Inflation Plucking Cycles

Oskar Arnt Juul
Copenhagen Business School

Peter Lihn Jørgensen
Copenhagen Business School

EEA Bordeaux
August 25, 2025

Motivation

- Advanced economies occasionally experience large inflation bursts (e.g. 1970s oil crises, post-pandemic inflation)
  - Since 1960.q1, inflation has been positively skewed in *all* 38 OECD countries
  - All countries, except Germany, have experienced double-digit inflation.
  - In contrast, since 1960.q1, not a single OECD country has experienced double-digit deflation.
- We document that inflation displays "plucking" cycles:
  - A tendency for inflation to rise temporarily above its longer-term trend but rarely drop below it

Motivation

- Advanced economies occasionally experience large inflation bursts (e.g. 1970s oil crises, post-pandemic inflation)
  - Since 1960.q1, inflation has been positively skewed in *all* 38 OECD countries
  - All countries, except Germany, have experienced double-digit inflation.
  - In contrast, since 1960.q1, not a single OECD country has experienced double-digit deflation.
- We document that inflation displays "plucking" cycles:
  - A tendency for inflation to rise temporarily above its longer-term trend but rarely drop below it

Friedman's "plucking" model

- Friedman (1964, 1993) introduced "plucking" to describe US business cycles
  - Output frequently drops below its longer-term trend but rarely rises above it:

    > *Output is viewed as bumping along the ceiling of maximum feasible output, except that every now and then it is plucked down by a cyclical contraction.*
    >
    > - *Friedman (1964)*

- A testable implication of the plucking theory:
  - The size of a recession predicts the size of the subsequent expansion, while the size of an expansion does not predict the size of the subsequent recession.
  - Dupraz, Nakamura, and Steinsson (2024) show that the behavior of the US unemployment rate is consistent with this pattern

Friedman's "plucking" model

- Friedman (1964, 1993) introduced "plucking" to describe US business cycles
  - Output frequently drops below its longer-term trend but rarely rises above it:

    > *Output is viewed as bumping along the ceiling of maximum feasible output, except that every now and then it is plucked down by a cyclical contraction.*
    >
    > \- *Friedman (1964)*

- A testable implication of the plucking theory:
  - The size of a recession predicts the size of the subsequent expansion, while the size of an expansion does not predict the size of the subsequent recession.
  - Dupraz, Nakamura, and Steinsson (2024) show that the behavior of the US unemployment rate is consistent with this pattern

This paper

- Our paper is the first to extend the concept of “plucking” to inflation dynamics
  - We provide empirical evidence of inflation plucking cycles in 33 out of 38 OECD countries, including the US
    - $\rightarrow$ Increases in inflation are followed by decreases of similar amplitude, while the amplitude of a decrease does not predict the amplitude of the subsequent increase
- We extend an otherwise standard New Keynesian model with a scarce non-labor input with low substitutability in production
  - The nonlinear version of the model–solved with global methods–can match the plucking property
  - The model gives rise to a convex price Phillips curve, a positive inflation bias, and a negative output gap bias
- Optimal monetary policy responds aggressively to large negative supply shocks while accommodating large positive ones
  - This policy mitigates the inflation and output gap biases, generating sizable welfare gains (work-in-progress)

This paper

- Our paper is the first to extend the concept of "plucking" to inflation dynamics
  - We provide empirical evidence of inflation plucking cycles in 33 out of 38 OECD countries, including the US
    - → Increases in inflation are followed by decreases of similar amplitude, while the amplitude of a decrease does not predict the amplitude of the subsequent increase
- We extend an otherwise standard New Keynesian model with a scarce non-labor input with low substitutability in production
  - The nonlinear version of the model–solved with global methods–can match the plucking property
  - The model gives rise to a convex price Phillips curve, a positive inflation bias, and a negative output gap bias
- Optimal monetary policy responds aggressively to large negative supply shocks while accommodating large positive ones
  - This policy mitigates the inflation and output gap biases, generating sizable welfare gains (work-in-progress)

This paper

- Our paper is the first to extend the concept of "plucking" to inflation dynamics
  - We provide empirical evidence of inflation plucking cycles in 33 out of 38 OECD countries, including the US
    - → Increases in inflation are followed by decreases of similar amplitude, while the amplitude of a decrease does not predict the amplitude of the subsequent increase
- We extend an otherwise standard New Keynesian model with a scarce non-labor input with low substitutability in production
  - The nonlinear version of the model–solved with global methods–can match the plucking property
  - The model gives rise to a convex price Phillips curve, a positive inflation bias, and a negative output gap bias
- Optimal monetary policy responds aggressively to large negative supply shocks while accommodating large positive ones
  - This policy mitigates the inflation and output gap biases, generating sizable welfare gains (work-in-progress)

Related literature

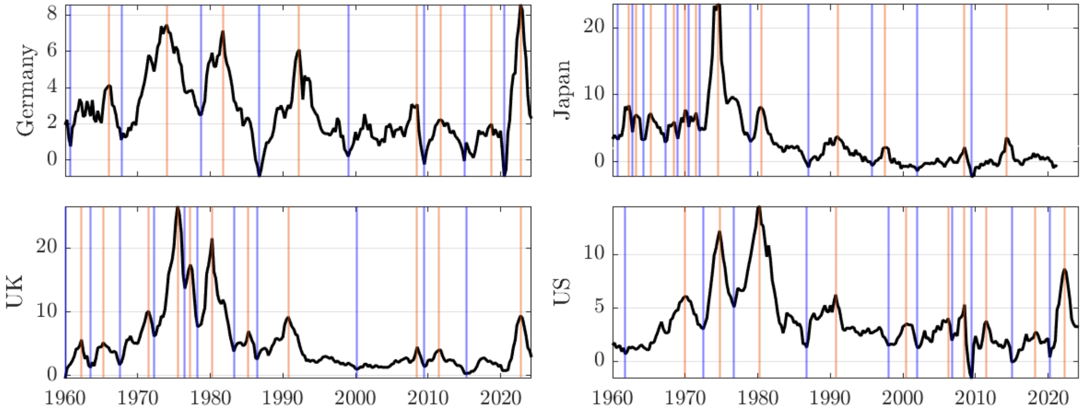
- Plucking cycles: Friedman (1964, 1993), Kim and Nelson (1999), Sinclair (2010), Hartley (2021), Kohlscheen, Moessner, and Rees (2024), Dupraz, Nakamura, and Steinsson (2024)
- Nonlinear Phillips curve: Phillips (1958), Boehm and Pandalai-Nayar (2022), Cerrato and Gitti (2022), Forbes, Gagnon, and Collins (2022), Comin, Johnson, and Jones (2023), Harding, Lindé, and Trabandt (2023), Benigno and Eggertsson (2024), Blanco et al. (2024)
- Nonlabor production input: Lorenzoni and Werning (2023), Gagliardone and Gertler (2024)
- Optimal monetary policy with nonlinear inflation dynamics: De Polis, Melosi, and Petrella (2024), Karadi et al. (2024)

Empirical evidence

Data

- Quarterly inflation data for all 38 OECD countries
  - For most countries, these data are available for the period 1960Q1-2024Q2 Details
- We run both cross-country and country-specific regressions
- We identify inflation peaks and troughs using the algorithm developed by Dupraz, Nakamura, and Steinsson (2024)

