Monetary Policy when the Phillips Curve is (Locally) Quite Flat

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Introduction : Inflation

- *Lowflation* just before the Great Lockdown.
- This is one in a set of puzzles in the behaviour of inflation, when observed through the lens of a New Keynesian model
  - × missing deflation in the Great Recession
  - × missing volatility of inflation at the ZLB
  - × price puzzle following a monetary shock
  - × missing inflation today given supply shock and lax monetary policy

1. Theoretical exploration of a model in which the Phillips curve of the type

$$\pi_t = \beta E_t[\pi_{t+1}] + \underbrace{\left(\gamma_y y_t + \gamma_r (i_t - E_t[\pi_{t+1}])\right)}_{\text{marginal cost}}$$

- We find interesting theoretical results when *"γ_y is small as compared to γ_r"* ...
- ... but is that empirically relevant?

2. Careful limited information estimation of a Phillips curve of the type

$$\pi_t = \beta E_t[\pi_{t+1}] + \left(\gamma_y y_t + \gamma_r(i_t - E_t[\pi_{t+1}])\right)$$

Result: $\gamma_y \approx 0$, $\gamma_r > 0$

3. Full information estimation of an extended NK model with a Phillips curve of the type

$$\pi_t = \beta E_t[\pi_{t+1}] + \left(\gamma_y y_t + \gamma_r(i_t - E_t[\pi_{t+1}])\right)$$

Result: $\gamma_y \approx 0$ and $\gamma_r > 0$

Roadmap

1. Theory
2. Phillips Curve Estimation
3. Full Information Estimation

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1. Theory
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- I don't want to spend time on microfoundations (nothing deep there)

$$y_t = E_t[y_{t+1}] - \alpha_r \underbrace{(i_t - E_t[\pi_{t+1}])}_{r_t} + d_t \qquad \text{Euler Equation (EE)}$$

$$\pi_t = \beta E_t[\pi_{t+1}] + \underbrace{(\gamma_y y_t + \gamma_r(i_t - E_t\pi_{t+1}))}_{\text{"marginal cost"}} + \mu_t \qquad \text{Phillips Curve (PC)}$$

- I don't want to spend time on microfoundations (nothing deep there)

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$$\pi_t = \beta E_t[\pi_{t+1}] + \underbrace{\left(\gamma_y y_t + \gamma_r (i_t - E_t \pi_{t+1})\right)}_{\text{"marginal cost"}} + \mu_t \qquad \text{Phillips Curve (PC)}$$

- α_y can be arbitrarily close to 1.

A Condition on parameters

- Let's define a condition on parameters that has simple interpretation and that happens to be key (and not studied previously)

The Patman condition

$$y_t = \alpha_y E_t[y_{t+1}] - \alpha_r r_t + d_t \qquad \text{Euler Equation (EE)}$$

$$\pi_t = \beta E_t[\pi_{t+1}] + \gamma_y y_t + \gamma_r r_t + \mu_t \qquad \text{Phillips Curve (PC)}$$

- Let's compute the effect on inflation of a small increase in r (set by policy) keeping expectations fixed.
  - × direct positive effect: γ_r
  - × indirect negative effect $-\alpha_r \gamma_y$

The Patman condition

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Patman condition :

An increase in r will increase π, keeping expectations fixed, if $\gamma_r > \alpha_r \gamma_y$

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Patman condition :

An increase in r will increase π, keeping expectations fixed, if $\gamma_r > \alpha_r \gamma_y$

- Note: this condition also describes what happens in equilibrium if shocks are iid and if policy is a real interest policy

$$i_i - E_t[\pi_{t+1}] = \phi_d d_t + \phi_\mu \mu_t + \nu_t$$

The Patman condition cannot hold globally

- Unlikely that the Phillips curve is flat for very positive or negative output gaps.
- Most likely,

$$\text{marginal cost} = \Gamma(y) + \gamma_r r$$

  - × $\Gamma'(y)$ minimum at zero
  - × $\Gamma'(0) = \gamma_y$
- The Patman condition is in essence a local condition.
- How local? Does it hold on average? Empirical work will tell us.

The Patman condition

- In the literature on the cost channel (e.g. Ravenna and Walsh, Surico, etc...), the model specification always implies that the Patman condition cannot hold.

