Real Keynesian Models and Sticky Prices

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June 6-7, 2019

3rd Workshop on "Macroeconomic and Financial Time Series Analysis"
Lancaster University

Introduction : Inflation

- A set of puzzles in the behaviour of inflation, when observed through the lens of a New Keynesian model
  - missing inflation
  - missing deflation
  - missing volatility of inflation at the ZLB
  - etc.
- One way out is to enrich the standard New Keynesian model
- We suggest an alternative perspective that questions the real side of the model that NK models build on

Introduction : Demand Shocks

- In many (most) macro models, "demand" shocks (optimism, positive sentiment, good news, possibly lax credit,...) are expansionary because prices are sticky.
- Smaller literature suggests that sticky prices may not be necessary for demand shocks to be expansionary. $\rightsquigarrow$ *Real Keynesian* models
- If *prices are sticky* (after all), this might be a rather theological distinction.
- Questions addressed in this paper: should we care that a model is *Real Keynesian*
  1. for our understanding of how monetary shocks affect the economy?
  2. for our understanding of the conduct of monetary policy?
  3. for the explained behaviour of inflation?
- Answers are yes, yes and yes.

Introduction: Contributions

- Propose a new class of simple extensions of the *New Keynesian* model
- *Real Keynesian* models have very different implications for monetary policy **when prices are sticky**.
- Show that it is empirically relevant

Roadmap

1. Theory
2. Empirical Relevance
3. Focus on the Zero Lower Bound and Missing Deflation

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The Real Structure of the Simplest NK Model

- No technology shock, no capital, CRS: $y_t = c_t = \ell_t$
- Model with sticky prices:

$$\ell_t = E_t \ell_{t+1} - \alpha_r (i_t - E_t \pi_{t+1}) + d_t \qquad \text{Euler Equation (EE)}$$
$$\pi_t = \beta E_t \pi_{t+1} + \kappa \; mc_t \qquad \text{Phillips Curve (PC)}$$

- Marginal cost is assumed to depend on labor market tightness (real wage) $\rightsquigarrow$ $mc_t = \gamma_\ell \ell_t$
- When prices are fully flexible:

$$\ell_t = E_t \ell_{t+1} - \alpha_r r_t + d_t \qquad \text{Euler Equation (EE)}$$
$$mc_t = 0 = \gamma_\ell \ell_t \qquad \text{Aggregate Supply (AS)}$$

The Real Structure of the Simplest NK Model

Flex price NK model :

$$\ell_t = E_t \ell_{t+1} - \alpha_r r_t + d_t \quad \text{(EE)}$$

$$0 = \gamma_\ell \ell_t \quad \text{(AS)}$$

The Real Structure of the Simplest NK Model

i.i.d. case :

$$\ell_t = \qquad -\alpha_r r_t + d_t \quad \text{(EE)}$$
$$0 = \gamma_\ell \ell_t \quad \text{(AS)}$$

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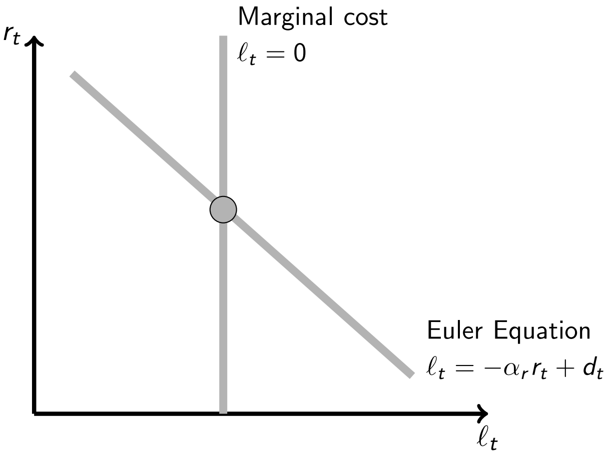

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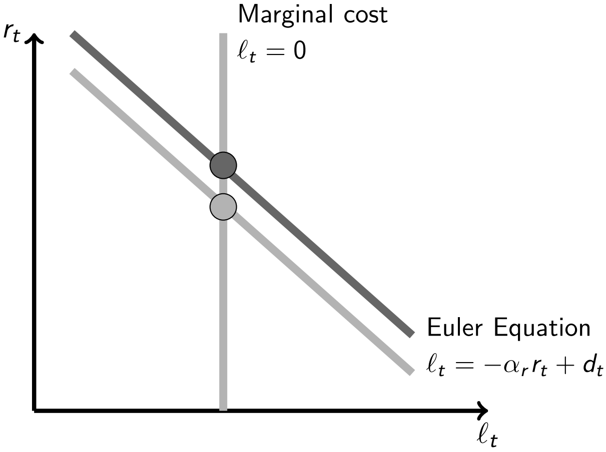

Enriching the Real Structure

- Let's have a more general model in which AS is not infinitely sloped.
- Assume now that marginal cost also depend on the real interest rate r (*cost channel*)

$$mc_t = \gamma_\ell \ell_t + \gamma_r r_t$$

Enriching the Real Structure

i.i.d. case :

$$\begin{aligned} \ell_t &= \qquad\qquad - \alpha_r r_t + d_t \quad \text{(EE)} \\ 0 &= \gamma_\ell \ell_t + \gamma_r r_t \qquad\qquad \text{(AS)} \end{aligned}$$

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- NK model corresponds to $\gamma_r = 0$

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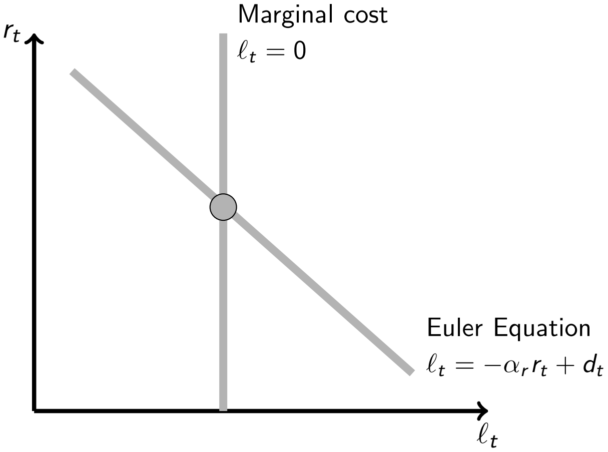