Identified peaks and troughs in four OECD countries



Inflation plucking cycles in the US

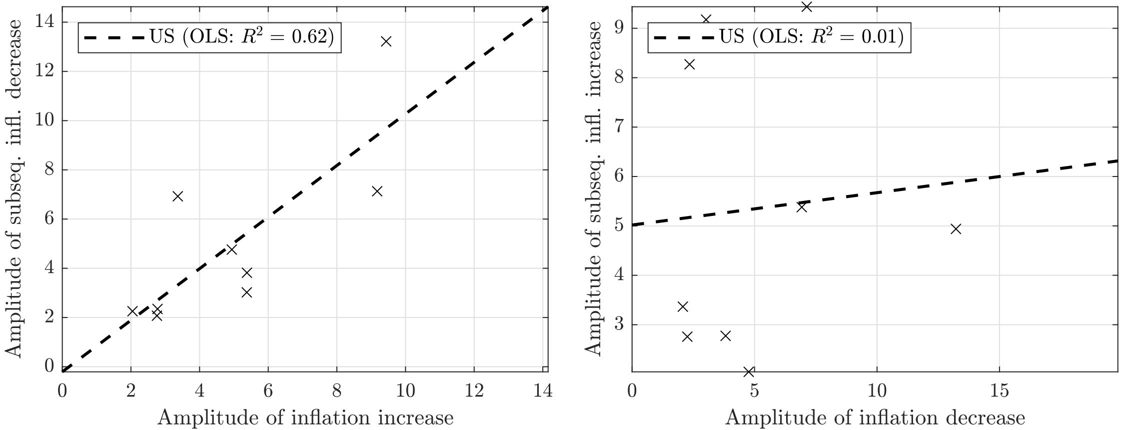


Figure 1: Inflation plucking cycles. This figure displays scatter plots of amplitudes of US inflation cycles. Dashed lines are OLS regression lines.

Inflation plucking cycles in the OECD

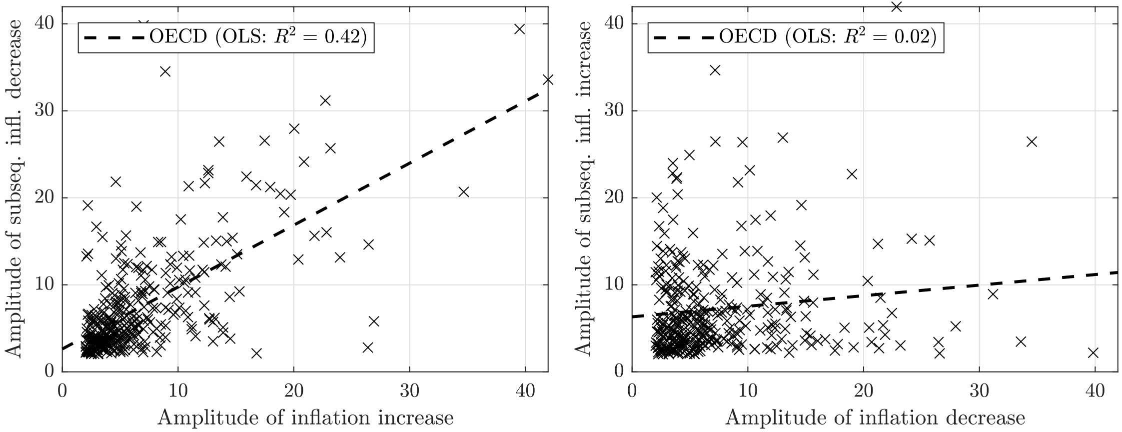


Figure 2: Inflation plucking cycles. This figure displays scatter plots of amplitudes of OECD countries' inflation cycles. Dashed lines are OLS regression lines.

Regression results

	United States		Cross-country OECD	
Regressor:	Increase	Decrease	Increase	Decrease
Regressand:	Subseq. decrease	Subseq. increase	Subseq. decrease	Subseq. increase
$\hat{\beta}_1$	1.05^{***} (0.27)	0.07 (0.27)	0.71^{***} (0.05)	0.12^{***} (0.05)
R^2	0.62	0.01	0.42	0.02
n	9	9	346	341

Table 1: **Plucking property of inflation.** This table reports OLS regression results. *** denotes significance at the 1 percent level.

Country-specific regressions Robustness: De-trended inflation Robustness: Low-inflation regimes

Model

Model outline

Standard NK model:

- Households derive utility from consumption and disutility from labor.
- Sticky prices and wages à la Rotemberg
- Monetary policy follows a Taylor rule
- Government subsidies ensure an efficient steady state

Model details

Non-standard features:

- Scarce non-labor production input with low substitutability
- Global solution to preserve nonlinear features

Model outline

Standard NK model:

- Households derive utility from consumption and disutility from labor.
- Sticky prices and wages à la Rotemberg
- Monetary policy follows a Taylor rule
- Government subsidies ensure an efficient steady state

Model details

Non-standard features:

- Scarce non-labor production input with low substitutability
- Global solution to preserve nonlinear features

Key nonlinearity

Intermediate goods producers use a CES production function:

$$Y_t = \left(\alpha L_t^{\frac{\phi-1}{\phi}} + (1-\alpha)\, X_t^{\frac{\phi-1}{\phi}}\right)^{\frac{\phi}{\phi-1}} \tag{1}$$

X_t is the non-labor production input

$\phi \in (0, \infty)$ is the elasticity of substitution

X_t follows a stochastic process:

$$X_t = (1-\rho_X)\,\mu_X + \rho_X X_{t-1} + \varepsilon_t^X \tag{2}$$

Key nonlinearity

Intermediate goods producers use a CES production function:

$$Y_t = \left(\alpha L_t^{\frac{\phi-1}{\phi}} + (1-\alpha)\, X_t^{\frac{\phi-1}{\phi}}\right)^{\frac{\phi}{\phi-1}} \tag{1}$$

X_t is the non-labor production input

$\phi \in (0, \infty)$ is the elasticity of substitution

X_t follows a stochastic process:

$$X_t = (1-\rho_X)\, \mu_X + \rho_X X_{t-1} + \varepsilon_t^X \tag{2}$$

Intuition: Kinked marginal costs

- Marginal costs can be expressed as:

$$mc_t = \frac{w_t}{\alpha}\left(\alpha + (1-\alpha)\left(\frac{L_t}{X_t}\right)^{\frac{1-\phi}{\phi}}\right)^{\frac{1}{1-\phi}}$$

- In the Leontief limit, we obtain:

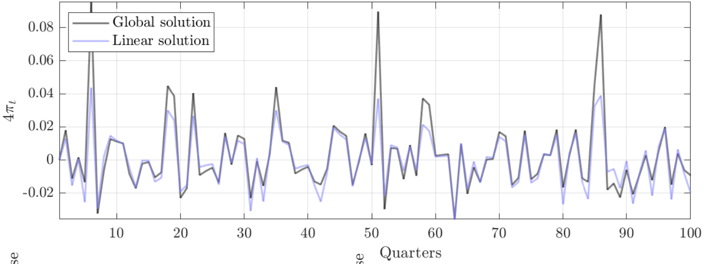
$$\lim_{\phi \to 0} mc_t = \begin{cases} \frac{w_t}{\alpha} & \text{if } X_t = L_t, \\ w_t & \text{if } X_t > L_t, \\ \infty & \text{if } X_t < L_t. \end{cases}$$

