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## Battle of the markups: conflict inflation and the aspirational channel of monetary policy transmission

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## Abstract

Since the post-Covid rise in inflation has been accompanied by strong wage growth, the distributional conflict between wage and price-setters (both wishing to attain a certain markup) has regained prominence. We examine how a central bank should resolve a 'battle of the markups' when aspired markups are cyclically sensitive, highlighting a new 'aspirational channel' of monetary transmission. We establish conditions under which an inflationary situation characterised by inconsistent aspirations requires a reduction in economic activity, to eliminate worker-firm disagreement over the appropriate level of the real wage. We find that countercyclical markups and/or a flat Phillips curve call for more dovish monetary policy. Estimating price markup cyclicality across 44 countries, we find that monetary contractions are better able to lower inflation when markups are procyclical.

**Key words:** Inflation, wage-price dynamics, markups, monetary policy transmission, Taylor principle, determinacy.

**JEL classification:** E31, E32, E52, E58.

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# 1 Introduction

*We need to ensure that firms absorb rising labour costs in margins. If monetary policy is sufficiently restrictive, the economy can achieve disinflation overall while real wages recover some of their losses. But this hinges on our policy dampening demand for some time so that firms cannot continue to display the pricing behaviour we have recently seen.*
– Christine Lagarde (2023)

As pointed out in seminal works by Rowthorn (1977), Blanchard (1986), and Layard and Nickell (1986), inflation can be seen as the result of a type of distributional conflict – a situation in which the sum of the competing claims, or "aspirations", by various groups (e.g., workers and firms) is inconsistent with the total size of the economy. Lorenzoni and Werning (2023ab) have recently resuscitated this wage-price-centric view by pointing out that disagreement is also driving inflation in a standard new-Keynesian model, while Beaudry, Carter, and Lahiri (2022) analyze the ability of central banks to "look through" supply shocks in a model featuring the possibility of a wage-price spiral.

Following the recent bout of inflation, which has led to renewed focus on wage-price dynamics, we build on this literature. Our novel contribution is to examine how a central bank should resolve a "battle of the markups" when aspired markups are cyclically sensitive. We show that central banks ought to create cyclical conditions to moderate the various claims as necessary, ensuring consistency with the total size of the economy. This leads to an "aspirational channel" of monetary policy transmission, which brings about changes in the relative power of workers versus firms. But the direction in which central banks should respond is shown to depend on the cyclicality of wage- and price markups (where the relevant concept is the "frictionless" markup that would be desired by firms and workers if prices and wages were fully flexible). If flexible price/wage markups are procyclical, a monetary contraction lowers inflation via the resulting slowdown reduces aspirations of workers and/or firms (getting them to settle for a lower markup). Here, economic slack (think: unemployment, or the output gap) fulfills a taming role, moderating unrealistic aspirations held by firms or workers. But if markups are countercyclical, a central bank responding aggressively to inflation may create indeterminacy – particularly if the Phillips curve is rather flat. Monetary policy may then need to take a more accommodating stance towards inflation to produce a determinate equilibrium, or place a bigger weight on the output gap – i.e., conduct monetary policy "more dovishly". Optimal policy considerations are shown to carry similar implications.

The notion that the optimal flexible-price markup varies over the business cycle is widespread and there are various reasons for why this may result. An economic slowdown could make firms afraid of having to carry large inventories of unsold products, or suffer from capacity under-utilisation. This would imply that price markups aspired by firms are procyclical. While such procyclicality is supported by some models,[1] others imply that firms' desired markups are countercyclical.[2] Throughout this paper, we remain agnostic on the precise channel(s) giving rise to the cyclicality in desired markups. Instead, we take a reduced-form approach to focus squarely on the impact of cyclicality as such.

Empirical evidence on the cyclicality of markups also abounds. On price markups, the seminal work by Rotemberg and Woodford (1999) has since been complemented by various studies, including: Bils and Kahn (2000) and Kryvtsov and Midrigan (2013), arguing that inventory behavior points to price markups being countercyclical; Gilchrist et al. (2017), who find that financially-constrained firms increased their markups in the Great Recession; and Bils, Klenow, and Malin's (2018), whose finding of a persistent, countercylical price markup also suggests that firms actively raise markups in downturns. Other studies support price markup *pro*cylicality, including Haskel, Martin, and Small (1995, on UK data), Nekarda and Ramey (2020, who show that the cyclicality may vary in response to different shocks, documenting procyclicality following demand shocks) and Afrouzi and Caloi (2023, who find that accounting for output dynamics is important and favors procyclicality). Hong (2019) and Burstein, Carvalho, and Grassi (2020) show how the various estimates can be reconciled via a "bottom-up" approach (distinguishing between various levels of aggregation, with markups being more procyclical for larger firms). When it comes to the cyclicality of flexible-wage markups, most can be learned from analyzing wages of newly-hired workers (ideally out of unemployment), as those are less affected by wage rigidities. Studies report these "marginal" wages to be procyclical – in line with the standard logic that workers have a worse bargaining position in recessions; see Haefke, Sonntag, and Van Rens (2013, for the U.S.), Lydon and Lozej (2018, for Ireland), and Albagli et al. (2022, for Chile).[3]

[1]See, e.g., Qiu and Ríos-Rull (2022, who consider a model with search frictions) or Harrod (1936, who believed markups to be procyclical because of lower price sensitivity of consumers during booms).

[2]Examples include: implicit collusion of oligopolists (Rotemberg and Woodford, 1992); the existence of customer markets (Phelps and Winter, 1970; Bils, 1989); cyclicality in income dispersion (Edmond and Veldkamp, 2009); firm entry/exit (Portier, 1995; Jaimovich and Floetotto, 2008; Bilbiie, Ghironi, and Melitz, 2012); and cyclical variations in demand composition (Galí, 1994). The general idea of countercyclical markups can be traced back to Pigou (1927), Kalecki (1938), and Keynes (1939), who thought that monopoly power in goods markets went up in recessions.

[3]The finding of Gertler, Huckfeldt, and Trigari (2020), that wages of new hires from unemployment are no more cyclical than those of existing workers, contrasts with Haefke, Sonntag, and Van Rens (2013). But, importantly for our paper, Gertler et al. still report wages for existing workers to be procyclical (it is just that they do not find greater procyclicality for new hires out of unemployment).

Following the significant rise in inflation that affected many countries post-2021, the role played by firms' price markups (and associated wage-price dynamics) has taken center-stage: in popular discussions (where references to "greedflation" and "profiteering" abound), among policymakers (Lagarde, 2023; Pill, 2023), as well as in academic circles. Lorenzoni and Werning (2023b) develop an analytical framework to distinguish between "adjustment" and "conflict" inflation, noting that conflict should be viewed as the most proximate cause of inflation; a related paper by Lorenzoni and Werning (2023a) studies wage-price dynamics in a new-Keynesian setting. Bilbiie and Känzig (2023) analyze how the cyclicality of profits affects shock propagation in a heterogeneous-agent setup. Arce, Hahn, and Koester (2023) suggest that about two-thirds of 2022 inflation in the Eurozone is driven by profit increases (compared to a pre-pandemic average of one-third), while Glover, Mustre-del-Río, and Von Ende-Becker (2023) find that markup growth likely contributed more than 50 percent to U.S. inflation in 2021 (though much of this seems to have happened in anticipation of future cost pressures). Weber and Wasner (2023) argue that interest rate hikes are not an appropriate policy response to (what they see as) "sellers' inflation". Our framework formalizes elements of this debate and establishes precise conditions under which interest rate hikes are an appropriate policy response (as well as those under which a more accommodating monetary policy is required).