Enriching the Real Structure

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$$\ell_t = \qquad - \alpha_r r_t + d_t \quad \text{(EE)}$$
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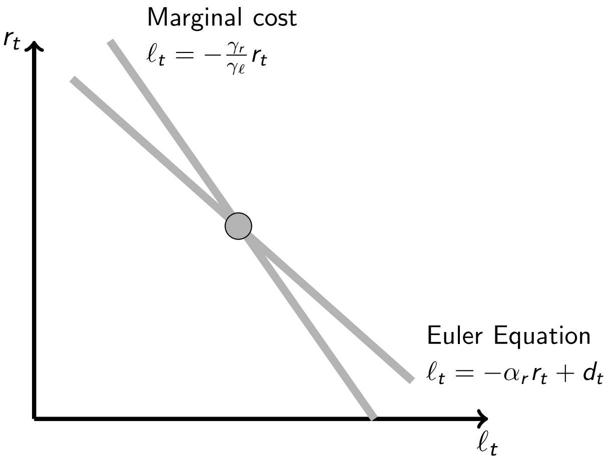
- Assume γ_r is small (compared to γ_ℓ)



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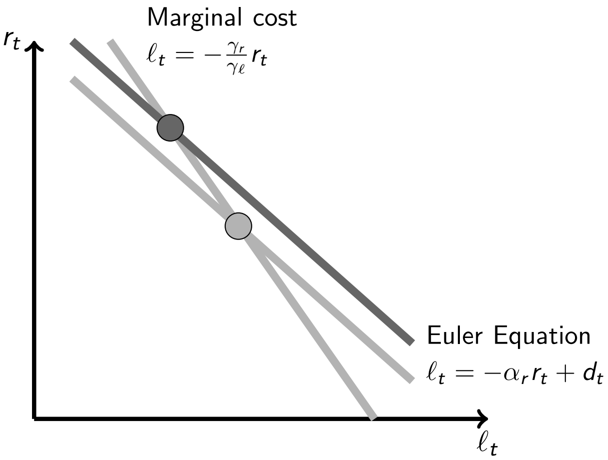

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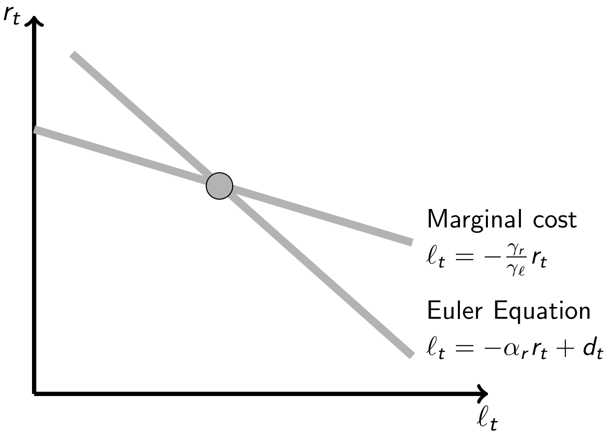

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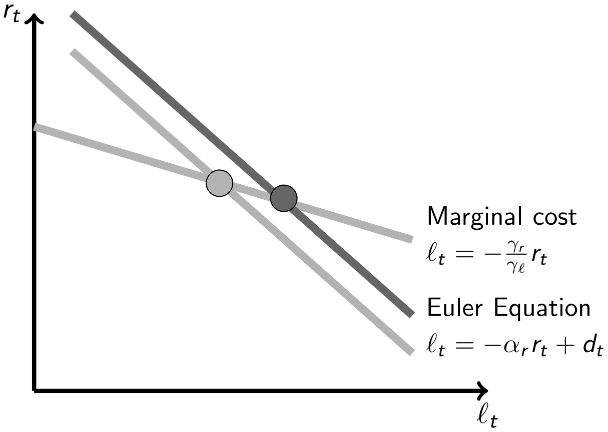

Towards An Extended Model

- Importance of the cost channel: $\frac{\gamma_r}{\gamma_\ell} \lessgtr \alpha_r$
- In the *i.i.d.* case, we say that the model is *Real Keynesian* if $\frac{\gamma_r}{\gamma_\ell} > \alpha_r$
- Need to go beyond the *i.i.d.* case
- $\rightsquigarrow$ Expectations in the Euler equation will matter

The RK condition

Result 1

With flex. prices, positive demand shocks (both current and expected future) of any persistence have a positive effect on ℓ if and only if

$$\frac{\gamma_r}{\gamma_\ell} > \frac{\alpha_r}{} \qquad (RK)$$

The RK condition

Result 1

With flex. prices, positive demand shocks (both current and expected future) of any persistence have a positive effect on ℓ if and only if

$$\frac{\gamma_r}{\gamma_\ell} > \frac{\alpha_r}{(1-\alpha_\ell)} \qquad (RK)$$

where the Euler Equation is

$$\ell_t = \alpha_\ell E_t \ell_{t+1} - \alpha_r (i_t - E_t \pi_{t+1}) + d_t$$

Extended Sticky Price Linearized Model

$$\ell_t = \alpha_\ell E_t \ell_{t+1} - \alpha_r (i_t - E_t \pi_{t+1}) + d_t \qquad \text{Euler Equation (EE)}$$

$$\pi_t = \beta E_t \pi_{t+1} + \kappa\big(\gamma_\ell \ell_t + \gamma_r (i_t - E_t \pi_{t+1})\big) \qquad \text{Phillips Curve (PC)}$$