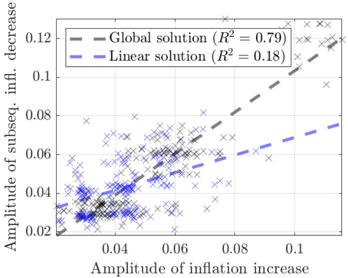
Calibration

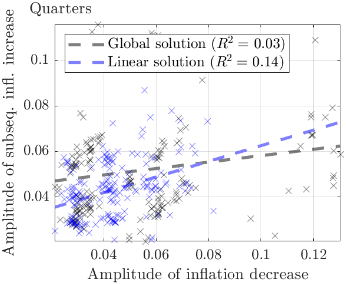
Parameters		Value	Source/Target
	Households		
β	Subjective discount factor	0.99	4% s.s. real interest rate
γ	Coefficient of relative risk aversion	2	Standard in the literature
φ	Inverse Frisch elasticity	1	Standard in the literature
γ_W	Rotemberg wage adjustment costs	465.3	Wage duration of 4 quarters
ε_w	Elasticity of substitution, labor	6	Standard in the literature
	Firms		
α	CES share parameter	0.9	US plucking property (Table 1)
ϕ	Elasticity of substitution of inputs	0.01	US plucking property (Table 1)
γ_P	Rotemberg price adjustment costs	29.4	Price duration of 3 quarters
ε	Elasticity of substitution, goods	6	Standard in the literature
	Monetary and fiscal authority		
μ_Π	Taylor coefficient on inflation	1.5	(Taylor, 1993)
μ_Y	Taylor coefficient on output gap	0.5	(Taylor, 1993)
τ_P	Production subsidy	$\frac{1}{\varepsilon-1}$	(Erceg et al., 2000)
τ_W	Labor subsidy	$\frac{1}{\varepsilon_W-1}$	(Erceg et al., 2000)
	Exogenous processes		
μ_X	Mean production of non-labor input	1	Normalization
ρ_X	Autoregressive coefficient, supply shock	0	*iid* assumption
σ_X	Standard deviation, supply shock	0.011	US inflation volatility
σ_i	Standard deviation, monetary policy shock	0.013	US FFR volatility

Quantitative analysis

Inflation plucking cycles in the model (1/2)







Inflation plucking cycles in the model (2/2)

	Global solution		Linear solution	
Regressor:	Increase	Decrease	Increase	Decrease
Regressand:	Subseq. decrease	Subseq. increase	Subseq. decrease	Subseq. increase
$\hat{\beta}_1$	$1.07^{\star\star\star}$ (0.04)	$0.14^{\star\star}$ (0.06)	$0.45^{\star\star\star}$ (0.07)	$0.34^{\star\star\star}$ (0.06)
R^2	0.79	0.03	0.18	0.14
n	189	189	190	190

Table 2: **Plucking property of model inflation.** This table reports OLS regression results. *** and ** denote significance at the 1 and 5 percent levels, respectively.

Nonlinear Phillips curve

With flex wages, the linearized version of the model entails a simple NKPC:

$$\pi_t = \beta \mathbb{E}_t[\pi_{t+1}] + \kappa \tilde{y}_t \qquad (3)$$

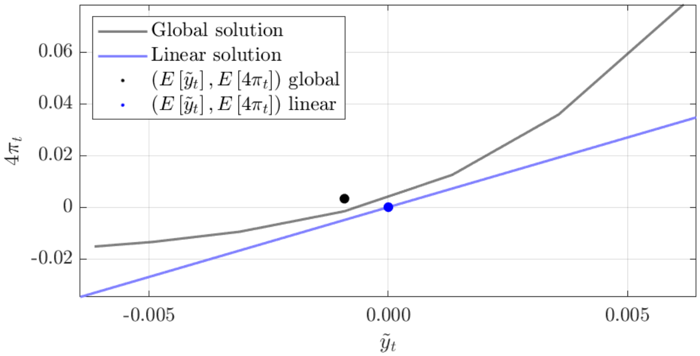
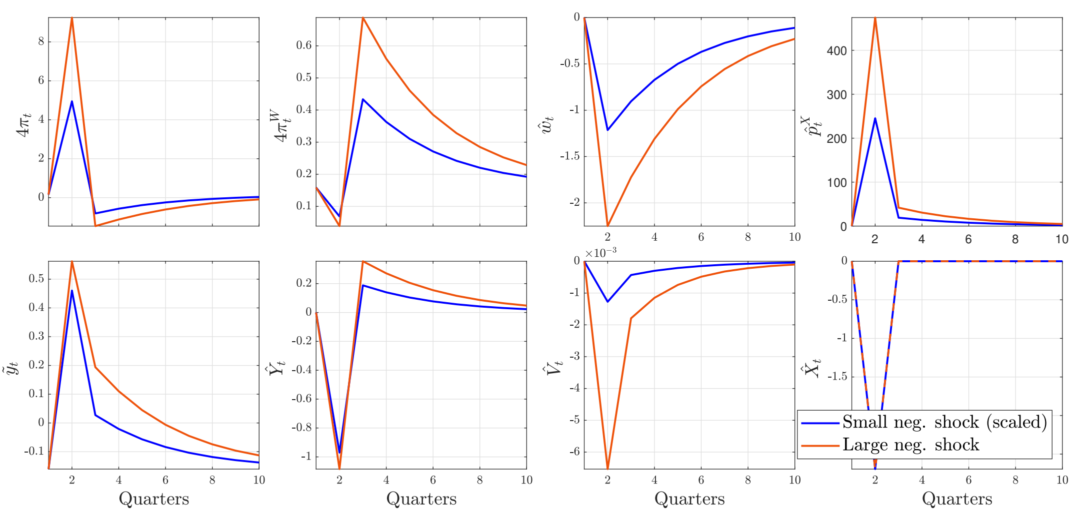


Figure 3: Phillips curves. The figure shows the Phillips curve relationship implied by the linear and nonlinear model, respectively, conditional on supply shocks.

Impulse responses: Small vs. large negative supply shock



Optimal policy

Optimal monetary policy

- We solve the fully nonlinear Ramsey problem under commitment
- The Ramsey planners maximizes social welfare

$$\max_{\{i_t, C_t, L_t, \Pi_t, X_t, mc_t, w_t\}_{t=0}^{\infty}} \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left[\frac{C_t^{1-\gamma}}{1-\gamma} - \frac{L_t^{1+\varphi}}{1+\varphi} \right]$$

subject to the FOC's of the model

Ramsey

- The state-space becomes too large for a global solution.
  - Instead, we rely on a (highly accurate) fifth-order approximation

Accuracy of perturbation

Optimal monetary policy

- We solve the fully nonlinear Ramsey problem under commitment
- The Ramsey planners maximizes social welfare

$$\max_{\{i_t, C_t, L_t, \Pi_t, X_t, mc_t, w_t\}_{t=0}^{\infty}} \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left[\frac{C_t^{1-\gamma}}{1-\gamma} - \frac{L_t^{1+\varphi}}{1+\varphi} \right]$$

subject to the FOC's of the model

Ramsey

- The state-space becomes too large for a global solution.
  - Instead, we rely on a (highly accurate) fifth-order approximation

