# Looking Through Energy Shocks*

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**Abstract**

When should a central bank look through an energy price shock whose persistence it cannot observe? We study this question in a New Keynesian model in which energy enters both production and the household consumption basket, with hand-to-mouth households, automatic stabilisers, sticky prices and wages, and a signal-extraction problem in which neither the central bank nor the private sector can tell persistent from transitory energy price movements. We derive a second-order approximation to utilitarian welfare and characterise impact inflation in closed form under look-through, Taylor rules on headline and core inflation, and optimal commitment and discretion. In every regime, incomplete information enters through a single posterior weight. Regimes differ in how they propagate perceived persistence: commitment propagates it less than discretion, and a sufficiently long peg most of all, especially when the peg is followed by a rule that responds to headline inflation. Wage rigidity governs this propagation, and the planner stabilises core and wage inflation. In the flexible-wage benchmark, look-through coincides with an active core rule when the energy shock leaves the natural rate unchanged. The shock lowers the natural rate, and is Keynesian, only when energy rents accrue to households that save them and are large enough. Quantitatively, look-through is very costly when wages pass through quickly and moderately costly when they are sticky. Followed by a headline rule, it beats Taylor rules only when the shock is strongly Keynesian; followed by a core rule, it beats a headline rule when wages are at least moderately sticky. The model delivers a testable prediction: looking through energy shocks is most costly when wages pass through quickly.

**Keywords:** monetary policy, look-through, energy shocks, incomplete information, Kalman filter, optimal policy, hand-to-mouth households, wage rigidity, headline and core inflation.

**JEL:** D83, E31, E52, E58, Q43.

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# 1 Introduction

In 2021 and early 2022 the Federal Reserve and the European Central Bank held policy rates unchanged for several quarters while inflation, driven to a large extent by energy and other supply shocks, rose. The stated rationale was that the shocks were transitory and should be looked through: tightening against a temporary relative-price increase imposes output costs without lasting benefits for inflation. The rationale is sound when the transitory nature of the shock is known. It is much less obvious when the central bank, and the households and firms whose expectations it needs to anchor, can only learn about the persistence of the shock gradually.

Figure 1 illustrates this tension in the euro area. Despite rising inflation, the ECB maintained its policy rate near the effective lower bound until mid-2022. Meanwhile, successive inflation projections initially anticipated a relatively rapid return toward the target, but were repeatedly revised upward as inflation persisted.

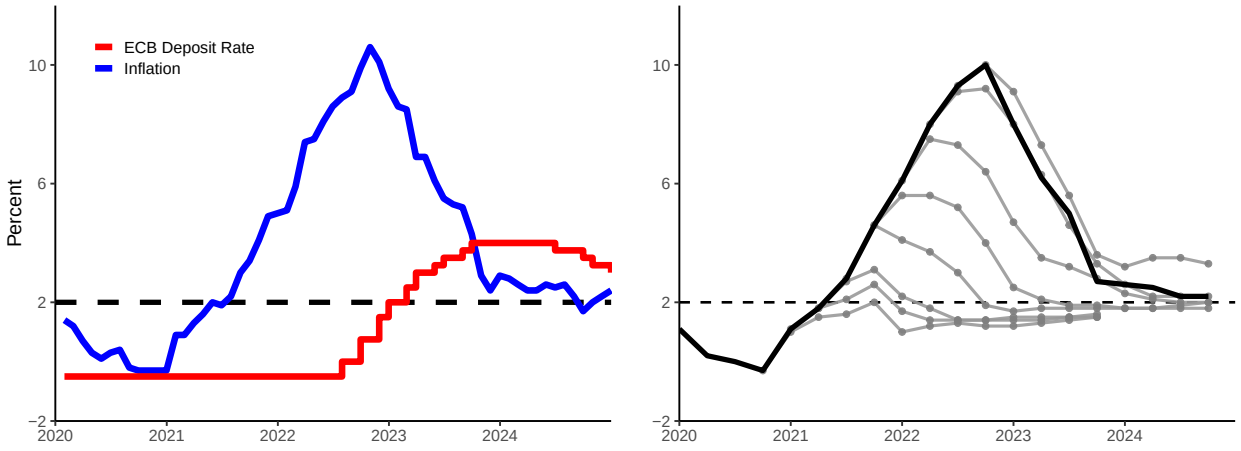



Figure 1: Inflation, Monetary Policy, and Inflation Expectations in the Euro Area

*Notes:* The left panel shows euro-area headline HICP inflation and the ECB deposit facility rate. The right panel shows realized HICP inflation (black) and successive ECB/Eurosystem staff inflation projections (grey) from 2021 and 2022. The dashed horizontal line denotes the 2% inflation target. *Source:* ECB Data Portal and ECB/Eurosystem Macroeconomic Projection Database.

This paper asks when looking through an energy price shock of uncertain persistence comes close to an active rule or to optimal monetary policy. We build on three strands of work. From Bušs and Traficante (2025), we take the question of whether a central bank should look through a cost-push shock whose persistence is unknown. They show, in a representative-agent model with a reduced-form cost-push shock, that look-through can be costly under incomplete information even when the shock is truly transitory. From Erceg and Levin (2003) and Erceg et al. (2024), we take the partial-information structure, in which agents observe the shock but not its persistent and transitory components. From Guerrieri et al. (2022), we take the notion of a Keynesian supply shock, which lowers the natural real interest rate by reducing demand by more than supply. Our contribution

is to bring these elements together in a model in which the energy shock is structural rather than a reduced-form cost-push shock. Energy enters firms' cost minimisation and the household consumption basket, so the shock moves natural and efficient output and opens a gap between headline and core inflation. A fraction of households is hand-to-mouth (HtM) and receives transfers from automatic stabilisers. In a flexible-wage benchmark and two wage-rigidity limits, we derive analytical expressions for inflation dynamics under look-through, Taylor rules on headline and core inflation, and optimal policy. We also derive welfare from household utility and characterise optimal monetary policy under commitment and discretion, all under the same information friction.

Our first result separates information from policy. Because agents filter the observed energy price with the steady-state Kalman filter, and the equilibrium is linear, impact inflation in every policy regime is a posterior-weighted average of the full-information responses to a persistent and a transitory shock. The information friction is therefore common to all regimes; policy determines how perceived persistence propagates into current inflation. Under look-through, impact inflation equals the structural effect of the energy shock—a direct marginal-cost effect plus an indirect demand effect—scaled by an amplification factor. A fixed nominal rate converts expected inflation into a lower real rate, so amplification rises with the look-through horizon and remains bounded only under a condition analogous to that of Carlstrom et al. (2015). Under commitment and discretion, impact inflation instead scales the welfare-relevant cost-push shock, and commitment propagates perceived persistence less than discretion. The rule that follows the peg also matters: a headline rule eases when the energy price falls back after a peg that ignored its increase, creating *asymmetric look-through*.

Our second result concerns welfare. The second-order approximation to utilitarian welfare penalises core price inflation, wage inflation and real allocation distortions, including consumption dispersion. The first-round effect of energy on headline inflation creates no price dispersion, so the planner looks through it, as in Aoki (2001). With a representative agent and flexible wages divine coincidence holds: the movement in natural output caused by the energy shock is efficient. Household heterogeneity breaks divine coincidence, because natural and efficient output differ, and wage rigidity creates an additional trade-off, as in Erceg et al. (2000).

Our third result identifies when look-through works. Wage rigidity governs the feedback from the demand stimulus of a fixed rate to marginal costs. With flexible prices and sticky wages, wage inflation replaces core inflation and the feedback from demand to inflation weakens. With rigid nominal wages, core inflation and its information amplification are identical under every regime, although output and welfare can still differ. The second determinant is the natural-rate effect of the shock. In the flexible-wage benchmark, inflation and the gap between output and natural output under look-through and core rules are proportional to the effect of the energy shock under a fixed nominal rate. When this effect is zero, the natural rate is unchanged and look-through coincides with a core rule. It is negative, so the shock is Keynesian in the sense of Guerrieri et al. (2022), if and only if sufficiently large domestic energy rents accrue to households who save part of a transitory windfall. A larger HtM share makes this condition more likely, whereas automatic stabilisers mitigate it only

up to a bound. Near the threshold, look-through and a core rule nearly coincide, and look-through can beat the rule when its residual stimulus moves output towards efficient output. Against a headline rule, look-through also gains when the shock is Keynesian, because that rule tightens in response to the first-round increase in consumer prices while the natural rate falls.

We also provide a quantitative analysis that measures the welfare costs of look-through and compares policy rules under alternative wage-setting and energy-market structures. Look-through is very costly when wages pass through quickly and only moderately costly when they are sticky. With sticky wages, a central bank that looks through should return to a core rather than a headline rule, and a core rule outperforms a headline rule. Followed by a headline rule, look-through beats Taylor rules only when the energy shock is strongly Keynesian. The model therefore delivers a testable prediction: holding beliefs about persistence fixed, look-through is more costly where wages pass through quickly and less costly where energy shocks are strongly Keynesian.

**Related literature.** Our analysis of look-through follows Bušs and Traficante (2025), and our information structure follows Erceg and Levin (2003) and Erceg et al. (2024). Relative to these papers, we derive analytical characterisations, a micro-founded welfare criterion and optimal policy under a common information friction, and show how wage rigidity and the Keynesian nature of the shock govern the case for looking through. The classic argument for accommodating supply shocks goes back to Gordon (1975), and the case for targeting sticky-price inflation rather than headline inflation to Aoki (2001) and Benigno (2004). Optimal policy with distinct core and headline inflation under oil shocks is studied by Bodenstein et al. (2008), Montoro (2012) and Natal (2012). The interaction of sticky prices and wages and the resulting failure of divine coincidence is due to Erceg et al. (2000), and real wage rigidity as a source of policy trade-offs to Blanchard and Galí (2007). Hand-to-mouth households originate in Campbell and Mankiw (1989) and Galí et al. (2007), the amplification of aggregate demand they generate in Bilbiie (2008), and optimal policy in two-agent models in Debortoli and Galí (2018). Keynesian supply shocks are due to Guerrieri et al. (2022). On energy shocks and heterogeneity we relate to Auclert et al. (2023), who show that locating energy in production or consumption delivers similar activity responses, and to Chan et al. (2024) and Kharroubi and Smets (2024). We provide an exact condition under which an energy shock is Keynesian and relate it to the look-through decision. The explosive behaviour of finite pegs is analysed by Carlstrom et al. (2015), certainty equivalence under symmetric partial information follows Svensson and Woodford (2003), and our computation of discretionary policy follows Söderlind (1999).

**Outline.** Section 2 presents the model and information structure. Section 3 derives welfare and characterises Keynesian energy shocks. Section 4 characterises impact inflation under look-through, Taylor rules and optimal policy. Section 5 studies when look-through comes close to an active rule or to optimal policy, including the role of wage rigidity. Section 6 presents the quantitative analysis, including Keynesian energy shocks, and Section 7 concludes. Derivations, proofs, the wage-rigidity limits and additional quantitative results are in the appendices.

# 2 Model

We consider a New Keynesian model with heterogeneous households, energy as an input into consumption and production, and counter-cyclical fiscal transfers. Prices and wages are subject to Calvo rigidities. The economy takes the world energy price as exogenous.

Despite these features, we show that the equilibrium under flexible wages reduces to a two-equation New Keynesian system (an IS curve and a Phillips curve) together with a policy rule. The structural features of the economy enter through the coefficients governing aggregate demand and inflation.

## 2.1 Economic Environment

A fraction $1-\mu$ of households are Ricardian and smooth consumption intertemporally, while the remaining fraction $\mu$ are hand-to-mouth (HtM) and consume their current disposable income. Both types have identical logarithmic preferences over a CES consumption basket of domestic goods and energy, with energy expenditure share $\alpha_C$ and substitution elasticity $\nu$. Labour disutility is convex, with inverse Frisch elasticity $\varphi$. Labour is allocated equally across households through a union, with a fraction $1-\xi_w$ of nominal wages reset each period.

Monopolistically competitive firms combine labour and energy using a CES production technology, where $\eta$ governs the elasticity of substitution between the two inputs. Firms face Calvo price rigidity, with a fraction $1-\xi_p$ resetting prices each period. Energy is traded at an exogenous world price. A domestic energy endowment, owned by Ricardian households, covers a fraction $\varsigma$ of steady state energy use, while the remainder is imported.

The fiscal authority provides counter-cyclical transfers to HtM households, financed by lump-sum taxes on Ricardian households. Transfers increase when GDP falls, with $\gamma \geq 0$ governing the strength of automatic stabilization.

These features introduce two transmission channels. First, household heterogeneity and fiscal transfers alter aggregate demand because HtM households cannot smooth consumption. Second, energy prices affect firms' production costs and the distribution of household income, generating both supply and demand effects. The full structural environment and equilibrium derivations are provided in Appendix A.

## 2.2 Information Structure

Following Bušs and Traficante (2025), the observed real energy price consists of persistent and transitory components:

$$q_t = q_t^P + q_t^T, \qquad q_{t+1}^j = \rho_j q_t^j + \sigma_j \varepsilon_{t+1}^j, \quad j \in \{P, T\}, \tag{1}$$

where $\rho_P > \rho_T$, $\sigma_T > \sigma_P$, and the innovations are independent standard normal disturbances.

All agents, including the central bank, observe $q_t$ but cannot distinguish its underlying components. They infer their persistence using a steady-state Kalman filter. Their expectations are given by

$$\mathbb{E}_t q_{t+k} = \rho_P^k q_{t|t}^P + \rho_T^k q_{t|t}^T, \tag{2}$$

where $q_{t|t}^j$ denotes the filtered estimate of component $j$.

Following an innovation in an economy initially at rest, agents attribute a fraction $L_1^*$ of the observed price movement to the persistent component and $1 - L_1^*$ to the transitory component, where $L_1^*$ is the steady-state Kalman gain.

### 2.3 Aggregate Equilibrium

The log-linear equilibrium with sticky prices and wages can be summarized by four equations:

$$c_t^R = \mathbb{E}_t c_{t+1}^R - (i_t - \mathbb{E}_t \pi_{t+1}), \tag{3}$$

$$\pi_t = \beta \mathbb{E}_t \pi_{t+1} + \kappa_p (s_C w_t + s_E q_t), \tag{4}$$

$$\pi_t^w = \beta \mathbb{E}_t \pi_{t+1}^w + \lambda_w (m_y y_t + m_w w_t + m_q q_t), \tag{5}$$

$$w_t = w_{t-1} + \pi_t^w - \pi_t. \tag{6}$$

Here, $y_t$ denotes GDP, $c_t^R$ Ricardian expenditure, $w_t$ the real wage, $q_t$ the real energy price, $\pi_t$ core inflation, and $\pi_t^w$ nominal wage inflation. The parameters $s_C$ and $s_E = 1 - s_C$ are the steady state labour and energy cost shares of gross output, respectively, while $\beta$ is the household discount factor. The coefficients $\kappa_p$ and $\lambda_w$ are the slopes of the price and wage Phillips curves, determined by the degree of nominal rigidity. The coefficients $m_y$, $m_w$, and $m_q$ capture how GDP, real wages, and energy prices affect the gap between the Ricardian marginal rate of substitution and the real wage.

The first equation governs Ricardian intertemporal expenditure decisions, while the remaining equations describe price and wage adjustment. Household heterogeneity and fiscal transfers enter through the relationship between Ricardian expenditure and aggregate GDP, as well as the wage Phillips curve. The full derivation and coefficient expressions are provided in Appendix A.6.

For the analytical results, we impose flexible wages. The real wage then adjusts to equate the Ricardian marginal rate of substitution with the real wage. Substituting this condition into the equilibrium reduces the system to

$$y_t = \mathbb{E}_t y_{t+1} - \sigma(i_t - \mathbb{E}_t \pi_{t+1}) + \psi(q_t - \mathbb{E}_t q_{t+1}), \tag{7}$$

$$\pi_t = \beta \mathbb{E}_t \pi_{t+1} + \kappa y_t + \alpha q_t. \tag{8}$$

The resulting system retains the familiar New Keynesian structure. The coefficients $\sigma$, $\psi$, $\kappa$, and $\alpha$ are reduced-form functions of the structural parameters, with expressions given in Appendix A.6. The coefficient $\sigma$ governs monetary transmission, while $\psi$ captures the effect of energy prices on

aggregate demand. Similarly, $\kappa$ determines the response of inflation to GDP, while $\alpha$ captures the effect of energy prices on marginal costs.

Importantly, these coefficients incorporate household heterogeneity, automatic stabilizers, and the energy sector. The richer economic environment can be analyzed using a simple two-equation system. We retain sticky wages in the subsequent quantitative analysis.

### 2.4 Monetary Policy and Amplification

Outside look-through episodes, monetary policy follows

$$i_t = \rho_i i_{t-1} + (1-\rho_i)(\phi_\pi \pi_t^{rule} + \phi_y y_t), \tag{9}$$

where $\rho_i$ is the interest-rate smoothing coefficient, $\phi_\pi$ and $\phi_y$ are the inflation and GDP response coefficients, and $\pi_t^{rule}$ denotes headline or core inflation. Headline inflation satisfies $\pi_t^H = \pi_t + \alpha_C(q_t - q_{t-1})$.

Under look-through policy, the central bank commits to keeping the nominal interest rate at its steady-state level for $T^*$ periods, $i_t = 0$ for $0 \leq t < T^*$, before returning to the Taylor rule. Following Bušs and Traficante (2025), look-through is adopted when $L_1^* < 1/2$. The commitment is fully credible.

The linearity of the equilibrium implies that the initial response under incomplete information is a weighted average of the corresponding full information responses. For any policy regime $j$, starting from an economy at rest,

$$\pi_0^{PI,j} = L_1^* \pi_0^{FI,j}(\rho_P) + (1-L_1^*)\pi_0^{FI,j}(\rho_T), \tag{10}$$

where $\pi^{FI,j}(\rho)$ denotes the impact inflation response to the same unit observed energy-price shock with persistence $\rho$.

This motivates our measure of information induced amplification:

$$\mathcal{A}^j \equiv \frac{\pi_0^{PI,j}}{\pi_0^{FI,j}(\rho_T)} - 1 = L_1^* \left[ \frac{\pi_0^{FI,j}(\rho_P)}{\pi_0^{FI,j}(\rho_T)} - 1 \right]. \tag{11}$$

The amplification index separates the common information friction, captured by $L_1^*$, from the policy dependent transmission of perceived persistence. Although agents face the same information problem under every policy regime, its implications for inflation depend on how monetary policy responds to the shock.

The following sections characterize this amplification under look-through, Taylor rules, and optimal monetary policy.

# 3 Welfare and Keynesian Energy Shocks

We now examine the welfare implications of energy price shocks. We first establish the welfare criterion and identify when monetary policy faces an inflation output stabilization trade-off. We then characterize the conditions under which an energy price shock becomes Keynesian, lowering the natural real interest rate through its effect on aggregate demand and discuss its implication for the optimal monetary policy.

## 3.1 Welfare and Optimal Stabilization

Monetary policy affects welfare through nominal price and wage dispersion, the allocation of production inputs, and consumption differences between Ricardian and HtM households.

A second-order approximation to utilitarian welfare around the efficient steady state gives the following loss function, up to policy independent terms:

$$\mathcal{L}_0 = \frac{1}{2}\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left[ \frac{\varepsilon_p}{\kappa_p s_x} \pi_t^2 + \frac{c\varepsilon_w}{\lambda_w} (\pi_t^w)^2 + \mathcal{Q}(y_t, w_t, q_t) \right], \tag{12}$$

where $\varepsilon_p$ and $\varepsilon_w$ are the elasticities of substitution across differentiated goods and labour services, $s_x$ (the steady-state GDP share of gross output) and $c = s_C/s_x$ (the labour share of GDP) are steady-state shares defined in Appendix A, and $\mathcal{Q}$ is a quadratic function capturing real allocation distortions, including inefficient production input allocation, labour disutility, and consumption dispersion between household types. The structural coefficients and full derivation are provided in Appendix C.

The first two terms capture the welfare costs of nominal price and wage dispersion. Inflation in the welfare criterion is core inflation: the direct contribution of flexible energy prices to headline inflation does not generate nominal price dispersion. Nevertheless, energy prices affect welfare through firms' production costs and the allocation of consumption across households.

For the flexible wage benchmark, the welfare criterion simplifies to

$$\mathcal{L}_0 = \frac{1}{2}\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left[ \pi_t^2 + \lambda_x (y_t - y_t^e)^2 \right], \tag{13}$$

where the loss is normalized by the coefficient on core inflation, $y_t^e$ is efficient GDP, and $\lambda_x > 0$ is the welfare weight on deviations from the efficient allocation.

The efficient allocation minimizes real distortions, including consumption dispersion between Ricardian and HtM households. It need not coincide with natural GDP, $y_t^n$, which is the allocation under flexible prices and wages.