- Two changes (microfoundations in the paper):
  - $\alpha_\ell \le 1$: *discounted EE*
  - $\gamma_r \ge 0$: *cost channel*
- Nothing novel, except for putting them together.
- Note: standard NK model: $\alpha_\ell = 1$, $\gamma_r = 0$
- To remember: α's for the EE, γ's for the PC

Extended Sticky Price Linearized Model

- with demand, cost-push and monetary policy shocks

$$\ell_t = \alpha_\ell E_t \ell_{t+1} - \alpha_r (i_t - E_t \pi_{t+1}) + d_t \tag{EE}$$

$$\pi_t = \beta E_t \pi_{t+1} + \kappa \big(\gamma_\ell \ell_t + \gamma_r (i_t - E_t \pi_{t+1})\big) + \mu_t \tag{PC}$$

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Theorem 1

For any Taylor rule $\quad i_t = \widetilde{\phi}_\pi \pi_t + \widetilde{\phi}_\ell \ell_t + \widetilde{\nu}_t$
that gives determinacy, there exists a policy rule

$$i_t = E_t[\pi_{t+1}] + \phi_\ell \ell_t + \nu_t$$

that produces the same allocations, with $\nu_t = a\mu_t + b\widetilde{\nu}_t$

Policy Rules

Corollary 1

If monetary policy is given by

$$i_t = E_t[\pi_{t+1}] + \phi_\ell \ell_t + \phi_\mu \mu_t + \nu_t$$

with $\phi_\ell > 0$*, then there is a unique stationary equilibrium.*

Irrelevance Result

Result 2

With sticky prices, RK and NK configurations are not qualitatively distinguishable for demand and markup shocks.

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i.i.d. case ($i_t = r_t$) :

$$\ell_t = \alpha_r r_t + d_t \qquad \text{(EE)}$$

$$\pi_t = \kappa\big(\gamma_\ell \ell_t + \gamma_r r_t\big) + \mu_t \qquad \text{(PC)}$$

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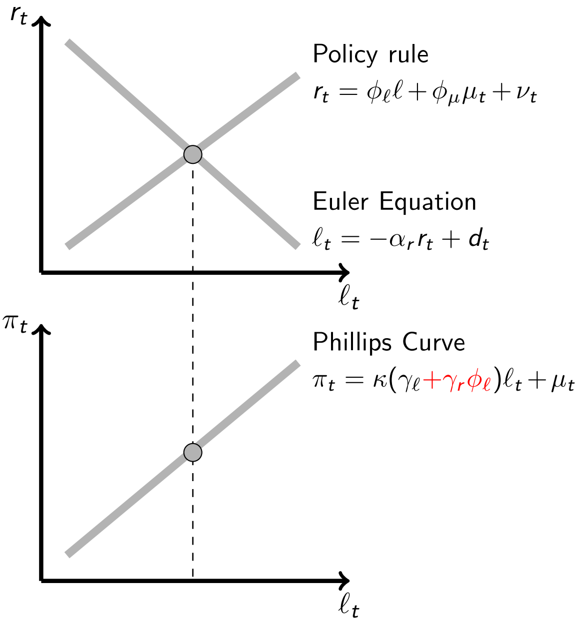

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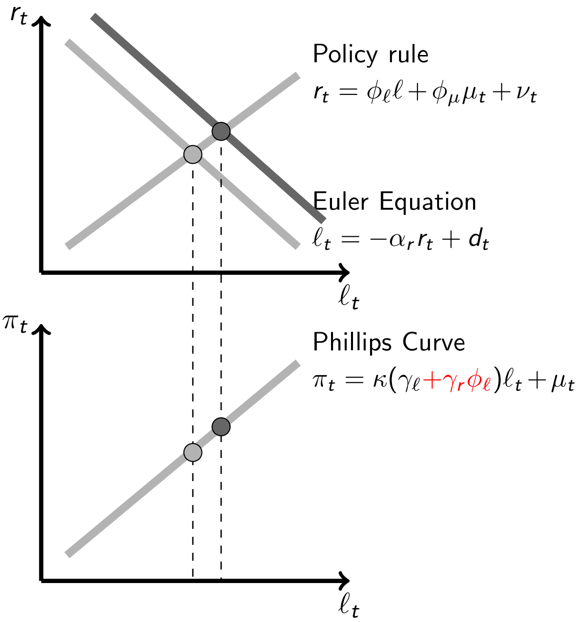

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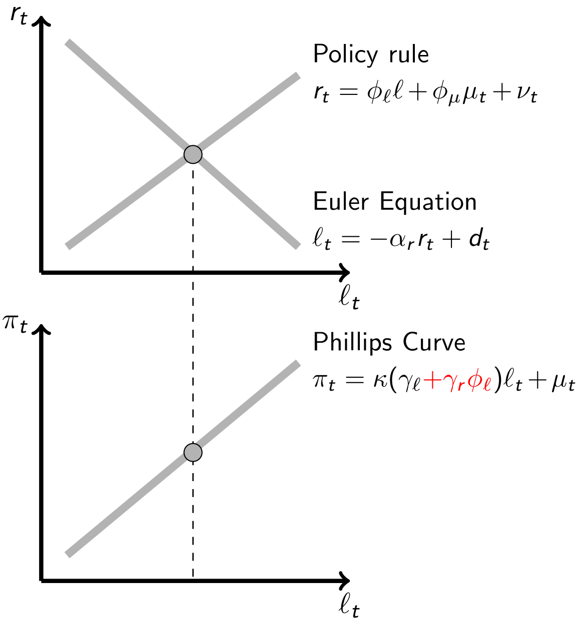