Accuracy of perturbation

Optimal monetary policy

- We solve the fully nonlinear Ramsey problem under commitment
- The Ramsey planners maximizes social welfare

$$\max_{\{i_t, C_t, L_t, \Pi_t, X_t, mc_t, w_t\}_{t=0}^{\infty}} \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left[\frac{C_t^{1-\gamma}}{1-\gamma} - \frac{L_t^{1+\varphi}}{1+\varphi} \right]$$

subject to the FOC's of the model

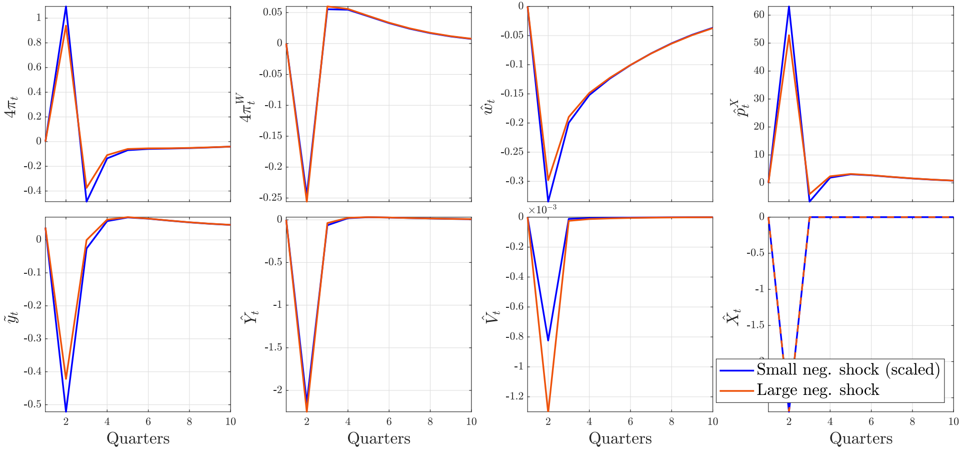
Ramsey

- The state-space becomes too large for a global solution.
    - Instead, we rely on a (highly accurate) fifth-order approximation

Accuracy of perturbation

Optimal monetary policy: Small vs. large negative supply shock

The Ramsey planner "neutralizes" the nonlinear effects of the large shock:



Ramsey vs. Taylor Biases

Conclusion

- We provide empirical evidence of inflation plucking cycles in nearly all OECD countries
  - → Increases in inflation are followed by decreases of similar amplitude, while the amplitude of a decrease does not predict the amplitude of the subsequent increase
- The nonlinear version of a standard New Keynesian model, extended with a scarce non-labor input with low substitutability in production, can account for the plucking property
  - The model gives rise to a convex price Phillips curve, a positive inflation bias, and a negative output gap bias
- Optimal monetary policy responds aggressively to large negative supply shocks while accommodating large positive ones
  - This policy mitigates the inflation and output gap biases, generating sizable welfare gains (work-in-progress)

Thank you for your time!

Link to paper

Appendix

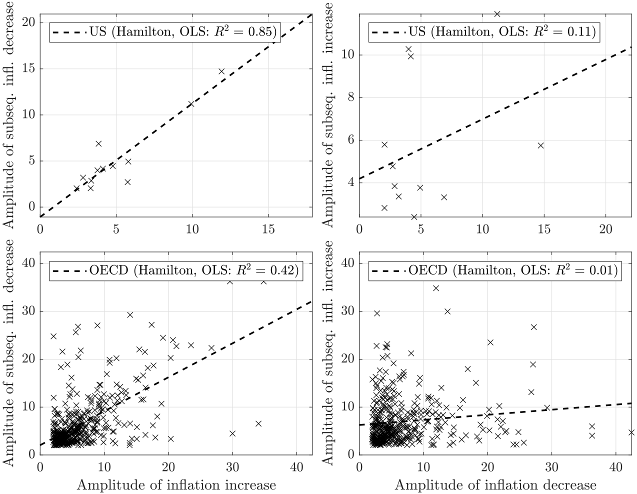


Figure 4: Inflation plucking cycles (Hamilton filter). This figure displays scatter plots of amplitudes of changes in de-trended inflation rates for the US (upper panels) and the OECD countries (lower panels).

Hamilton filter	United States		Cross-country OECD	
Regressor:	Increase	Decrease	Increase	Decrease
Regressand:	Subseq. decrease	Subseq. increase	Subseq. decrease	Subseq. increase
$\hat{\beta}_1$	1.23^{***} (0.15)	0.28 (0.23)	0.71^{***} (0.04)	0.11^{***} (0.04)
R^2	0.85	0.11	0.42	0.01
n	12	12	418	416

Table 3: Plucking property of de-trended inflation This table reports OLS regression results. *, **, and *** denote significance at the 10, 5, and 1 percent levels, respectively.

Return

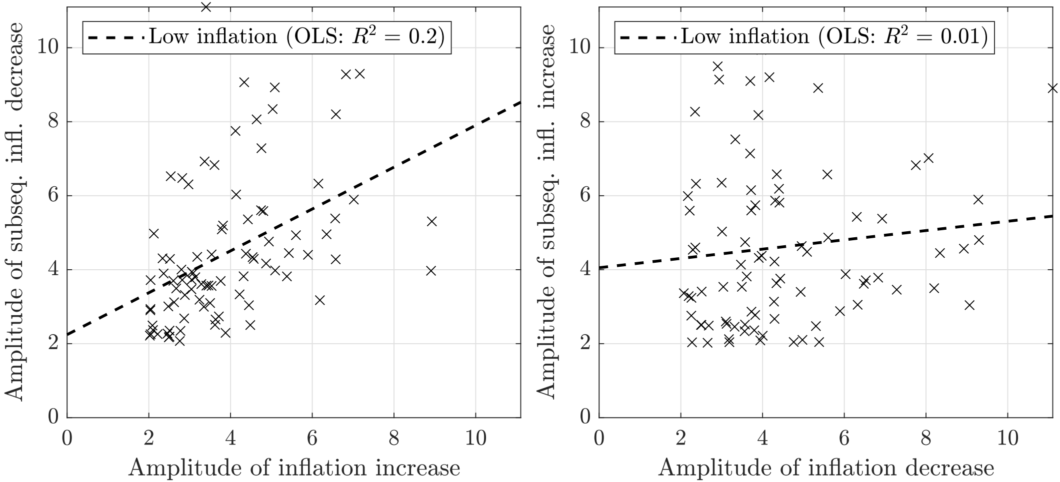


Figure 5: Inflation plucking cycles in low-inflation regimes. This figure displays scatter plots of amplitudes of inflation cycles for low inflation regimes from pooled cross-country OECD observations. The dashed lines are univariate OLS regression lines.

Regressor:	Increase	Decrease
Regressand:	Subseq. decrease	Subseq. increase
$\hat{\beta}_1$	0.57^{***} (0.12)	0.13 (0.12)
R^2	0.20	0.01
n	88	86

Table 4: Plucking property in low-inflation regimes. This table reports OLS regression results for "low-inflation regimes." *, **, and *** denote significance at the 10, 5, and 1 percent levels, respectively.