From the Phillips curve in Section 2, natural GDP satisfies

$$y_t^n = -\frac{\alpha}{\kappa} q_t. \tag{14}$$

The Phillips curve can therefore be rewritten as

$$\pi_t = \beta \mathbb{E}_t \pi_{t+1} + \kappa(y_t - y_t^e) + u_t^*, \tag{15}$$

where

$$u_t^* \equiv \kappa(y_t^e - y_t^n) = \zeta_q q_t. \tag{16}$$

Here $\zeta_q$ denotes the response of the welfare-relevant wedge to a unit energy-price shock. The term $u_t^*$ is the welfare-relevant cost push shock. It measures the difference between the natural and efficient responses to energy prices, rather than the direct effect of energy prices on firms' marginal costs.

**Proposition 1** (Energy Shocks and Divine Coincidence)**.** *In the flexible wage benchmark:*

1. *With a representative household, natural and efficient GDP coincide, $y_t^n = y_t^e$. Hence, $u_t^* = 0$, and monetary policy can stabilize core inflation while implementing the efficient allocation.*

2. *With HtM households, natural and efficient GDP generally differ. Energy price shocks therefore introduce a welfare relevant inflation output stabilization trade-off, whose magnitude depends on household heterogeneity and fiscal transfers.*

The first result extends the familiar divine coincidence to an economy with energy in production. Although an increase in energy prices changes natural GDP, this adjustment is efficient in the representative agent and flexible wage benchmark. Monetary policy need not offset the resulting movement in economic activity.

With HtM households, however, wage setting reflects the Ricardian marginal rate of substitution, while household consumption is not fully insured. The planner also internalizes consumption dispersion, so the natural allocation generally will not be efficient. Stabilizing core inflation alone then fails to implement the welfare maximizing allocation.

When wages are sticky, monetary policy faces an additional trade-off between price and wage stabilization, as in Erceg et al. (2000). We account for this additional margin in the quantitative analysis.

### 3.2 Keynesian Energy Shocks

An increase in energy prices raises firms' production costs and typically reduces productive capacity. However, the effect on aggregate demand depends on household heterogeneity, fiscal transfers, and the distribution of domestic energy rents.

Following Guerrieri et al. (2022), we define an energy price shock as *Keynesian* when it lowers the natural real interest rate. This occurs when the contraction in aggregate demand, at a given real interest rate, exceeds the adjustment in aggregate supply.

To characterize this condition, consider the flexible wage New Keynesian system:

$$y_t = \mathbb{E}_t y_{t+1} - \sigma(i_t - \mathbb{E}_t \pi_{t+1}) + \psi(q_t - \mathbb{E}_t q_{t+1}), \tag{17}$$

$$\pi_t = \beta \mathbb{E}_t \pi_{t+1} + \kappa y_t + \alpha q_t. \tag{18}$$

Recall that natural GDP is $y_t^n = -(\alpha/\kappa) q_t$. Substituting this allocation into the IS curve gives the natural real interest rate:

$$r_t^n = \frac{\alpha + \kappa\psi}{\kappa\sigma}(q_t - \mathbb{E}_t q_{t+1}). \tag{19}$$

The expression highlights the competing effects of energy prices. The coefficient $\alpha$ captures the marginal cost channel, while $\kappa\psi$ captures the aggregate demand channel and its implications for inflation.

For a mean-reverting energy price increase, $q_t > \mathbb{E}_t q_{t+1}$, the natural real interest rate falls if and only if the combined effect on inflation under a fixed nominal rate is negative, typically because the demand channel dominates the supply effect:

$$\alpha + \kappa\psi < 0. \tag{20}$$

The following proposition provides the corresponding condition in terms of the economy's structural characteristics. The steady-state consumption-to-output ratio $s_x$ is defined in Appendix A.

**Proposition 2** (Keynesian Energy Shocks)**.** *Suppose wages are flexible, $\sigma > 0$, and the energy price shock is mean reverting. Let $\varrho$ denote domestic energy rents as a share of gross output, and let $g = \gamma/s_x$ denote the normalized strength of automatic stabilizers.*

*An increase in energy prices lowers the natural real interest rate if and only if*

$$\varrho\varphi(1+g) > s_E(1+\varphi)(1-\mu+g). \tag{21}$$

*The condition has three implications:*

1. *Without domestic energy rents ($\varrho = 0$), the shock cannot be Keynesian.*
2. *A larger HtM share $\mu$ makes the Keynesian condition more likely to be satisfied.*
3. *Stronger automatic stabilizers can mitigate the condition, but cannot always eliminate the Keynesian demand effect.*

**The role of domestic energy rents.** The key mechanism is a leakage of aggregate demand associated with the ownership of domestic energy.

An increase in energy prices raises the value of domestic energy rents, which accrue to Ricardian households. Since these households smooth expenditure intertemporally, they save part of a transitory increase in energy income rather than spending it immediately. As a result, current aggregate demand does not increase proportionally with domestic income. At an unchanged real

interest rate, this demand shortfall reduces domestic production and employment. Lower labour income then reduces HtM consumption, reinforcing the initial contraction in aggregate demand.

The natural real interest rate must therefore fall to restore equilibrium between demand and supply. The presence of domestic energy rents is essential to this mechanism. When all energy is imported, higher energy expenditure is financed by exports of domestic goods, and the same domestic rent induced demand leakage does not arise. Under the maintained assumptions, the shock cannot become Keynesian without domestic energy rents.

Energy rents also affect the supply side. When domestic energy rents are sufficiently large relative to production energy costs, higher energy prices can reduce the labour required to sustain a given level of GDP. This weakens the conventional marginal cost effect and makes a decline in the natural real interest rate more likely.

**Household heterogeneity.** HtM households amplify the demand implications of energy rents. Because energy rents accrue to Ricardian households, part of the additional income is saved rather than immediately consumed. When aggregate demand and employment decline, HtM households experience lower labour income and reduce their consumption one-for-one.

This creates an additional contractionary feedback that is absent when all households can smooth consumption. A larger HtM share therefore strengthens the demand channel relative to the supply effect and makes the condition in Proposition 2 more likely to hold.

Importantly, household heterogeneity is not necessary for the shock to be Keynesian. Even with a representative household, sufficiently large domestic energy rents, $\varrho\varphi > s_E(1+\varphi)$, lower the natural real interest rate. In that case $\psi = 0$ and the channel is on the supply side: rents larger than the production energy bill reduce the hours needed per unit of GDP and turn the direct effect $\alpha$ negative. Heterogeneity adds the demand leakage described above.

**Automatic fiscal stabilization.** Counter-cyclical transfers operate in the opposite direction. When GDP falls, the fiscal authority increases transfers to HtM households, supporting their disposable income and consumption.

This mitigates the feedback from lower employment to weaker demand. Stronger automatic stabilizers therefore reduce the likelihood that an energy price shock becomes Keynesian.

However, this effect is limited because the transfer rule responds to GDP rather than directly redistributing changes in energy rents. In particular, as $g \to \infty$, condition (21) approaches

$$\frac{\varrho}{s_E} > \frac{1+\varphi}{\varphi}. \tag{22}$$

When domestic energy rents exceed this threshold, the shock remains Keynesian regardless of the strength of automatic stabilization.

**Implications for monetary policy.** The Keynesian condition has an important implication for the appropriate monetary policy response. When an energy price increase lowers the natural

real interest rate, monetary accommodation may be necessary even though headline inflation rises mechanically with energy prices.

A Taylor rule responding aggressively to headline inflation may instead raise the nominal interest rate, increasing the real rate relative to its natural level and exacerbating the demand shortfall.

This distinction is central to the evaluation of look-through policy. The desirability of accommodating an energy price shock depends not simply on whether energy prices are persistent, but also on whether the underlying disturbance creates inflationary pressure, a contraction in demand, or both.

# 4 Look-through and Optimal Policy: Analytical Results

We now characterize how incomplete information affects inflation under alternative monetary policy regimes. The analysis builds on the flexible-wage New Keynesian system derived in Section 2. As discussed, agents attribute a common fraction $L_1^*$ of an observed energy price innovation to its persistent component. However, the effect of this perceived persistence on inflation depends on the monetary policy regime.

We first examine look-through policy, followed by optimal commitment and discretion. We then compare headline and core Taylor rules and provide a common decomposition of inflation across regimes. For analytical tractability, we set $\rho_T = 0$ when deriving the amplification formulas and consider Taylor rules without interest-rate smoothing or an output response. These restrictions are relaxed in the quantitative analysis.

## 4.1 Look-Through Policy

Under look-through policy, the central bank holds the nominal interest rate fixed for $T^*$ periods before returning to a core Taylor rule. We first consider a fully observed energy-price shock with persistence $\rho$, normalized to one at impact. Let $\pi_0^{LT}(\rho, T^*)$ denote the impact response of core inflation per unit of the energy-price shock under a $T^*$-period look-through commitment.

Under a core Taylor rule without look-through, the full information impact response is

$$\pi_0^{TR}(\rho) = \frac{\alpha + \kappa\psi}{1 - \beta\rho + \kappa\sigma\frac{\phi_\pi - \rho}{1-\rho}}. \tag{23}$$

When the central bank initially looks through the shock, the inflation response also depends on the duration of the commitment. For any finite $T^*$, the equilibrium can be solved backward from the subsequent Taylor rule allocation. The exact scalar solution is provided in Appendix D.

**Proposition 3** (Look-Through Policy)**.** *Consider a $T^*$-period look-through commitment followed by a core Taylor rule.*

1. Incomplete information amplification.

*When the transitory component has zero persistence, $\rho_T = 0$, initial core inflation for $T^* \geq 1$ satisfies*

$$\pi_0^{PI,LT} = \left( \underbrace{\alpha}_{Direct} + \underbrace{\kappa\psi}_{Indirect} \right) \underbrace{(1 + \mathcal{A}^{LT})}_{Information\ Amplification}, \tag{24}$$

*where*

$$\mathcal{A}^{LT} = L_1^* \left[ \frac{\pi_0^{LT}(\rho_P, T^*)}{\alpha + \kappa\psi} - 1 \right], \tag{25}$$

*provided $\alpha + \kappa\psi \neq 0$.*

*2.* Long-horizon amplification.

*Define the propagation coefficient*

$$\Lambda^{LT}(\rho) = \beta + \frac{\kappa\sigma}{1 - \rho}. \tag{26}$$

*As the look-through horizon increases, the impact response converges to*

$$\lim_{T^* \to \infty} \pi_0^{LT}(\rho, T^*) = \frac{\alpha + \kappa\psi}{1 - \rho\Lambda^{LT}(\rho)} \tag{27}$$

*provided $\rho\Lambda^{LT}(\rho) < 1$. When this condition fails, extending the commitment horizon generically amplifies rather than attenuates the effects of future economic conditions.*

The proposition identifies two distinct amplification mechanisms. First, incomplete information causes agents to attribute part of an observed energy price shock to a persistent disturbance. The resulting inflation response depends on the Kalman gain $L_1^*$ and the policy dependent amplification factor $\mathcal{A}^{LT}$. Second, a longer look-through commitment strengthens the feedback between expected inflation and aggregate demand. With the nominal interest rate fixed, higher expected inflation lowers the expected real interest rate, stimulating demand and reinforcing current inflation.

The long-horizon condition determines whether this feedback remains bounded as the commitment is extended (Carlstrom et al., 2015). When it fails, the effect of distant future conditions can grow with the length of the peg, although the equilibrium remains well defined for any finite horizon under the maintained terminal Taylor rule.

Proposition 3 separates the structural effect of an energy price shock from its amplification under incomplete information. The structural effect, $\alpha + \kappa\psi$, combines the marginal cost and aggregate demand channels. The amplification factor captures the additional response arising when agents attribute part of the observed shock to a persistent disturbance.

The mechanism operates through expectations. During the peg, higher expected inflation lowers the expected real interest rate, stimulating aggregate demand. Stronger demand raises current inflation, creating a feedback between expected inflation and current economic activity.

The duration of the commitment determines how strongly this feedback operates. The condition $\rho\Lambda^{LT}(\rho) < 1$, closely related to Carlstrom et al. (2015), distinguishes whether the influence of distant

periods diminishes as the peg is extended. Importantly, failure of this condition does not imply that a finite peg is indeterminate. Rather, it means that extending the commitment horizon can generate increasingly large inflation responses. The infinite horizon formula is not valid as the limit in that case.

### 4.2 Optimal Commitment and Discretion

We next consider how the same information friction operates under optimal monetary policy. Unlike look-through, the central bank now chooses policy to minimize the welfare loss derived in Section 3.

Let

$$x_t \equiv y_t - y_t^e$$

denote the welfare relevant output gap. The planner minimizes

$$\mathcal{L}_0 = \frac{1}{2}\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t (\pi_t^2 + \lambda_x x_t^2), \tag{28}$$

subject to

$$\pi_t = \beta \mathbb{E}_t \pi_{t+1} + \kappa x_t + \zeta_q q_t. \tag{29}$$

The relevant disturbance is therefore $\zeta_q q_t = \kappa(y_t^e - y_t^n)$, which measures $\kappa$ times the gap between efficient and natural GDP, rather than the structural effect $\alpha + \kappa\psi$ governing inflation under a fixed nominal interest rate.

**Proposition 4** (Optimal Monetary Policy)**.** *Consider an energy-price shock with persistence $\rho$ under full information. The central bank minimizes the welfare loss (13) subject to the welfare-relevant Phillips curve (15).*

1. Commitment.

   *Under optimal commitment from the timeless perspective, the targeting criterion is*

   $$\pi_t = -\frac{\lambda_x}{\kappa}(x_t - x_{t-1}), \tag{30}$$

   *where $x_t = y_t - y_t^e$ is the welfare-relevant output gap. Let $r \in (0,1)$ denote the stable root of*

   $$\beta r^2 - \left(1 + \beta + \frac{\kappa^2}{\lambda_x}\right) r + 1 = 0. \tag{31}$$

   *For a shock arriving in an economy initially at its undisturbed steady state, the full information impact response is*

   $$\pi_0^{FI,C}(\rho) = \frac{\zeta_q r}{1 - \beta r \rho} q_0. \tag{32}$$

2. Discretion.

*Under discretion, the central bank reoptimizes each period, taking future expectations as given. The targeting criterion becomes*

$$\pi_t = -\frac{\lambda_x}{\kappa} x_t. \tag{33}$$

*Define*

$$r_D = \frac{\lambda_x}{\lambda_x + \kappa^2}. \tag{34}$$

*The full-information impact response is*

$$\pi_0^{FI,D}(\rho) = \frac{\zeta_q r_D}{1 - \beta r_D \rho} q_0. \tag{35}$$

*3.* Incomplete information.

*When $\rho_T = 0$, the initial inflation response under either optimal policy is*

$$\pi_0^{PI,j} = \pi_0^{FI,j}(0)(1 + \mathcal{A}^j), \qquad j \in \{C, D\}, \tag{36}$$

*where*

$$\mathcal{A}^j = L_1^* \frac{\rho_P \Lambda^j}{1 - \rho_P \Lambda^j}, \qquad \Lambda^C = \beta r, \quad \Lambda^D = \beta r_D. \tag{37}$$

The optimal-policy responses share the same structure as the look-through result: incomplete information scales the response to a known transitory shock through the perceived persistent component.

However, the propagation mechanism differs across policy regimes.

Under discretion, the planner balances inflation against the efficient output gap period by period. The coefficient $r_D$ determines how much of the welfare-relevant cost-push disturbance passes into inflation.

Under commitment, the central bank can influence expectations through promises about future policy. The stable root $r$ captures this history dependence, which reduces the propagation of perceived persistence relative to discretion.

The comparison is summarized in the following proposition.

**Proposition 5** (Ranking of Amplification)**.** *The optimal-policy roots satisfy*

$$0 < r < r_D < 1. \tag{38}$$

*Their propagation coefficients satisfy*

$$\Lambda^C < \Lambda^D < \beta < \Lambda^{LT}(\rho_P). \tag{39}$$

*For $0 < \rho_P < 1$, the associated amplification indices satisfy*

$$\mathcal{A}^C < \mathcal{A}^D. \tag{40}$$

*Moreover, when* $\zeta_q \neq 0$,

$$|\pi_0^{PI,C}| < |\pi_0^{PI,D}|. \tag{41}$$

*If the condition* $\rho_P \Lambda^{LT}(\rho_P) < 1$ *holds, the long-horizon look-through amplification exceeds that under optimal discretion.*

The ranking shows that the same information friction is propagated differently under alternative monetary policies.

Commitment generates the weakest propagation because future policy promises help stabilize current inflation. Discretion provides less stabilization because policy cannot exploit this history dependence. Under look-through, the fixed nominal interest rate instead allows expected inflation to stimulate aggregate demand, reinforcing inflationary pressure.

For a finite peg, however, the look-through amplification depends on the commitment horizon. A sufficiently short peg need not generate greater amplification than optimal policy. The long-horizon ranking therefore should not be interpreted as a universal ranking for every finite $T^*$.

### 4.3 Headline and Core Inflation Rules

So far, we have focused on core inflation. But when energy also enters household consumption, it creates a distinction between headline and core inflation:

$$\pi_t^H = \pi_t + \alpha_C(q_t - q_{t-1}). \tag{42}$$

A monetary policy rule responding to headline inflation therefore reacts directly to movements in energy prices.

**Proposition 6** (Headline and Core Rules)**.** *Consider an energy price shock arriving in an economy initially at the steady state.*

1. Headline inflation.

   *Impact headline inflation satisfies*

   $$\pi_0^H = \pi_0 + \alpha_C q_0. \tag{43}$$

   *The direct contribution* $\alpha_C q_0$ *is common across monetary policy regimes and is not itself amplified by incomplete information.*

2. Taylor rules.

   *Consider a fully observed AR(1) energy price shock with persistence* $\rho$ *and initial magnitude* $q_0$*. Under a core Taylor rule without interest rate smoothing or an output response, impact core inflation is*

   $$\pi_0^{FI,TR-C}(\rho) = \frac{\alpha + \kappa\psi}{1 - \beta\rho + \kappa\sigma\frac{\phi_\pi - \rho}{1-\rho}} q_0. \tag{44}$$

*Under a headline Taylor rule, $i_t = \phi_\pi \pi_t^H$, impact core inflation is*

$$\pi_0^{FI,TR-H}(\rho) = \pi_0^{FI,TR-C}(\rho) + \alpha_C \Xi(\rho) q_0, \tag{45}$$

*where*

$$\Xi(\rho) = \frac{\kappa\sigma\phi_\pi}{1+\kappa\sigma\phi_\pi} \frac{\beta(1-\rho) - \kappa\sigma(\phi_\pi - 1)}{(1-\rho)(1-\beta\rho) + \kappa\sigma(\phi_\pi - \rho)}. \tag{46}$$

*In particular, since $\phi_\pi > 1 > \rho$ implies*

$$\Xi(\rho) < 0 \quad \Longleftrightarrow \quad \kappa\sigma(\phi_\pi - 1) > \beta(1-\rho). \tag{47}$$

*3.* Look-through followed by a headline rule.

*Suppose the central bank holds the nominal interest rate fixed for $T^*$ periods before returning to either a headline or core Taylor rule.*

*Let $\pi_0^{FI,LT-H}(\rho, T^*)$ and $\pi_0^{FI,LT-C}(\rho, T^*)$ denote the corresponding full information impact responses for a shock with persistence $\rho$ and magnitude $q_0$.*

*When $\rho_T = 0$ and $T^* \geq 2$, the difference under incomplete information satisfies*

$$\pi_0^{PI,LT-H} - \pi_0^{PI,LT-C} = L_1^* \left[ \pi_0^{FI,LT-H}(\rho_P, T^*) - \pi_0^{FI,LT-C}(\rho_P, T^*) \right]. \tag{48}$$

*The finite-horizon responses are obtained using the scalar recursions in Appendix D.*

Proposition 6 distinguishes the direct contribution of energy prices to headline inflation from the additional effects generated by monetary policy. Under a headline Taylor rule, an increase in energy prices initially raises the nominal interest rate relative to a core rule, which, for a persistent component, reduces aggregate demand and domestic inflation. However, when the energy price subsequently declines, headline inflation receives a negative contribution from energy prices. A headline rule may therefore lower the policy rate even while domestic inflation remains elevated.

This mechanism becomes particularly relevant when look-through is followed by a headline rule. The central bank accommodates the initial energy price increase during the peg but may respond to its subsequent reversal after the commitment expires. We refer to this mechanism as *asymmetric look-through*. The anticipated future response of policy affects current inflation through the same forward-looking demand channel that operates during the peg.

# 5 The Case for Look-Through Policy

The preceding analysis shows that incomplete information can amplify inflation under look-through policy. We now examine when look-through may nevertheless resemble an active Taylor rule or optimal policy in terms of welfare.

Two mechanisms are particularly important. First, nominal wage rigidity can weaken the transmission from aggregate demand to firms' marginal costs, reducing the inflationary consequences of holding the interest rate fixed. Second, when an energy price shock has little effect on the natural real interest rate, look-through and an active rule may generate similar allocations.

### 5.1 The Role of Wage Rigidity

In the flexible wage benchmark, an expansion in aggregate demand raises real wages and firms' marginal costs, reinforcing inflation. When nominal wages adjust slowly, this feedback weakens.

To illustrate this mechanism, we consider two limiting cases of the general model.