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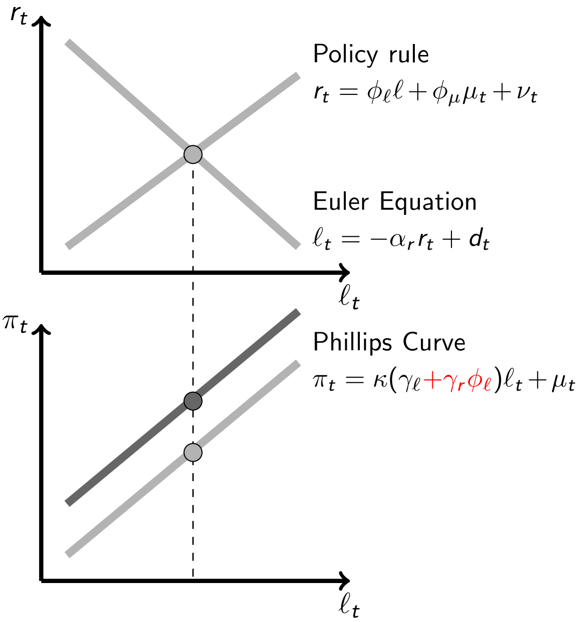


RK Matters for Monetary Policy and Monetary Shocks

- Monetary Policy and Stabilization
- Determinacy under i peg
- Monetary Shocks

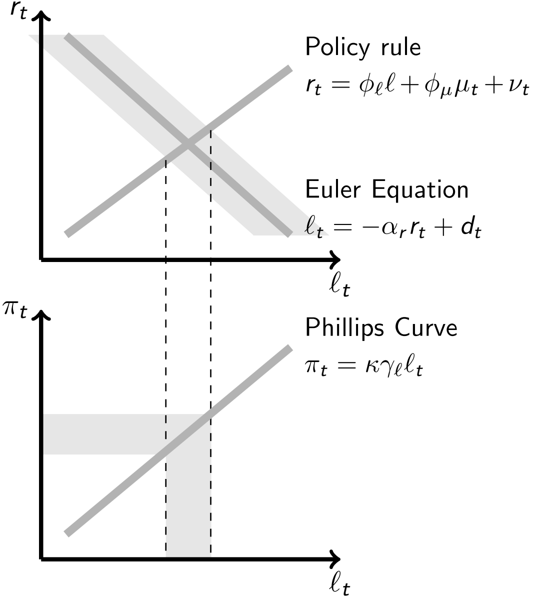
Effects of Stabilization with Demand Shocks

$$i_t = E_t \pi_{t+1} + \phi_\ell \ell_t + \phi_\mu \mu_t + \nu_t$$

Result 3

A more aggressive policy (ϕ_ℓ larger) always decreases σ_ℓ^2 at the cost of increasing σ_π^2 iff the RK condition is satisfied.

NK Configuration ($\gamma_r = 0$, $\alpha_\ell = 1$)



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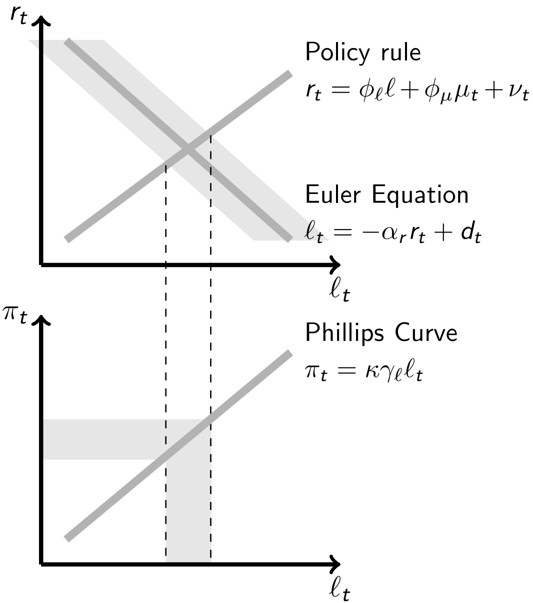
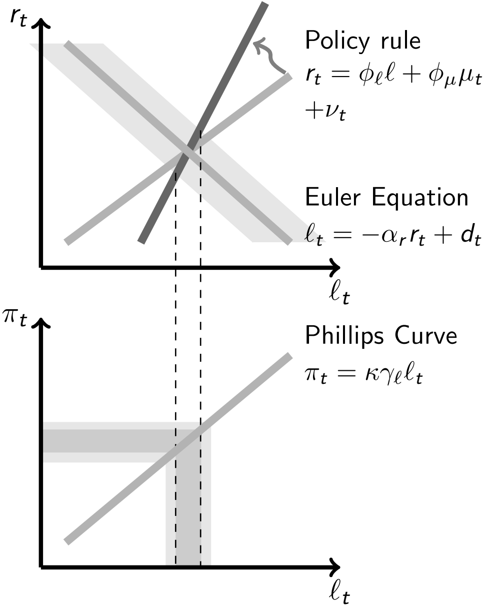
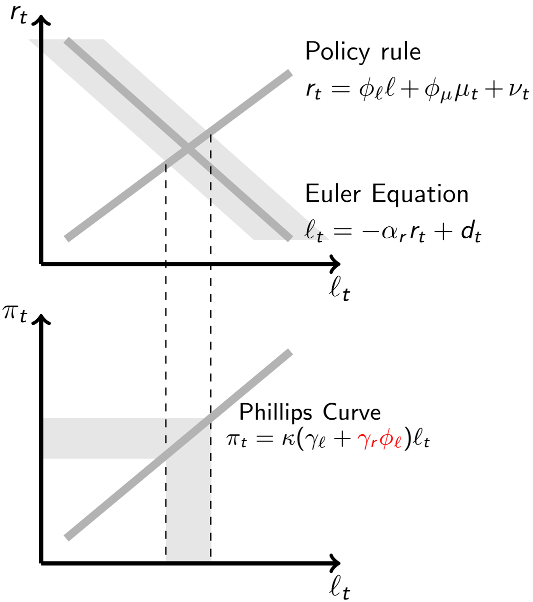




Under RK ($\frac{\gamma_r}{\gamma_\ell} > \frac{\alpha_r}{(1-\alpha_\ell)}$)