Demand and markup shocks

- The response of the economy to demand and markup shocks, for standard Taylor rules, is qualitatively similar regardless of the Patman condition holding or not
- Patman condition matters for monetary policy and monetary shocks

Implication for monetary policy

- A lot of results that counter the intuition of the NK model, but not the facts
  - × How to stabilize inflation?
  - × ZLB trap
  - × Price puzzle

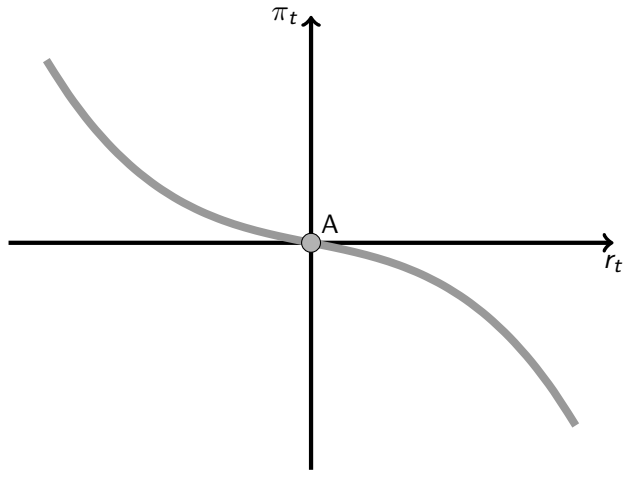
How to stabilize inflation?

$$y_t = \alpha_y E_t[y_{t+1}] - \alpha_r r_t + d_t \qquad \text{Euler Equation (EE)}$$

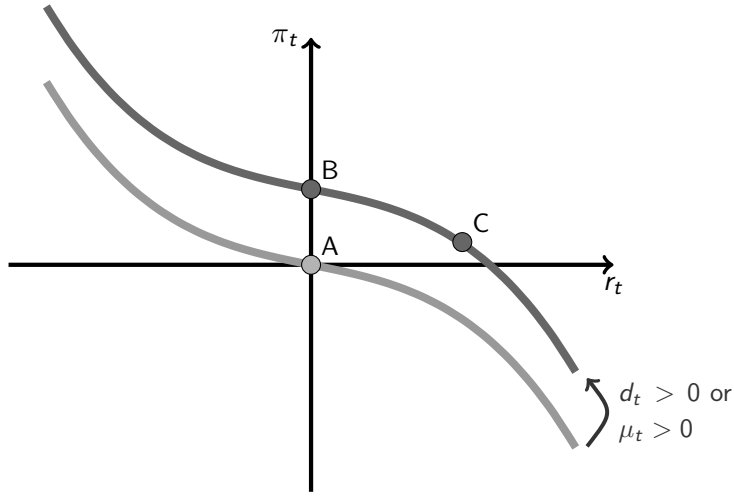
$$\pi_t = \beta E_t[\pi_{t+1}] + \left(\Gamma(y_t) + \gamma_r r_t\right) + \mu_t \qquad \text{Phillips Curve (PC)}$$

- Start at steady state
- Consider a $d > 0$ or a $\mu > 0$
- Monetary policy is to keep r constant during N periods and then return to zero.
- We derive $\pi(r)$ in equilibrium

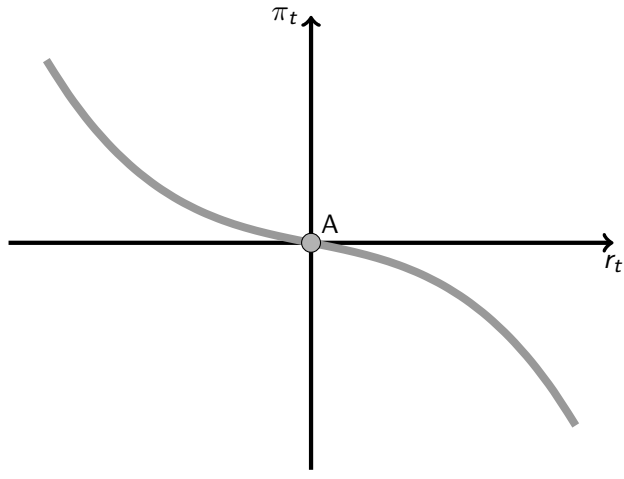
π_t as a Function of r_t when the Patman Condition is Not Met



