss}})$$

$$1+\pi_{ss} = 1+\frac{B'-B}{B}$$

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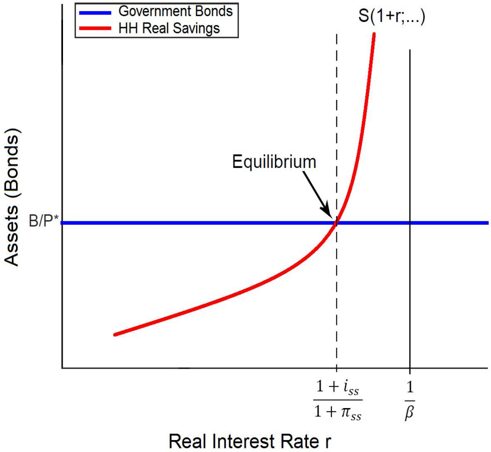
Steady State Price Level

With capital K



Steady-state Conditions:

$$K + \frac{B}{P^*} = S\left(\frac{1+i_{ss}}{1+\pi_{ss}}\right)$$

$$1+\pi_{ss} = 1 + \frac{B' - B}{B}$$

i : nominal interest rate
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Steady State Price Level

With endogenous Money M

Steady-state Conditions

$$\frac{B}{P^*} = S(\frac{1+i_{ss}}{1+\pi_{ss}}, 1+\pi_{ss})$$

$$\frac{M}{P^*} = L(\frac{1+i_{ss}}{1+\pi_{ss}}, 1+\pi_{ss})$$

$$1+\pi_{ss} = 1+\frac{B'-B}{B} = 1+\frac{M'-M}{M}$$

Central bank provides

$$M = P^* L(\frac{1+i_{ss}}{1+\pi_{ss}}, 1+\pi_{ss})$$

Steady State Price Level

With endogenous Money M

Steady-state Conditions [Open Market operations]

$$\frac{B - M}{P^*} = S\left(\frac{1 + i_{ss}}{1 + \pi_{ss}}, 1 + \pi_{ss}\right)$$

$$\frac{M}{P^*} = L\left(\frac{1 + i_{ss}}{1 + \pi_{ss}}, 1 + \pi_{ss}\right)$$

$$1 + \pi_{ss} = 1 + \frac{B' - B}{B} = 1 + \frac{M' - M}{M}$$

Central bank provides

$$M = P^* L\left(\frac{1 + i_{ss}}{1 + \pi_{ss}}, 1 + \pi_{ss}\right)$$

Steady State Price Level

With endogenous Money M

Steady-state Conditions [Open Market operations]

$$\frac{B - M}{P^*} = S(\frac{1 + i_{ss}}{1 + \pi_{ss}}, 1 + \pi_{ss})$$

$$\frac{M}{P^*} = L(\frac{1 + i_{ss}}{1 + \pi_{ss}}, 1 + \pi_{ss})$$

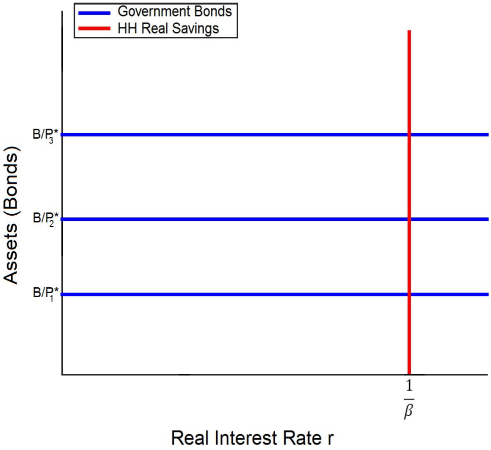
$$\frac{B}{P^*} = S(\frac{1 + i_{ss}}{1 + \pi_{ss}}, 1 + \pi_{ss}) + L(\frac{1 + i_{ss}}{1 + \pi_{ss}}, 1 + \pi_{ss})$$

$$1 + \pi_{ss} = 1 + \frac{B' - B}{B} = 1 + \frac{M' - M}{M}$$

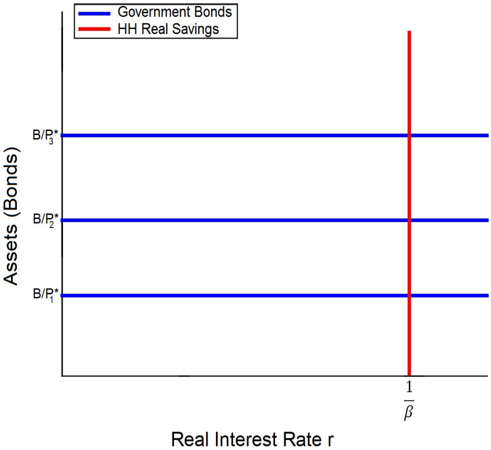
Central bank provides

$$M = P^* L(\frac{1 + i_{ss}}{1 + \pi_{ss}}, 1 + \pi_{ss})$$

Steady State Price Level: Complete Markets



Steady State Price Level:
Why TANK does not deliver



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<u>Monetary Policy:</u>

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