The remainder of this paper is structured as follows. First, Section 2 develops a stylized model which demonstrates what role monetary policy can play in a setup where workers and firms disagree about the appropriate level of the real wage. It shows that if aspired markups of workers and firms respond with different intensity to changes in cyclical conditions, monetary policy can bring competing claimants back in line by using the extent of economic slack to moderate markup aspirations. Section 3 subsequently brings the core insight to a new-Keynesian environment and analyzes issues related to determinacy and optimal policy. Next, Section 4 provides empirical evidence supporting the model's prediction that monetary contractions have stronger anti-inflationary effects in countries with procyclical price markups. Section 5 concludes.

## 2 Stylized model

In this section we build a stylized model to capture the "competing claims" notion of inflation. In Section 3 we will amend a new-Keynesian model with the features necessary to capture the essence of our simple setting – examining implications for monetary policy. Section 2.1 starts by analyzing a static setup, to build core intuition (in particular with respect to the role played by cyclical conditions in moderating markup aspirations), after which Section 2.2 will add adjustment dynamics and a central bank.

## 2.1 Static setup

First consider the following setup, inspired by Layard, Nickell, and Jackman (1991). Firms want to set their price as a "frictionless" aspired markup $\mu_p$ over the unit cost of labor and imported inputs to production (where the label "frictionless" indicates that this notion of markups abstracts from nominal rigidities; instead it is the markup firms would set if prices were fully flexible). Assuming that imported inputs account for a production cost share $\zeta_p$, such a pricing strategy boils down to:

$$P^{\#} = e^{\mu_p} \left( \frac{WN}{Y} \right)^{1-\zeta_p} P_f^{\zeta_p},$$

where $P^{\#}$ denotes the price that is aspired by firms, $W$ represents the nominal wage rate, $N$ is labor input, $P_f$ is the price of imported goods (in local currency)[4]; domestic output is denoted by $Y$. Firms thus aspire to be fully compensated for increases in production costs, either stemming from domestic or international pressures.

Workers want to set their real consumption wage (the nominal wage divided by the consumer price level, accounting for imports) by enjoying a frictionless aspired markup $\mu_w$ over the marginal product of labor. So they aspire to be compensated for increases in consumer prices (either stemming from domestic or international pressures), as well as wishing to capture gains from increased labor productivity $Y/N$:

$$W^{\#} = e^{\mu_w} \left( \frac{Y}{N} \right) P^{1-\zeta_w} P_f^{\zeta_w},$$

where $P^{1-\zeta_w} P_f^{\zeta_w}$ is the price of the consumption basket: it consists of the domestic price level $P$ and the price of imported goods $P_f$, which carries a share $\zeta_w$ in the basket. Letting $S \equiv P_f/P$ denote the terms-of-trade, we obtain the following in logs (using lower-case letters to represent natural logarithms of variables, and defining $\gamma \equiv \ln(Y/N)$):

$$p^{\#} = w + \frac{\mu_p + \zeta_p s}{1 - \zeta_p} - \gamma, \tag{1}$$

$$w^{\#} = p + \zeta_w s + \mu_w + \gamma. \tag{2}$$

[4]To keep the analysis simple, we abstract from movements in the nominal exchange rate $\mathcal{E}$, effectively thus considering a case of local currency pricing or a pegged exchange rate regime ($\mathcal{E} = 1$).

Depending on the aspiration levels for firms ($\mu_p$) and workers ($\mu_w$) , and the terms-of-trade ($s$), aspired markups are unlikely to be compatible with the size of the economy. This is only the case if aspirations by workers and firms are consistent with the "space" created by the terms-of-trade, i.e., if

$$(1-\zeta_p)\mu_w + \mu_p = -(\zeta_p + \zeta_w - \zeta_p\zeta_w)s.$$

If the competing claims exceed this space, there is an unresolved "battle of the markups".

Layard and Nickell (1986) argue that fluctuations in unemployment $u$ have an impact on aspirations held by firms and workers, giving $u$ the ability to function like a clearing mechanism through which inconsistent aspirations can be resolved. In particular, they argue that the markup desired by workers is procyclical and declines in unemployment, as the bargaining power of workers (or their representing unions) is lower when $u$ is higher. Unemployment here acts like a moderating device, lowering workers' markup aspirations. This can be captured, in a reduced-form way, by specifying that the frictionless wage markup consists of a structural component ("$\overline{\mu}_w$") and a cyclically-sensitive one ("$-k_w u$"):

$$\mu_w = \overline{\mu}_w - k_w u. \tag{3}$$

The slope $k_w$ captures the cyclicality in the frictionless wage markup desired by workers. Setting $k_w > 0$ implies that greater unemployment reduces the wage markup aspired by workers (or unions on their behalf), leading to a procyclical frictionless wage markup.[5]

Similarly, one can also allow for unemployment to affect the markup desired by firms:

$$\mu_p = \overline{\mu}_p - k_p u. \tag{4}$$

As discussed in the Introduction, the cyclicality of the price markup aspired by firms is debated – both theoretically and empirically. This suggests that price markups may be less cyclically-sensitive than wage markups, making us most comfortable to proceed under the assumption that $k_w > |k_p| > 0$, without assuming anything about the sign of $k_p$ or the

[5] This may seem at odds with empirical studies reporting the wage markup to be countercyclical (Galí, Gertler, and López-Salido (2007); Hall (2009); Karabarbounis (2014)), but they are looking at wage outcomes *observed in equilibrium*. Those are also affected by aspirations of firms, who strive for a higher value of $P/W$ (as opposed to workers' objectives being increasing in $W/P$). Moreover, a countercyclical wage markup in the data is not at odds with $k_w > 0$ because of wage stickiness (remember that $k_w$ only governs the "frictionless" cyclicality in a counterfactual world where wages are perfectly flexible). Consequently, looking at the cyclicality of wages for *newly-hired workers* is most informative in this context (as they are less affected by wage rigidities), and those are widely reported to be procyclical (Haefke, Sonntag, and Van Rens, 2013; Lydon and Lozej, 2018; Albagli et al., 2022).

exact theoretical underpinning of such cyclicality. Instead, we stick with a reduced-form approach to focus purely on the general implications of aspired markups being cyclically sensitive.

By substituting (3) and (4) into (1) and (2), and allowing unemployment to resolve the "battle of the markups", we obtain levels for the real wage $(w-p)^\diamond$ and unemployment $u^\diamond$ at which the various aspirations have become compatible and conflict is resolved:

$$(w-p)^\diamond = \frac{k_p\overline{\mu}_w - k_w\overline{\mu}_p - (k_w\zeta_p - k_p\zeta_w)s}{k_p + k_w(1-\zeta_p)} + \gamma, \tag{5}$$

$$u^\diamond = \frac{\overline{\mu}_p + (1-\zeta_p)\overline{\mu}_w + [\zeta_w(1-\zeta_p)+\zeta_p]\, s}{k_p + k_w(1-\zeta_p)}. \tag{6}$$

For the most standard case where $k_p + k_w(1-\zeta_p) > 0$,[6] we distill several insights:

1. First considering the case where $\zeta_p = 0$, meaning that the terms-of-trade has no direct effect on firms, (5) and (6) show that unemployment will only be able to resolve a situation of incompatible claims when it affects aspirations of firms and workers with different intensity (so that different levels of unemployment are associated with differences in relative market power of workers versus firms). That is: one needs $k_p + k_w \neq 0$, or one encounters a singularity in equations (5)-(6).[7] Economically, having $k_p + k_w = 0$ implies that changes in unemployment bring about changes in aspired markups that exactly offset – meaning that fluctuations in $u$ have no role to play in resolving distributional conflict.[8] When $\zeta_p > 0$, wages account for a smaller share of production costs (and imported materials for more), meaning that the parameter governing the cyclicality of the wage markup ($k_w$) becomes less important.