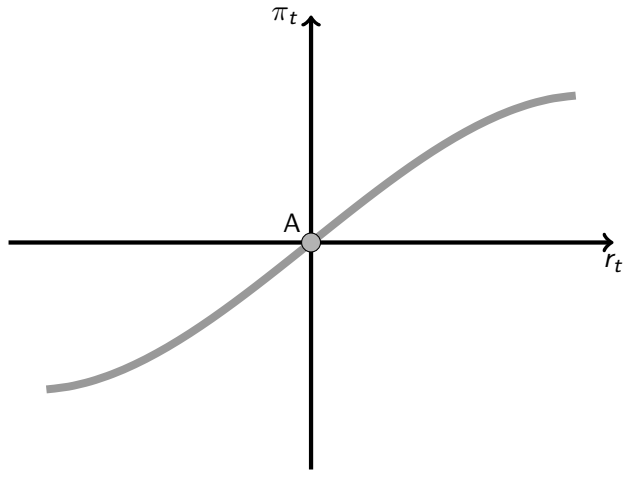
π_t as a Function of r_t when the Patman Condition is Not Met



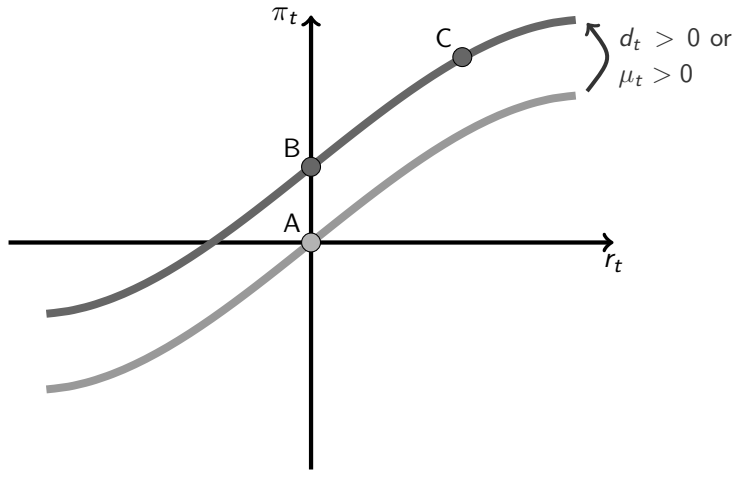
π_t as a Function of r_t when the Patman Condition is Not Met



π_t as a Function of r_t when the Patman Condition Holds



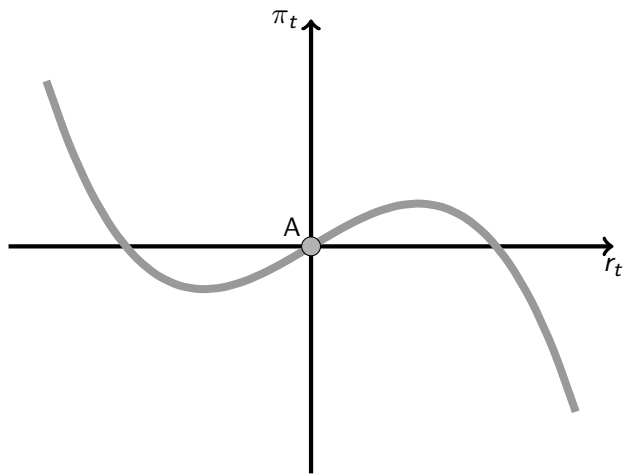
π_t as a Function of r_t when the Patman Condition Holds