First, suppose domestic prices are flexible but nominal wages remain sticky. In this case, real marginal cost remains constant, and real wages adjust to changes in energy prices. The equilibrium can again be reduced to a three-equation New Keynesian system, with wage inflation replacing core inflation. The relevant feedback from demand to inflation is then governed by the wage Phillips curve, which becomes flatter as wages become more rigid.

Second, consider the limit in which nominal wages are completely rigid. In this case, movements in aggregate demand no longer affect firms' marginal costs independently of domestic prices. Core inflation is therefore determined by the energy price disturbance and is independent of the monetary policy regime. Look-through, Taylor rules, and optimal policy generate identical core inflation responses, although their implications for GDP and welfare may differ.

The effective coefficients $\kappa_w$ and $\sigma_w$ used below are derived in Appendix F. Table 1 summarizes these limiting cases. Formal derivations are provided in Appendix F.

Table 1: Wage Rigidity and the Transmission of Look-Through Policy

| | Flexible wages | Flexible prices<br>Sticky wages | Rigid wages |
|---|---|---|---|
| Inflation margin | Core | Wage | Core |
| Demand-inflation feedback | $\kappa\sigma$ | $\kappa_w\sigma_w$ | 0 |
| Policy dependence of core inflation | Present | Through wage inflation | None |
| Look-through amplification | Policy dependent | Wage-rigidity dependent | Common across regimes |

*Notes:* The table compares the flexible-wage benchmark, the flexible-price/sticky-wage limit, and the completely rigid nominal wage limit. $\kappa_w$ and $\sigma_w$ denote the effective wage Phillips-curve slope and IS coefficient. The flexible-price column concerns wage inflation; core inflation additionally reflects relative energy-price adjustments. Formal coefficient expressions and policy comparisons are provided in Appendix F.

These results suggest that greater nominal wage rigidity can reduce differences in core inflation across monetary policy regimes. However, smaller inflation differences do not necessarily imply smaller welfare differences, since monetary policy continues to affect output and the allocation of resources.

### 5.2 When Does Look-Through Approximate Active Policy?

A second mechanism operates through the natural real interest rate. Recall from Proposition 2 that its response to an energy price shock is proportional to

$$\alpha + \kappa\psi.$$

When this expression is close to zero, the shock has little effect on the natural real interest rate, and holding the nominal interest rate fixed need not generate large deviations from the natural allocation.

The following proposition formalizes this comparison and establishes when look-through may also minimize the welfare loss compared to an active Taylor rule.

**Proposition 7** (When Does Look-Through Work?)**.** *Consider the flexible-wage benchmark under full or incomplete information. Compare look-through followed by a core Taylor rule with an active core Taylor rule, where both rules respond only to current and past core inflation (with or without interest-rate smoothing) and not to GDP ($\phi_y = 0$).*

1. ***Information frictions and welfare.*** *Core inflation and the deviation of GDP from its natural level are proportional to $\alpha + \kappa\psi$. For a fixed policy regime and structural calibration, the welfare loss can be expressed as*

$$\mathcal{L}_j = (\alpha + \kappa\psi)^2 \mathsf{A}_j(\mathcal{A}_j) + 2(\alpha + \kappa\psi)\zeta_q \mathsf{B}_j(\mathcal{A}_j) + \zeta_q^2 \mathsf{C}, \tag{49}$$

   *where $\mathsf{A}_j \geq 0$ and $\mathsf{B}_j$ capture the policy-dependent propagation of perceived persistence, while $\mathsf{C} \geq 0$ is common across regimes.*

   *Information frictions therefore affect welfare through the amplification of equilibrium responses, but need not scale losses uniformly across policies.*

2. ***Policy equivalence.*** *If $\alpha + \kappa\psi = 0$, the natural real interest rate is unchanged and both policies implement*

$$\pi_t = 0, \qquad y_t = y_t^n,$$

   *regardless of the information friction.*

   *Their welfare losses coincide at $\zeta_q^2 \mathsf{C}$, although this allocation need not be efficient when $\zeta_q \neq 0$.*

3. ***Welfare ranking.*** *Define*

$$\Delta\mathsf{A} = \mathsf{A}_{LT}(\mathcal{A}_{LT}) - \mathsf{A}_{TR}(\mathcal{A}_{TR}),$$

$$\Delta\mathsf{B} = \mathsf{B}_{LT}(\mathcal{A}_{LT}) - \mathsf{B}_{TR}(\mathcal{A}_{TR}).$$

   *Suppose $\zeta_q \neq 0$ and $\Delta\mathsf{A} > 0$. Look-through has a lower welfare loss than the active rule if and*

*only if* $\alpha + \kappa\psi$ *lies strictly between zero and*

$$-\frac{2\zeta_q \Delta \mathsf{B}}{\Delta \mathsf{A}}, \tag{50}$$

*Here* $(\mathsf{A}_j, \mathsf{B}_j)$ *depend on the regime's entire inflation and gap paths per unit of* $\alpha + \kappa\psi$*, and the threshold holds them and* $\zeta_q$ *fixed.*

Proposition 7 shows that information frictions affect the welfare ranking through policy-dependent amplification rather than uniformly increasing losses. When $\alpha + \kappa\psi = 0$, look-through and an active core rule implement the same natural allocation regardless of perceived persistence, although this allocation need not be efficient when $\zeta_q \neq 0$. Away from this point, look-through can outperform an active rule if its additional demand accommodation moves output closer to the efficient allocation. The welfare threshold depends on information amplification, highlighting how beliefs about shock persistence influence the case for looking through. We examine these mechanisms quantitatively in the next section.

# 6 Quantitative Analysis

We now examine whether the conditions identified in Section 5 make look-through policy a plausible alternative to conventional or optimal monetary policy. The analysis concentrates on three comparisons: persistent and transitory shocks in the baseline economy, the role of nominal wage rigidity, and energy shocks that lower the natural real interest rate. Additional calibrations and robustness exercises are reported in Appendix I.

## 6.1 Calibration and Policy Comparisons

Table 2 summarizes the quarterly calibration. We set $T^* = 8$ quarters in the baseline calibration. The shock process, look-through horizon, and Taylor-rule parameters follow Bušs and Traficante (2025), while nominal rigidities and markups take conventional values (Erceg et al., 2000). The HtM share is $\mu = 0.3$, the production energy share is $s_E = 0.05$, and the household energy share is $\alpha_C = 0.08$. In the baseline all energy is imported ($\varsigma = 0$). With $\sigma_T/\sigma_P = 6$, the steady-state Kalman gain is $L_1^* = 0.138$, so agents initially assign relatively little weight to persistence.

We compare headline and core Taylor rules, look-through followed by either rule, and optimal policy under commitment and discretion. The baseline has sticky nominal wages ($\xi_w = 0.75$); we subsequently vary wage rigidity. Look-through lasts eight quarters. Each impulse response is generated by an initial 10% increase in the energy price.

Table 2: Baseline calibration (quarterly)

| Parameter | Description | Value |
|---|---|---|
| *Households and fiscal policy* | | |
| $\beta$ | Discount factor | 0.99 |
| $\mu$ | Hand-to-mouth share | 0.30 |
| $\gamma$ | Automatic stabiliser: transfer response to GDP | 0.10 |
| $\varphi$ | Inverse Frisch elasticity | 1.00 |
| $\alpha_C$ | Energy share of household expenditure | 0.08 |
| $\nu$ | Household energy/non-energy elasticity | 0.20 |
| *Production, energy supply and nominal rigidities* | | |
| $s_E$ | Energy cost share in production | 0.05 |
| $\eta$ | Labour–energy elasticity of substitution | 0.50 |
| $\varsigma$ | Share of energy supplied domestically (Section 9) | 0 |
| $\xi_p$ | Calvo price stickiness | 0.75 |
| $\xi_w$ | Calvo wage stickiness (baseline) | 0.75 |
| $\theta_p,\ \theta_w$ | Net price and wage markups | 0.15, 0.15 |
| $\kappa_p,\ \lambda_w$ | Implied price and wage Phillips-curve slopes | 0.0858, 0.0099 |
| *Energy prices and information* | | |
| $\rho_P,\ \rho_T$ | Persistence of the two components | 0.98, 0.10 |
| $\sigma_T/\sigma_P$ | Relative volatility of innovations | 6 |
| *Monetary policy* | | |
| $\rho_i,\ \phi_\pi,\ \phi_x$ | Taylor rule (headline or core inflation) | 0.85, 1.50, 0.00 |
| $T^*$ | Look-through horizon (quarters) | 8 |

### 6.2 Persistent and Transitory Energy Shocks

Figure 2 reports the response to a persistent energy price shock. Although the true shock is persistent, agents initially attribute only 1.38 percentage points of the 10% increase to the persistent component. The resulting underestimation of persistence changes expected energy prices, aggregate demand, and the optimal policy response. The direct energy contribution raises headline inflation by about 3.2 percentage points under every regime, while core inflation and GDP respond differently across policies. Under incomplete information, look-through raises GDP by 0.27% and core inflation by 0.26 percentage points on impact. The Ramsey planner instead adjusts the policy rate to stabilize the welfare relevant trade-off. Real consumption falls in every regime because higher energy prices reduce purchasing power.

Figure 3 shows the transitory shock. Because agents initially mistake part of it for a persistent movement, look-through still produces a prolonged core inflation response even though the observed energy price quickly reverses. Headline inflation turns negative as the price falls back, and a headline Taylor rule subsequently lowers the nominal interest rate. Under the Taylor rules and Ramsey policy, core inflation returns toward target relatively quickly; look-through generates the most persistent response. Thus, incomplete information can make accommodation costly even when the disturbance

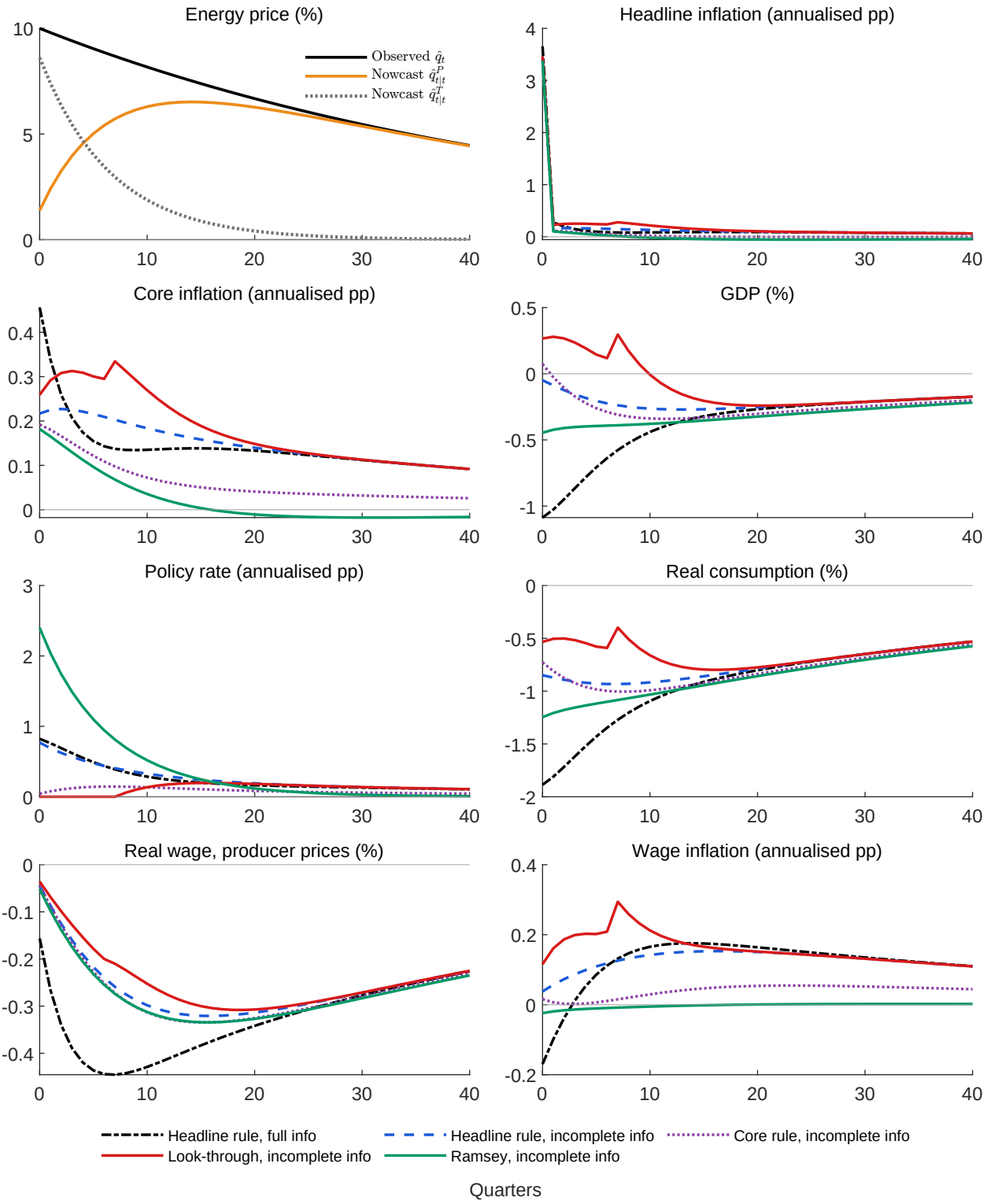



Figure 2: Responses to a 10% persistent energy price shock, baseline economy (sticky wages)

*Notes:* The top-left panel shows the observed energy price and the agents' nowcasts of its components under incomplete information. Inflation, the policy rate and wage inflation in annualised percentage points; GDP, real consumption ($y_t - \alpha_C q_t$) and the real wage in percent. Look-through returns to the headline rule after eight quarters.

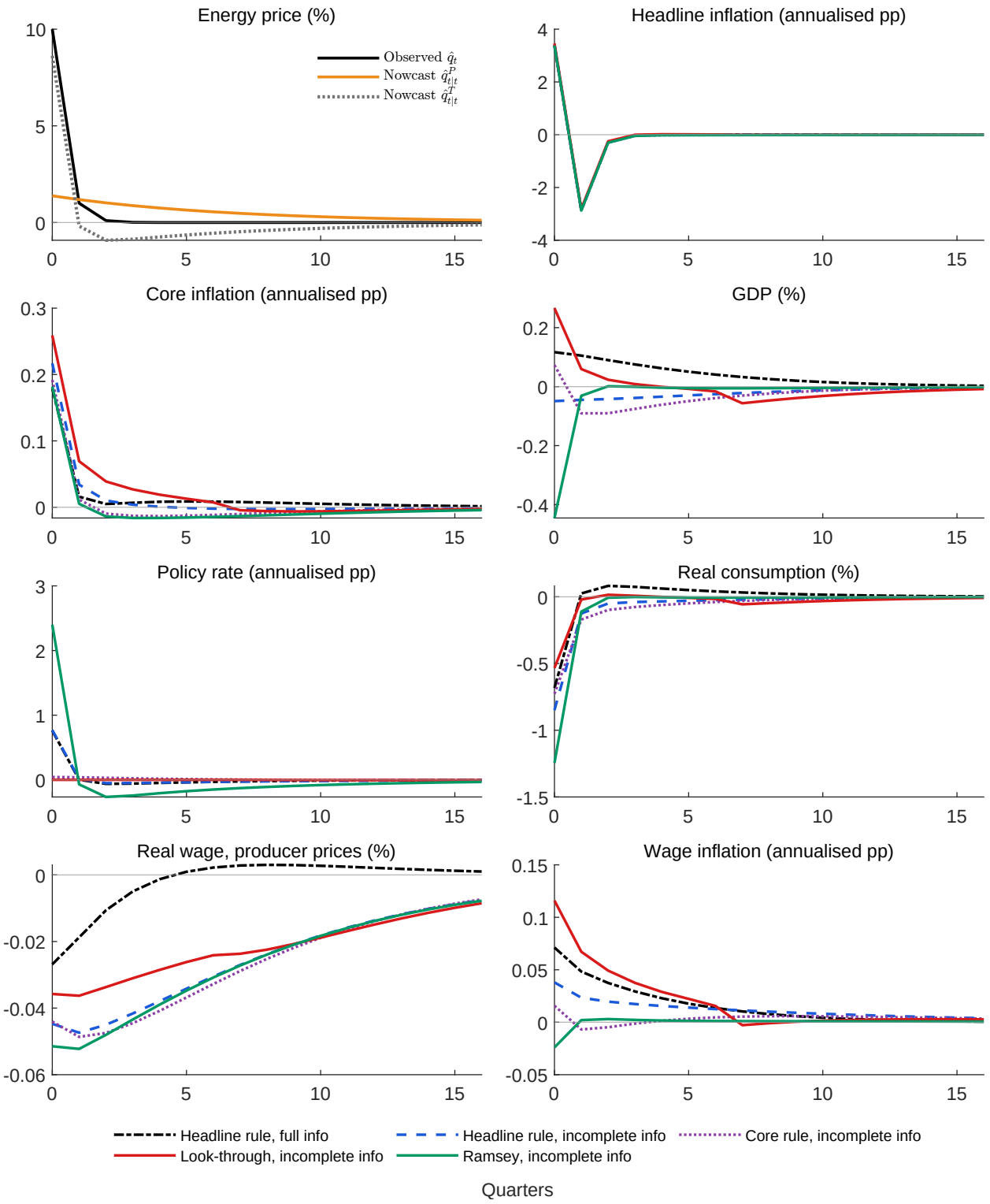



Figure 3: Responses to a 10% transitory energy price shock, baseline economy (sticky wages)

is truly transitory.

The welfare comparisons are reported in Table 3. In the baseline sticky wage economy, look-through is substantially less costly than in the flexible wage benchmark, but remains more costly than optimal commitment. The policy adopted after the peg also matters: returning to a core rule avoids part of the response to the subsequent reversal in headline energy inflation. The table distinguishes losses conditional on each shock from the ex ante loss over the shock distribution; the latter is defined in Appendix I.

Table 3: Welfare losses

| | Flexible wages | | | Fast ($\xi_w = 0.5$) | | | Baseline | | |
|---|---|---|---|---|---|---|---|---|---|
| | P | T | EA | P | T | EA | P | T | EA |
| *A. Welfare loss (basis points)* | | | | | | | | | |
| Headline Taylor rule, FI | 4.56 | 1.49 | 0.58 | 11.3 | 0.92 | 0.44 | 24.7 | 0.87 | 0.56 |
| Headline Taylor rule, PI | 5.07 | 0.75 | 0.32 | 7.59 | 0.47 | 0.24 | 22.1 | 0.52 | 0.41 |
| Core Taylor rule, PI | 3.67 | 1.42 | 0.55 | 2.56 | 0.60 | 0.24 | 4.25 | 0.56 | 0.24 |
| Look-through, then headline rule, PI | 236.2 | 73.2 | 28.7 | 32.2 | 4.21 | 1.84 | 37.2 | 1.47 | 0.90 |
| Look-through, then core rule, PI | 60.6 | 18.3 | 7.21 | 9.42 | 1.71 | 0.71 | 7.66 | 0.85 | 0.38 |
| Ramsey commitment, FI | 0.093 | 1.4e-03 | 1.4e-03 | 1.47 | 0.19 | 0.083 | 1.77 | 0.17 | 0.079 |
| Ramsey commitment, PI | 0.074 | 1.8e-03 | 1.4e-03 | 1.00 | 0.23 | 0.092 | 1.08 | 0.21 | 0.088 |
| Discretion, PI | 0.19 | 3.1e-03 | 3.0e-03 | 0.99 | 0.23 | 0.093 | 1.11 | 0.22 | 0.089 |
| *B. Loss ratios (PI unless stated)* | | | | | | | | | |
| Look-through (headline) / headline rule | 46.6 | 98.1 | 90.0 | 4.24 | 8.99 | 7.52 | 1.69 | 2.80 | 2.20 |
| Look-through (core) / core rule | 16.5 | 12.9 | 13.1 | 3.68 | 2.84 | 2.93 | 1.80 | 1.52 | 1.57 |
| Core rule / headline rule | 0.73 | 1.91 | 1.72 | 0.34 | 1.28 | 0.99 | 0.19 | 1.06 | 0.59 |
| Look-through (headline) / Ramsey | 3.2e+03 | 4.0e+04 | 2.1e+04 | 32.3 | 18.5 | 20.0 | 34.5 | 6.85 | 10.2 |
| Ramsey: PI / FI | 0.80 | 1.29 | 0.97 | 0.68 | 1.20 | 1.10 | 0.61 | 1.25 | 1.11 |

*Notes:* Panel A: welfare loss in basis points of one quarter's steady-state consumption, from (12). P and T: conditional on a 10% persistent or transitory shock. EA: ex ante, for one quarter's innovations with $\sigma_P = 1\%$ and $\sigma_T = 6\%$. FI: full information; PI: incomplete information. Panel B: ratios of losses. Loss levels are comparable within, not across, wage settings (Appendix I).