2. An increase in the structural part of the wage markup aspired by workers ($\overline{\mu}_w \uparrow$)

[6] This condition holds when the wage markup aspired by workers $\mu_w$ is (a) important to price setters (the share of firms' imports $\zeta_p$ not too large), (b) most cyclically sensitive ($|k_w| > |k_p|$) and (c) procyclical ($k_w > 0$, as suggested by bargaining logic). Building on the analysis in Section 2.2, Appendix A discusses dynamics when $k_p + (1-\zeta_p)k_w < 0$, showing that this case features a somewhat odd form of negative pass-through (which is why we view $k_p + (1-\zeta_p)k_w > 0$ as the most natural case).

[7] Note that it is fine to have $k_p = k_w$ (since firms and workers aspire to push the real wage in opposite directions); it is just a situation of equality with opposite sign that needs to be avoided.

[8] Note that unemployment comes about somewhat curiously in this simple setup: "it" somehow understands that it needs to clear the conflict – tilting the relative market power of workers and firms in a way to ensure compatibility between the various competing claims. In Section 2.2 we will move away from this notion by introducing a central bank that can affect the cycle – thereby altering markup aspirations of workers and firms – with an eye towards producing a determinate equilibrium.

pushes up unemployment in order to resolve the "markup battle" – but less so the closer $\zeta_p$ is to 1, as the importance of wage costs to firms falls with $\zeta_p$. The implications for the real wage depend on the sign of $k_p$, which is the cyclicality of the markup aspired by firms. When $k_p > 0$ a higher aspired wage markup by workers increases their real wage, as the increase in unemployment lowers the price markup charged by firms. This creates room for workers to enjoy a higher real wage, in line with their elevated aspirations. But if $k_p < 0$ higher structural aspirations by workers end up backfiring: the resulting increase in unemployment raises the markup charged by firms (as this is now countercyclical), which requires the real wage to fall in order to re-establish consistency.

3. An increase in the structural part of the price markup aspired by firms ($\overline{\mu}_p \uparrow$) pushes up unemployment, while reducing the real wage (by lowering the wage markup, via a worsened bargaining position for labor in the standard case where $k_w > 0$).

4. A worse terms-of-trade ($s \uparrow$) pushes up unemployment. It shrinks the size of the pie that can be divided domestically (a greater share falls to foreigners, as importing a given quantity now requires more real resources). Absent a reduction in structural aspirations $\overline{\mu}_p$ or $\overline{\mu}_w$ or offsetting increases in productivity $\gamma$, that implies distributional conflict. To re-impose consistency between competing claims, $u$ needs to rise. The effect on the real wage depends on the sign of $(k_w\zeta_p - k_p\zeta_w)$. Since this expression involves two interaction terms, the intuition is best understood when fixing each part in turn. First, fix $\zeta_p = \zeta_w = \zeta > 0$. Then, $k_w\zeta - k_p\zeta < 0$ implies that price markups are most exposed to the cycle (meaning that firms have to bear the brunt of the recession), and firms end up having to pay a higher real wage; the opposite applies if $k_w\zeta - k_p\zeta > 0$. Next, fix $k_p = k_w = k > 0$. Then, $k\zeta_p - k\zeta_w < 0$ implies that workers (who ultimately care about their ability to purchase consumption goods) see their real consumption wage fall after a terms-of-trade loss, since part of consumption is imported – now at a less favorable rate. This leads to a higher real wage $W/P$ (where $P$ is the *domestic* price level) as consumers partly pass on this loss to producers; the opposite applies if $k\zeta_p - k\zeta_w > 0$.

## 2.2 Dynamic extension

Next, let us enrich the static model developed in Section 2.1 with adjustment dynamics in the presence of price and wage rigidities (for example stemming from a Calvo (1983) friction or price adjustment costs of the Rotemberg (1982) type). In addition, we introduce a central bank which sets the interest rate – steering the economy with an eye towards preventing indeterminacy. This enables us to move away from the stylized setting of Section 2.1, where unemployment somehow takes on the "clearing" role of steering the relative markup aspirations of workers and firms in a way to ensure compatibility between the various competing claims (recall footnote 8). A priori, there is no strong reason as to why unemployment would take on this role. After all: unemployment has many other determinants, including search frictions (Pissarides, 2000) or preventing workers from shirking (Shapiro and Stiglitz, 1984), implying that it is not "free" to assume other roles. But (part of) the *raison d'être* of central banks lies in stabilizing inflation and the economy, so we now move to a setting in which a central bank conducts monetary policy taking note of the effects that changes in cyclical conditions have on aspired markups.

To simplify the analysis, we hold labor productivity constant at 1 (so that its natural log $\gamma = 0$) and take the price of the imported good to be exogenous. That leads to:

$$\dot{w}_t = \lambda_w[p_t + \zeta_w s + \mu_{w,t} - w_t], \tag{7}$$

$$\dot{p}_t = \lambda_p[w_t + \widetilde{\zeta}_p s + \widetilde{\mu}_{p,t} - p_t], \tag{8}$$

where variables carrying a tilde are defined as $\widetilde{x} \equiv (1-\zeta_p)^{-1}x$. These equations state that wages and prices will gradually move to their aspired levels, with the speed of adjustment being governed by $\lambda_w > 0$ and $\lambda_p > 0$, respectively.[9] Combining (7) and (8) (and using time-variant versions of (3) and (4)) leads to an equation describing the evolution of the real wage $\omega_t \equiv w_t - p_t$:

$$\dot{\omega}_t = \lambda_w \overline{\mu}_w - \lambda_p \widetilde{\overline{\mu}}_p + \left[\lambda_w \zeta_w - \lambda_p \widetilde{\zeta}_p\right] s - \left[\lambda_w k_w - \lambda_p \widetilde{k}_p\right] u_t - [\lambda_w + \lambda_p]\omega_t. \tag{9}$$

It seems natural to take $\lambda_w k_w > \lambda_p \widetilde{k}_p$, so that the real wage falls as unemployment rises.

Next, consider a standard Euler equation that arises under log-utility by households:

$$\dot{c}_t = R_t - \pi_t - \varrho, \tag{10}$$

where $\varrho$ represents the constant rate of time preference, $\pi_t \equiv \dot{p}_t$ (the rate of inflation),

[9] Note that equations (7) and (8) are only correct if workers and firms are myopic, as they do not take future aspiration levels into account (see Lorenzoni and Werning (2023ab) for the differential equations in the case where agents are forward looking). Section 3 will model foreward-looking behavior along fully rational lines, but this turns out to be of minor importance to the point we want to highlight below – which is why we simplify along this dimension here.

and $R_t$ the nominal interest rate. The latter is set by the central bank, with the aim of steering the economy in a way that ensures determinacy. We assume that the interest rate is set according to a simple Taylor-type rule responding to inflation and unemployment with reaction coefficients $\phi_\pi, \phi_u \geq 0$, respectively:

$$R_t = \phi_\pi \pi_t - \phi_u u_t. \tag{11}$$

The negative sign in (11), combined with $\phi_u \geq 0$, captures the notion that the central bank will set a lower interest rate when unemployment is higher. We define the Taylor principle in a narrow way, as the central bank responding more than one-for-one to inflation deviations from target, i.e., having $\phi_\pi > 1$.