Going Global

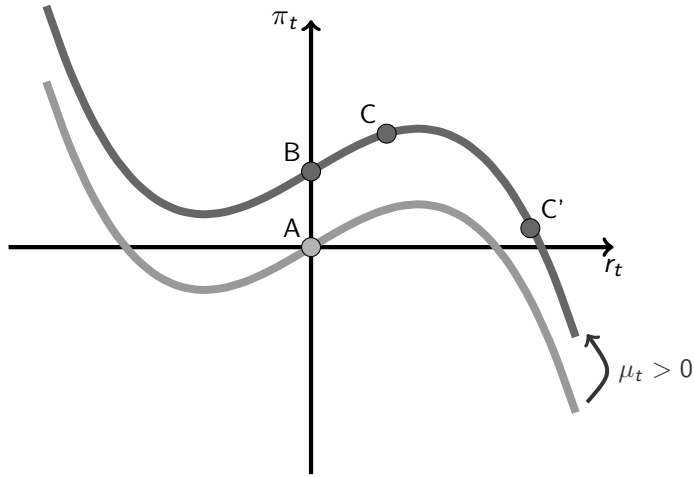
Going Global

π_t as a Function of r_t when the Patman Condition Holds



π_t as a function of r_t when the Patman condition is (locally) met

Go Big or Stay Home



The ZLB Trap

The ZLB Trap

- Under Patman condition, the ZLB is quasi inevitable following a persistent fall in demand.
- Under Patman condition, both the fall in demand and the response of monetary authorities favours lower inflation:
  - × Initial negative demand shock $\rightsquigarrow$
  - × Low activity and low inflation $\rightsquigarrow$
  - × Monetary expansion stimulus $\rightsquigarrow$
  - × Lower i and lower inflation $\rightsquigarrow$
  - × More monetary expansion $\rightsquigarrow$
  - × Even lower i $\rightsquigarrow$
  - × Hit the zero lower bound.
- Typically what will happen under price level targeting

Price puzzle

- If the Patman condition holds, we have a price "puzzle".
- Only in the short run in a model with endogenous propagation.

Roadmap

1. Theory
2. Phillips Curve Estimation
3. Full Information Estimation

- Here we build on the large literature that estimate single equation Phillips curves.

Phillips Curve Estimation

$$\pi_t = \beta E_t \pi_{t+1} + \gamma_y y_t + \gamma_r (i_t - E_t \pi_{t+1}) + \theta z_t + \mu_t$$

Phillips Curve Estimation

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Phillips Curve Estimation

$$\pi_t = \beta \quad \pi^e_{t+1} + \gamma_y x_t + \gamma_r(i_t - \quad \pi^e_{t+1}) + \theta z_t + \mu_t$$

Phillips Curve Estimation

$$\pi_t = \beta \quad \pi^e_{t+1} + \gamma_y x_t + \gamma_r(i_t - \quad \pi^e_{t+1}) + \theta z_t + \mu_t$$

- π_t: Headline CPI
- π^e_t: University of Michigan Survey of Consumers
- x_t: *minus* Unemployment gap from U.S. Congressional Budget Office
- z_t: Oil price

Endogenity

$$\pi_t = \beta \pi^e_{t+1} + \gamma_y x_t + \gamma_r (i_t - \pi^e_{t+1}) + \theta z_t + \mu_t$$

- Need to deal with endogeneity of x
- Need to deal with endogeneity of $i_t - \pi^e_{t+1}$
- Need to deal with endogeneity of π^e_{t+1}

Phillips Curve Estimation: Basic

$$\pi_t = \beta\pi^e_{t+1} + \gamma_y x_t + \gamma_r(i_t - \pi^e_{t+1}) + \theta z_t + \mu_t$$

	OLS
β	0.99***
γ_y	0.17***
γ_r	

- × Controlling for oil price,
- × Sample: 1969Q1-2017Q4,
- × Newey & West correction for heteroskedasticity and autocorrelation,

Phillips Curve Estimation: Basic

$$\pi_t = \beta\pi^e_{t+1} + \gamma_y x_t + \gamma_r(i_t - \pi^e_{t+1}) + \theta z_t + \mu_t$$

	OLS	IV gap
β	0.99^{***}	0.98^{***}
γ_y	0.17^{***}	0.15^{**}
γ_r		

- $\times$ Controlling for oil price,
- $\times$ Sample: 1969Q1-2017Q4,
- $\times$ Newey & West correction for heteroskedasticity and autocorrelation,
- $\times$ x_t instrumented with its two first lags ,

Phillips Curve Estimation: Basic

$$\pi_t = \beta \pi^e_{t+1} + \gamma_y x_t + \gamma_r (i_t - \pi^e_{t+1}) + \theta z_t + \mu_t$$