### 6.3 The Role of Nominal Wage Rigidity

Figure 4 compares flexible wages, faster wage adjustment ($\xi_w = 0.5$), and the baseline sticky-wage economy ($\xi_w = 0.75$). With flexible wages, look-through produces impact core inflation of 3.75 percentage points, 12.55 times the headline-rule response. The corresponding ratio declines to 2.13 with faster wage pass-through and 1.19 in the baseline.

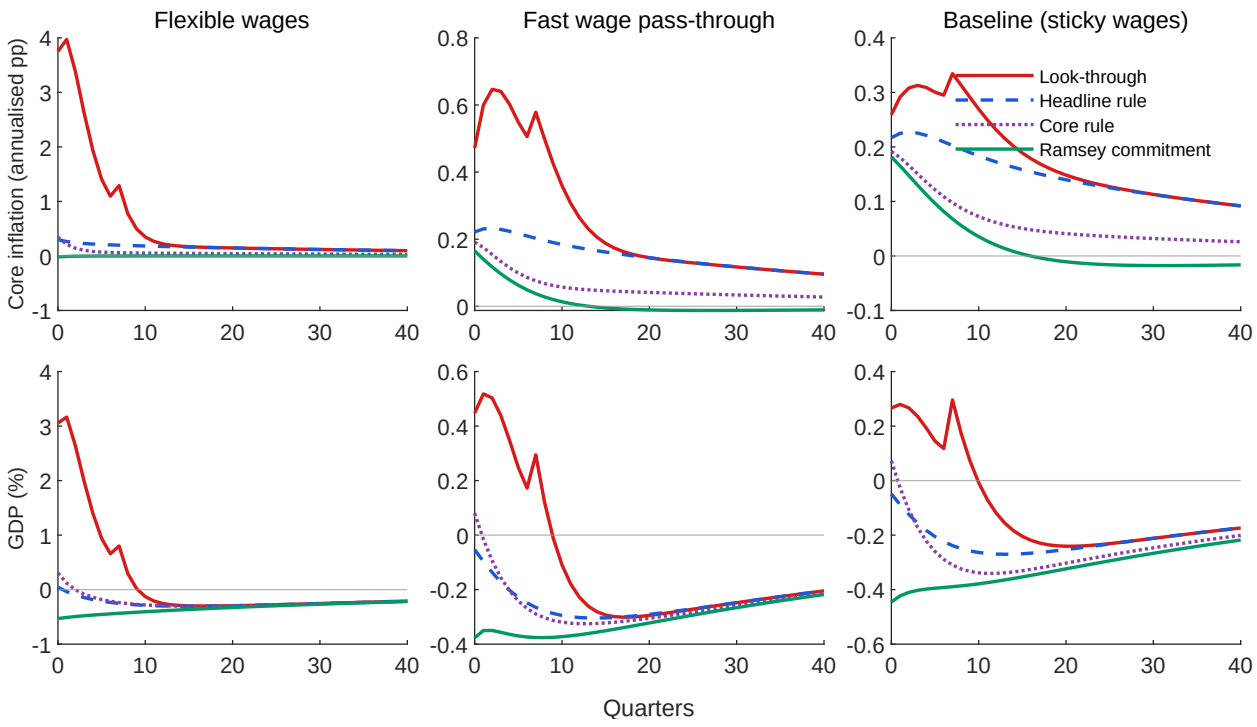



Figure 4: Persistent shock under incomplete information: the role of wage setting

*Notes:* Responses to a 10% persistent shock under incomplete information. Core inflation in annualised percentage points; GDP in percent.

The mechanism follows directly from the price Phillips curve:

$$\pi_0^H = \underbrace{\alpha_C q_0}_{\text{first round}} + \underbrace{\kappa_p s_E q_0}_{\text{energy cost}} + \underbrace{\kappa_p s_C w_0}_{\text{wage channel}} + \underbrace{\beta \mathbb{E}_0 \pi_1}_{\text{expectations}} . \tag{51}$$

The first two contributions are common across policies and wage settings. Wage rigidity weakens the effect of demand on current marginal costs and dampens the expectations feedback generated by the interest-rate peg. The detailed decomposition appears in Table 6 in Appendix I. Importantly, similar core inflation responses need not imply similar welfare outcomes: the policies can still generate different paths for GDP and consumption.

### 6.4 Keynesian Energy Shocks

We finally consider an economy with domestic energy rents. Increasing the domestic share of energy supply $\varsigma$ raises the rents accruing to Ricardian households. Part of this windfall is saved rather than immediately spent, weakening current aggregate demand. Proposition 2 shows that the energy shock becomes Keynesian when it lowers the natural real interest rate, or equivalently when $b \equiv \alpha + \kappa\psi < 0$.

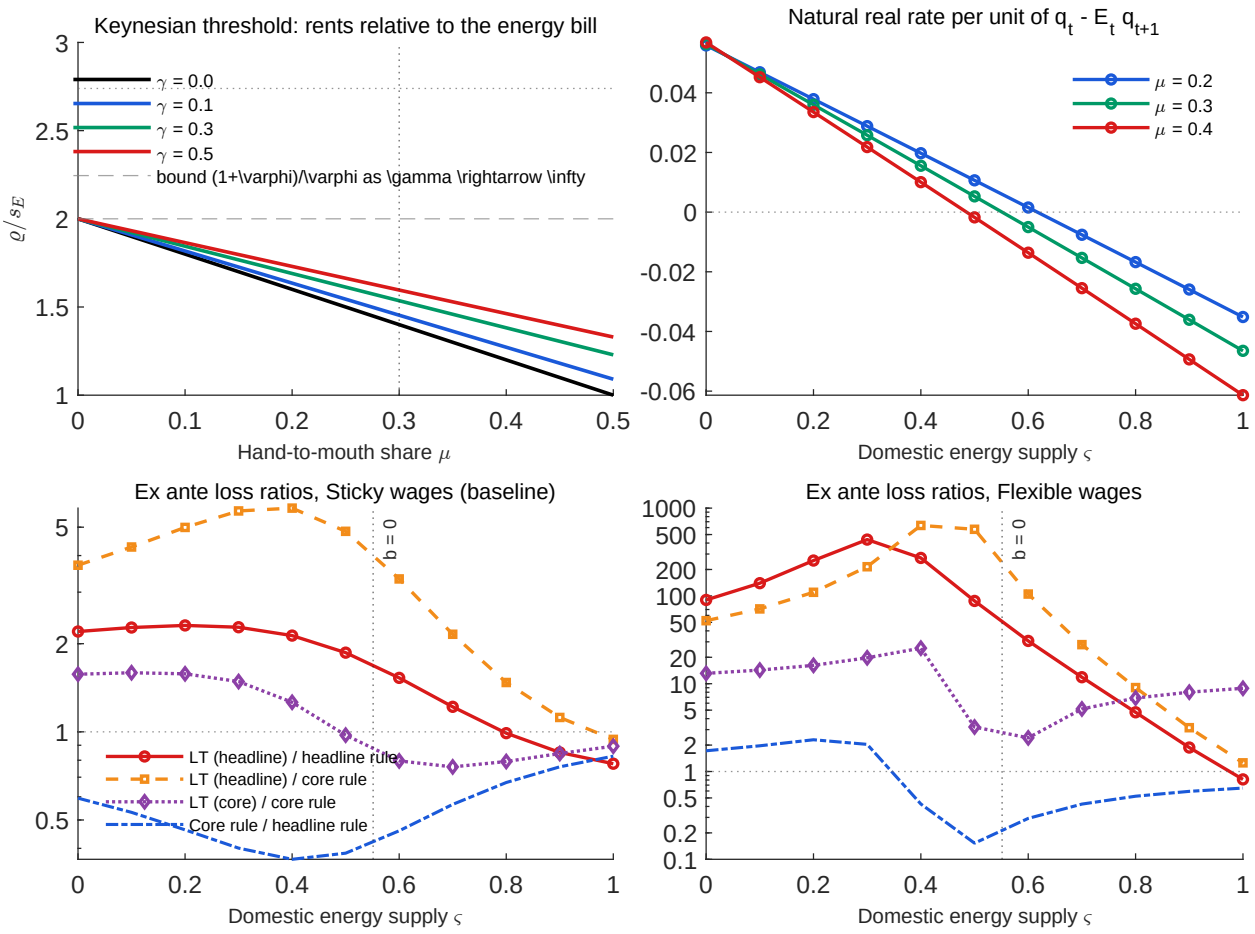



Figure 5: Keynesian energy shocks

*Notes:* Top left: threshold of Proposition 2 for the energy rents relative to the production energy bill, $\varrho/s_E$, as a function of the HtM share for several transfer coefficients; the shock is Keynesian above the line. The dashed line is the bound as $\gamma \to \infty$; the dotted horizontal line is the rent ratio when the economy supplies all its energy ($\varsigma = 1$, $\alpha_C = 0.08$). Top right: natural-rate coefficient $b/(\kappa\sigma)$ of (19) against the share of energy supplied domestically. Bottom: ex ante loss ratios under incomplete information; "LT (headline)" returns to the headline rule after the peg.

Table 4: Keynesian energy shocks: domestic energy supply and the case for looking through

| | | | | Sticky wages | | | Flexible wages | | |
|---|---|---|---|---|---|---|---|---|---|
| $\varsigma$ | $\varrho/s_E$ | $10^3 b$ | $b/\mathcal{K}$ | LT/H | LT/C | C/H | LT/H | LT/C | C/H |
| 0.0 | 0.00 | 13.68 | 0.056 | 2.20 | 3.71 | 0.59 | 90.0 | 52.2 | 1.72 |
| 0.2 | 0.51 | 8.88 | 0.036 | 2.31 | 4.99 | 0.46 | 253 | 110 | 2.30 |
| 0.4 | 1.04 | 3.90 | 0.016 | 2.13 | 5.81 | 0.37 | 271 | 635 | 0.43 |
| 0.6 | 1.59 | −1.28 | −0.005 | 1.53 | 3.33 | 0.46 | 30.7 | 105 | 0.29 |
| 0.8 | 2.15 | −6.67 | −0.026 | 0.99 | 1.47 | 0.67 | 4.73 | 9.03 | 0.52 |
| 1.0 | 2.74 | −12.27 | −0.046 | 0.78 | 0.94 | 0.83 | 0.81 | 1.26 | 0.65 |

*Notes:* $\varsigma$: share of steady-state energy use supplied by a domestic endowment owned by Ricardian households. $\varrho/s_E$: rents relative to the production energy bill. $b = \alpha + \kappa\psi$ and $b/\mathcal{K}$, with $\mathcal{K} \equiv \kappa\sigma$: Proposition 2. Ex ante loss ratios under incomplete information: LT/H look-through (then headline rule) over the headline rule; LT/C look-through (then headline rule) over the core rule; C/H core over headline rule.

Figure 5 and Table 4 vary $\varsigma$ and report the resulting natural rate response and ex ante welfare comparisons. The Keynesian threshold occurs at $\varsigma = 0.55$, corresponding to domestic rents of $\varrho/s_E = 1.45$ relative to the production energy bill. With all energy supplied domestically, the structural coefficient is $b = -0.0123$, so the shock lowers the natural interest rate.

Near the threshold, look-through followed by a core rule approximates the core Taylor rule in the flexible-wage benchmark, as predicted by Proposition 7. With sticky wages, the welfare ranking also changes as domestic rents increase. In the strongly Keynesian case, the headline rule raises the policy rate in response to the first-round CPI increase despite a decline in the natural rate. The Ramsey planner instead cuts its rate, which moves by $-1.52$ percentage points, while look-through holds the rate fixed. Look-through can consequently resemble the direction of optimal policy more closely than a headline rule, although this does not establish that it is optimal.

These experiments suggest that the case for look-through is strongest when the underlying shock creates a sufficiently large demand shortfall and nominal wage rigidity limits the inflationary feedback from policy accommodation. The result is conditional on the economy's structure and on the policy rule that follows the peg. Appendix I examines the robustness of these comparisons to changes in energy shares, automatic stabilizers, shock beliefs, and the look-through horizon.

# 7 Conclusion

We study look-through policy when neither the central bank nor the public can tell persistent from transitory energy price movements. Incomplete information enters every policy regime in the same way, through a single posterior weight on persistence. Regimes differ in the shock they scale and in how they propagate that perceived persistence: commitment propagates it less than discretion, and look-through most of all, with an amplification that grows with the horizon and that rises further when the peg is followed by a rule that responds to headline inflation. We derive the welfare criterion from household utility: the planner stabilises core and wage inflation and looks through

the first-round effect of energy on headline inflation, while heterogeneity and wage rigidity, not the energy shock as such, create the stabilisation trade-off.

The central message is that wage rigidity determines whether looking through is costly. When wages pass through quickly, the demand stimulus of a fixed policy rate feeds back into marginal cost, and look-through is far inferior to an active rule. When wages are rigid, inflation is essentially independent of the policy regime, and look-through costs only output. Look-through comes close to an active rule when the energy shock leaves the natural rate nearly unchanged, and, followed by a headline rule, beats Taylor rules only when the shock is strongly Keynesian, which requires large energy rents that accrue to households who save them. Automatic stabilisers reduce the cost of looking through when energy is imported, but with sticky wages they weaken the case for it when the shock is Keynesian. In welfare terms look-through remains well short of optimal policy, which leans against the belief-driven movement in the natural rate. With sticky wages, a central bank that looks through should return to a rule that responds to core inflation, and a core rule dominates a headline rule throughout.

The model delivers a testable prediction. Holding beliefs about persistence fixed, the inflation cost of a look-through episode is increasing in the speed of wage pass-through, and it is lower in economies where the shock is strongly Keynesian, because they produce all or nearly all of their own energy and leave the rents with households who save them. Natural extensions are an open-economy treatment of the energy bill, non-unit intertemporal elasticities, heterogeneous energy shares across households, beliefs that are learned rather than filtered with a steady-state gain, and the effective lower bound.

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# A Structural Environment and Equilibrium Derivations

This appendix provides the household and firm optimality conditions, aggregate resource constraints, and the derivation of the log-linear equilibrium presented in Section 2.

Throughout, uppercase variables denote levels, while lowercase variables denote log deviations from steady state, except inflation and interest rates. We distinguish gross output $Y_t$ from GDP $V_t$. The log deviation of GDP, $v_t$, corresponds to $y_t$ in the main text; outside this appendix, including in the welfare appendix, $y_t$ denotes GDP. We write $c_t^h \equiv \log(X_t^h/\bar{X}^h)$ for the log deviation of household expenditure in units of the domestic good.

## A.1 Steady-State Normalizations

Normalize steady-state gross output and the relative energy price to one. With subsidies removing steady-state markups, $\bar{w} = \overline{mc} = 1$, $\bar{N} = s_C$, and $\bar{E}^P = s_E$. Let $\varsigma$ denote the fraction of steady-state energy use supplied domestically. Since $\bar{X} = s_C + \varrho$ and household energy use is $\alpha_C \bar{X}$, the rent share satisfies

$$\varrho = \frac{\varsigma(s_E + \alpha_C s_C)}{1 - \varsigma\alpha_C}. \tag{52}$$

The steady-state transfer $\bar{\mathcal{T}} = \mu\varrho$ equalizes expenditure between household types. The corresponding preference scale is $\chi = 1/(s_C^{\varphi} s_x)$.

## A.2 Households

The economy is populated by a unit continuum of households, consisting of Ricardian households of measure $1 - \mu$ and hand-to-mouth households of measure $\mu$.

Both household types have period utility

$$U_t^h = \log \mathcal{C}_t^h - \chi \frac{N_t^{1+\varphi}}{1+\varphi}, \qquad h \in \{R, H\}. \tag{53}$$

Composite consumption combines domestic goods $D_t^h$ and energy $E_t^{C,h}$:

$$\mathcal{C}_t^h = \left[(1-\alpha_C)^{1/\nu}(D_t^h)^{\frac{\nu-1}{\nu}} + \alpha_C^{1/\nu}(E_t^{C,h})^{\frac{\nu-1}{\nu}}\right]^{\frac{\nu}{\nu-1}}. \tag{54}$$

Let $P_t$ denote the domestic goods price, $Q_t$ the nominal energy price, and $P_t^C$ the consumer price index. Expenditure minimization implies

$$P_t^C = \left[(1-\alpha_C)P_t^{1-\nu} + \alpha_C Q_t^{1-\nu}\right]^{\frac{1}{1-\nu}}, \tag{55}$$

with corresponding demands

$$D_t^h = (1-\alpha_C)\left(\frac{P_t}{P_t^C}\right)^{-\nu}\mathcal{C}_t^h, \tag{56}$$

$$E_t^{C,h} = \alpha_C\left(\frac{Q_t}{P_t^C}\right)^{-\nu}\mathcal{C}_t^h. \tag{57}$$

Define household expenditure in units of domestic goods as

$$X_t^h \equiv D_t^h + \frac{Q_t}{P_t}E_t^{C,h} = \frac{P_t^C}{P_t}\mathcal{C}_t^h. \tag{58}$$

With log utility and homothetic preferences, the marginal utility of nominal expenditure is $1/(P_t X_t^h)$. Consequently, Ricardian intertemporal decisions can be expressed in terms of total expenditure.

**Ricardian households.** Ricardian households trade one-period nominal bonds, receive firm profits and domestic energy rents, and pay lump-sum taxes. Their optimal expenditure decision satisfies

$$\frac{1}{P_t X_t^R} = \beta R_t \mathbb{E}_t\left[\frac{1}{P_{t+1}X_{t+1}^R}\right], \tag{59}$$

where $R_t$ denotes the gross nominal interest rate.

Log-linearization gives

$$c_t^R = \mathbb{E}_t c_{t+1}^R - (i_t - \mathbb{E}_t\pi_{t+1}). \tag{60}$$

The use of total expenditure is important: under logarithmic utility, changes in the composition of expenditure between domestic goods and energy do not independently alter the intertemporal Euler equation.

**Hand-to-mouth households.** HtM households cannot save or borrow and consume their current disposable income:

$$X_t^H = \frac{W_t}{P_t}N_t + \frac{\mathcal{T}_t}{\mu}, \tag{61}$$

where $\mathcal{T}_t$ is aggregate real transfers to HtM households.

Labour is allocated equally across households through a union, so that $N_t$ denotes hours per household for both types.

**Headline inflation.** Normalizing the steady-state relative energy price to unity, the consumer price index satisfies, to first order,

$$\log(P_t^C/P_t) - \log(\bar{P}^C/\bar{P}) = \alpha_C q_t. \tag{62}$$

Headline and domestic inflation are therefore related by

$$\pi_t^H = \pi_t + \alpha_C(q_t - q_{t-1}). \tag{63}$$

Similarly, composite consumption satisfies

$$\log \mathcal{C}_t^h - \log \bar{\mathcal{C}}^h = c_t^h - \alpha_C q_t. \tag{64}$$

Hence, the household energy basket directly affects purchasing power and headline inflation, even when its composition does not independently affect the expenditure Euler equation.

### A.3 Firms and Energy

Intermediate goods firms produce differentiated domestic goods using labour and energy:

$$Y_t(i) = \left[(1-\omega_E)^{1/\eta} N_t(i)^{\frac{\eta-1}{\eta}} + \omega_E^{1/\eta} E_t^P(i)^{\frac{\eta-1}{\eta}}\right]^{\frac{\eta}{\eta-1}}. \tag{65}$$

Cost minimization implies the input demand condition

$$\frac{E_t^P(i)}{N_t(i)} = \frac{\omega_E}{1-\omega_E}\left(\frac{W_t/P_t}{Q_t/P_t}\right)^{\eta}. \tag{66}$$

The corresponding real unit cost is

$$MC_t = \left[(1-\omega_E)(W_t/P_t)^{1-\eta} + \omega_E(Q_t/P_t)^{1-\eta}\right]^{\frac{1}{1-\eta}}. \tag{67}$$

Let $s_C$ and $s_E$ denote the steady-state labour and energy cost shares, respectively, with $s_C + s_E = 1$. To first order,

$$mc_t = s_C w_t + s_E q_t. \tag{68}$$

Firms reset prices with probability $1-\xi_p$. With the steady-state markup offset by a production subsidy, the New Keynesian Phillips curve is

$$\pi_t = \beta \mathbb{E}_t \pi_{t+1} + \kappa_p(s_C w_t + s_E q_t), \tag{69}$$

where

$$\kappa_p = \frac{(1-\beta\xi_p)(1-\xi_p)}{\xi_p}. \tag{70}$$

Energy prices thus enter domestic inflation through firms' marginal costs. The real wage also adjusts endogenously, so the total effect of energy prices on inflation need not coincide with their direct cost contribution.

## A.4 GDP, Energy Rents, and Fiscal Transfers

Let $\bar{E}$ denote an exogenous domestic energy endowment. Balanced trade implies the aggregate resource constraint

$$Y_t = D_t + \frac{Q_t}{P_t}(E_t^C + E_t^P - \bar{E}), \tag{71}$$

where $D_t$ and $E_t^C$ denote aggregate household consumption of domestic goods and energy.

Aggregate household expenditure is therefore

$$X_t = Y_t - \frac{Q_t}{P_t}E_t^P + \frac{Q_t}{P_t}\bar{E}. \tag{72}$$

Define GDP as value added,

$$V_t \equiv Y_t - \frac{Q_t}{P_t}E_t^P + \frac{Q_t}{P_t}\bar{E}. \tag{73}$$

Thus $X_t = V_t$. Domestic energy rents accrue to Ricardian households.