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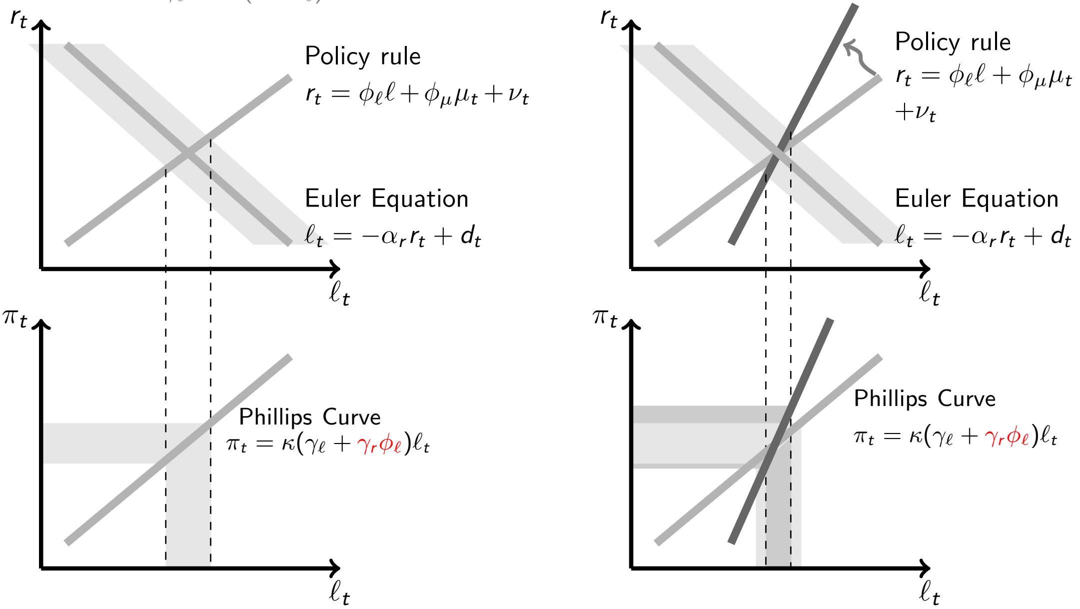

Nominal Interest Rate Peg (ZLB)

- Suppose policy goes from

$$i_t = E_t\pi_{t+1} + \phi_\ell \ell_t + \phi_\mu \mu_t + \nu_t$$

to

$$i_t = 0.$$

Result 4

In the NK configuration,

- × *indeterminacy*
- × *in all equilibria, σ_ℓ^2 and σ_π^2 move together (conditional on demand shocks)*

In the RK configuration,

- × *determinacy*
- × *σ_ℓ^2 increases but σ_π^2 decreases (conditional on demand shocks)*

Monetary Shocks

Result 5

In response to a contractionary monetary shocks,

- *If the shock is not very persistent, then NK and RK cannot be distinguished.*
- *If shock is sufficiently persistent,*
  - × *it increases inflation in RK case (neo-Fisherian effect)*
  - × *it decreases inflation in the NK case*

- RK favoured if we observe both (*i*) persistent monetary shock that (*ii*) do not lead to a fall in inflation
- "*Congressman Wright Patman effect*" (1970) : raising interest rates to fight inflation is like "throwing gasoline on fire"

Roadmap

1. Theory
2. Empirical Relevance
3. Focus on the Zero Lower Bound and Missing Deflation

$$\pi_t = \gamma_f E_t \pi_{t+1} + \kappa \gamma_\ell \ell_t + \kappa \gamma_r (i_t - E_t \pi_{t+1}) + \mu_t$$

Empirical Relevance
Phillips Curve Estimates

$$\pi_t = \gamma_f E_t \pi_{t+1} + \kappa \gamma_\ell \ell_t + \kappa \gamma_r (i_t - E_t \pi_{t+1}) + \mu_t$$

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Empirical Relevance

Phillips Curve Estimates

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$$\pi_t = \gamma_f \quad \pi^e_{t+1} + \quad \gamma_\ell x_t + \quad \gamma_r(i_t - \quad \pi^e_{t+1}) + \mu_t$$

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

Empirical Relevance
Phillips Curve Estimates: Basic

$$\pi_t = \gamma_f \pi^e_{t+1} + \gamma_\ell x_t + \gamma_r (i_t - \pi^e_{t+1}) + \mu_t$$

	OLS	OLS	IV
γ_f	$1.17^{\star\star\star}$	$1.11^{\star\star\star}$	$1.10^{\star\star\star}$
γ_ℓ	$0.25^{\star\star\star}$	$0.12^{\star}$	0.01
γ_r	–	$0.24^{\star\star\star}$	$0.28^{\star\star\star}$

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

Empirical Relevance

Phillips Curve Estimates: Hybrid

$$\pi_t = \gamma_f \pi^e_{t+1} + \gamma_b \pi_{t-1} + \gamma_\ell x_t + \gamma_r (i_t - \pi^e_{t+1}) + \mu_t$$

	OLS	OLS	IV
γ_f	$0.77^{\star\star\star}$	$0.88^{\star\star\star}$	$0.89^{\star\star\star}$
γ_b	$0.35^{\star\star\star}$	$0.22^{\star}$	$0.21^{\star\star\star}$
γ_ℓ	$0.12^{\star}$	0.06	0.02
γ_r	–	$0.18^{\star\star\star}$	$0.20^{\star\star\star}$

- Controlling for oil price,
- $i_t - \pi_{t+1}$ is instrumented with 6 lags of Romer & Romer shocks and their square ,
- Sample: 1969Q1-2017Q4,
- Newey & West correction for heteroskedasticity and autocorrelation.