	OLS	IV gap	IV rate
β	0.99***	0.98***	0.96***
γ_y	0.17***	0.15**	-0.01
γ_r			0.20***

- × Controlling for oil price,
- × Sample: 1969Q1-2017Q4,
- × Newey & West correction for heteroskedasticity and autocorrelation,
- × x_t instrumented with its two first lags ,
- × $i_t - \pi^e_{t+1}$ instrumented with 6 lags of Romer & Romer shocks and their square

Phillips Curve Estimation: Basic

$$\pi_t = \beta \pi^e_{t+1} + \gamma_y x_t + \gamma_r (i_t - \pi^e_{t+1}) + \theta z_t + \mu_t$$

	OLS	IV gap	IV rate	IV both
β	0.99***	0.98***	0.96***	0.95***
γ_y	0.17***	0.15**	-0.01	0.02
γ_r			0.20***	0.20***

- Controlling for oil price,
- Sample: 1969Q1-2017Q4,
- Newey & West correction for heteroskedasticity and autocorrelation,
- x_t instrumented with its two first lags ,
- $i_t - \pi^e_{t+1}$ instrumented with 6 lags of Romer & Romer shocks and their square

Phillips Curve Estimation: Also Instrumenting π^e

$$\pi_t = \beta\pi^e_{t+1} + \gamma_y x_t + \gamma_r(i_t - \pi^e_{t+1}) + \theta z_t + \mu_t$$

	Michigan Survey
β	0.96^{***}
γ_y	0.04
γ_r	0.18^{***}

$\times$ Controlling for oil price,
$\times$ Sample: 1969Q1-2017Q4,
$\times$ NEWEY & WEST correction for heteroskedasticity and autocorrelation,
$\times$ Instruments: two first lags of x_t, 6 lags of ROMER & ROMER shocks and their square, two lags of π_t

Phillips Curve Estimation: Also Instrumenting π^e

$$\pi_t = \beta\pi^e_{t+1} + \gamma_y x_t + \gamma_r(i_t - \pi^e_{t+1}) + \theta z_t + \mu_t$$

	Michigan Survey	Rational Expectation
β	0.96^{***}	0.86^{***}
γ_y	0.04	0.04
γ_r	0.18^{***}	0.22^{***}

$\times$ Controlling for oil price,
$\times$ Sample: 1969Q1-2017Q4,
$\times$ Newey & West correction for heteroskedasticity and autocorrelation,
$\times$ Instruments: two first lags of x_t, 6 lags of Romer & Romer shocks and their square, two lags of π_t

Phillips Curve Estimation: Hybrid

$$\pi_t = \beta_{+1}\pi^e_{t+1} + \beta_{-1}\pi_{t-1} + \gamma_y x_t + \gamma_r(i_t - \pi^e_{t+1}) + \theta z_t + \mu_t$$

- We obtain similar results.

Phillips Curve Estimation: 1969–1992

- Period 1969–1992 is often thought to be a period with a steeper Phillips curve,
- We obtain similar results.

$$\pi_t = \beta \pi^e_{t+1} + \gamma_y x_t + \gamma_r (i_t - \pi^e_{t+1}) + \theta z_t + \mu_t$$

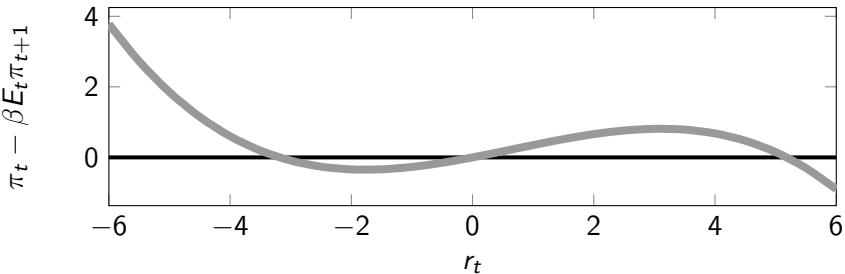
	OLS	IV gap	IV rate	IV both
β	0.83***	0.77***	1.13***	1.1***
γ_y	0.41**	0.49***	-0.16	-0.08
γ_r			0.30***	0.29***