In this case, combining our linear production technology $y_t = n_t$ with (10), (11) and goods-market clearing, implies the following for the evolution of unemployment $u_t \equiv 1 - n_t$:

$$\dot{u}_t = \varrho - (\phi_\pi - 1)\pi_t + \phi_u u_t. \tag{12}$$

Using equation (8) in (12), along with a time-variant version of (4), yields:

$$\dot{u}_t = \varrho - (\phi_\pi - 1)\lambda_p[\omega_t + \widetilde{\zeta}_p s + \widetilde{\overline{\mu}}_p - \widetilde{k}_p u_t] + \phi_u u_t. \tag{13}$$

Together, equations (9) and (13) describe a system of two equations in two unknowns (unemployment and the real wage), with its dynamics described by:

$$\begin{bmatrix} \dot{\omega}_t \\ \dot{u}_t \end{bmatrix} = \underbrace{\begin{bmatrix} -(\lambda_w + \lambda_p) & -(\lambda_w k_w - \lambda_p \widetilde{k}_p) \\ -(\phi_\pi - 1)\lambda_p & (\phi_\pi - 1)\lambda_p \widetilde{k}_p + \phi_u \end{bmatrix}}_{J} \begin{bmatrix} \omega_t - \omega^* \\ u_t - u^* \end{bmatrix} + \begin{bmatrix} \lambda_w \overline{\mu}_w - \lambda_p \widetilde{\overline{\mu}}_p + \left(\lambda_w \zeta_w - \lambda_p \widetilde{\zeta}_p\right) s \\ \varrho - (\phi_\pi - 1)\lambda_p \left(\widetilde{\zeta}_p s + \widetilde{\overline{\mu}}_p\right) \end{bmatrix}, \tag{14}$$

where the steady-state outcomes $\omega^*$ and $u^*$ follow from setting (9) and (13) equal to zero.

### 2.2.1 Determinacy

In this setting, the central bank can affect cyclical conditions (here proxied by unemployment) which, in turn, has a bearing on markup aspirations of workers and firms (as governed by equations (3) and (4)). This affects the model's stability properties. To see this, note that the determinant of the Jacobian matrix $J$ in (14) is given by:

$$\det(J) = -\lambda_p \lambda_w (\widetilde{k}_p + k_w)(\phi_\pi - 1) - (\lambda_w + \lambda_p)\phi_u, \tag{15}$$

which features the "aggregate" degree of markup cyclicality in the economy $(\widetilde{k}_p + k_w)$.

Armed with (15) we can establish the following with regards to the Rational Expectations Equilibrium (REE):

**Proposition 1.** *If the central bank abides by the Taylor principle* ($\phi_\pi > 1$) *the REE is determinate iff*

$$\widetilde{k}_p + k_w > -\frac{\phi_u(\lambda_w + \lambda_p)}{(\phi_\pi - 1)\lambda_p \lambda_w}. \tag{16}$$

*Proof.* Since the model consists of one predetermined variable, $\omega$, and one jump variable, $u$, we need the matrix $J$ to have one stable and one unstable eigenvalue to obtain saddle-path stability. Since the determinant of $J$ is equal to the product of its two eigenvalues, this requires $\det(J) < 0$, which – in turn – requires (16) when $\phi_\pi > 1$.■

**Corollary 1.** *If the central bank does not abide by the Taylor principle* ($\phi_\pi < 1$) *the REE is determinate iff*

$$\widetilde{k}_p + k_w < -\frac{\phi_u(\lambda_w + \lambda_p)}{(\phi_\pi - 1)\lambda_p \lambda_w}.$$

Condition (16) is easiest to understand when considering a narrow Taylor rule that is solely focused on inflation (i.e., $\phi_u = 0$); (16) then simplifies to $\widetilde{k}_p + k_w > 0$. This condition tells us that the Taylor principle only delivers determinacy when there is enough procyclicality in wage and price markups (which co-determine the evolution of the real wage $\omega \equiv w - p$). In that case, inflation resulting from "inconsistent aspirations" can only be resolved through an increase in unemployment when $\widetilde{k}_p + k_w > 0$. Only in that case does greater unemployment tame aggregate aspirations (one can define those as $\mu_p + \mu_w$). This logic indeed seems to be on policymakers' minds: Lagarde (2023) for example stated that the anti-inflationary success of ECB rate hikes hinges on "policy dampening demand for some time so that firms cannot continue to display the pricing behaviour we have recently seen". In terms of our model, she thus takes the view that $\widetilde{k}_p > 0$, leading to a transmission channel whereby a cyclical deterioration reduces firms' markup aspirations and therewith inflation.

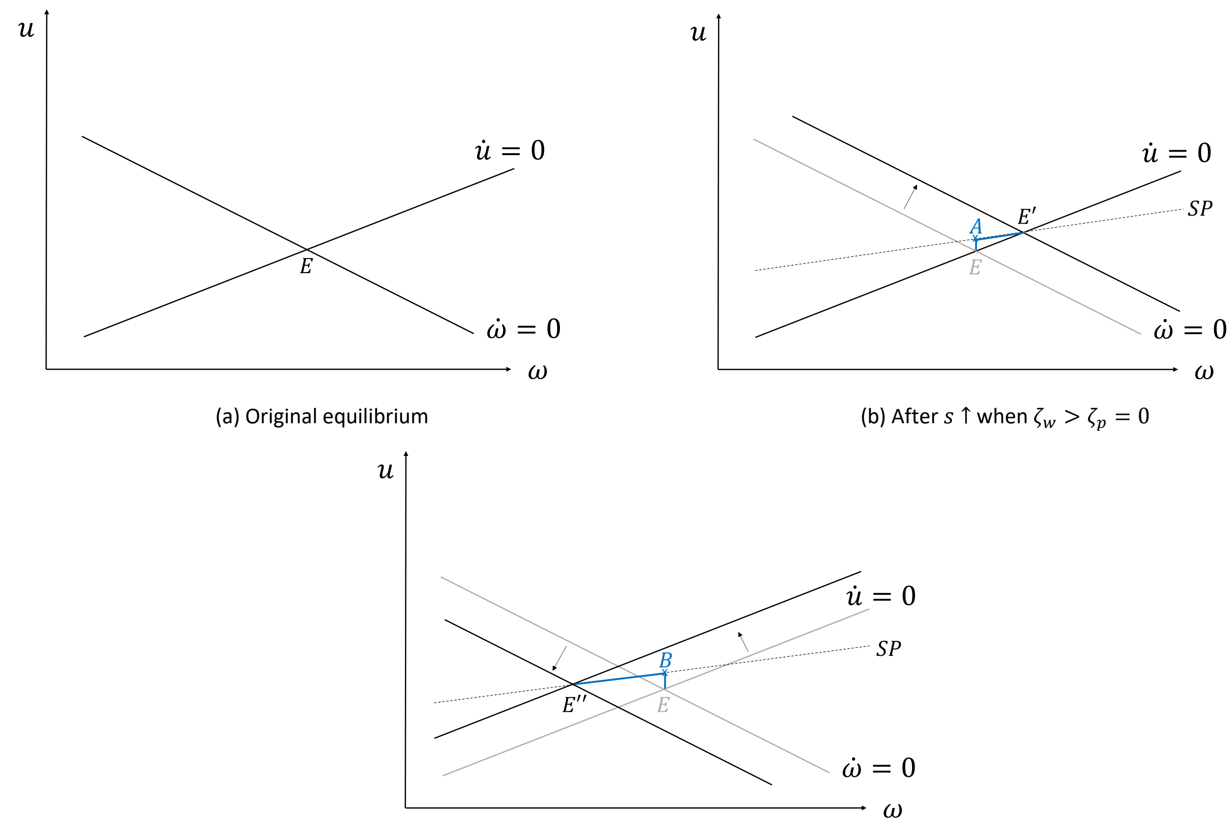
But if $\widetilde{k}_p + k_w < 0$, for example because of strong countercyclicality in frictionless price markups ($\widetilde{k}_p < -k_w < 0$), the Taylor principle is unable to resolve the "battle of the markups" and fails to deliver determinacy: in that case the dominant effect of higher rates is to raise the aspired price markup $\mu_p$. In our simple model, this worsens the recession (unemployment rises by (13)) which increases firms' markup aspirations *even more*. Here, responding "actively" to higher inflation (i.e., with $\phi_\pi > 1$) fails to resolve the inflation conflict (in contrast: it feeds inflation) and a passive approach is required (Corollary 1).