Empirical Relevance

Phillips Curve Estimates: Hybrid, Various Samples

$$\pi_t = \gamma_f \pi^e_{t+1} + \gamma_b \pi_{t-1} + \gamma_\ell x_t + \gamma_r (i_t - \pi^e_{t+1}) + \mu_t$$

	1969-2006	1969-1992	1992-2017	1984-2006
γ_f	0.82***	0.84***	0.79***	0.85***
γ_b	0.32***	0.34***	-0.03	-0.08
γ_ℓ	-0.06	-0.05	0.08	-0.49***
γ_r	0.20***	0.25***	0.08	0.40***

- × Controlling for oil price,
- × $i_t - \pi_{t+1}$ is instrumented with 6 lags of Romer & Romer shocks and their square ,
- × Sample: 1969Q1-2006Q4,
- × Newey & West correction for heteroskedasticity and autocorrelation.

Empirical Relevance

Phillips Curve Estimates: Hybrid, Instrumenting More Variables

$$\pi_t = \gamma_f \pi^e_{t+1} + \gamma_b \pi_{t-1} + \gamma_\ell x_t + \gamma_r (i_t - \pi^e_{t+1}) + \mu_t$$

	Instrumented variables	
	$\{\pi^e_{t+1}, \pi_{t-1}, r_t, x_t\}$	$\{\pi^e_{t+1}, r_t, x_t\}$
γ_f	$1.31^{\star\star\star}$	$0.87^{\star\star\star}$
γ_b	$0.26^{\star\star\star}$	$0.27^{\star\star\star}$
γ_x	-0.03	0.20
γ_r	$0.23^{\star\star\star}$	$0.16^{\star\star\star}$

× Controlling for oil price,

× Instruments are 6 lags of Romer & Romer shocks and their square ,

× Newey & West correction for heteroskedasticity and autocorrelation.

Empirical Relevance

Phillips Curve Estimates: Hybrid, Full Info Rat. Exp.

$$\pi_t = \gamma_f \pi_{t+1} + (1-\gamma_f)\pi_{t-1} + \gamma_\ell x_t + \gamma_r(i_t - \pi_{t+1}) + \mu_t$$

	x: Labor Share			x: Unempl. gap		
	(1)	(2)	(3)	(4)	(5)	(6)
γ_f	$0.66^{\star\star\star}$	$0.66^{\star\star\star}$	$0.56^{\star\star\star}$	$0.57^{\star\star\star}$	$0.61^{\star\star\star}$	$0.60^{\star\star\star}$
γ_b	$1-\gamma_f$	$1-\gamma_f$	$1-\gamma_f$	$1-\gamma_f$	$1-\gamma_f$	$1-\gamma_f$
γ_ℓ	$4.72^{\star\star}$	-3.38	-10.12	-0.01	-0.03	-0.09
γ_r	–	$0.18^{\star\star\star}$	$0.15^{\star\star\star}$	–	$0.17^{\star\star\star}$	$0.12^{\star\star}$

× Controlling for oil price,

× Instruments are: (1), (2), (4) and (5): Galí & Gerler's instruments, (3) and (6): 6 lags of Romer & Romer shocks and their square, '

× Sample: 1969Q1-2006Q4,

× Newey & West correction for heteroskedasticity and autocorrelation.

Empirical Relevance
Phillips Curve Estimates: Recap

- Recap: The effect of the real interest rate on inflation can be
  - indirect, thought its impact on the gap
  - direct, on top of the effect of the gap
- Very strong evidence of the direct effect, not much of the indirect one.
- Results are (by and large) robust to
  - various measures of the gap
  - various measures of the inflation rate
  - Choice of instruments

Empirical Relevance
Full Information

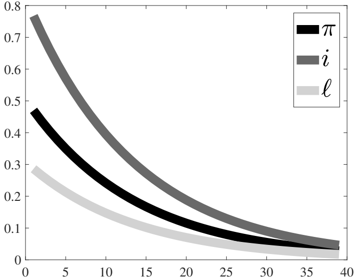
- Here we estimate the full model by Maximum Likelihood
- Data:
  - π: GDP deflator,
  - i_t: fed funds rate,
  - ℓ_t: minus unemployment rate.
- Sample:
  - long: 1954:3- 2007:4,
  - post-Volker-deflation sample: 1983:4-2007:4
- Maximum Likelihood estimation

Result 6

Estimation shows that the model is in the Real Keynesian region.