Let $\varrho$ denote steady-state domestic energy rents relative to gross output, and define

$$s_x = s_C + \varrho, \qquad c = \frac{s_C}{s_x}, \qquad \theta_n = \frac{s_E - \varrho}{s_C}. \tag{74}$$

Here, $s_x$ is the steady-state ratio of GDP to gross output, and $c$ measures labour income relative to GDP.

Combining firm input demands and the GDP identity gives

$$n_t = \frac{v_t}{c} + \theta_n q_t. \tag{75}$$

Employment therefore depends on GDP and the net energy cost borne by the domestic economy. The effect of higher energy prices on labour requirements is weaker when domestic energy rents are larger.

Fiscal transfers satisfy

$$\frac{\mathcal{T}_t - \bar{\mathcal{T}}}{\bar{Y}} = -\gamma v_t. \tag{76}$$

As in the main text, transfers are financed through lump-sum taxes on Ricardian households. We assume the steady-state transfer $\bar{\mathcal{T}} = \mu\bar{Q}\bar{E}/\bar{P}$, which equalizes steady-state expenditure across household types.

Defining $g = \gamma/s_x$, the log-linear HtM expenditure constraint becomes

$$c_t^H = c(w_t + n_t) - \frac{g}{\mu}v_t. \tag{77}$$

Using the employment relation gives

$$c_t^H = \left(1 - \frac{g}{\mu}\right)v_t + cw_t + c\theta_n q_t. \tag{78}$$

Aggregate expenditure is

$$v_t = (1-\mu)c_t^R + \mu c_t^H. \tag{79}$$

Substituting HtM expenditure into this identity yields

$$c_t^R = a_y v_t + a_w w_t + a_q q_t, \tag{80}$$

where

$$a_y = 1 + \frac{g}{1-\mu}, \qquad a_w = -\frac{\mu c}{1-\mu}, \qquad a_q = -\frac{\mu c \theta_n}{1-\mu}. \tag{81}$$

This relationship is the key aggregation step. Because HtM expenditure depends on contemporaneous income and transfers, Ricardian expenditure differs from aggregate GDP. The coefficients $a_y, a_w, a_q$ capture this distributional channel.

### A.5 Nominal Wage Setting

Competitive labour packers aggregate differentiated labour services with elasticity $\varepsilon_w$. Nominal wages are reset with probability $1-\xi_w$.

Under logarithmic utility, the Ricardian marginal rate of substitution in domestic goods is

$$MRS_t^R = \chi N_t^{\varphi} X_t^R. \tag{82}$$

The real-wage gap is therefore

$$mrs_t^R - w_t = c_t^R + \varphi n_t - w_t. \tag{83}$$

Substituting (75) and (80),

$$mrs_t^R - w_t = m_y v_t + m_w w_t + m_q q_t, \tag{84}$$

where

$$m_y = a_y + \frac{\varphi}{c}, \qquad m_w = a_w - 1, \qquad m_q = a_q + \varphi\theta_n. \tag{85}$$

Calvo wage setting implies

$$\pi_t^w = \beta \mathbb{E}_t \pi_{t+1}^w + \lambda_w (m_y v_t + m_w w_t + m_q q_t), \tag{86}$$

where

$$\lambda_w = \frac{(1-\beta\xi_w)(1-\xi_w)}{\xi_w(1+\varphi\varepsilon_w)}. \tag{87}$$

The evolution of the real wage satisfies

$$w_t = w_{t-1} + \pi_t^w - \pi_t. \tag{88}$$

Equations (60), (69), (86), and (88), together with the aggregation identity (80), characterize the log-linear equilibrium under sticky prices and wages.

### A.6 Flexible-Wage Reduction

Under flexible wages, the wage markup gap vanishes:

$$m_y v_t + m_w w_t + m_q q_t = 0. \tag{89}$$

The real wage therefore satisfies

$$w_t = \omega_y v_t + \omega_q q_t, \tag{90}$$

where

$$\omega_y = -\frac{m_y}{m_w}, \qquad \omega_q = -\frac{m_q}{m_w}. \tag{91}$$

Substituting the flexible-wage relation into Ricardian expenditure gives

$$c_t^R = A_y v_t + A_q q_t, \tag{92}$$

where

$$A_y = a_y + a_w \omega_y, \qquad A_q = a_q + a_w \omega_q. \tag{93}$$

The Ricardian Euler equation then implies

$$v_t = \mathbb{E}_t v_{t+1} - \frac{1}{A_y}(i_t - \mathbb{E}_t \pi_{t+1}) - \frac{A_q}{A_y}(q_t - \mathbb{E}_t q_{t+1}). \tag{94}$$

Defining

$$\sigma = \frac{1}{A_y}, \qquad \psi = -\frac{A_q}{A_y}, \tag{95}$$

the IS curve becomes

$$v_t = \mathbb{E}_t v_{t+1} - \sigma(i_t - \mathbb{E}_t \pi_{t+1}) + \psi(q_t - \mathbb{E}_t q_{t+1}). \tag{96}$$

Likewise, substituting the flexible-wage condition into the price Phillips curve yields

$$\pi_t = \beta \mathbb{E}_t \pi_{t+1} + \kappa v_t + \alpha q_t, \tag{97}$$

where

$$\kappa = \kappa_p s_C \omega_y, \qquad \alpha = \kappa_p(s_E + s_C \omega_q). \tag{98}$$

For completeness, define

$$\Delta = 1 - \mu(1 - c), \qquad D = 1 - \mu(1 + \varphi) + g. \tag{99}$$

The IS coefficients simplify to

$$\sigma = \frac{\Delta}{D}, \qquad \psi = \frac{\mu c \theta_n (1+\varphi)}{D}. \tag{100}$$

The real-wage coefficients can be written as

$$\omega_y = \frac{1 - \mu + g + \varphi(1-\mu)/c}{\Delta}, \tag{101}$$

and

$$\omega_q = \frac{\theta_n[\varphi(1-\mu) - \mu c]}{\Delta}. \tag{102}$$

These expressions, together with the definitions of $\kappa$ and $\alpha$, provide the mapping from structural parameters to the four coefficients of the reduced New Keynesian system.

**Imported-energy benchmark.** When all energy is imported, $\varrho = 0$, so $c = 1$ and $\theta_n = s_E/s_C$. Consequently,

$$\sigma = \frac{1}{D}, \qquad \psi = \frac{\mu(s_E/s_C)(1+\varphi)}{D}, \tag{103}$$

and

$$\alpha = \kappa_p s_E (1+\varphi)(1-\mu), \tag{104}$$

where $D = 1 - \mu(1+\varphi) + g$.

In this benchmark, the energy-demand coefficient is positive whenever $D > 0$ and $\mu > 0$; it is zero with a representative agent ($\mu = 0$). More generally, domestic energy rents can alter the sign of the demand effect.

The elasticity of substitution between labour and energy, $\eta$, does not appear in these first-order coefficients conditional on steady-state cost shares. It nevertheless affects the allocation of production inputs and the second-order welfare approximation.

This completes the derivation of the two-equation New Keynesian system used in the analytical sections.

## A.7 Proof of the Keynesian Energy-Shock Condition

Under flexible prices, $s_C w_t + s_E q_t = 0$, and natural GDP satisfies $y_t^n = -(\alpha/\kappa) q_t$. Substituting this allocation into the IS curve yields

$$r_t^n = \frac{\alpha + \kappa\psi}{\kappa\sigma}(q_t - \mathbb{E}_t q_{t+1}). \tag{105}$$

Substituting the structural coefficients from (100) and the closed forms for $\omega_y$ and $\omega_q$ derived from (91), with $D = 1 - \mu(1+\varphi) + g$, gives

$$\alpha + \kappa\psi = \frac{\kappa_p}{D}\left[D s_E + \varphi(1+g)(s_E - \varrho)\right]. \tag{106}$$

Since $\Delta = 1 - \mu(1-c) > 1 - \mu > 0$ always, and $D > 0$ is equivalent to $\sigma > 0$ (a non-inverted IS curve), the natural real rate falls after a mean-reverting energy-price increase precisely when

$$\varrho\varphi(1+g) > s_E(1+\varphi)(1-\mu+g), \tag{107}$$

which is condition (21). The threshold is relaxed by a larger hand-to-mouth share and tightened by stronger automatic stabilization, holding the other primitives fixed. As $g \to \infty$, the limiting rent-to-cost threshold is $(1+\varphi)/\varphi$.

# B Information Structure and Kalman Filtering

The information structure is the same as in Bušs and Traficante (2025), which follows Erceg and Levin (2003) and Erceg et al. (2024). We state it in full.

**State space.** Let $\xi_t = (\hat{q}_t^P, \hat{q}_t^T)'$. The state and observation equations are

$$\xi_{t+1} = F\xi_t + Q\epsilon_{t+1}, \qquad \hat{q}_t = H'\xi_t, \qquad F = \operatorname{diag}(\rho_P, \rho_T), \quad Q = \operatorname{diag}(\sigma_P, \sigma_T), \quad H = (1,1)',$$

with $\epsilon_{t+1} = (\epsilon_{t+1}^P, \epsilon_{t+1}^T)'$ independent standard normal. The restrictions $\rho_P > \rho_T$ and $\sigma_T > \sigma_P$ identify the components: persistent shocks are more durable but less volatile.

**The Kalman filter.** All agents, including the central bank, share the information set $\mathcal{I}_t = \{\hat{q}_s : s \le t\}$ and the model. The minimum mean-squared-error nowcast $\hat{\xi}_{t|t} = \mathbb{E}[\xi_t \mid \mathcal{I}_t]$ satisfies the recursions

$$\hat{\xi}_{t|t} = \hat{\xi}_{t|t-1} + L_t\big(\hat{q}_t - H'\hat{\xi}_{t|t-1}\big), \qquad L_t = P_{t|t-1}H(H'P_{t|t-1}H)^{-1}, \qquad \hat{\xi}_{t+1|t} = F\hat{\xi}_{t|t},$$

$$P_{t+1|t} = F\big[P_{t|t-1} - P_{t|t-1}H(H'P_{t|t-1}H)^{-1}H'P_{t|t-1}\big]F' + QQ'.$$

Because the observation is noiseless, $H'L_t = 1$: the nowcasts of the two components add up to the observed price.

**Steady state.** We assume the filter has converged before the shock arrives. The steady-state one-step-ahead covariance $P^*$ is the fixed point of the Riccati equation $P^* = F[P^* - P^*H(H'P^*H)^{-1}H'P^*]F' + QQ'$, and the steady-state gain is $L = P^*H(H'P^*H)^{-1} = (L_1^*, 1-L_1^*)'$, with

$$L_1^* = \frac{P_{11}^* + P_{12}^*}{P_{11}^* + 2P_{12}^* + P_{22}^*} \in (0,1).$$

Given the persistences, the gain depends only on the relative volatility $\sigma_T/\sigma_P$ (the Riccati equation is homogeneous in $QQ'$), and it falls as that ratio rises: the noisier the price, the less weight new information gets as evidence of persistence. At our persistences it exceeds one half only when the

transitory component is less than about 40 percent more volatile than the persistent one. At our calibration $L_1^* = 0.138$ (0.139 with $\rho_T = 0$); in Table 7 it ranges from 0.08 to 0.48.

**Beliefs after a shock.** Consider an economy at rest, $\hat{\xi}_{-1|-1} = 0$, hit by a shock $\hat{q}_0$. On impact $\hat{q}^P_{0|0} = L_1^* \hat{q}_0$ and $\hat{q}^T_{0|0} = (1 - L_1^*)\hat{q}_0$, whatever the true composition of the shock. Agents forecast $\mathbb{E}_0\, \hat{q}_k = \rho_P^k L_1^* \hat{q}_0 + \rho_T^k (1 - L_1^*)\hat{q}_0$. Thereafter they revise the nowcasts with each observation. After a persistent shock the observed price decays slowly and the persistent nowcast rises towards the truth over several years (Figure 2). After a transitory shock the price falls back quickly and the transitory nowcast absorbs the movement (Figure 3).

**The look-through decision.** The central bank's posterior weight on persistence on impact is $\hat{q}^P_{0|0}/\hat{q}_0 = L_1^*$ for every shock, so the look-through criterion of Bušs and Traficante (2025), a weight below one half, is the same for persistent and transitory shocks: the central bank looks through every shock if $L_1^* < 1/2$, and none otherwise. All belief scenarios we consider satisfy $L_1^* < 1/2$.

**Full and incomplete information.** Under full information the components are observed and $\hat{\xi}_{t|t} = \xi_t$. Under incomplete information decision rules are those of the full-information model evaluated at the nowcasts (certainty equivalence), and expectations of future energy prices use $F\hat{\xi}_{t|t}$. The replication package verifies that the steady-state gain minimises the variance of the nowcast error and recomputes all paths with the re-solve algorithm of Bušs and Traficante (2025), in which agents solve a perfect-foresight problem each period for their updated expected path.

### B.1 Proof of Posterior Weighting

For an economy initially at rest, the Kalman filter implies

$$\mathbb{E}_0 q_k = \left[ L_1^* \rho_P^k + (1 - L_1^*)\rho_T^k \right] q_0. \tag{108}$$

Under a fixed linear monetary policy regime with the same predetermined state and policy commitment, impact equilibrium outcomes are linear in the expected energy-price path. Superposition therefore yields the posterior-weighting result. This argument also applies to linear-quadratic optimal policy under certainty equivalence; see Svensson and Woodford (2003).

## C The welfare approximation

This appendix derives the second-order welfare criterion in Section 3. We first consider the general economy with sticky prices and wages, and then derive the flexible-wage criterion used in the analytical policy exercises.

**Household welfare and expenditure.** Period utilitarian welfare is

$$\mathcal{W}_t = (1-\mu)\log \mathcal{C}_t^R + \mu \log \mathcal{C}_t^H - \frac{\chi}{1+\varphi}\int_0^1 N_{j,t}^{1+\varphi} dj. \tag{109}$$

Recall that household composite consumption satisfies

$$\log \mathcal{C}_t^h = \log X_t^h - \log(P_t^C/P_t).$$

The consumer price index enters utility additively. Because the real energy price is exogenous, its direct contribution to utility is independent of monetary policy. Accordingly, the household energy basket does not independently affect the welfare criterion, except through domestic energy rents.

Aggregate expenditure satisfies

$$X_t = (1-\mu)X_t^R + \mu X_t^H.$$

Around the steady state with equal expenditure across household types, a second-order expansion gives

$$(1-\mu)c_t^R + \mu c_t^H = y_t - \frac{1}{2}\mu(1-\mu)(c_t^H - c_t^R)^2 + \text{t.i.p.}, \tag{110}$$

where t.i.p. denotes terms independent of policy.

Hence, differences in expenditure across household types generate an additional welfare loss, even though both households have identical preferences.

**Aggregate expenditure and production.** Let price dispersion be

$$\Delta_t^p = \int_0^1 \left(\frac{P_t(i)}{P_t}\right)^{-\varepsilon_p} di, \qquad \delta_t^p = \log \Delta_t^p.$$

Aggregate expenditure is given by

$$X_t = \frac{F(N_t, E_t^P)}{\Delta_t^p} - \frac{Q_t}{P_t}E_t^P + \frac{Q_t}{P_t}\bar{E}, \tag{111}$$

where $F$ is the CES production technology.

A second-order expansion of production gives

$$f_t = s_C n_t + s_E e_t + \frac{1}{2}\frac{\eta-1}{\eta} s_C s_E (n_t - e_t)^2. \tag{112}$$

Define $s_x = s_C + \varrho$ as the steady-state ratio of GDP to gross output, where $\varrho$ is the steady-state value of domestic energy rents relative to gross output.

Expanding the aggregate resource constraint,

$$s_x e^{y_t} = e^{f_t - \delta_t^p} - s_E e^{q_t + e_t} + \varrho e^{q_t},$$

and using the first-order resource relation $s_x y_t = s_C n_t - (s_E - \varrho) q_t$ in the quadratic terms yields

$$\begin{aligned} s_x y_t = s_C n_t - (s_E - \varrho) q_t - \delta_t^p \\ - \frac{s_C s_E}{2\eta}(n_t - e_t)^2 + s_E q_t (n_t - e_t) \\ + \frac{\varrho}{s_x}\left(\frac{s_C}{2} n_t^2 - q_t n_t\right) + \text{t.i.p.} \end{aligned} \tag{113}$$

The final term captures the contribution of domestic energy rents to aggregate expenditure, because rents enter expenditure but not production.

**Labour disutility.** At the efficient steady state,

$$\chi \bar{N}^{1+\varphi} = \frac{\bar{w}\bar{N}}{\bar{X}} = c, \qquad c = \frac{s_C}{s_x}.$$

Define wage dispersion by

$$\delta_t^w = \frac{1}{1+\varphi} \log \int_0^1 \left(\frac{N_{j,t}}{N_t}\right)^{1+\varphi} dj.$$

Labour disutility can then be approximated by

$$\frac{\chi}{1+\varphi} \int_0^1 N_{j,t}^{1+\varphi} dj = c \left[ n_t + \frac{1+\varphi}{2} n_t^2 + \delta_t^w \right] + \text{t.i.p.} \tag{114}$$

Combining household expenditure, aggregate production and labour disutility, the linear terms in employment cancel because $s_C / s_x = c$.

**The quadratic welfare criterion.** Under Calvo price and wage setting, discounted dispersion satisfies

$$\sum_{t=0}^{\infty} \beta^t \delta_t^p = \frac{\varepsilon_p}{2\kappa_p} \sum_{t=0}^{\infty} \beta^t \pi_t^2, \tag{115}$$

$$\sum_{t=0}^{\infty} \beta^t \delta_t^w = \frac{\varepsilon_w}{2\lambda_w} \sum_{t=0}^{\infty} \beta^t (\pi_t^w)^2, \tag{116}$$

up to initial dispersion terms (Woodford, 2003; Erceg et al., 2000).

Collecting the second-order terms, utilitarian welfare can be expressed, up to policy-independent terms and terms of third order, as

$$\mathcal{W}_0 = -\frac{1}{2} \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left[ \frac{\varepsilon_p}{\kappa_p s_x} \pi_t^2 + \frac{c \varepsilon_w}{\lambda_w} (\pi_t^w)^2 + \mathcal{Q}(y_t, w_t, q_t) \right]. \tag{117}$$

The real allocation term is

$$\mathcal{Q} = \underbrace{\frac{s_C s_E}{\eta s_x}(n_t - e_t)^2 - \frac{2s_E}{s_x} q_t (n_t - e_t)}_{\text{Production input allocation}} + \underbrace{c\left(1 + \varphi - \frac{\varrho}{s_x}\right) n_t^2 + \frac{2\varrho}{s_x^2} q_t n_t}_{\text{Labour and energy rents}} + \underbrace{\mu(1-\mu)(c_t^H - c_t^R)^2}_{\text{Consumption dispersion}}. \tag{118}$$

The corresponding first-order relationships are

$$n_t - e_t = -\eta(w_t - q_t), \qquad n_t = \frac{y_t}{c} + \theta_n q_t, \tag{119}$$

where $\theta_n = (s_E - \varrho)/s_C$.

Equation (118) identifies three sources of real allocation distortions. The first captures the allocation of labour and energy across production inputs. The second reflects labour disutility and domestic energy rents. The final term captures consumption dispersion across household types.

The nominal dispersion terms depend on domestic price and wage inflation. In particular, headline inflation does not enter the welfare criterion directly because the flexible energy price does not generate domestic price dispersion.

## C.1 Flexible-Wage Welfare Criterion

Under flexible wages, the real wage satisfies

$$w_t = \omega_y y_t + \omega_q q_t, \tag{120}$$

as derived in Appendix A.

Substituting this relationship and (119) into (118) yields

$$\mathcal{Q} = A_{yy} y_t^2 + 2A_{yq} y_t q_t + A_{qq} q_t^2. \tag{121}$$

The coefficients $A_{yy}$, $A_{yq}$ and $A_{qq}$ are functions of the structural parameters and summarize the real allocation distortions under flexible wages.

Completing the square gives

$$\mathcal{Q} = A_{yy}(y_t - y_t^e)^2 + \left(A_{qq} - \frac{A_{yq}^2}{A_{yy}}\right) q_t^2, \tag{122}$$

where efficient GDP is

$$y_t^e = -\frac{A_{yq}}{A_{yy}} q_t. \tag{123}$$

Since $q_t$ is exogenous, the remaining quadratic term in the energy price is independent of monetary policy.

With flexible wages ($\xi_w \to 0$, so $\lambda_w \to \infty$) the wage-dispersion term vanishes. Normalizing the welfare loss by the coefficient on core inflation yields

$$\mathcal{L}_0 = \frac{1}{2}\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left[\pi_t^2 + \lambda_x (y_t - y_t^e)^2\right], \tag{124}$$

where

$$\lambda_x = \frac{\kappa_p s_x A_{yy}}{\varepsilon_p}. \tag{125}$$

Thus, in the flexible-wage benchmark, all real allocation distortions relevant for monetary policy can be summarized by the deviation of GDP from its efficient level.