When the monetary policy rule becomes responsive to unemployment in a countercyclical way (i.e., with $\phi_u > 0$), abiding by the Taylor principle "$\phi_\pi > 1$" becomes more compatible with determinacy – even if $\widetilde{k}_p + k_w < 0$ (the case where markups are countercyclical on aggregate). The reason is that the central bank's countercyclical response to unemployment puts a break on inflation driven by the countercyclicality in firm markups – making the conventional Taylor principle more compatible with a determinate equilibrium. As we show in Section 3, similar logic applies in a new-Keynesian setup – only with an important role to be played by the slope of the Phillips curve.

### 2.2.2 Dynamics following a terms-of-trade shock

To better understand the forces at play, and given recent events (where many energy-importing countries experienced a negative terms-of-trade shock), we analyze the model's dynamics following a permanent, unanticipated adverse terms-of-trade shock, pushing up $s$. The system (14) can be represented graphically through the phase diagram in Figure 1a. The effects of $s \uparrow$ vary with the exposure to the shock of workers versus firms. Let us therefore consider two polar cases in turn. For brevity and ease of exposition, the main text focuses on the most standard case where $\phi_\pi > 1$, meaning that the $\dot{u} = 0$ locus is upward-sloping in $\omega$. But we know (from Corollary 1) that our model also allows for cases where the $\dot{u} = 0$ locus is *downward*-sloping in $\omega$ (as long as its slope is smaller in absolute value than that of the $\dot{\omega} = 0$ locus). The dynamics for that case are shown and discussed in Appendix A (which also discusses how this case leads to "burden-concentration/multiplication", in contrast to the burden-sharing described below for the case where the $\dot{u} = 0$ locus is positively sloped).

**Case I: $\zeta_w > \zeta_p = 0$.** In the first case workers are more reliant on imports ("energy") than firms, whose exposure we have normalized to zero for ease of exposition. Starting from the original equilibrium $E$, an adverse terms-of-trade shock leaves the $\dot{u} = 0$ locus untouched, but pushes up the $\dot{\omega} = 0$ locus since any given real wage $W/P$ buys each worker less in terms of consumption (which is partly imported, now at a higher price). The higher real wage gives rise to inflation, to which the central bank (aiming to keep prices stable through its interest rate rule (11)) responds by tightening. This increases unemployment, which first jumps to point $A$ (located on the saddle path, $SP$) in Figure 1b. Along the transition path, both the real wage and unemployment keep rising until, ultimately, the inflation conflict is cleared. This gives rise to a new steady state at $E'$, featuring higher unemployment and a higher real wage; the latter reflects that there is positive pass-through of the terms-of-trade loss from workers to firms (who are not *directly* exposed to the shock under $\zeta_p = 0$); this process is similar to that of "tax shifting" in public finance. Still, because pass-through is incomplete, workers' ability to buy consumption goods is lower in this new steady state – reflecting the worsened terms of trade, along with the fact that consumption is partly imported when $\zeta_w > 0$.




(a) Original equilibrium

(b) After $s \uparrow$ when $\zeta_w > \zeta_p = 0$

(c) After $s \uparrow$ when $\zeta_p > \zeta_w = 0$

Figure 1: Phase diagrams following an adverse terms-of-trade shock for the case (b) where only workers rely on imports and the case (c) where only firms rely on imports.

**Case II: $\zeta_p > \zeta_w = 0$.** Next consider the opposite scenario where firms are exposed to the energy shock (and workers are not). This causes an upward shift in the $\dot{u} = 0$ locus, but also moves the $\dot{\omega} = 0$ locus down – capturing that firms are more energy-reliant, meaning that they wish to pass part of the pain on to workers (who are not directly exposed to the energy shock, since $\zeta_w = 0$), by paying a lower real wage.

This reduces steady-state real wages $\omega$, while increasing steady-state unemployment $u$ (Figure 1c). The reason is as discussed in the final paragraph of Section 2.1: following the adverse development in the terms-of-trade there is a smaller pie to be divided domestically, which requires greater unemployment to clear the resulting inflation conflict. Due to the response of monetary policy, $u$ overshoots in the short run (jumping from $E$ to $B$ on impact of the shock) and falls only gradually along the transition path.

### 2.2.3 The impact of equilibrium reasoning

It is also worthwhile to note that a greater degree of economic sophistication could decrease the need for a central bank to respond to adverse terms-of-trade shocks. To see this, suppose that aspirations held by workers and firms are *directly* sensitive to $s$ – reflecting a situation in which workers and firms engage in "equilibrium reasoning", realizing (and internalizing) that a terms-of-trade loss reduces the size of the pie that is to be divided domestically. In that case, (3) and (4) are extended to:

$$\mu_w = \overline{\mu}_w - k_w u - m_w s,$$
$$\mu_p = \overline{\mu}_p - k_p u - m_p s,$$

where $m_w, m_p > 0$ captures the notion that a worse terms-of-trade will moderate markup aspirations of workers and firms. The conflict-clearing level of unemployment is then given by:

$$u^{\diamond} = \frac{\overline{\mu}_p + (1-\zeta_p)\overline{\mu}_w + \left[(1-\zeta_p)\zeta_w + \zeta_p - (1-\zeta_p)m_w - m_p\right]s}{k_p + (1-\zeta_p)k_w}.$$

This shows that unemployment ceases to be sensitive to $s$ when:

$$m_p + (1-\zeta_p)m_w = \zeta_p + (1-\zeta_p)\zeta_w.$$

An obvious and intuitive constellation that meets this condition is $m_p = \zeta_p$ and $m_w = \zeta_w$. It requires that the sensitivity of aspired markups to $s$ is equal to the import exposure of firms, respectively workers. Hence, a central bank that is able to successfully communicate to workers and firms that, because production and consumption are import-intensive, a terms-of-trade loss reduces the size of the pie that is to be divided domestically, convincing workers and firms to "settle for less", will be able to bring inflation back to target *without* needing to worsen cyclical conditions.[10]

In cases where this does not hold, workers and firms will try to shift the burden on to each other, which ultimately requires the central bank to clear the conflict by affecting the business cycle. That strategy is not reliant on workers and firms thinking through, and internalizing, equilibrium considerations. Instead, it operates by relying on the moderating effect that unemployment has on markup aspirations – tilting the relative bargaining power of workers versus firms (as governed by $k_p$ and $k_w$) in a way to ensure consistency between competing claims.

# 3 New-Keynesian setup

Now that we have a better understanding of the role played by cyclical fluctuations in ensuring consistency between the various claims on national income, both statically and dynamically, we move to a new-Keynesian environment – adapted to capture the essence of Section 2's stylized model. This means that the standard model needs to be enriched with sticky wages, as well as with an optimal flexible-price markup rule that varies with the business cycle (so that it can act like a clearing mechanism, taming "excessive" markup aspirations if need be). Given the aim of this paper, we do not take an explicit stance on the exact origins of this cyclicality – as discussed in the Introduction, reasons to suspect that such cyclicality exists abound – choosing to focus on its implications instead.[11]

As we will show in Section 3.3, the cyclicality of the optimal frictionless markups has important consequences for the stability of the system and the associated Taylor principle. In particular, we will show that when

[10]Such a benign outcome is likely to require a substantial degree of coordination between representatives of both workers and firms, as this is ultimately a story of internalizing externalities. Interestingly, this is what the Dutch corporatist "polder model" is all about. From 1982 onwards, Dutch labor unions, employers' organizations, and government have been engaging in regular dialogue with the aim of maximizing employment opportunities whilst bringing down inflation via nominal wage restraint (supported by other policies, such as directed tax cuts), with considerable success. See Visser (1998) for a discussion.