Return

Regressor:		Increase				Decrease			
Regressand:		Subseq. decrease				Subseq. increase			
Country	Period	$\hat{\beta}_0$	$\hat{\beta}_1$	R^2	n	$\hat{\beta}_0$	$\hat{\beta}_1$	R^2	n
Australia	1960Q1-2024Q2	3.68** (1.30)	0.22 (0.23)	0.07	13	4.78** (1.79)	0.04 (0.34)	0.00	13
Austria	1960Q1-2024Q2	2.56** (0.86)	0.42* (0.18)	0.37	9	4.76 (2.98)	0.02 (0.65)	0.00	9
Belgium	1960Q1-2024Q2	0.85 (1.18)	0.85*** (0.16)	0.78	8	9.70** (2.55)	−0.54 (0.38)	0.22	7
Canada	1960Q1-2024Q2	3.09* (1.36)	0.38 (0.24)	0.23	8	6.76** (2.48)	−0.31 (0.46)	0.05	8
Chile	1971Q1-2023Q4	42.41 (32.84)	0.46** (0.16)	0.44	11	10.98** (4.13)	0.05* (0.03)	0.25	11
Colombia	1971Q1-2024Q2	4.42 (2.57)	0.56** (0.24)	0.30	13	6.78** (2.94)	0.26 (0.26)	0.07	13
Costa Rica	1977Q1-2021Q4	1.32 (0.96)	0.93*** (0.03)	0.99	12	7.43*** (1.74)	0.04 (0.06)	0.05	11
Czech Republic	1992Q1-2024Q2	1.95 (2.09)	0.94** (0.26)	0.73	5	14.37** (4.10)	−0.74 (0.42)	0.38	5
Denmark	1967Q1-2024Q2	1.34 (1.73)	0.83** (0.29)	0.45	10	5.29** (1.82)	0.01 (0.27)	0.00	10
Estonia	1998Q1-2024Q2	0.24 (1.89)	1.10* (0.26)	0.82	4	20.80 (8.66)	−1.14 (1.03)	0.23	4
Finland	1960Q1-2024Q2	2.04 (2.26)	0.72* (0.31)	0.37	9	9.13*** (1.83)	−0.36 (0.24)	0.20	9

Table 5: Country specific regressions. This table reports OLS regression results for OECD countries. *, **, and *** denote significance at the 10, 5, and 1 percent levels, respectively.

Regressor:		Increase				Decrease			
Regressand:		Subseq. decrease				Subseq. increase			
Country	Period	$\hat{\beta}_0$	$\hat{\beta}_1$	R^2	n	$\hat{\beta}_0$	$\hat{\beta}_1$	R^2	n
France	1960Q1-2024Q2	3.77 (2.74)	0.32 (0.44)	0.08	6	$6.54^{\star}$ (2.35)	−0.22 (0.35)	0.06	6
Germany	1960Q1-2024Q2	1.37 (1.32)	$0.72^{\star}$ (0.29)	0.46	7	4.24 (2.38)	0.17 (0.50)	0.02	7
Greece	1960Q1-2024Q2	$4.04^{\star\star}$ (1.61)	$0.54^{\star\star\star}$ (0.14)	0.57	12	$12.17^{\star\star}$ (4.10)	−0.36 (0.39)	0.07	12
Hungary	1981Q1-2024Q2	2.74 (2.78)	$0.70^{\star\star}$ (0.28)	0.39	10	$12.30^{\star\star}$ (3.88)	−0.30 (0.36)	0.07	10
Iceland	1960Q1-2024Q2	2.49 (3.66)	$0.83^{\star\star\star}$ (0.17)	0.53	20	$13.10^{\star\star\star}$ (4.29)	0.17 (0.19)	0.04	20
Ireland	1976Q1-2024Q2	$12.99^{\star\star\star}$ (3.19)	−0.79 (0.45)	0.28	8	$5.53^{\star}$ (2.42)	0.14 (0.24)	0.04	8
Israel	1971Q1-2024Q2	−9.02 (5.52)	$1.28^{\star\star\star}$ (0.07)	0.96	17	34.73 (20.06)	−0.07 (0.18)	0.01	17
Italy	1960Q1-2024Q2	$3.98^{\star}$ (1.74)	$0.50^{\star\star}$ (0.17)	0.52	8	$11.95^{\star\star}$ (4.46)	−0.47 (0.49)	0.10	8
Japan	1960Q1-2021Q2	0.11 (0.63)	$1.08^{\star\star\star}$ (0.09)	0.92	11	$5.46^{\star\star}$ (2.01)	−0.06 (0.27)	0.00	11
Latvia	1992Q1-2024Q2	1.68 (5.55)	$1.68^{\star\star\star}$ (0.02)	1.00	6	$10.87^{\star\star}$ (3.16)	−0.00 (0.01)	0.05	6
Lithuania	1992Q1-2024Q2	119.53 (111.23)	$0.96^{\star}$ (0.45)	0.43	6	12.60 (10.79)	0.03 (0.03)	0.19	6

Table 6: Country specific regressions. This table reports OLS regression results for OECD countries. *, **, and *** denote significance at the 10, 5, and 1 percent levels, respectively.

Regressor:		Increase				Decrease			
Regressand:		Subseq. decrease				Subseq. increase			
Country	Period	$\hat{\beta}_0$	$\hat{\beta}_1$	R^2	n	$\hat{\beta}_0$	$\hat{\beta}_1$	R^2	n
Luxembourg	1960Q1-2024Q2	−0.83	1.14**	0.64	6	7.07**	−0.12	0.03	6
		(2.21)	(0.35)			(1.85)	(0.28)		
Mexico	1969Q1-2024Q2	−1.80	1.09***	0.87	11	29.14*	0.04	0.00	11
		(6.04)	(0.12)			(13.88)	(0.26)		
Netherlands	1960Q2-2024Q2	1.33	0.70***	0.50	11	5.54**	−0.08	0.00	10
		(1.27)	(0.21)			(2.23)	(0.46)		
New Zealand	1960Q1-2023Q3	2.35	0.62*	0.26	13	4.24**	0.33	0.17	12
		(2.04)	(0.29)			(1.61)	(0.21)		
Norway	1960Q1-2024Q2	1.53	0.69***	0.50	13	4.67**	0.11	0.01	13
		(1.12)	(0.19)			(1.61)	(0.28)		
Poland	1996Q1-2024Q2	2.92	0.87***	0.79	12	4.42	0.58	0.05	11
		(1.65)	(0.13)			(6.44)	(0.76)		
Portugal	1960Q1-2024Q2	2.81	0.70**	0.33	15	11.84***	−0.20	0.07	15
		(2.88)	(0.26)			(2.34)	(0.20)		
Slovakia	1992Q1-2024Q2	1.06	1.01***	0.97	6	5.03	0.24	0.09	6
		(0.72)	(0.07)			(3.28)	(0.30)		
Slovenia	1981Q1-2024Q2	−7.76	1.04***	1.00	15	224.01	0.00	0.00	15
		(5.58)	(0.01)			(194.97)	(0.25)		
South Korea	1960Q1-2023Q3	6.33**	0.32	0.11	19	6.02**	0.32	0.09	19
		(2.46)	(0.21)			(2.68)	(0.23)		

Table 7: Country specific regressions. This table reports OLS regression results for OECD countries. *, **, and *** denote significance at the 10, 5, and 1 percent levels, respectively.