**Structural representation.** For completeness, the coefficients of the quadratic form can be obtained directly from the structural expenditure relationships.

Recall that

$$c_t^R = a_y y_t + a_w w_t + a_q q_t,$$

and

$$c_t^H = \left(1 - \frac{g}{\mu}\right) y_t + c w_t + c\theta_n q_t.$$

Under flexible wages, their expenditure difference takes the form

$$c_t^H - c_t^R = d_y y_t + d_q q_t, \tag{126}$$

where

$$d_y = 1 - \frac{g}{\mu} - a_y + (c - a_w)\omega_y, \tag{127}$$

$$d_q = c\theta_n - a_q + (c - a_w)\omega_q. \tag{128}$$

Substituting into (118), the coefficient on squared GDP is

$$A_{yy} = \frac{s_C s_E \eta}{s_x}\omega_y^2 + \frac{1}{c}\left(1 + \varphi - \frac{\varrho}{s_x}\right) + \mu(1-\mu)d_y^2. \tag{129}$$

The interaction coefficient is

$$A_{yq} = \frac{s_C s_E \eta}{s_x}\omega_y(\omega_q - 1) + \frac{s_E \eta}{s_x}\omega_y + \left(1 + \varphi - \frac{\varrho}{s_x}\right)\theta_n + \frac{\varrho}{c s_x^2} + \mu(1-\mu)d_y d_q. \tag{130}$$

These coefficients characterize both the efficient GDP response and the welfare weight entering the optimal policy problem.

## C.2 Natural GDP and Divine Coincidence

The natural allocation is the allocation under flexible prices and wages. From the New Keynesian Phillips curve,

$$\pi_t = \beta \mathbb{E}_t \pi_{t+1} + \kappa y_t + \alpha q_t,$$

the natural level of GDP satisfies

$$y_t^n = -\frac{\alpha}{\kappa} q_t. \tag{131}$$

In contrast, efficient GDP minimizes the real allocation distortions in welfare, including consumption dispersion.

The difference between the two allocations defines the welfare-relevant cost-push shock:

$$u_t^* = \kappa(y_t^e - y_t^n) = \zeta_q q_t. \tag{132}$$

Consequently, the Phillips curve can be rewritten as

$$\pi_t = \beta \mathbb{E}_t \pi_{t+1} + \kappa(y_t - y_t^e) + u_t^*. \tag{133}$$

When $y_t^e = y_t^n$, the welfare-relevant cost-push shock vanishes. Monetary policy can then stabilize core inflation and implement efficient GDP simultaneously.

With a representative household and flexible wages, the natural allocation satisfies the planner's first-order conditions once the steady-state monopolistic distortions are offset by appropriate subsidies. Natural and efficient GDP therefore coincide.

With HtM households, nominal wage setting reflects the Ricardian marginal rate of substitution, while the planner additionally internalizes consumption dispersion. Natural and efficient GDP therefore generally differ, creating a welfare-relevant stabilization trade-off.

Finally, with sticky wages, the welfare criterion additionally penalizes wage inflation. The adjustment of real wages following an energy-price shock introduces a further stabilization trade-off, even in the representative-agent benchmark (Erceg et al., 2000).

# D Analytical Solution under Look-Through

This appendix derives the finite-horizon inflation response under look-through policy and proves Proposition 3.

Consider a fully observed energy-price shock with persistence $\rho \in [0, 1)$, normalized to one at impact. The central bank holds the nominal interest rate fixed for $H$ periods before returning to the core Taylor rule $i_t = \phi_\pi \pi_t$.

Let $\pi_0^{LT}(\rho, H)$ denote the impact core-inflation response per unit of the energy-price innovation. For an innovation of magnitude $q_0$, the actual response is $\pi_0^{LT}(\rho, H)q_0$. Define $b = \alpha + \kappa\psi$.

**Terminal Taylor-rule allocation.** Once the peg expires, inflation and GDP are proportional to the energy-price shock. Conjecturing $\pi_t = pq_t$ and $y_t = dq_t$, we obtain

$$d = \rho d - \sigma(\phi_\pi - \rho)p + \psi(1 - \rho), \tag{134}$$

$$p = \beta\rho p + \kappa d + \alpha. \tag{135}$$

Solving gives the terminal inflation response

$$\pi_0^{TR}(\rho) = \frac{b}{1 - \beta\rho + \kappa\sigma\frac{\phi_\pi - \rho}{1-\rho}}. \tag{136}$$

The corresponding GDP loading is

$$y_0^{TR}(\rho) = \psi - \frac{\sigma(\phi_\pi - \rho)}{1 - \rho}\pi_0^{TR}(\rho). \tag{137}$$

Here, both responses are coefficients per unit of the energy-price shock.

**Finite-horizon recursion.** For notational convenience within this proof, write

$$p_h = \pi_0^{LT}(\rho, h),$$

where $h$ is the number of fixed-rate periods remaining, not calendar time.

Let $d_h$ denote the corresponding impact response of GDP. During the fixed-rate episode, the IS and Phillips curves imply

$$d_h = \rho d_{h-1} + \sigma\rho p_{h-1} + \psi(1 - \rho), \tag{138}$$

$$p_h = \beta\rho p_{h-1} + \kappa d_h + \alpha. \tag{139}$$

The initial conditions at $h = 0$ are

$$p_0 = \pi_0^{TR}(\rho), \qquad d_0 = y_0^{TR}(\rho). \tag{140}$$

We can eliminate GDP from these equations. From the Phillips curve,

$$\kappa d_{h-1} = p_{h-1} - \beta\rho p_{h-2} - \alpha.$$

Substituting into the IS equation and then the Phillips curve gives

$$p_h = \rho(1 + \beta + \kappa\sigma)p_{h-1} - \beta\rho^2 p_{h-2} + (1-\rho)b, \tag{141}$$

for $h \geq 2$.

The recursion is initialized by

$$p_0 = \frac{b}{1 - \beta\rho + \kappa\sigma\frac{\phi_\pi - \rho}{1-\rho}}, \tag{142}$$

$$p_1 = b + \rho\left[\beta + \kappa\sigma - \frac{\kappa\sigma(\phi_\pi - \rho)}{1-\rho}\right]p_0. \tag{143}$$

Equations (141)–(143) give the exact full-information impact response for any finite look-through horizon:

$$\pi_0^{LT}(\rho, H) = p_H. \tag{144}$$

Importantly, the subscript $h$ counts the remaining commitment periods. Every $p_h$ represents inflation at the impact date under a different commitment horizon.

**Incomplete information amplification.** Suppose $\rho_T = 0$. For a purely transitory shock, the energy-price disturbance has no effect on expectations beyond impact.

Under any positive-length peg, the impact response is therefore

$$\pi_0^{LT}(0, T^*) = b, \qquad T^* \geq 1. \tag{145}$$

By posterior weighting, the initial inflation response under incomplete information is

$$\begin{aligned}\pi_0^{PI,LT} &= \left[L_1^*\pi_0^{LT}(\rho_P, H) + (1 - L_1^*)b\right] \\ &= b\left[1 + L_1^*\left(\frac{\pi_0^{LT}(\rho_P, H)}{b} - 1\right)\right].\end{aligned} \tag{146}$$

This establishes

$$\mathcal{A}_H^{LT} = L_1^*\left[\frac{\pi_0^{LT}(\rho_P, H)}{b} - 1\right], \tag{147}$$

as stated in Proposition 3.

**Long-horizon propagation.** We next characterize the behavior of $p_H$ as $H$ increases.

If the recursion converges, its limit $\bar{p}$ satisfies

$$\bar{p} = \rho(1 + \beta + \kappa\sigma)\bar{p} - \beta\rho^2\bar{p} + (1 - \rho)b. \tag{148}$$

Solving gives

$$\begin{aligned} \bar{p} &= \frac{(1-\rho)b}{(1-\rho)(1-\beta\rho) - \kappa\sigma\rho} \\ &= \frac{b}{1 - \beta\rho - \frac{\kappa\sigma\rho}{1-\rho}}. \end{aligned} \tag{149}$$

Defining

$$\Lambda^{LT}(\rho) = \beta + \frac{\kappa\sigma}{1-\rho},$$

we obtain

$$\bar{p} = \frac{b}{1 - \rho\Lambda^{LT}(\rho)}. \tag{150}$$

To establish convergence, consider deviations from the stationary solution, $z_h = p_h - \bar{p}$. They satisfy

$$z_h = \rho(1 + \beta + \kappa\sigma)z_{h-1} - \beta\rho^2 z_{h-2}. \tag{151}$$

For $\rho > 0$, the characteristic roots are $\rho\vartheta_1$ and $\rho\vartheta_2$, where

$$\vartheta^2 - (1 + \beta + \kappa\sigma)\vartheta + \beta = 0. \tag{152}$$

Under the maintained restrictions $\beta \in (0, 1)$ and $\kappa\sigma > 0$, the roots satisfy

$$0 < \vartheta_2 < 1 < \vartheta_1.$$

The recursion converges generically if and only if

$$\rho\vartheta_1 < 1. \tag{153}$$

This is equivalent to

$$\rho\kappa\sigma < (1 - \rho)(1 - \beta\rho), \tag{154}$$

or

$$\rho\Lambda^{LT}(\rho) < 1. \tag{155}$$

When this condition fails, the influence of the terminal Taylor-rule allocation generically grows with the commitment horizon.

Nevertheless, the finite-horizon solution remains well defined through the scalar recursion for each finite $H$. This completes the proof.

# E Additional Analytical Policy Proofs

**Optimal commitment and discretion (Proposition 4).** Let $x_t = y_t - y_t^e$. The optimal commitment targeting rule is $\pi_t = -(\lambda_x/\kappa)(x_t - x_{t-1})$ under the timeless perspective. Substitution into the welfare-relevant Phillips curve yields

$$\beta \mathbb{E}_t x_{t+1} - \left(1 + \beta + \frac{\kappa^2}{\lambda_x}\right) x_t + x_{t-1} = \frac{\kappa}{\lambda_x} u_t^*. \tag{156}$$

Selecting the bounded solution with $x_{-1} = 0$, the impact inflation coefficient for a unit AR(1) shock of persistence $\rho$ is $\zeta_q r/(1 - \beta r \rho)$, with the stable root $r$ defined in Proposition 4. From steady state, the date-zero optimal plan coincides with this solution. Under discretion, $\pi_t = -(\lambda_x/\kappa)x_t$ instead, implying $\pi_t = r_D(\beta \mathbb{E}_t \pi_{t+1} + u_t^*)$ and the stated impact response. Posterior weighting gives the incomplete-information expressions.

**Ranking (Proposition 5).** For $a = \kappa^2/\lambda_x > 0$, define $f(z) = \beta z^2 - (1 + \beta + a)z + 1$ and $r_D = 1/(1 + a)$. Then $f(0) > 0$ and $f(r_D) = -\beta a/(1 + a)^2 < 0$, hence the stable root satisfies $0 < r < r_D < 1$. Therefore $\Lambda^C = \beta r < \Lambda^D = \beta r_D < \beta < \beta + \kappa\sigma/(1 - \rho_P) = \Lambda^{LT}(\rho_P)$. Since $\mathcal{A} = L_1^* \rho_P \Lambda/(1 - \rho_P \Lambda)$ is strictly increasing in $\Lambda$ for $\rho_P \Lambda < 1$, and $L_1^* > 0$, $0 < \rho_P < 1$, we have $\mathcal{A}^C < \mathcal{A}^D$, and, when $\rho_P \Lambda^{LT}(\rho_P) < 1$, the long-horizon look-through amplification exceeds $\mathcal{A}^D$. Finally, $\pi_0^{PI,j} = \zeta_q r_j [1 + L_1^*(1/(1 - \beta r_j \rho_P) - 1)] q_0$ with $r_j \in \{r, r_D\}$ is increasing in $r_j$ in absolute value, so $|\pi_0^{PI,C}| < |\pi_0^{PI,D}|$ for $\zeta_q \neq 0$.

**Headline and core rules (Proposition 6).** The headline rule differs from the core rule by $\phi_\pi \alpha_C (q_t - q_{t-1})$. Consider an AR(1) component $z_t = \rho^t z_0$ with $\rho \in (0, 1)$ and $z_{-1} = 0$. For $t \geq 1$, $q_t - q_{t-1} = -((1 - \rho)/\rho) z_t$, so the rule is $i_t = \phi_\pi [\pi_t - \alpha_C (1 - \rho) z_t/\rho]$, and the stationary loadings $(g_\pi, g_y)$ on $z_t$ solve $g_\pi D(\rho) = \alpha + \kappa\psi + \kappa\sigma\phi_\pi\alpha_C/\rho$ and $g_y = \psi - \sigma(\phi_\pi - \rho) g_\pi/(1 - \rho) + \sigma\phi_\pi\alpha_C/\rho$. At $t = 0$, $q_0 - q_{-1} = z_0$ and $i_0 = \phi_\pi(\pi_0 + \alpha_C z_0)$. Combining the date-zero IS and Phillips curves with the loadings at $t = 1$ gives $\pi_0(1 + \kappa\sigma\phi_\pi) = g_\pi(1 + \kappa\sigma\phi_\pi) - \kappa\sigma\phi_\pi\alpha_C z_0/\rho$, which yields $\Xi(\rho)$ in Proposition 6. With $\rho = 0$ the continuation is not stationary ($q_1 - q_0 = -z_0$), and solving dates 0 and 1 directly gives the limit $\Xi(0)$. The sign condition follows from $D(\rho) - (1 + \kappa\sigma\phi_\pi) = \rho[\kappa\sigma(\phi_\pi - 1)/(1 - \rho) - \beta]$. Under a finite peg of length $T^* \geq 1$, the post-peg terminal loadings are these stationary headline loadings, which enter the recursion in Appendix D; with $\rho_T = 0$ and $T^* \geq 2$ the transitory component is zero and unchanged when the rule resumes, so its loading is $b$.

# F Wage Rigidity and Look-Through Policy

This appendix characterizes two limiting cases of the general sticky-price, sticky-wage model and establishes how wage rigidity affects the transmission of monetary policy.

Recall the equilibrium conditions (3)–(6). Ricardian expenditure satisfies

$$c_t^R = a_y y_t + a_w w_t + a_q q_t, \tag{157}$$

where the coefficients are derived in Appendix A.

### F.1 Flexible Prices and Sticky Wages

Consider the limit in which domestic prices are fully flexible, $\xi_p \to 0$, while nominal wages remain sticky.

With flexible prices, firms' real marginal cost is constant. The real wage therefore satisfies

$$w_t = -\theta q_t, \qquad \theta \equiv \frac{s_E}{s_C}. \tag{158}$$

Since

$$w_t = w_{t-1} + \pi_t^w - \pi_t,$$

core inflation is related to wage inflation by

$$\pi_t = \pi_t^w + \theta(q_t - q_{t-1}). \tag{159}$$

Substituting the real-wage condition into Ricardian expenditure and the Euler equation gives

$$y_t = \mathbb{E}_t y_{t+1} - \sigma_w(i_t - \mathbb{E}_t \pi_{t+1}^w) + \psi_w(q_t - \mathbb{E}_t q_{t+1}), \tag{160}$$

where

$$\sigma_w = \frac{1}{a_y}, \qquad \psi_w = -\sigma_w \left[a_q + \theta(1 - a_w)\right]. \tag{161}$$

The wage Phillips curve becomes

$$\pi_t^w = \beta \mathbb{E}_t \pi_{t+1}^w + \kappa_w y_t + \alpha_w q_t, \tag{162}$$

where

$$\kappa_w = \lambda_w m_y, \qquad \alpha_w = \lambda_w(m_q - \theta m_w). \tag{163}$$

Thus, the equilibrium has the same two-equation New Keynesian structure as the flexible-wage benchmark, with wage inflation replacing core inflation.

**Proposition 8** (Flexible Prices and Sticky Wages)**.** *Suppose domestic prices are fully flexible while nominal wages remain sticky.*

1. *The equilibrium is characterized by* (160) *and* (162)*.*

*2. Core and headline inflation satisfy*

$$\pi_t = \pi_t^w + \theta \Delta q_t, \tag{164}$$

$$\pi_t^H = \pi_t^w + (\theta + \alpha_C)\Delta q_t. \tag{165}$$

*3. The natural GDP allocation coincides with the flexible-wage benchmark:*

$$\frac{\alpha_w}{\kappa_w} = \frac{\alpha}{\kappa}. \tag{166}$$

*4. For the positive results (look-through and Taylor rules), if the post-peg monetary policy rule responds to wage inflation, the analytical results for the flexible-wage benchmark apply to wage inflation after replacing the corresponding IS and Phillips-curve coefficients by* $(\sigma_w, \psi_w, \kappa_w, \alpha_w)$.

The feedback from aggregate demand to wage inflation is governed by $\kappa_w \sigma_w$.

As nominal wages become more rigid, the wage Phillips curve becomes flatter, weakening this feedback. Moreover, the effective intertemporal elasticity $\sigma_w$ is no larger than its flexible-wage counterpart under the maintained parameter restrictions (strictly smaller when $\mu > 0$, equal with a representative agent).

Consequently, the inflationary effects of the demand stimulus generated by a fixed nominal interest rate become weaker as wage rigidity increases.

The equivalence to the flexible-wage analytical system concerns wage inflation. Under a policy rule responding to core or headline inflation, the relative energy-price terms must additionally be included in the monetary policy rule.

### F.2 Completely Rigid Nominal Wages

Next, consider the limit $\lambda_w \to 0$, in which nominal wage inflation is zero.

Because the nominal wage is fixed, the real wage satisfies

$$w_t = -p_t, \tag{167}$$

where $p_t$ denotes the deviation of the domestic price level from steady state.

Substituting into the price Phillips curve yields

$$\beta \mathbb{E}_t p_{t+1} - (1 + \beta + \kappa_p s_C) p_t + p_{t-1} = -\kappa_p s_E q_t. \tag{168}$$

Importantly, this equation contains neither GDP nor the nominal interest rate. The domestic price level is determined by the energy-price process and nominal wage rigidity.

Let $\delta \in (0, 1)$ denote the stable root of

$$\beta \delta^2 - (1 + \beta + \kappa_p s_C)\delta + 1 = 0. \tag{169}$$

For an energy-price shock with persistence $\rho$, the bounded full-information impact inflation response is

$$\pi_0^{FI,j}(\rho) = \frac{\delta \kappa_p s_E}{1 - \beta\delta\rho} q_0, \tag{170}$$

for any monetary policy regime $j$.

When $\rho_T = 0$, posterior weighting gives

$$\pi_0^{PI,j} = \delta \kappa_p s_E (1 + \mathcal{A}^B) q_0, \tag{171}$$

where

$$\mathcal{A}^B = L_1^* \frac{\beta\delta\rho_P}{1 - \beta\delta\rho_P}. \tag{172}$$

**Proposition 9** (Rigid Nominal Wages)**.** *Suppose nominal wages are completely rigid.*

*Then core inflation is independent of the monetary policy regime and is characterized by* (170) *under full information and* (171) *under incomplete information.*

*Monetary policy continues to affect GDP and welfare, but not core inflation.*

In this limit, movements in aggregate demand cannot affect marginal costs independently of domestic prices. Consequently, look-through, Taylor rules, commitment and discretion generate the same bounded core inflation response.

The information friction continues to influence inflation through perceived energy-price persistence, but this effect is common across policy regimes.

The limit therefore eliminates the additional core inflation cost of look-through relative to other monetary policies without implying that their welfare consequences coincide.

# G Proof of Proposition 7

We establish the relationship between the natural real interest rate, monetary policy, and welfare in the flexible-wage benchmark.

**Transformation of the equilibrium.** Recall the New Keynesian system:

$$y_t = \mathbb{E}_t y_{t+1} - \sigma(i_t - \mathbb{E}_t \pi_{t+1}) + \psi(q_t - \mathbb{E}_t q_{t+1}), \tag{173}$$

$$\pi_t = \beta \mathbb{E}_t \pi_{t+1} + \kappa y_t + \alpha q_t. \tag{174}$$

Define

$$\tilde{y}_t \equiv y_t - \psi q_t. \tag{175}$$

The equilibrium becomes

$$\tilde{y}_t = \mathbb{E}_t \tilde{y}_{t+1} - \sigma(i_t - \mathbb{E}_t \pi_{t+1}), \tag{176}$$

$$\pi_t = \beta \mathbb{E}_t \pi_{t+1} + \kappa \tilde{y}_t + (\alpha + \kappa\psi) q_t. \tag{177}$$

Thus, the energy-price shock enters the transformed system only through $\alpha + \kappa\psi$.

Under look-through or a Taylor rule responding only to current and past core inflation, linearity implies that the responses of $\tilde{y}_t$ and $\pi_t$ are proportional to this structural coefficient, for a fixed shock process and monetary policy specification.