× Controlling for oil price,
× Sample: 1969Q1-2017Q4,
× x_t instrumented with its two first lags ,
× $i_t - \pi^e_{t+1}$ instrumented with 6 lags of Romer & Romer shocks and their square

Phillips Curve Estimation: Nonlinear estimation

$$\pi_t = \beta\pi^e_{t+1} + (\gamma_{y,1}x_t + \gamma_{y,2}x_t^2 + \gamma_{y,3}x_t^3) + \gamma_r(i_t - \pi^e_{t+1}) + \theta z_t + \mu_t$$

- $\pi_t - \beta\pi^e_{t+1}$ as a function of r_t implied by the estimation:



- Patman zone for $r \in [-2\%, +3\%]$ around historical average value

Roadmap

1. Theory
2. Phillips Curve Estimation
3. Full Information Estimation

Simple Model

- To compare to existing literature, we estimate a local approximation of the model.

$$y_t = \alpha_y E_t[y_{t+1}] - \alpha_r(i_t - E_t[\pi_{t+1}]) + d_t, \tag{EE}$$

$$\pi_t = \beta E_t[\pi_{t+1}] + \left(\gamma_y y_t + \gamma_r(i_t - E_t[\pi_{t+1}])\right) + \mu_t, \tag{PC}$$

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$$\pi_t = \beta E_t[\pi_{t+1}] + \left(\gamma_y y_t + \gamma_r(i_t - E_t[\pi_{t+1}])\right) + \mu_t, \tag{PC}$$

$$i_t = E_t[\pi_{t+1}] + \phi_d d_t + \phi_\mu \mu_t + \nu_t. \tag{Policy}$$

- We prove in the paper that such a real interest rate rule encompasses the traditional Taylor rule.

Simple Model

$$y_t = \alpha_y E_t[y_{t+1}] - \alpha_r(i_t - E_t[\pi_{t+1}]) + d_t, \tag{EE}$$

$$\pi_t = \beta E_t[\pi_{t+1}] + \left(\gamma_y y_t + \gamma_r(i_t - E_t[\pi_{t+1}])\right) + \mu_t, \tag{PC}$$

$$i_t = E_t[\pi_{t+1}] + \phi_d d_t + \phi_\mu \mu_t + \nu_t. \tag{Policy}$$

Quasi-No Euler Discounting

$$y_t = .99E_t[y_{t+1}] - \alpha_r(i_t - E_t[\pi_{t+1}]) + d_t, \tag{EE}$$

$$\pi_t = .99E_t[\pi_{t+1}] + \left(\gamma_y y_t + \gamma_r(i_t - E_t[\pi_{t+1}])\right) + \mu_t, \tag{PC}$$

$$i_t = E_t[\pi_{t+1}] + \phi_d d_t + \phi_\mu \mu_t + \nu_t. \tag{Policy}$$

Variables & Samples

- Baseline: Headline CPI inflation, *minus* unemployment gap (CBO), Fed. fund rate.
- alose look at output gap, Core CPI, GDP deflator
- Baseline sample: `1957Q3-2008Q4`
- Also look at `1957Q3-2017Q4`
- ML estimation

Table 1: Estimated Parameters, Simple Model, ML

Parameter	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
γ_y	0.01	0.00	0.01	0.04	0.06	0.02	0.00	0.00	-0.01	-0.01
	(0.02)	(0.05)	(0.02)	(0.02)	(0.02)	(0.03)	(0.02)	(0.02)	(0.02)	(0.02)
γ_r	0.04	0.04	0.05	0.09	0.07	0.05	0.05	0.07	0.02	0.02
	(0.02)	(0.01)	(0.02)	(0.04)	(0.03)	(0.02)	(0.02)	(0.03)	(0.01)	(0.01)
$(\cdots)$										
Patman	0.04	0.04	0.05	0.09	0.07	0.05	0.05	0.07	0.02	0.02
	(0.02)	(0.01)	(0.02)	(0.04)	(0.03)	(0.02)	(0.02)	(0.03)	(0.01)	(0.01)