[11]Ultimately, it is important to understand better *why* desired markups vary over the cycle – also since that mechanism could imply that the degree of cyclicality varies with the source of the driving shock (Nekarda and Ramey, 2020). We leave this issue for future work and proceed under the assumption that at least the direction of cyclicality (pro- or countercyclical?) is independent of the driving force. We return to this in Section 4, which offers some empirical evidence supporting this notion.

**(a)** frictionless price (or wage) markups are countercyclical, and

**(b)** the slope of the new-Keynesian Phillips curve is rather flat,

following an active Taylor rule may lead to indeterminacy – unless the rule features a strong enough response to the output gap. Hence, a constellation of (a) and (b) may call for a more "dovish" conduct of monetary policy (less sensitive to inflation, more to the output gap).

## 3.1 Model

Our model builds on Erceg, Henderson, and Levin (2000, "EHL"), who enriched the standard new-Keynesian sticky-price model with sticky wages. We augment this with an elasticity of substitution between varieties "$\varepsilon$" that fluctuates with the business cycle.[12] We equate the latter to the output gap ($y_t \equiv \mathrm{y}_t - \mathrm{y}_t^*$, the log-deviation of output from its efficient level) but one may also think of an unemployment gap if one prefers to stay closer in spirit to Layard and Nickell (1986). Introducing cyclicality in substitution elasticities is not crucial to our model *per se*, but forms a tractable way of producing frictionless desired markups that vary with the output gap (which is crucial to our model), enabling us to capture the essence of the stylized setup discussed in Section 2. Since the determinacy issue to which we will turn next is more easily established in continuous time, we work in that setting. This also eases comparisons with our results in Section 2.2, but is by no means essential. In contrast to Section 2, we now focus on a closed economy (so, in terms of our earlier notation, $\zeta_p = \zeta_w = 0$).

While the EHL-model is well known, its continuous-time formulation is less common; moreover, our extension to cyclical markups is novel. Consequently, we proceed with a brief description of the model here. Time is continuous and the model hosts a continuum of monopolistically competitive firms (indexed by $i \in [0,1]$) who all produce a differentiated good, $Y_{i,t}$. Those are subsequently aggregated into a final output good with an aggregator featuring an elasticity of substitution between varieties denoted by $\varepsilon_p$, where the novel feature is that $\varepsilon_p$ varies with the output gap, i.e., $\varepsilon_p = \varepsilon_p(y_t)$:

$$Y_t = \left[\int_0^1 Y_{i,t}^{\frac{\varepsilon_p(y_t)-1}{\varepsilon_p(y_t)}}\, di\right]^{\frac{\varepsilon_p(y_t)}{\varepsilon_p(y_t)-1}}.$$

[12]This makes our model also related to Steinsson (2003), who considered *exogenous* fluctuations in substitution elasticities between goods varieties.

Associated with this output aggregator, there is also the aggregate price index: $P_t = \left[\int_0^1 P_{i,t}^{1-\varepsilon_p(y_t)} di\right]^{1/(1-\varepsilon_p(y_t))}$.

With respect to the cyclicality of $\varepsilon_p(y_t)$ we assume a constant super-elasticity $\eta_p \equiv -\frac{d\varepsilon_p(y_t)}{dy_t}\frac{1+y_t}{\varepsilon_p(y_t)}$.[13] The function $\varepsilon_p(\cdot)$ is such that when $\eta_p = 0$, $\varepsilon_p(y_t) = \varepsilon_p(0) \;\; \forall y_t$. To ensure positive marginal revenues we make the standard assumption that $\varepsilon_p(y_t) > 1$ for all possible realizations of $y_t$. Given the aggregator structure, it is well known that the desired frictionless price markup (applied to the firm's marginal cost) is equal to:

$$\mu_{p,t}(y_t) = \frac{\varepsilon_p(y_t)}{\varepsilon_p(y_t) - 1},$$

for which it is the case that $sgn(d\mu_{p,t}/dy_t) = sgn(\eta_p)$ – hence why $sgn(\eta_p)$ determines the cyclicality of the price markup. If $\eta_p > 0$, the elasticity of substitution is falling in $y_t$ ($d\varepsilon_p(y_t)/dy_t < 0$) and the frictionless price markup is procyclical ($d\mu_{p,t}/dy_t > 0$), while $\eta_p < 0$ implies markup countercyclicality in a flexible-price world.[14] Note that the way in which we have made the frictionless markup a function of cyclical conditions (here, the output gap $y_t$) fulfills the role played by equation (4) in Section 2's simple model. In the new-Keynesian setup the markup rule is grounded in the elasticity of substitution between varieties ($\varepsilon$) but our results continue to hold when envisioning a more general markup rule $\mu(y_t)$, which could leave room for true "aspirations" – not necessarily rooted in rational arguments, but driven by conceptions of what markup agents feel entitled to. This is closer to the setting envisioned by Layard and Nickell (1986), and our model in Section 2.

Along similar lines, there is a continuum of monopolistically competitive households (indexed by $j \in [0,1]$) who all supply a differentiated labor service to firms. As with goods, the different varieties of labor services are imperfect substitutes with an elasticity of substitution "$\varepsilon_w$" that similarly varies with the output gap – now with constant super-elasticity $\eta_w$; as before, if $\eta_w = 0$ it will be the case that $\varepsilon_w(y_t) = \varepsilon_w(0) \;\; \forall y_t$. Aggregate labor services are given by:

$$N_t = \left[\int_0^1 N_{j,t}^{\frac{\varepsilon_w(y_t)-1}{\varepsilon_w(y_t)}} dj\right]^{\frac{\varepsilon_w(y_t)}{\varepsilon_w(y_t)-1}}.$$

Similar to with prices, this aggregator structure is associated with the aggregate wage

[13]Because the output gap $y_t$ can also be negative, we assume that the super-elasticity is driven by *one plus* the output gap ("$1+y_t$") to ensure that the second term of the elasticity formula is always positive.

[14]Keep in mind that the *ultimate* degree of markup cyclicality is also affected by nominal rigidities. For example, the standard new-Keynesian model (which has acyclical frictionless markups, alongside flexible wages) still features countercyclical price markups due to price stickiness.

index $W_t = \left[\int_0^1 W_{j,t}^{1-\varepsilon_w(y_t)} dj\right]^{1/(1-\varepsilon_w(y_t))}$ and the following desired frictionless wage markup (applied to the household's marginal rate of substitution between consumption and leisure, with *real wage* $= \mu_{w,t}(y_t) \cdot MRS_{C,L}$),

$$\mu_{w,t}(y_t) = \frac{\varepsilon_w(y_t)}{\varepsilon_w(y_t) - 1}.$$

Analogous to the price markup, we again have that $sgn(d\mu_{w,t}/dy_t) = sgn(\eta_w)$, so $sgn(\eta_w)$ determines the cyclicality of the wage markup.

Firm $i$ sets prices with an eye to maximizing the present discounted value of profits, subject to a price adjustment cost of the Rotemberg (1982) type (parameterized by $\psi_p > 0$).[15] Using $N_{i,t}$ to denote the labor services utilized by firm $i$, this means that their per-period profits are given by:

$$P_{i,t}Y_{i,t} - W_{i,t}N_{i,t} - \frac{\psi_p}{2}\left(\frac{\dot{P}_{i,t}}{P_{i,t}}\right)^2 P_tY_t.$$

Here, $W$ is the nominal wage rate, while the last term captures that price adjustment costs are proportional to the value of total output $PY$.