**Natural allocation.** Natural GDP satisfies

$$y_t^n = -\frac{\alpha}{\kappa} q_t. \tag{178}$$

Consequently,

$$y_t - y_t^n = \tilde{y}_t + \frac{\alpha + \kappa\psi}{\kappa} q_t. \tag{179}$$

Since $\tilde{y}_t$ is proportional to $\alpha + \kappa\psi$, deviations from natural GDP are also proportional to this coefficient.

If $\alpha + \kappa\psi = 0$ and the economy is initially at rest, the transformed system admits

$$\tilde{y}_t = 0, \qquad \pi_t = 0 \tag{180}$$

under both look-through and an active core Taylor rule, assuming a determinate equilibrium.

It follows that

$$y_t = y_t^n. \tag{181}$$

Thus, when the natural real interest rate is unaffected by the shock, the two monetary policy regimes implement the same natural allocation.

**Welfare decomposition.** Recall that the welfare-relevant output gap is

$$x_t = y_t - y_t^e$$

and that

$$\zeta_q q_t = \kappa(y_t^e - y_t^n).$$

Combining these definitions with (179) gives

$$x_t = \tilde{y}_t + \frac{\alpha + \kappa\psi}{\kappa} q_t - \frac{\zeta_q}{\kappa} q_t. \tag{182}$$

For a given monetary policy regime $j$, linearity implies that the endogenous responses may be represented as

$$\tilde{y}_t = (\alpha + \kappa\psi) f_t^j, \qquad \pi_t = (\alpha + \kappa\psi) h_t^j, \tag{183}$$

where $f_t^j$ and $h_t^j$ depend on the monetary policy regime and the energy-price process, but not on the common structural shock coefficient when the remaining parameters are held fixed.

It follows that

$$x_t = (\alpha + \kappa\psi)\left(f_t^j + \frac{q_t}{\kappa}\right) - \frac{\zeta_q}{\kappa} q_t. \tag{184}$$

Substituting into the flexible-wage welfare loss,

$$\mathcal{L}_j = \frac{1}{2}\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left(\pi_t^2 + \lambda_x x_t^2\right), \tag{185}$$

and collecting terms gives

$$\mathcal{L}_j = (\alpha + \kappa\psi)^2 \mathsf{A}_j + 2(\alpha + \kappa\psi)\zeta_q \mathsf{B}_j + \zeta_q^2 \mathsf{C}. \tag{186}$$

The coefficients are

$$\mathsf{A}_j = \frac{1}{2}\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left[(h_t^j)^2 + \lambda_x \left(f_t^j + \frac{q_t}{\kappa}\right)^2\right], \tag{187}$$

$$\mathsf{B}_j = -\frac{\lambda_x}{2\kappa}\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left(f_t^j + \frac{q_t}{\kappa}\right) q_t, \tag{188}$$

$$\mathsf{C} = \frac{\lambda_x}{2\kappa^2}\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t q_t^2. \tag{189}$$

The coefficients $\mathsf{A}_j$ and $\mathsf{B}_j$ depend on monetary policy, while $\mathsf{C}$ is common across regimes. Moreover, $\mathsf{A}_j \geq 0$ and $\mathsf{C} \geq 0$.

When $\alpha + \kappa\psi = 0$, welfare loss therefore reduces to

$$\mathcal{L}_j = \zeta_q^2 \mathsf{C}, \tag{190}$$

independently of the core monetary policy regime.

This proves the first two statements of Proposition 7.

**Welfare ranking.** The welfare difference between look-through and the active Taylor rule is

$$\begin{aligned}\mathcal{L}_{LT} - \mathcal{L}_{TR} = (\alpha + \kappa\psi)^2(\mathsf{A}_{LT} - \mathsf{A}_{TR}) \\ + 2(\alpha + \kappa\psi)\zeta_q(\mathsf{B}_{LT} - \mathsf{B}_{TR}).\end{aligned} \tag{191}$$

Suppose $\mathsf{A}_{LT} > \mathsf{A}_{TR}$. The welfare difference is negative when $\alpha + \kappa\psi$ lies strictly between zero and

$$-\frac{2\zeta_q(\mathsf{B}_{LT} - \mathsf{B}_{TR})}{\mathsf{A}_{LT} - \mathsf{A}_{TR}}, \tag{192}$$

provided these endpoints are distinct.

In this region, the demand response generated by look-through offsets part of the welfare-relevant distortion and improves welfare relative to the active Taylor rule.

**Headline inflation targeting.** Finally, the headline Taylor rule responds to

$$\pi_t^H = \pi_t + \alpha_C \Delta q_t. \tag{193}$$

Even if $\alpha + \kappa\psi = 0$, the headline rule generally produces a nonzero nominal interest rate response to the direct energy-price contribution to CPI inflation.

If $\zeta_q = 0$ as well, stabilizing core inflation implements efficient GDP in the flexible-wage benchmark.

Look-through followed by a core rule and an active core Taylor rule therefore implement the efficient allocation, while a headline rule generally introduces unnecessary fluctuations in the welfare-relevant output gap.

This completes the proof.

# H A Common Decomposition Across Policy Regimes

This appendix provides a common decomposition of inflation across the monetary policy regimes considered in Section 4. Although incomplete information affects all regimes through the same perceived persistence of energy-price shocks, monetary policy determines how these expectations influence inflation and aggregate demand.

An important distinction is that different policy regimes transmit different structural effects of energy prices. Under look-through, the relevant effect is $\alpha + \kappa\psi$, which combines the marginal-cost and aggregate-demand channels. Under optimal policy, the relevant disturbance is instead $u_t^* = \zeta_q q_t$, which captures the difference between natural and efficient GDP.

These effects can be expressed within a common framework. Combining the welfare-relevant Phillips curve with the definition of headline inflation gives

$$\begin{aligned} \pi_0^H = \; & \underbrace{\alpha_C q_0}_{\text{First-round effect}} + \underbrace{\zeta_q q_0}_{\text{Welfare-relevant shock}} \\ & + \underbrace{\kappa x_0}_{\text{Output-gap channel}} + \underbrace{\beta \mathbb{E}_0 \pi_1}_{\text{Expectations channel}}, \end{aligned} \tag{194}$$

for an economy initially at rest ($q_{-1} = 0$), where $x_t = y_t - y_t^e$ is the welfare-relevant output gap.

The first two terms depend on the observed energy price and are common across policy regimes and information sets. The remaining terms reflect endogenous changes in the welfare-relevant output gap and inflation expectations, both of which depend on monetary policy.

The relationship between the structural effect under look-through and the welfare-relevant disturbance follows from

$$\alpha + \kappa\psi = \zeta_q + \kappa \left( \psi - \frac{y_t^e}{q_t} \right), \tag{195}$$

where the ratio $y_t^e / q_t$ is constant in the log-linear equilibrium.

This identity separates the welfare-relevant cost-push disturbance from the inflationary effect of

the efficient output gap generated by a transitory energy-price shock under a fixed nominal interest rate.

Importantly, $\alpha + \kappa\psi = 0$ does not imply $\zeta_q = 0$. A fixed nominal interest rate may stabilize core inflation following a transitory shock even when the resulting allocation differs from the efficient allocation.

The decomposition therefore distinguishes the direct contribution of energy prices to headline inflation, the welfare-relevant disturbance, and the endogenous output-gap and expectations channels through which monetary policy affects inflation.

# I Additional Quantitative Results and Robustness

This appendix reports the analytical calibration benchmarks, detailed inflation decompositions, and robustness exercises omitted from Section 6. All numerical values, figure sources, and table inputs are preserved from the quantitative analysis.

**Welfare measures and numerical methods.** Losses are computed from (12) along each path over 400 quarters, net of a policy-invariant lower bound on $\mathcal{Q}$ (a fixed multiple of $q_t^2$): the minimum over $(y, w)$ with sticky wages, and over $y$ with the real wage tied to GDP (flexible wages) or to the energy price (flexible prices). The bound does not affect comparisons of policies within an economy, but it differs across wage settings, so loss levels, in particular the small Ramsey losses, are not strictly comparable between the flexible-wage and sticky-wage columns of Table 3. The ex ante measure is the expected discounted loss generated by one quarter's innovations hitting the economy at rest, $\sum_j \sigma_j^2 \mathcal{L}_j$, where $\mathcal{L}_j$ is the loss after a unit innovation in component $j \in \{P, T\}$. It weighs the two possible shocks by their variances before agents learn which one occurred. Look-through is triggered anew by each shock, so we interpret the measure as the cost of a single look-through episode. Decision rules are computed in state-space form: Taylor rules by time iteration (with residual, stability, uniqueness and Blanchard–Kahn checks), look-through by backward recursion from the Taylor-rule solution, Ramsey policy from the planner's first-order conditions with lagged multipliers as states, and discretion with Söderlind (1999).

## I.1 Analytical Benchmark at the Calibration

In the flexible-wage benchmark, the calibration gives $\omega_y = 1.51$, $\sigma = 1.98$, $\kappa = 0.1227$, $\psi = 0.0625$, and $\alpha = 0.0060$. Thus $\alpha + \kappa\psi = 0.0137 > 0$, consistent with a rise in the natural real interest rate when energy is imported. Natural and efficient GDP respond by $-0.0490\, q_t$ and $-0.0550\, q_t$, respectively, and the welfare-relevant shock is $\zeta_q = -7.41 \times 10^{-4}$.

The long-horizon convergence condition fails at the calibration: $\rho_P \Lambda^{LT} = 12.9$. The exact finite-horizon amplification at eight quarters is $\mathcal{A}_8^{LT} = 0.734$, whereas the infinite-horizon expression is inappropriate in this case. Under optimal policy, the stable roots are $r = 0.489$ and $r_D = 0.650$

Table 5: Impact inflation across regimes: analytical benchmark at the calibration

| | Core inflation $\pi_0$ | | | | Decomposition (PI) | | | Headline |
|---|---|---|---|---|---|---|---|---|
| Regime | FI, pers. | FI, trans. | PI | $\mathcal{A}^j$ | $u_0^*$ | $\kappa(\hat{x}_0 - \hat{x}_0^e)$ | $\beta\,\mathbb{E}_0\,\pi_1$ | $\pi_0^H$ (PI) |
| Look-through, then core rule ($T^* = 8$) | 86.136 | 13.680 | 23.720 | 0.734 | −0.741 | 17.234 | 7.226 | 103.72 |
| Look-through, then headline rule | 209.832 | 13.680 | 40.861 | 1.987 | −0.741 | 23.915 | 17.686 | 120.86 |
| Core Taylor rule | 2.156 | 10.026 | 8.936 | −0.109 | −0.741 | 9.387 | 0.290 | 88.94 |
| Headline Taylor rule | −14.959 | 23.627 | 18.280 | −0.226 | −0.741 | −0.120 | 19.141 | 98.28 |
| Ramsey commitment | −0.689 | −0.362 | −0.408 | 0.125 | −0.741 | 0.220 | 0.114 | 79.59 |
| Discretion | −1.302 | −0.481 | −0.595 | 0.236 | −0.741 | 0.321 | −0.175 | 79.40 |

*Notes:* Flexible wages, $\rho_T = 0$, $L_1^* = 0.139$, no interest-rate smoothing. Inflation per unit of $\hat{q}_0$, $\times 10^3$. Core-inflation entries are the closed forms of Propositions 3, 4 and 6; the channel split of the rule regimes is taken from the numerical solution. Headline inflation adds the first-round term $\alpha_C$ ($\times 10^3$). The replication package checks every closed form against the numerical solution of the full model.

and the amplification indices are $\mathcal{A}^C = 0.125$ and $\mathcal{A}^D = 0.236$. The correction associated with a headline rule depends on the shock component and on the subsequent policy regime.

Table 5 evaluates the impact responses and the decomposition in Appendix H. The direct energy component accounts for 77% of headline inflation under look-through followed by a core rule. Under look-through, the output-gap and expectations channels account for about 73% and 30% of impact core inflation, respectively. The component-specific headline-rule corrections also explain why anticipated easing as a transitory shock reverses may raise current core inflation.

## I.2 Detailed Wage and Inflation Decomposition

Table 6: Cost-side decomposition of impact inflation (persistent shock, incomplete information)

| | | | Core inflation $\pi_0$ | | | | |
|---|---|---|---|---|---|---|---|
| Economy | Regime | $\pi_0^H$ | First round | Energy cost | Wages | Expectations | GDP (%) |
| Flexible wages | Look-through | 6.95 | 3.20 | 0.172 | 1.570 | 2.011 | 3.06 |
| | Headline rule | 3.50 | 3.20 | 0.172 | 0.090 | 0.037 | 0.04 |
| | Core rule | 3.54 | 3.20 | 0.172 | 0.220 | −0.048 | 0.31 |
| | Ramsey commitment | 3.18 | 3.20 | 0.172 | −0.192 | 0.004 | −0.53 |
| Fast wage pass-through | Look-through | 3.67 | 3.20 | 0.172 | 0.013 | 0.288 | 0.45 |
| | Headline rule | 3.42 | 3.20 | 0.172 | −0.012 | 0.062 | −0.05 |
| | Core rule | 3.39 | 3.20 | 0.172 | −0.009 | 0.029 | 0.08 |
| | Ramsey commitment | 3.37 | 3.20 | 0.172 | −0.021 | 0.015 | −0.38 |
| Baseline (sticky wages) | Look-through | 3.46 | 3.20 | 0.172 | −0.012 | 0.099 | 0.27 |
| | Headline rule | 3.42 | 3.20 | 0.172 | −0.015 | 0.060 | −0.05 |
| | Core rule | 3.39 | 3.20 | 0.172 | −0.014 | 0.035 | 0.07 |
| | Ramsey commitment | 3.38 | 3.20 | 0.172 | −0.017 | 0.027 | −0.45 |

*Notes:* Annualised percentage points, 10% energy price shock. Decomposition (51); the last three columns of inflation sum to core inflation. Look-through returns to the headline rule.

Table 6 decomposes impact headline inflation according to (51). The wage and expectations channels are larger with flexible wages, while stronger wage rigidity weakens both channels. The underlying structural energy cost and first-round CPI effects are common across the policy regimes for a given shock.

### I.3 Wage Stickiness, Commitment Horizon, and Beliefs

The first set of robustness exercises varies wage rigidity, the duration of the interest-rate peg, and the Kalman gain. Figure 6 shows how the welfare ranking changes continuously between flexible and sticky wages. Although differences in impact core inflation diminish as wages become rigid, the welfare loss of look-through can remain positive because monetary policy still changes GDP.

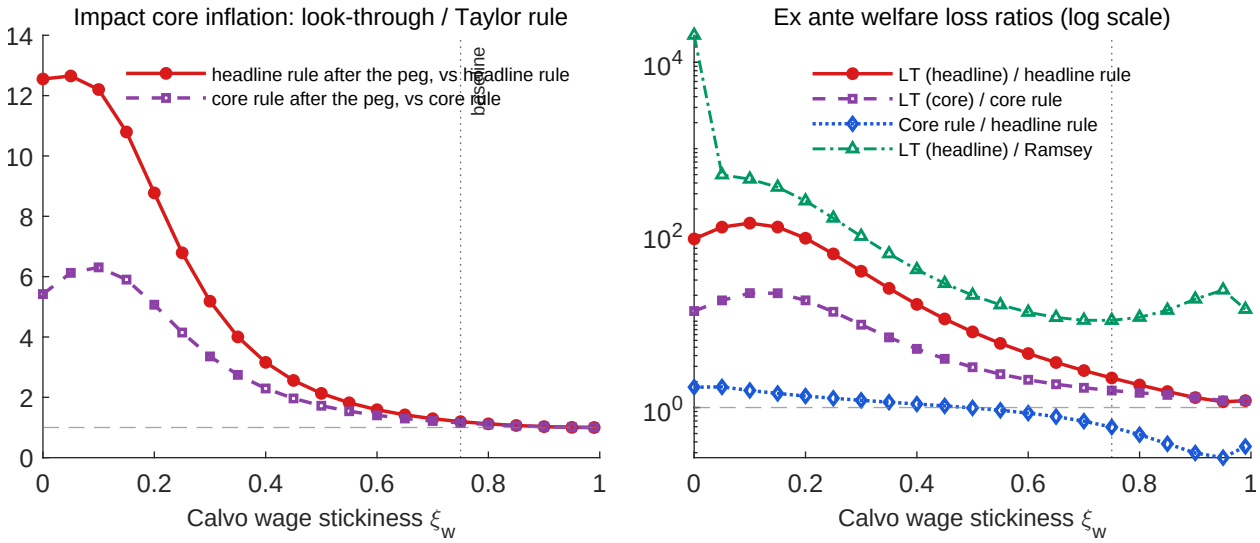



Figure 6: Policy dependence and welfare cost of look-through against wage stickiness

*Notes:* Incomplete information, $T^* = 8$. $\xi_w = 0$: flexible wages. Left: impact core inflation under look-through relative to the Taylor rule it returns to, persistent 10% shock. Right: ex ante loss ratios (log scale).

Figure 7 varies the commitment horizon. With a core rule following the peg, longer commitments tend to raise the welfare cost. With a headline rule, the comparison is not necessarily monotone because the rule may resume when the transitory energy-price reversal is occurring.

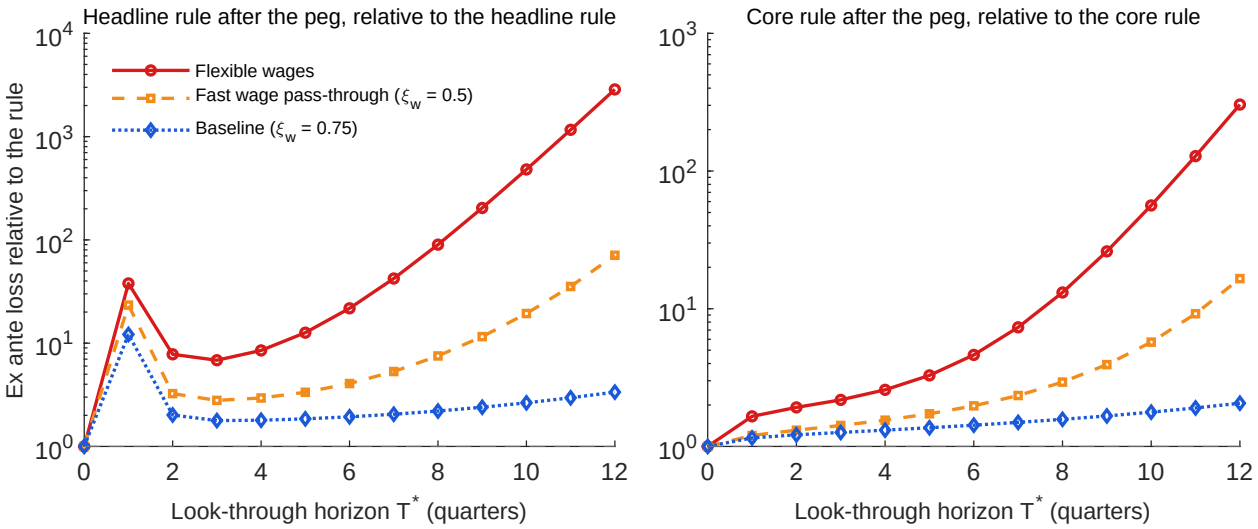



Figure 7: Ex ante welfare cost of look-through against the look-through horizon

*Notes:* Ex ante loss of look-through relative to the Taylor rule it returns to, incomplete information; log scale.

Table 7 changes the relative shock volatilities and hence the posterior gain $L_1^*$. Look-through becomes costlier when agents attribute a larger portion of the observed shock to its persistent component, particularly when nominal wages are flexible.

Table 7: Beliefs about persistence and the cost of look-through

| | | Flexible wages | | Baseline (sticky wages) | |
|---|---|---|---|---|---|
| $\sigma_T/\sigma_P$ | $L_1^*$ | headline | core | headline | core |
| 10.0 | 0.078 | 29.3 | 6.63 | 1.58 | 1.32 |
| 6.0 | 0.138 | 90.0 | 13.1 | 2.20 | 1.57 |
| 3.0 | 0.273 | 491 | 40.4 | 2.76 | 2.12 |
| 2.0 | 0.386 | 973 | 84.2 | 2.87 | 2.45 |
| 1.5 | 0.480 | 1061 | 143 | 2.91 | 2.63 |

*Notes:* Ex ante loss of look-through relative to the Taylor rule it returns to (headline or core), incomplete information. $L_1^*$ is the steady-state Kalman gain implied by $\sigma_T/\sigma_P$; all rows satisfy $L_1^* < 1/2$, so look-through is triggered.

## I.4 Energy Dependence

The next exercises vary the production energy share $s_E$ and household energy share $\alpha_C$, holding other structural features fixed. Production energy affects firms' costs and domestic stabilization; household energy affects the direct CPI term and is particularly important for policy rules responding to headline inflation.