Max Likelihood Estimation, Full Sample

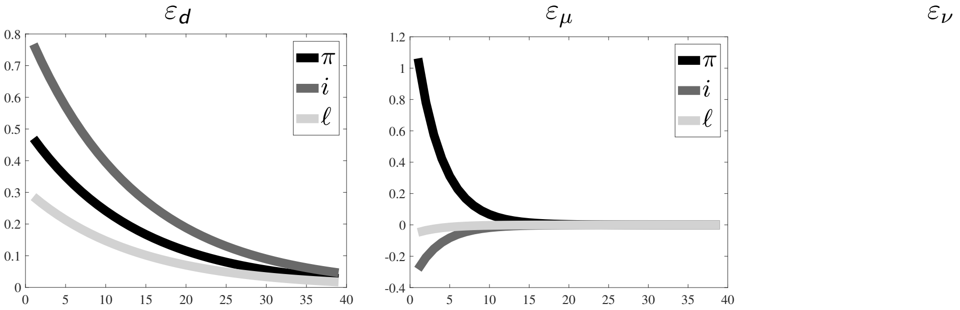
ε_d



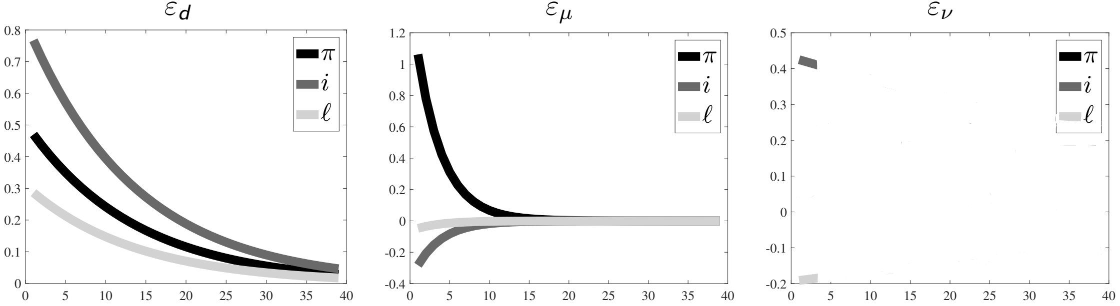
ε_μ

ε_ν

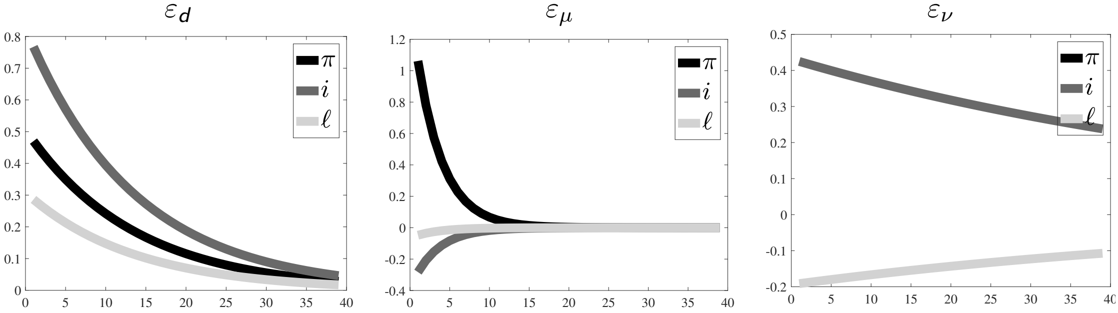
Max Likelihood Estimation, Full Sample



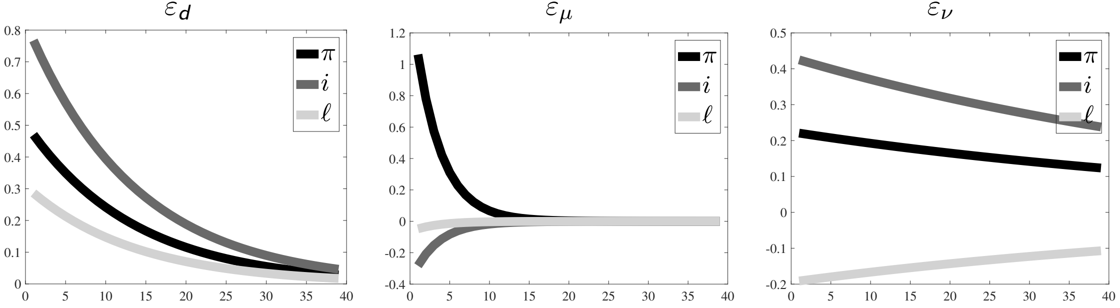
Max Likelihood Estimation, Full Sample



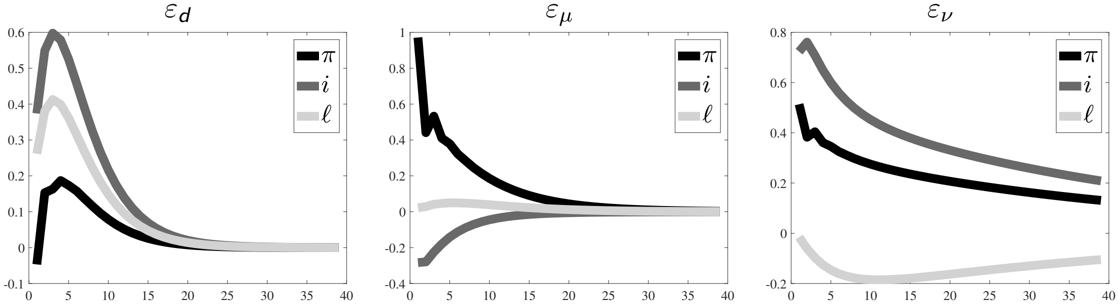
Max Likelihood Estimation, Full Sample



Max Likelihood Estimation, Full Sample



Max Likelihood Estimation, Full Sample, Habit persistence, gradual adjustment of i and hybrid New Phillips curve



Robustness

- Results are robust across the 3 following sub-samples
  I. Pre Volker dis-inflation period (1954:3-1979:1)
  II. Post Volker dis-inflation period (1983:4-2007:1)
  III. Zero Lower Bound period (2009:1-2016:3)
- Results robust when allowing the model to have endogenous propagation (hybrid PC + habit persistence + i_{t-1} in the policy rule)
- Results robust when allowing the model to have more shocks
- Results robust when varying the measure of inflation (CPI of GDP deflator) and of activity (unemployment or hours)

Roadmap

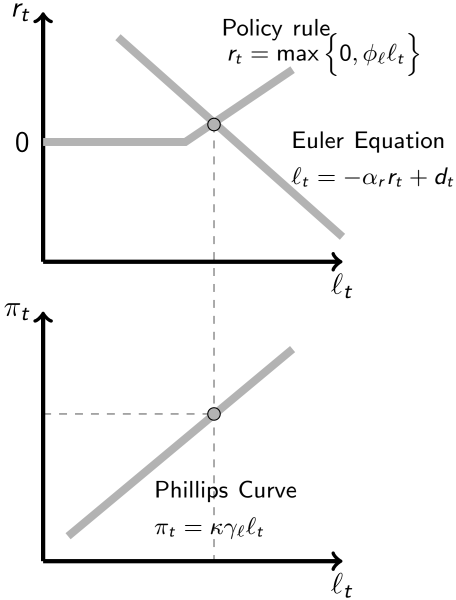
1. Theory
2. Empirical Relevance
3. Focus on the Zero Lower Bound and Missing Deflation