When maximizing the present discounted value of future profits (while entertaining the household's discount rate $\varrho$), firms are subject to the demand curve for their product as well as their production technology (which follows the simple linear relation $Y_{i,t} = N_{i,t}$):

$$Y_{i,t} = \left(\frac{P_{i,t}}{P_t}\right)^{-\varepsilon_p(y_t)} Y_t,$$
$$N_{i,t} = Y_{i,t}.$$

Solving the associated problem (and exploiting symmetry) leads to the standard new-Keynesian Phillips curve that one obtains with Rotemberg pricing – but adapted to allow $\varepsilon_p$ to be a function of the output gap $y_t$. Taking a log-linear approximation around the steady state yields:

$$\dot{\pi}_t = \varrho\pi_t - \frac{\varepsilon_p(0) - 1}{\psi_p}\omega_t - \frac{\eta_p}{\psi_p}y_t \tag{17}$$

where $\pi_t \equiv \dot{P}_t/P_t$ represents the aggregate rate of price inflation, while $\varepsilon_p(0)$ is the

[15] Rotemberg pricing and Calvo pricing are first-order equivalent (Roberts, 1995); the same will apply to the setup for wage stickiness (see below).

elasticity of substitution between good-varieties when $y_t = 0$ (i.e., when the output gap is closed). The final term (in blue) is novel and represents the first-order approximation to the fact that the substitution elasticity is not constant at $\varepsilon_p(0)$ in the model, but varies with the output gap $y_t$ as governed by its super-elasticity $\eta_p$.

Each household $j$ maximizes the present discounted value of its per-period utility stream, which is given by:

$$\log C_{j,t} - \frac{N_{j,t}^{1+\theta}}{1+\theta},$$

subject to demand for their labor services as well as their period budget constraint, which features wage adjustment costs of the Rotemberg (1982) type (parameterized by $\psi_w$):

$$N_{j,t} = \left(\frac{W_{j,t}}{W_t}\right)^{-\varepsilon_w(y_t)} N_t,$$

$$\dot{B}_{j,t} = W_{j,t}N_{j,t} + R_t B_{j,t} - P_{j,t}C_{j,t} - \frac{\psi_w}{2}\left(\frac{\dot{W}_t}{W_t}\right)^2 P_t Y_t + T_t,$$

where $B_j$ are household $j$'s bond holdings, $R$ is the nominal interest rate, and $T$ is the lump-sum component of income (including taxes).

Exploiting symmetry, this setup gives rise to the consumption Euler equation:

$$\dot{c}_t = R_t - \pi_t - \varrho, \tag{18}$$

where we use lower-case letters to denote natural logarithms of the original variable, i.e., $c_t \equiv \ln C_t$ so that $\dot{c}_t = \dot{C}_t / C_t$ (the growth rate of consumption). Solving the household's wage-setting problem produces the following new-Keynesian Phillips curve for nominal wages (again allowing for $\varepsilon_w$ to be systematically related to the output gap $y_t$):

$$\dot{\pi}_{w,t} = \varrho\pi_{w,t} - \frac{\varepsilon_w(0) - 1}{\psi_w}\left[\theta n_t + \mathsf{y}_t - \omega_t\right] - \frac{\eta_w}{\psi_w} y_t, \tag{19}$$

where $\pi_{w,t} \equiv \dot{W}_t / W_t$ represents the rate of nominal wage growth. As with (17), the additional blue term stems from taking a first-order approximation to the fact that the elasticity of substitution between different labor types is not constant at its steady-state value $\varepsilon_w(0)$ but varies with the output gap $y_t$ as governed by super-elasticity $\eta_w$.

The model is furthermore characterized by a law of motion for the log of the real wage rate $\omega_t \equiv w_t - p_t$:

$$\dot{\omega}_t = \pi_{w,t} - \pi_t, \tag{20}$$

and the aggregate production function, which reads (in logs):

$$\mathsf{y}_t = n_t. \tag{21}$$

The model is closed by a monetary policy rule, for which we will assume a simple formulation that responds to inflation and the output gap (with $\phi_\pi, \phi_y \geq 0$):

$$R_t = \phi_\pi \pi_t + \phi_y y_t. \tag{22}$$

As before, we say that a central bank with $\phi_\pi > 1$ abides by the Taylor principle.

The crucial modifications, relative to the standard EHL model, are the final terms featuring in the Phillips curves for prices and wages (the blue terms in equations (17) and (19)): they capture the effect that cyclicality in the price- and wage-markups has on price and wage inflation. When $\eta_p > 0$ the optimal flexible-price markup of prices over marginal cost is procyclical, meaning that a negative output gap works to lower inflation by reducing price markup aspirations; but when $\eta_p < 0$ (i.e., when the frictionless markup is countercyclical), a negative output gap *increases* inflation. In this case firms wish to raise their markup as the economy falters. Per equation (19) a similar effect operates over wage inflation whenever $\eta_w \neq 0$. By standard logic, the strength of this effect is decreasing in the price/wage adjustment cost parameters, $\psi_p$ and $\psi_w$.

## 3.2 Dynamics following monetary policy shocks

At this stage it may be instructive to analyze the model's dynamics when markups are cyclical, and compare Impulse Response Functions (IRFs) following a plain-vanilla monetary policy shock. In particular, we consider IRFs to a persistent, additive shock to the monetary policy rule (22), where we set $\phi_y = 0$ for simplicity. In discrete time (to facilitate numerical implementation with standard packages, in our case Dynare), this can be represented as:

$$R_t = \phi_\pi \pi_t + \nu_t,$$
$$\nu_t = \rho_v \nu_{t-1} + \epsilon_t^R.$$

$\nu_t$ thus follows an AR(1) process, while $\epsilon_t^R$ is an i.i.d. innovation.

Table 1 describes the calibration, which is fairly common for the standard parameters. But our extended model also features cyclical price and wage markups, as governed by $\eta_p$ and $\eta_w$ respectively. Estimating these super-elasticities is not straightforward, and doing so carefully goes well beyond the scope of our paper. Instead, we will just pick illustrative values for these. In particular, for the dashed lines in Figure 2 we will set $\eta_p = 15$ or $\eta_p = -15$ (where the sign depends on whether we want the price markup to be pro- or countercyclical). This implies that, starting from steady state ($y_t = 0$; $\varepsilon_p(0) = 6$), a 1% opening up of the output gap will move $\varepsilon_p$ by about one unit. The wage markup is believed to be more decidedly procyclical (capturing the notion that workers have lower bargaining power in downturns) and we set it equal to 2x$|\eta_p|$ for the dashed lines in Figure 2. The standard EHL model results for $\eta_p = \eta_w = 0$.

Table 1: Calibration (quarterly frequency)

| Parameter | Description | Value | Comments |
|---|---|---|---|
| $\beta$ | quarterly discount factor | 0.99 | 4% annual risk free rate |
| $\varepsilon_p(0)$ | substitution elasticity b/w goods varieties | 6 | as in Christiano et al. (2005) |
| $\varepsilon_w(0)$ | substitution elasticity b/w labor varieties | 21 | as in Christiano et al. (2005) |
| $\theta$ | inverse Frisch elasticity of labor supply | 1 | as in Gali (2008) |
| $\psi_p$ | adjustment cost for prices | 58.8 | match NKPC slope of Gali (2008) |
| $\psi_w$ | adjustment cost for wages | 117.6 | 2x that for prices |
| $\phi_\pi$ | Taylor coefficient on inflation | 1.1 | moderately active monetary policy |
| $\rho_v$ | autocorrelation of monetary shock | 0.75 | moderately persistent shock |
| $\eta_p$ | super-elasticity of price markup cyclicality | $\pm 15$ | see text |
| $\eta_w$ | super-elasticity of wage markup cyclicality | 30 | 2x as cyclical as the price markup |

Given this calibration (which delivers determinacy; more on which in Section 3.3) Figure 2 shows the IRFs following a contractionary monetary policy shock. The most prominent difference shows up in the response of price inflation: if the price markup is countercyclical ($\eta_p < 0$), the ensuing recession creates an upward pressure on the price level – due to firms increasing their markups during downturns (this is our "aspirational" transmission channel working in the inflationary direction). This may even lead to a "price puzzle" at short horizons, as visible in Figure 2; at longer horizons Phillips' force takes over, reducing inflation by lowering real wage pressures. For higher (i.e., more positive) values of $\eta_p$ the price puzzle disappears, but for $\eta_p < 0$ the response of inflation is always more muted relative to the response in the standard EHL model ($\eta_p = 0$).