Regressor:		Increase				Decrease			
Regressand:		Subseq. decrease				Subseq. increase			
Country	Period	$\hat{\beta}_0$	$\hat{\beta}_1$	R^2	n	$\hat{\beta}_0$	$\hat{\beta}_1$	R^2	n
Spain	1960Q1-2024Q2	0.09 (3.83)	1.00* (0.44)	0.36	9	9.85*** (1.84)	−0.26 (0.18)	0.19	9
Sweden	1960Q1-2024Q2	0.44 (1.64)	0.94** (0.30)	0.43	13	5.26*** (1.48)	0.08 (0.25)	0.01	13
Switzerland	1960Q1-2024Q2	0.66 (0.76)	0.89*** (0.15)	0.79	9	3.34* (1.66)	0.23 (0.33)	0.05	9
Turkey	1960Q1-2024Q2	4.42 (3.51)	0.69*** (0.13)	0.52	28	18.27*** (5.26)	0.06 (0.21)	0.00	27
United Kingdom	1960Q1-2024Q2	2.48 (1.65)	0.65*** (0.18)	0.56	10	9.88** (3.00)	−0.33 (0.35)	0.08	10
United States	1960Q1-2024Q2	−0.21 (1.55)	1.05*** (0.27)	0.62	9	5.02** (1.64)	0.07 (0.27)	0.01	9

Table 8: Country specific regressions . This table reports OLS regression results for OECD countries. *, **, and *** denote significance at the 10, 5, and 1 percent levels, respectively.

Return to data

Return to regressions

- A continuum of households maximizes their lifetime utility

$$\mathbb{E}_t \left[\sum_{s=0}^{\infty} \beta \left\{ \frac{C_{jt+s}^{1-\gamma}}{1-\gamma} - \frac{L_{jt+s}^{1+\varphi}}{1+\varphi} \right\} \right],$$

subject to their per-period real budget constraint

$$C_{jt} + b_{jt-1} \left(1 + i_{t-1}\right) / \Pi_t = (1 + \tau_W) w_{jt} L_{jt} + b_{jt} + d_{jt} - T_{jt} - \Upsilon_{jt}^{W},$$

- An employment agency aggregates households' differentiated labor as in Erceg et al. (2000)

$$L_{jt} = \left(\frac{w_{jt}}{w_t} \right)^{-\varepsilon_W} L_t,$$

Households set wages subject to quadratic adjustment costs

$$\Upsilon_{jt}^{W} = \frac{\gamma_W}{2} \left(\Pi_t^{W} - 1 \right)^2 Y_t.$$

- Optimality gives an Euler equation and a wage Phillips curve

$$
\begin{aligned}
C_t^{-\gamma} &= \beta \mathbb{E}_t \left[C_{t+1}^{-\gamma} \frac{(1+i_t)}{\Pi_{t+1}} \right], \\
{L_t}^{\varphi+1} \varepsilon_W &= C_t^{-\gamma} \left[(1+\tau_W)\left(\varepsilon_W - 1\right) L_t w_t + \gamma_W \left(\Pi_t^W - 1 \right) Y_t \Pi_t^W \right] \\
&\quad - \beta \mathbb{E}_t \left[C_{t+1}^{-\gamma} \gamma_W \left(\Pi_{t+1}^W - 1 \right) Y_{t+1} \Pi_{t+1}^W \right].
\end{aligned}
$$

- The households' stochastic endowment of the non-labor input follows an AR(1) process

$$
X_t = (1-\rho_X)\,\mu_X + \rho_X X_{t-1} + \varepsilon_t^X, \qquad \varepsilon_t^X \sim \mathcal{N}(0, \sigma_X^2).
$$

- Intermediate firms supply in monopolistic competition the final good producer

$$Y_{it} = (P_{it}/P_t)^{-\varepsilon} Y_t.$$

- Intermediate goods firm produce with

$$Y_{it} = \left(\alpha L_{it}^{\frac{\phi-1}{\phi}} + (1-\alpha) X_{it}^{\frac{\phi-1}{\phi}}\right)^{\frac{\phi}{\phi-1}},$$

- Cost minimization yields the factor demands,

$$L_{it} = \left[\frac{w_{it}}{\alpha mc_{it}}\right]^{-\phi} Y_{it},$$

$$X_{it} = \left[\frac{p_t^X}{(1-\alpha) mc_{it}}\right]^{-\phi} Y_{it}.$$

- Intermediate firms maximize the infinite horizon of discounted dividends

$$\max_{\{P_{it}\}_{t=0}^{\infty}} \mathbb{E}_t \sum_{j=0}^{\infty} q_{t,t+j} m_{it},$$

where

- $q_{t,t+j}$ is the household's stochastic discount factor
- Per-period profits are

$$m_{it} = (1+\tau_P)(P_{it}/P_t) Y_{it} - mc_{it} Y_{it} - \Upsilon_{it}^P (P_{it}, P_{it-1})$$

- Rotemberg (1982) price adjustment costs

$$\Upsilon_{it}^P = \frac{\gamma_P}{2} \left(\frac{P_{it}}{P_{it-1}} - 1 \right)^2 Y_t.$$

- The symmetric equilibrium yields the following price Phillips curve

$$(\Pi_t - 1)\,\Pi_t = \frac{1}{\gamma_P}\left((1+\tau_P)(1-\varepsilon) + \varepsilon mc_t\right) + \mathbb{E}_t\left[\frac{q_{t,t+1}}{q_{t,t}}\,(\Pi_{t+1} - 1)\,\Pi_{t+1}\frac{Y_{t+1}}{Y_{t+1}}\right].$$

- Monetary policy

$$1 + i_t = (1+i)\,\Pi_t^{\mu_\Pi}\,\tilde{Y}_t^{\mu_Y}\,\varepsilon_t^i, \qquad \varepsilon_t^i \sim \mathcal{N}(1, \sigma_i^2).$$

- The goods market clearing condition is given by

$$Y_t = C_t + \mathit{\Upsilon}_t^P + \Upsilon_t^W.$$

Return

Parameters		Value	Source/Target
	Households		
β	Subjective discount factor	0.99	4% s.s. real interest rate
γ	Coefficient of relative risk aversion	2	Standard in the literature
φ	Inverse Frisch elasticity	1	Standard in the literature
γ_W	Rotemberg wage adjustment costs	465.3	Wage duration of 4 quarters
ε_w	Elasticity of substitution, labor	6	Standard in the literature
	Firms		
α	CES share parameter	0.9	US plucking property (Table 1)
ϕ	Elasticity of substitution of inputs	0.01	US plucking property (Table 1)
γ_P	Rotemberg price adjustment costs	29.4	Price duration of 3 quarters
ε	Elasticity of substitution, goods	6	Standard in the literature
	Monetary and fiscal authority		
μ_Π	Taylor coefficient on inflation	1.5	(Taylor, 1993)
μ_Y	Taylor coefficient on output gap	0.5	(Taylor, 1993)
τ_P	Production subsidy	$\frac{1}{\varepsilon-1}$	(Erceg et al., 2000)
τ_W	Labor subsidy	$\frac{1}{\varepsilon_W-1}$	(Erceg et al., 2000)
	Exogenous processes		
μ_X	Mean production of non-labor input	1	Normalization
ρ_X	Autoregressive coefficient, supply shock	0	*iid* assumption
σ_X	Standard deviation, supply shock	0.011	US inflation volatility
σ_i	Standard deviation, monetary policy shock	0.013	US FFR volatility