Low Variance of Inflation at the ZLB

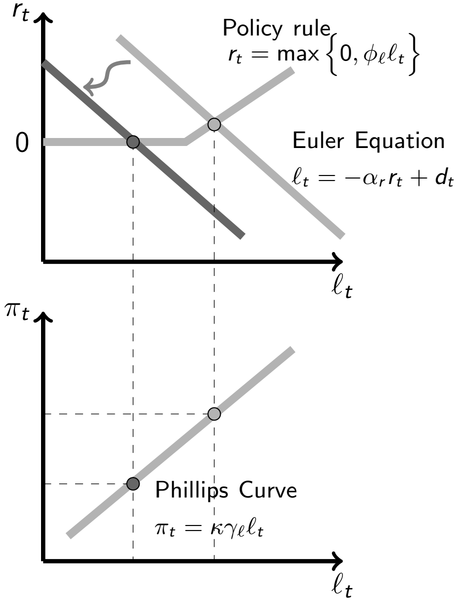
		σ_u	σ_π	σ_i
Post-Volcker	:	1.3	.9	2.5
ZLB	:	1.7	.8	.1

- Observation: the variance of inflation slightly decreased at ZLN.
- It should have increased in the NK configuration (*under the assumption that demand shocks drove the economy*)
- But this is consistent with the RK configuration

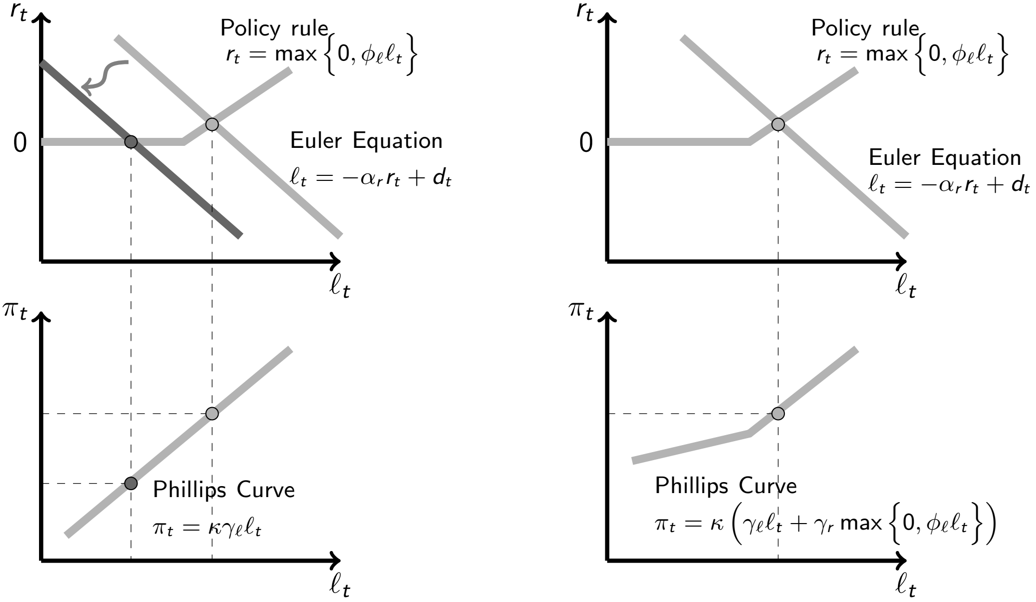
Zero Lower Bound and Missing Deflation



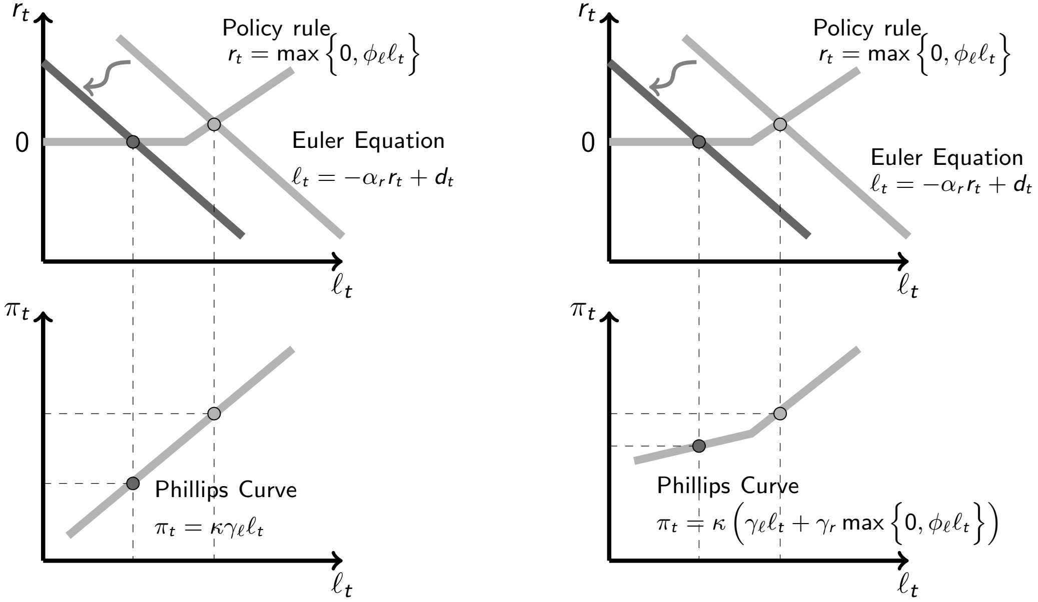
Zero Lower Bound and Missing Deflation



Zero Lower Bound and Missing Deflation



Zero Lower Bound and Missing Deflation



The ZLB Trap

- RK framework suggest that ZLB was quasi inevitable following a persistent fall in demand.
- In RK, 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.

Summary

- When demand matters with flexible prices (*Real Keynesian* models), adding sticky prices affect the way we think of monetary policy:
  - × trade-off between stabilising inflation and output when facing demand shocks
  - × Determinacy at the ZLB
  - × Variance of inflation and output moving in opposite direction at the ZLB
- Data favours Phillips Curve with cost channel
- Data favours *Real Keynesian* configuration
- Main reason is that monetary shocks are persistent and they have neo-Fisherian effect