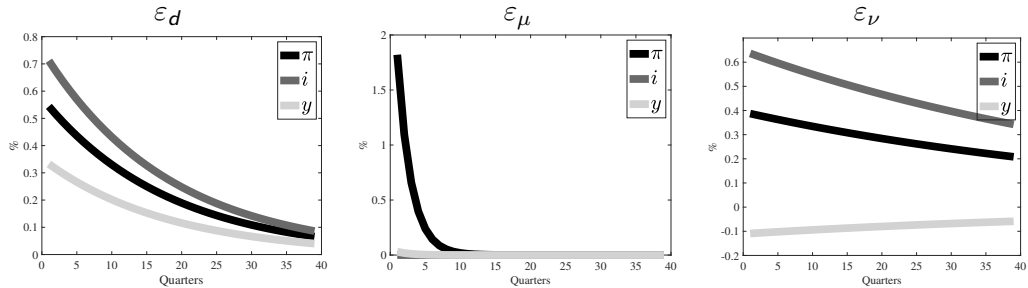
Notes: (1) unemployment gap, Core CPI, 1957Q3–2017Q4; (2) unemployment gap, headline CPI, 1957Q3–2017Q4; (3) output gap, Core CPI, 1957Q3–2017Q4; (4) output gap, Core CPI, 1957Q3–2008Q4; (5) unemployment gap, Core CPI, 1957Q3–2008Q4; (6) unemployment gap, headline CPI, 1957Q3–2008Q4; (7) output gap, headline CPI, 1957Q3–2017Q4; (8) output gap, headline CPI, 1957Q3–2008Q4;(9) unemployment gap, GDP deflator, 1957Q3–2017Q4; (10) unemployment gap, GDP deflator, 1957Q3–2008Q4.

Table 2: Estimated Parameters, Simple Model, ML

Parameter	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
γ_y	0.01	0.00	0.01	0.04	0.06	0.02	0.00	0.00	-0.01	-0.01
	(0.02)	(0.05)	(0.02)	(0.02)	(0.02)	(0.03)	(0.02)	(0.02)	(0.02)	(0.02)
γ_r	0.04	0.04	0.05	0.09	0.07	0.05	0.05	0.07	0.02	0.02
	(0.02)	(0.01)	(0.02)	(0.04)	(0.03)	(0.02)	(0.02)	(0.03)	(0.01)	(0.01)
$(\cdots)$										
Patman	0.04	0.04	0.05	0.09	0.07	0.05	0.05	0.07	0.02	0.02
	(0.02)	(0.01)	(0.02)	(0.04)	(0.03)	(0.02)	(0.02)	(0.03)	(0.01)	(0.01)

Notes: (1) unemployment gap, Core CPI, 1957Q3–2017Q4; (2) unemployment gap, headline CPI, 1957Q3–2017Q4; (3) output gap, Core CPI, 1957Q3–2017Q4; (4) output gap, Core CPI, 1957Q3–2008Q4; (5) unemployment gap, Core CPI, 1957Q3–2008Q4; (6) unemployment gap, headline CPI, 1957Q3–2008Q4; (7) output gap, headline CPI, 1957Q3–2017Q4; (8) output gap, headline CPI, 1957Q3–2008Q4;(9) unemployment gap, GDP deflator, 1957Q3–2017Q4; (10) unemployment gap, GDP deflator, 1957Q3–2008Q4.

Figure 1: Impulse Responses to Shocks, Simple Model, Baseline



Extended Model

- We add habit persistence, hybrid Phillips curve and persistence in policy rule.
- Estimation using Bayesian technique.

$$y_t = \alpha_y\big(\alpha_{y,+1}E_t[y_{t+1}] + (1-\alpha_{y,+1})y_{t-1}\big) - \alpha_r(i_t - E_t[\pi_{t+1}]) + \alpha_\mu\mu_t + d_t, \quad \text{(EE')}$$

$$\pi_t = \beta\big((1-\beta_{-1})E_t[\pi_{t+1}] + \beta_{-1}\pi_{t-1}\big) + \big(\gamma_y y_t + \gamma_{y,-1}y_{t-1} + \gamma_r(i_t - E_t[\pi_{t+1}])\big) + \mu_t, \quad \text{(PC')}$$

$$i_t = E_t[\pi_{t+1}] + \phi_{r,-1}\big(i_{t-1} - E_{t-1}[\pi_t]\big) + \phi_{\pi,-1}\pi_{t-1} + \phi_{y,-1}y_{t-1} + \phi_d d_t + \phi_\mu\mu_t + \nu_t. \quad \text{(Policy')}$$