Return

The Lagrangian of the Ramsey planner is given by

$$\mathcal{L} = \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left[\frac{C_t^{1-\gamma}}{1-\gamma} - \frac{L_t^{1+\varphi}}{1+\varphi} + \mu_{1t} \left[C_t^{-\gamma} - \beta \mathbb{E}_t \left[C_{t+1}^{-\gamma} \frac{(1+i_t)}{\Pi_{t+1}} \right] \right] \right.$$
$$+ \mu_{2t} \left[C_t^{-\gamma} \left[(1+\tau_W)(\varepsilon_W - 1) w_t L_t + \gamma_W \left(\Pi_t^W - 1 \right) Y_t \Pi_t^W \right] \right.$$
$$\left. - L_t{}^{\varphi+1} \varepsilon_W - \beta \mathbb{E}_t \left[C_{t+1}^{-\gamma} \gamma_W \left(\Pi_{t+1}^W - 1 \right) Y_{t+1} \Pi_{t+1}^W \right] \right]$$
$$+ \mu_{3t} \left[\frac{1}{\gamma_P} \left[(1+\tau_P)(1-\varepsilon) + \varepsilon mc_t \right] + \beta \mathbb{E}_t \left[\left(\frac{C_{t+1}}{C_t} \right)^{-\gamma} (\Pi_{t+1} - 1) \Pi_{t+1} \frac{Y_{t+1}}{Y_t} \right] - (\Pi_t - 1) \Pi_t \right]$$
$$\left. + \mu_{4t} \left[\left[\frac{w_t}{\alpha mc_t} \right]^{-\phi} Y_t - L_t \right] + \mu_{5t} \left[\left[\frac{p_t^X}{mc_t (1-\alpha)} \right]^{-\phi} Y_t - X_t \right] + \mu_{6t} \left[Y_t - \Upsilon_t^P - \Upsilon_t^W - C_t \right] \right].$$

Return

To assess the accuracy of the perturbation approximations, we propose the following metric:

$$E\left(w, X, \varepsilon^{i}\right) = 100 \times \left| \frac{U^{pa}\left(w, X, \varepsilon^{i}\right) - U\left(w, X, \varepsilon^{i}\right)}{U\left(w, X, \varepsilon^{i}\right)} \right|,$$

Perturbation	First order	Second order	Third order	Fourth order	Fifth order
Mean of E	0.046	0.024	0.019	0.013	0.012

Table 9: Accuracy of perturbation. This table reports the mean errors of perturbation of increasing order using the per-period utility. We use the ergodic distribution of the global solution to evaluate the errors.

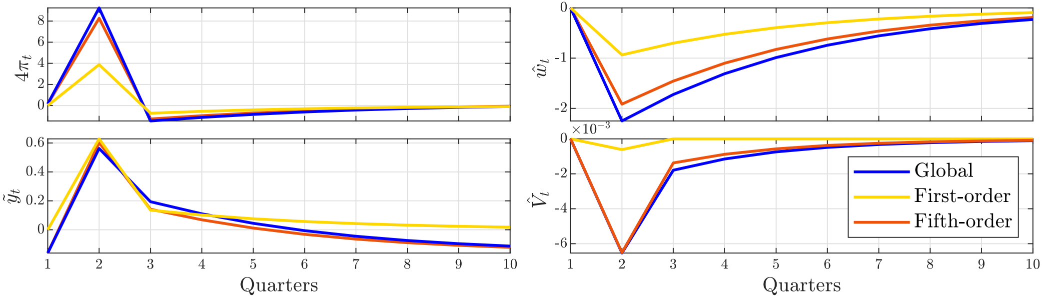


Figure 6: Impulse response functions. Impulse responses to a large negative shock using a global (blue), Dynare's first-order (yellow), and fifth-order (red) solution, respectively. Hatted variables are denoted in percentage deviations from the stochastic steady state.

Return

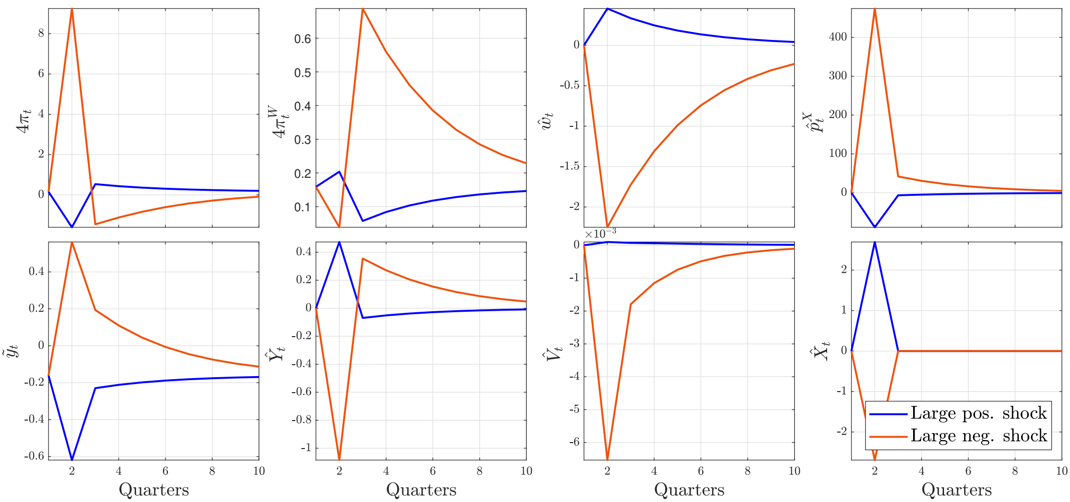


Figure 7: Impulse responses, Taylor: Large positive vs. large negative supply shock

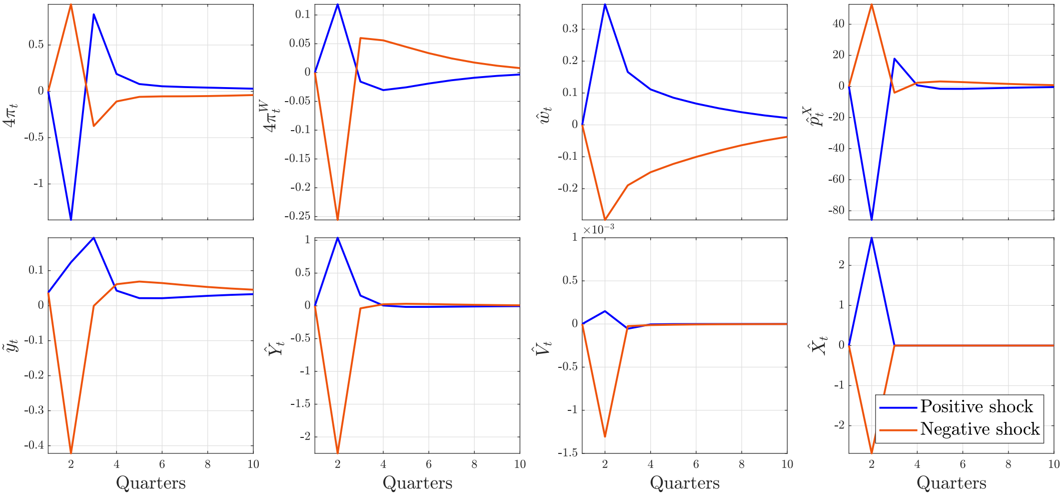


Figure 8: Impulse responses to a large positive (blue) and large negative (red) supply shock with a Ramsey planner.