Table 8 and Figure 8 report the welfare comparisons. Under core rules, the household energy share does not separately enter the first-order equilibrium when all energy is imported. The detailed

Table 8: Energy dependence: ex ante loss ratios

| | Flexible wages | | | | Baseline (sticky wages) | | | |
|---|---|---|---|---|---|---|---|---|
| $s_E$ | 0.025 | 0.05 | 0.1 | 0.15 | 0.025 | 0.05 | 0.1 | 0.15 |
| *Look-through (headline) / headline rule* | | | | | | | | |
| $\alpha_C = 0.00$ | 14.1 | 13.1 | 11.3 | 9.71 | 1.58 | 1.57 | 1.56 | 1.55 |
| $\alpha_C = 0.04$ | 103 | 38.6 | 19.3 | 13.6 | 2.22 | 2.00 | 1.79 | 1.70 |
| $\alpha_C = 0.08$ | 332 | 90.0 | 30.9 | 18.5 | 2.21 | 2.20 | 1.97 | 1.83 |
| $\alpha_C = 0.15$ | 455 | 258 | 62.7 | 30.2 | 2.05 | 2.22 | 2.15 | 2.00 |
| *Core rule / headline rule* | | | | | | | | |
| $\alpha_C = 0.00$ | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| $\alpha_C = 0.04$ | 1.75 | 1.32 | 1.14 | 1.08 | 0.58 | 0.83 | 0.94 | 0.96 |
| $\alpha_C = 0.08$ | 2.47 | 1.72 | 1.29 | 1.17 | 0.28 | 0.59 | 0.84 | 0.91 |
| $\alpha_C = 0.15$ | 1.33 | 2.38 | 1.61 | 1.35 | 0.11 | 0.32 | 0.64 | 0.79 |
| *Look-through (core) / core rule, any $\alpha_C$* | | | | | | | | |
| | 14.1 | 13.1 | 11.3 | 9.71 | 1.58 | 1.57 | 1.56 | 1.55 |
| *Look-through (headline) loss, bp ($\alpha_C = 0.08$)* | | | | | | | | |
| | 17.4 | 28.7 | 59.0 | 99.4 | 0.45 | 0.90 | 2.56 | 5.53 |

*Notes:* Ex ante losses under incomplete information, all energy imported. Columns: production energy share $s_E$; rows: household energy share $\alpha_C$. The ratio of look-through followed by the core rule to the core rule does not depend on $\alpha_C$ when all energy is imported.

numerical values also indicate that the production substitution elasticity changes welfare more than the first-order inflation dynamics.

### I.5 Automatic Stabilizers and HtM Households

We vary the hand-to-mouth population share and the strength of counter-cyclical transfers in both imported-energy and domestically supplied energy economies.

When energy is imported, automatic stabilizers dampen the demand feedback created by the fixed interest rate, making look-through less costly. When domestic rents are large and the shock is Keynesian, transfers support HtM expenditure, reduce the demand leakage, and can weaken the case for look-through. Table 9 and Figure 9 report these interactions. The additional experiment that redistributes energy rents directly is described in Appendix J.

### I.6 Comparison across Structural Economies

For completeness, we compare the entire responses and welfare outcomes under the baseline, an energy-intensive calibration, and an economy with large domestic energy rents. The latter reproduces the Keynesian demand mechanism analyzed in Section 6.4.

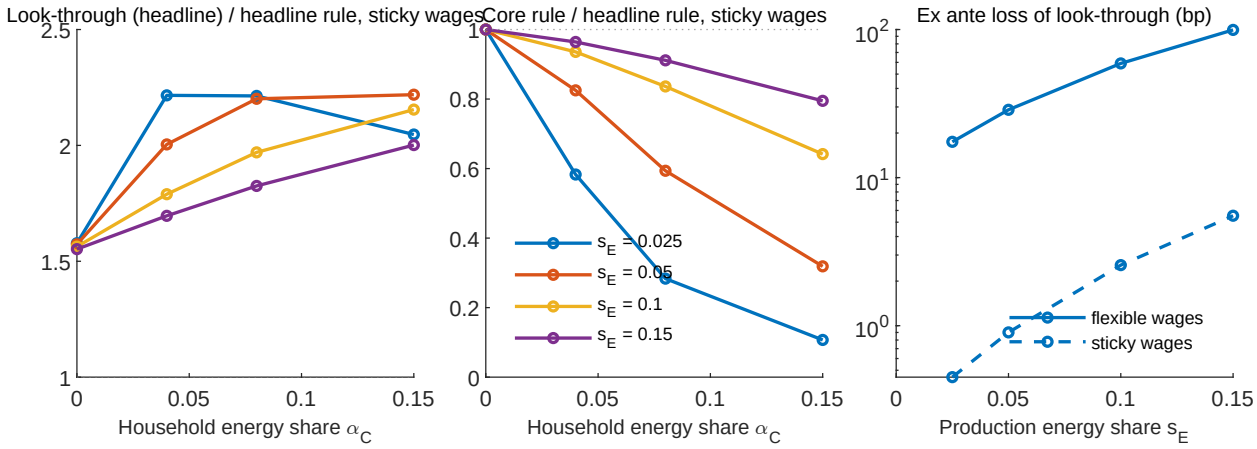



Figure 8: Energy dependence and the cost of look-through

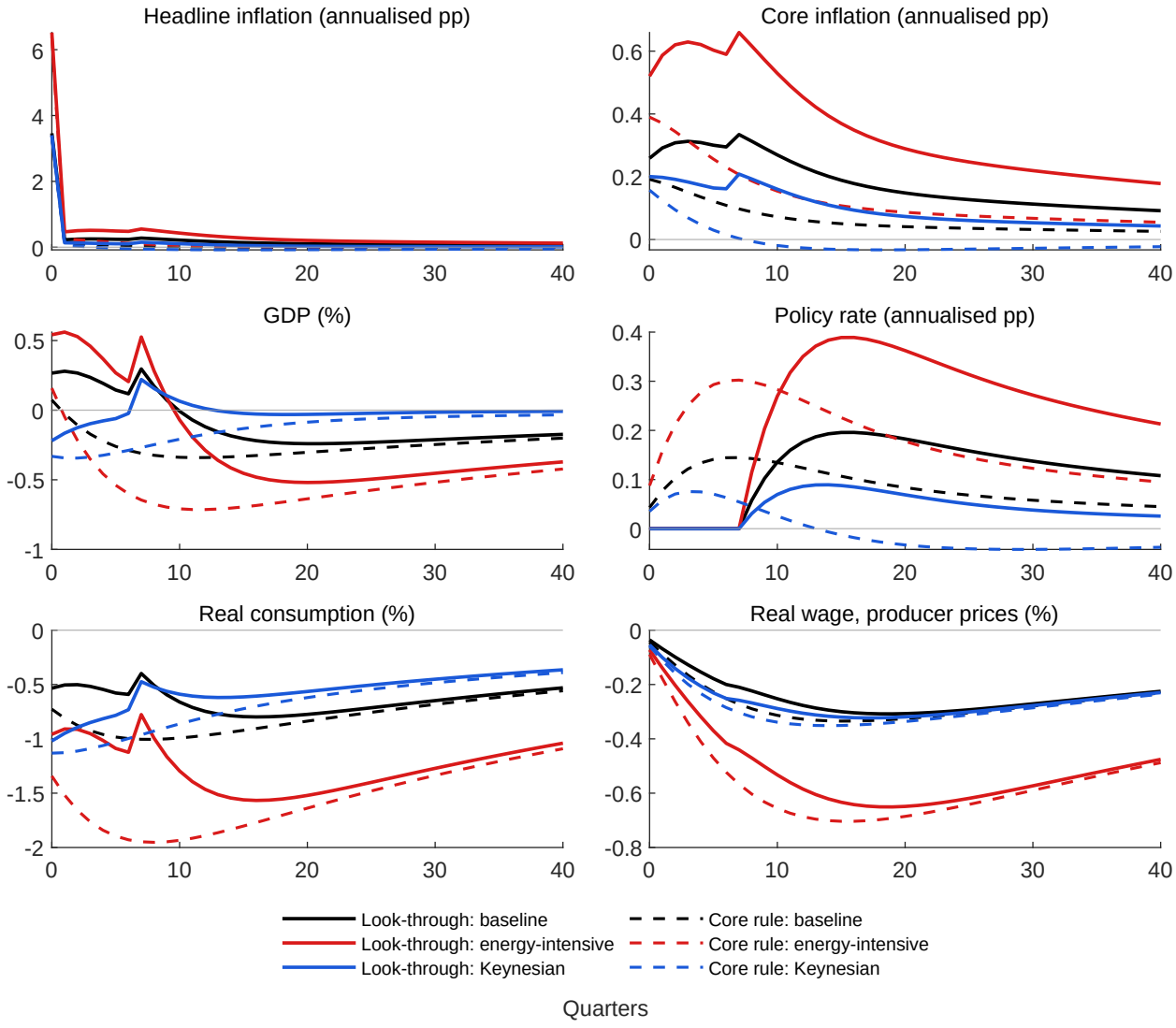



Figure 10: Baseline, energy-intensive and Keynesian economies (sticky wages)

*Notes:* Responses to a 10% persistent shock under incomplete information, baseline wage stickiness. Solid: look-through (then headline rule); dashed: core Taylor rule. Energy-intensive: $s_E = 0.10$, $\alpha_C = 0.15$. Keynesian: all energy supplied domestically ($\varsigma = 1$).

Table 9: Hand-to-mouth households and automatic stabilisers

*A. All energy imported: look-through (headline) / headline rule*

| | Flexible wages | | | | Baseline (sticky wages) | | | |
|---|---|---|---|---|---|---|---|---|
| $\mu \setminus \gamma$ | 0.0 | 0.1 | 0.3 | 0.5 | 0.0 | 0.1 | 0.3 | 0.5 |
| 0.1 | 59.8 | 45.2 | 37.6 | 36.2 | 2.46 | 2.27 | 2.01 | 1.84 |
| 0.2 | 85.3 | 57.3 | 36.3 | 31.0 | 2.44 | 2.25 | 1.99 | 1.83 |
| 0.3 | 169 | 90.0 | 43.2 | 30.3 | 2.40 | 2.20 | 1.95 | 1.80 |
| 0.4 | 1132 | 250 | 64.7 | 35.3 | 2.33 | 2.14 | 1.90 | 1.76 |
| 0.5 | – | – | 167 | 51.0 | – | – | 1.83 | 1.71 |

*B. Keynesian economy ($\varsigma = 1$): automatic stabilisers*

| | | Flexible wages | | | Baseline (sticky wages) | | |
|---|---|---|---|---|---|---|---|
| $\gamma$ | $10^3 b$ | LT/H | LT/C | $\text{LT}_C$/C | LT/H | LT/C | $\text{LT}_C$/C |
| 0.0 | −14.37 | 1.02 | 1.60 | 12.4 | 0.72 | 0.88 | 0.89 |
| 0.1 | −12.27 | 0.81 | 1.26 | 8.87 | 0.78 | 0.94 | 0.89 |
| 0.3 | −9.80 | 0.74 | 1.12 | 6.39 | 0.87 | 1.05 | 0.90 |
| 0.5 | −8.38 | 0.75 | 1.14 | 5.86 | 0.94 | 1.15 | 0.90 |
| 1.0 | −6.56 | 0.87 | 1.55 | 7.83 | 1.07 | 1.37 | 0.90 |

*Notes:* Ex ante loss ratios under incomplete information. Panel A: all energy imported; –: flexible-wage IS curve inverted or nearly inverted ($1/\tilde{\sigma} < 0.15$), a criterion applied to both wage settings. Panel B: all energy supplied domestically. LT/H and LT/C: look-through then headline rule, over the headline and core rules; $\text{LT}_C$/C: look-through then core rule, over the core rule.

Table 10: Five economies: impact responses and welfare

| | | Impact core inflation (ann. pp) | | | Impact GDP (%) | | | Ex ante loss | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Economy | $10^3 b$ | LT | C | RC | LT | C | RC | LT (bp) | LT/H | LT/C | RC (bp) |
| *Baseline wage stickiness* | | | | | | | | | | | |
| Baseline | 13.68 | 0.26 | 0.19 | 0.18 | 0.27 | 0.07 | −0.45 | 0.90 | 2.20 | 3.71 | 0.088 |
| Energy-intensive | 27.24 | 0.52 | 0.39 | 0.37 | 0.54 | 0.16 | −0.93 | 3.66 | 2.15 | 3.36 | 0.40 |
| Keynesian ($\varsigma = 1$) | −12.27 | 0.20 | 0.16 | 0.19 | −0.22 | −0.33 | 0.13 | 0.30 | 0.78 | 0.94 | 0.15 |
| Keynesian, $\gamma = 0.5$ | −8.38 | 0.20 | 0.16 | 0.18 | −0.15 | −0.23 | −0.02 | 0.25 | 0.94 | 1.15 | 0.15 |
| HtM 0.4, $\gamma = 0.5$ | 13.31 | 0.26 | 0.20 | 0.18 | 0.22 | 0.10 | −0.19 | 0.85 | 1.76 | 3.07 | 0.18 |
| *Flexible wages* | | | | | | | | | | | |
| Baseline | 13.68 | 3.75 | 0.34 | −0.02 | 3.06 | 0.31 | −0.53 | 28.71 | 90.0 | 52.2 | 0.001 |
| Energy-intensive | 27.24 | 6.62 | 0.70 | −0.04 | 5.58 | 0.66 | −1.12 | 96.25 | 62.7 | 38.9 | 0.007 |
| Keynesian ($\varsigma = 1$) | −12.27 | 0.47 | −0.30 | 0.13 | −0.17 | −0.71 | 0.22 | 0.96 | 0.81 | 1.26 | 0.068 |
| Keynesian, $\gamma = 0.5$ | −8.38 | 0.15 | −0.23 | 0.08 | −0.25 | −0.43 | 0.11 | 0.31 | 0.75 | 1.14 | 0.030 |
| HtM 0.4, $\gamma = 0.5$ | 13.31 | 2.70 | 0.36 | −0.05 | 1.85 | 0.34 | −0.49 | 13.81 | 35.3 | 25.7 | 0.015 |

*Notes:* 10% persistent shock, incomplete information. Core inflation in annualised percentage points, GDP in percent; LT: look-through (then headline rule); C: core rule; RC: Ramsey policy. Ex ante losses in basis points of one quarter's consumption and ratios to the headline (H) and core (C) rules.

Figure 10 and Table 10 report the comparisons. The energy-intensive economy increases the magnitude of cost pressure without changing the qualitative policy ranking. In the Keynesian economy, look-through partially accommodates the output contraction, whereas the headline rule reacts to the first-round CPI jump. The comparison also shows why similarity to the optimal

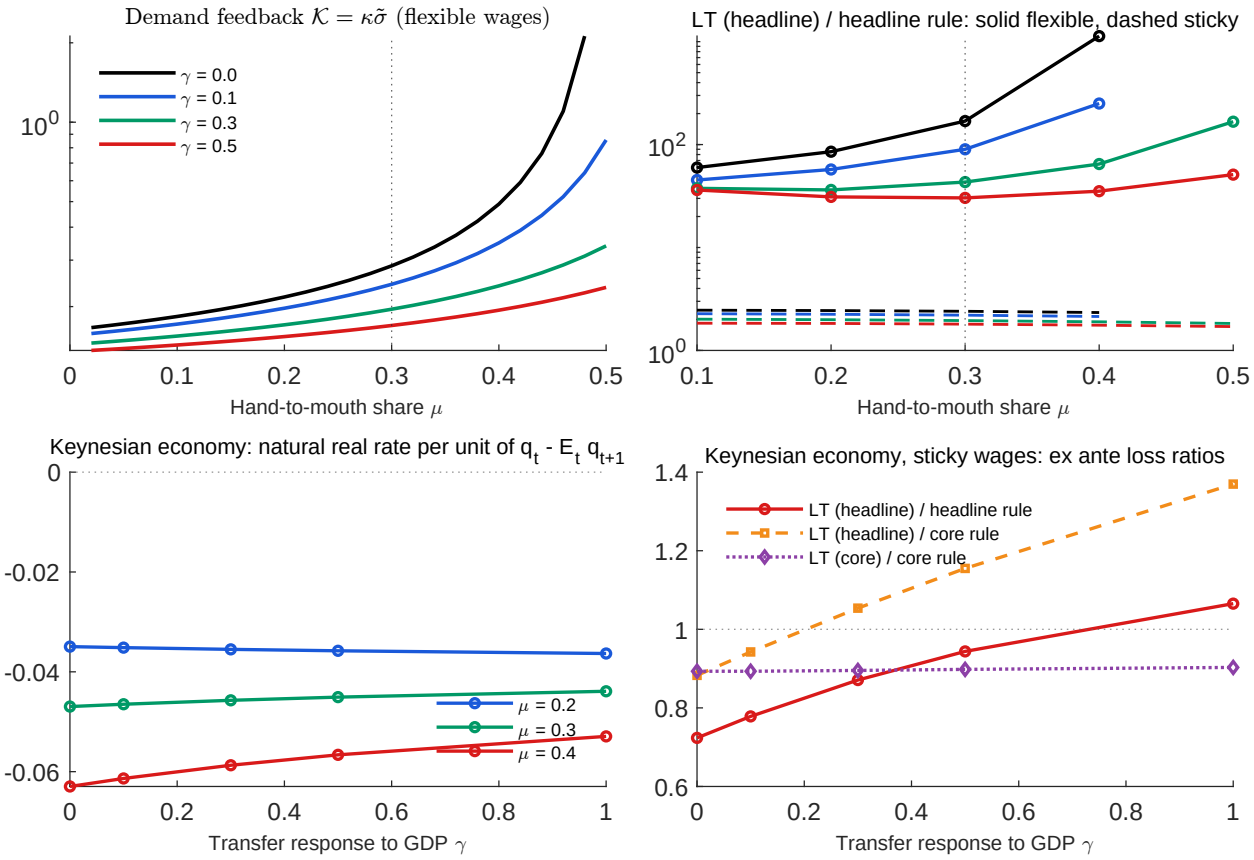



Figure 9: Hand-to-mouth households and automatic stabilisers

*Notes:* Top: all energy imported. Top left: demand feedback $\mathcal{K} = \kappa\tilde{\sigma}$ (flexible wages, log scale; curves stop where the IS curve inverts). Top right: ex ante loss of look-through relative to the headline rule. Bottom: all energy supplied domestically ($\varsigma = 1$), against the transfer coefficient.

interest-rate response is not equivalent to identical welfare.

## J Extension: recycling the energy windfall

Suppose the transfer rule also recycles a share $\tau_R$ of the energy windfall to HtM households,

$$\frac{\mathcal{T}_t - \bar{\mathcal{T}}}{\bar{Y}} = -\gamma y_t + \tau_R \frac{(Q_t/P_t - \bar{q})\bar{E}}{\bar{Y}}.$$

Then $a_q = -(\mu c\theta_n + \tau_R \varrho/s_x)/(1-\mu)$, $\psi = [\mu c\theta_n(1+\varphi) + \tau_R\varrho/s_x]/D$, with $D = 1 - \mu(1+\varphi) + g$ as in Appendix A; $\kappa$ and $\sigma$ are unchanged, and the Keynesian condition of Proposition 2 becomes

$$\varrho\,\varphi\,(1 + g - \tau_R) > s_E(1+\varphi)(1-\mu+g).$$

Recycling makes the condition harder to satisfy; with full recycling ($\tau_R = 1$) it holds if and only if $\varrho\varphi g > s_E(1+\varphi)(1-\mu+g)$, which fails at our baseline transfer coefficient (it can hold again for very strong automatic stabilisers, since then $\tau_R > \mu$ and higher $\gamma$ eases the condition). At the

threshold, a higher $\gamma$ makes the condition harder to satisfy if and only if $\tau_R < \mu$. Table 11 reports the economy that supplies all its own energy. The shock stops being Keynesian when more than a share 0.51 of the windfall is recycled ($b = 0.0116$ with full recycling). The case for look-through followed by the headline rule disappears earlier: recycling a quarter of the windfall already makes it lose to that rule (1.19 with sticky wages, against 0.78 without recycling). Look-through followed by the core rule behaves differently: with sticky wages its advantage over the core rule widens at moderate recycling (0.68 at $\tau_R = 0.25$), as the shock moves towards the threshold. Unlike automatic stabilisers, whose effect on the threshold is bounded, a transfer that targets the rents can remove the Keynesian channel at the baseline transfer coefficient.

Table 11: Recycling the energy windfall in the economy that supplies all its own energy

| | | Sticky wages | | | Flexible wages | | |
|---|---|---|---|---|---|---|---|
| $\tau_R$ | $10^3 b$ | LT/H | LT/C | $\text{LT}_C$/C | LT/H | LT/C | $\text{LT}_C$/C |
| 0.00 | −12.27 | 0.78 | 0.94 | 0.89 | 0.81 | 1.26 | 8.87 |
| 0.25 | −6.30 | 1.19 | 2.24 | 0.68 | 10.2 | 27.5 | 13.0 |
| 0.50 | −0.33 | 1.59 | 2.25 | 1.03 | 186 | 221 | 0.88 |
| 0.75 | 5.65 | 1.44 | 1.64 | 1.09 | 59.1 | 36.8 | 3.92 |
| 1.00 | 11.62 | 1.33 | 1.42 | 1.10 | 28.0 | 20.8 | 4.90 |

*Notes:* $\varsigma = 1$, baseline $\gamma$. Ex ante loss ratios under incomplete information, defined as in Table 9.