Table 3: Estimated Parameters, Extended Model, Robustness

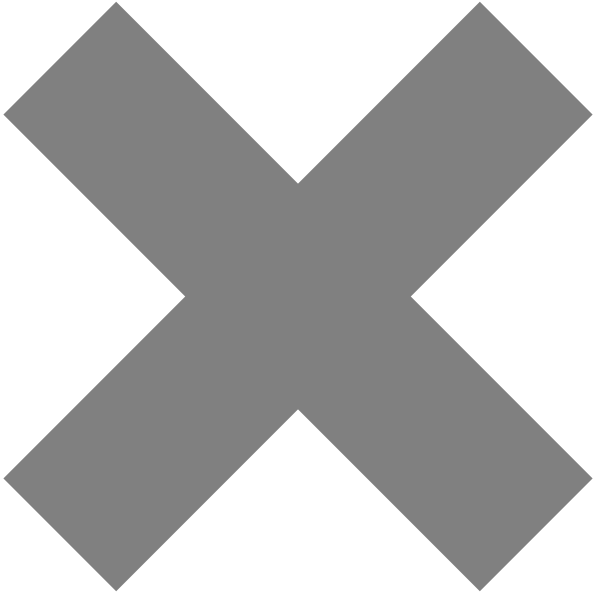
Parameter	(1)	(2)	(3)	(4)	(5)	(6)
γ_y	-0.06	-0.01	-0.09	-0.02	-0.07	-0.04
	[-0.22,0.09]	[-0.18,0.15]	[-0.25,0.07]	[-0.21,0.15]	[-0.22,0.07]	[-0.21,0.13]
γ_r	0.11	0.19	0.14	0.23	0.08	0.15
	[0.05,0.15]	[0.10,0.27]	[0.05,0.24]	[0.08,0.39]	[0.04,0.13]	[0.05,0.26]
$(\cdots)$						
Patman	0.11	0.19	0.15	0.23	0.09	0.15
	[0.07,0.17]	[0.11,0.28]	[0.07,0.33]	[0.10,0.45]	[0.05,0.14]	[0.07,0.29]

Notes: (1) unemployment gap, Headline CPI, 1957Q3–2017Q4; (2) unemployment gap, Headline CPI, 1957Q3–2008Q4; (3) unemployment gap, Core CPI, 1957Q3–2017Q4; (4) unemployment gap, Core CPI, 1957Q3–2008Q4; (5) unemployment gap, GDP deflator, 1957Q3–2017Q4; (6) unemployment gap, GDP deflator, 1957Q3–2008Q4.

Table 4: Estimated Parameters, Extended Model, Robustness

Parameter	(1)	(2)	(3)	(4)	(5)	(6)
γ_y	-0.06	-0.01	-0.09	-0.02	-0.07	-0.04
	[-0.22,0.09]	[-0.18,0.15]	[-0.25,0.07]	[-0.21,0.15]	[-0.22,0.07]	[-0.21,0.13]
γ_r	0.11	0.19	0.14	0.23	0.08	0.15
	[0.05,0.15]	[0.10,0.27]	[0.05,0.24]	[0.08,0.39]	[0.04,0.13]	[0.05,0.26]
$(\cdots)$						
Patman	0.11	0.19	0.15	0.23	0.09	0.15
	[0.07,0.17]	[0.11,0.28]	[0.07,0.33]	[0.10,0.45]	[0.05,0.14]	[0.07,0.29]

Notes: (1) unemployment gap, Headline CPI, 1957Q3–2017Q4; (2) unemployment gap, Headline CPI, 1957Q3–2008Q4; (3) unemployment gap, Core CPI, 1957Q3–2017Q4; (4) unemployment gap, Core CPI, 1957Q3–2008Q4; (5) unemployment gap, GDP deflator, 1957Q3–2017Q4; (6) unemployment gap, GDP deflator, 1957Q3–2008Q4.

To conclude

- The cost channel is strong compared to the slope of the Phillips curve (Patman condition holds)
- This is shown estimating full DSGE-like models or Phillips curve alone.
- This has implications for the effect of monetary policy aiming at stabilizing inflation.