We can visually inspect the effects of policy by computing the difference between the IRFs:

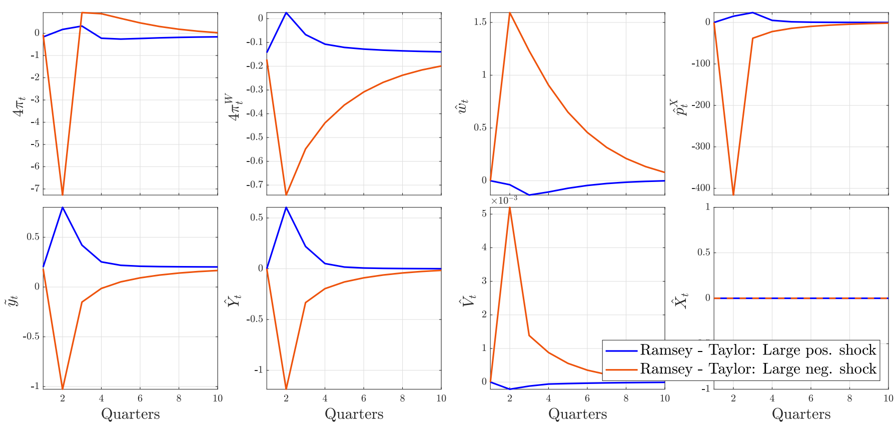


Figure 9: Impulse responses, Ramsey minus Taylor: Large positive vs. large negative supply shock.

We can visually inspect the effects of policy by computing the difference between the IRFs:

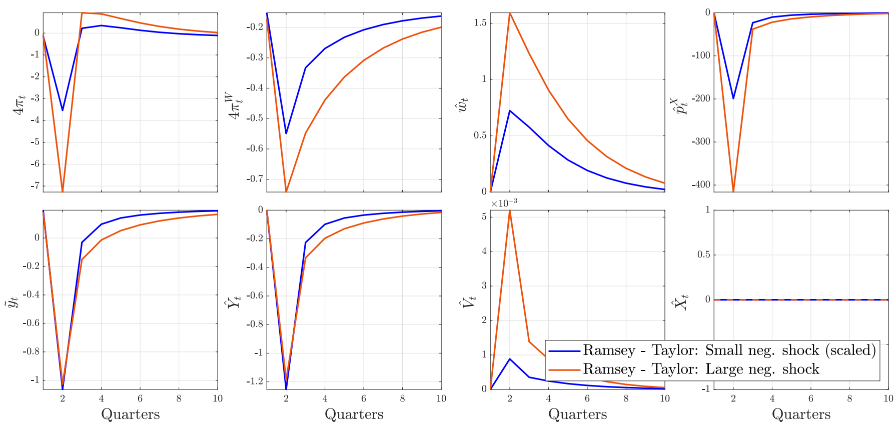


Figure 10: Impulse responses, Ramsey minus Taylor: Small vs. large negative supply shock.

Return

- In standard linearized models, stabilization policy has no effect on average levels, hence the welfare gains are trivial (Lucas, 1987, 2003).

- In the nonlinear model, stabilization policy mitigates the inflation and output gap biases:

	Taylor	Ramsey
$\mathbb{E}[4\pi_t]$	0.3	0.0
$\mathbb{E}[4\pi_t^W]$	0.3	0.0
$\mathbb{E}[\tilde{y}_t]$	-0.1	0.0

Table 10: **Average values in pct.**

Return

Benigno, P. and G. B. Eggertsson (2024): "The Slanted-L Phillips Curve," *AEA Papers and Proceedings*, 114, 84–89.

Blanco, A., C. Boar, C. J. Jones, and V. Midrigan (2024): "Nonlinear Inflation Dynamics in Menu Cost Economies," Working Paper 32094, National Bureau of Economic Research.

Boehm, C. E. and N. Pandalai-Nayar (2022): "Convex Supply Curves," *American Economic Review*, 112, 3941–69.

Cerrato, A. and G. Gitti (2022): "Inflation Since COVID: Demand or Supply," Working Paper 4193594, Social Science Research Network, accessed via SSRN.

Comin, D. A., R. C. Johnson, and C. J. Jones (2023): "Supply Chain Constraints and Inflation," Working Paper 31179, National Bureau of Economic Research.

De Polis, A., L. Melosi, and I. Petrella (2024): "The Taming of the Skew: Asymmetric Inflation Risk and Monetary Policy," CEPR Discussion Paper DP19760, Centre for Economic Policy Research.

Dupraz, S., E. Nakamura, and J. Steinsson (2024): "A Plucking Model of Business Cycles," Working Paper 26351, National Bureau of Economic Research.

Erceg, C. J., D. W. Henderson, and A. T. Levin (2000): "Optimal monetary policy with staggered wage and price contracts," *Journal of Monetary Economics*, 46, 281–313.

Forbes, K., J. Gagnon, and C. G. Collins (2022): "Low Inflation Bends the Phillips Curve around the World," *Economia*, 45, 52–72.

Friedman, M. (1964): "Monetary studies of the national bureau," *The National Bureau Enters Its 45th Year*, 44, 7–25.

——— (1993): "The "Plucking Model" of Business Fluctuations Revisited," *Economic Inquiry*, 31, 171–177.

Gagliardone, L. and M. Gertler (2024): "Oil Prices, Monetary Policy and Inflation Surges," Working Paper 4381781, Social Science Research Network.

Harding, M., J. Lindé, and M. Trabandt (2023): "Understanding post-COVID inflation dynamics," *Journal of Monetary Economics*, 140, 101–118.

Hartley, J. S. (2021): "Friedman's plucking model: New international evidence from Maddison Project data," *Economics Letters*, 199, 109724.

Karadi, P., A. Nakov, G. Nuño, E. Pastén, and D. Thaler (2024): "Strike While the Iron Is Hot: Optimal Monetary Policy with a Nonlinear Phillips Curve," Discussion Paper 19339, Centre for Economic Policy Research, accessed from CEPR Discussion Papers series.

Kim, C.-J. and C. R. Nelson (1999): "Friedman's Plucking Model of Business Fluctuations: Tests and Estimates of Permanent and Transitory Components," *Journal of Money, Credit and Banking*, 31, 317–334.

Kohlscheen, E., R. Moessner, and D. M. Rees (2024): "The shape of business cycles: A cross-country analysis of Friedman's plucking theory," *Kyklos*, 77, 351–370.

Lorenzoni, G. and I. Werning (2023): "Wage Price Spirals," Working paper.

Lucas, R. (1987): "Models of business cycles: By Robert E. Lucas, Jr, (Oxford: Basil Blackwell, 1987. pp. 120. ISBN 0 631 147918)," *Structural Change and Economic Dynamics*, 3, 177–182.

Lucas, R. E. J. (2003): "Macroeconomic Priorities," *American Economic Review*, 93, 1–14.

Phillips, A. W. (1958): "The Relation Between Unemployment and the Rate of Change of Money Wage Rates in the United Kingdom, 1861–1957," *Economica*, 25, 283–299.

Rotemberg, J. (1982): "Monopolistic Price Adjustment and Aggregate Output," *The Review of Economic Studies*, 49, 517–531.

Sinclair, T. M. (2010): "Asymmetry in the Business Cycle: Friedman's Plucking Model with Correlated Innovations," *Studies in Nonlinear Dynamics and Econometrics*, 14, 1–31.

Taylor, J. B. (1993): "Discretion versus policy rules in practice," *Carnegie-Rochester Conference Series on Public Policy*, 39, 195–214.