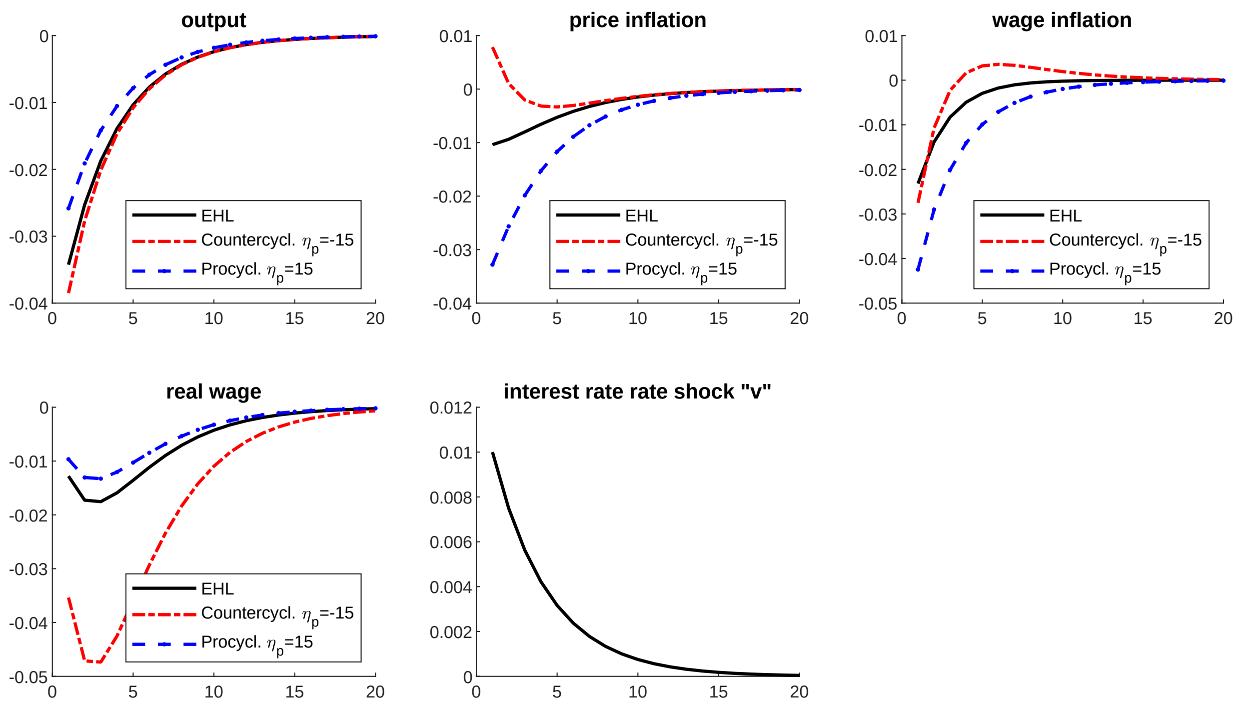



Figure 2: Role of cyclicality of price markups: IRFs following a contractionary monetary policy shock, quarterly frequency.

The introduction of price markup countercyclicality thus works similar to increasing the degree of nominal rigidities – with a stronger output response as a result (see the top-left panel of Figure 2). In this sense, countercyclical price markups can be seen as a source of "real rigidity" – helpful with an eye towards generating greater monetary non-neutralities *without* resorting to mechanically lowering price flexibility. Due to inflation falling by less when $\eta_p < 0$, the monetary contraction induces a bigger (and more persistent) hit to the real wage, relative to the standard EHL model. If the price markup is procyclical on the other hand, inflation is more responsive to monetary policy shocks (and output less so).

## 3.3 Determinacy

Now that we better understand the model dynamics, let us analyze its stability properties. Our economy can be summarized by a four-dimensional state-space system featuring the output gap, price inflation, wage inflation, and the real wage rate (with only the latter being pre-determined); see Appendix B. The determinant of the Jacobian is given by:

$$\det(J) = -(\phi_\pi - 1)\left[\frac{\varepsilon_w(0)-1}{\psi_w}\frac{\eta_p}{\psi_p} + \frac{\varepsilon_p(0)-1}{\psi_p}\frac{(\varepsilon_w(0)-1)(1+\theta)+\eta_w}{\psi_w}\right]$$
$$- \phi_y \varrho \left[\frac{\varepsilon_p(0)-1}{\psi_p} + \frac{\varepsilon_w(0)-1}{\psi_w}\right]. \tag{23}$$

Armed with (23) we can formulate the following lemma, which will be useful in subsequently proving our main propositions:

**Lemma 1.** *The REE is determinate if* $\det(J) < 0$.

*Proof.* See Appendix B.

Using Lemma 1, and first proceeding under the assumption that the central bank sets the interest rate solely with an eye towards inflation (neglecting the output gap, i.e., with $\phi_y = 0$ in (22)), we can establish our main result:

**Proposition 2.** *Under* $\phi_y = 0$*, the central bank abiding by the Taylor principle* ($\phi_\pi > 1$) *yields determinacy of the REE iff*

$$\eta_p + (\varepsilon_p(0) - 1)\left(1 + \theta + \frac{\eta_w}{\varepsilon_w(0) - 1}\right) > 0. \tag{24}$$

*Proof.* We know from Lemma 1 that we need $\det(J) < 0$ to obtain determinacy. If $\phi_\pi > 1$, this requires condition (24) to hold.■

Much like Proposition 1, this result tells us that the Taylor principle only delivers determinacy when an appropriate transformation of "aggregate markups" (summing over both price- and wage markups) is procyclical. In that case, a cyclical deterioration ($y_t \downarrow$) is able to reduce aggregate markup aspirations to a degree that suffices to ensure determinacy. On the other hand:

**Corollary 2.** *Under* $\phi_y = 0$ *and* $\eta_p + (\varepsilon_p(0) - 1)\left(1 + \theta + \frac{\eta_w}{\varepsilon_w(0)-1}\right) < 0$*, determinacy of the REE requires* $\phi_\pi < 1$.

To see through this case, consider a new-Keynesian Phillips curve that is totally flat. Real wages now no longer affect inflation. But with countercyclical price markups ($\eta_p < 0$) a negative output gap pushes up inflation by our "aspirational" transmission channel, which has the effect of raising firms' desired price markups $\mu_{p,t}$. So when a central bank then responds to an inflationary shock by raising real rates – in an attempt to bring down inflation by cooling the economy – it ends up *feeding* the inflationary process by raising firms' desired frictionless markups. In this (rather extreme) environment, the central bank should behave passively ("$\phi_\pi < 1$") to resolve the "battle of the markups" and deliver determinacy.

If the new-Keynesian Phillips curve is positively sloped ($\varepsilon_p(0) > 1$), pursuing an active Taylor rule becomes more compatible with determinacy – even when frictionless price markups are countercyclical ($\eta_p < 0$): in this case a monetary contraction may still raise price markups, but if $\eta_w > 0$ and the slope of the Phillips curve is steep enough, the central bank can lower inflation by cooling the economy.[16] The force of this effect will be magnified by any procyclicality in the frictionless wage markup ($\eta_w > 0$): in that case a cyclical deterioration ends up lowering the market power of workers, thereby moderating wage markup aspirations ($\mu_{w,t}$), which cools inflation. In the knife-edge case where $\frac{\eta_p}{\varepsilon_p(0)-1} = -\left(1+\theta+\frac{\eta_w}{\varepsilon_w(0)-1}\right)$ the model encounters the singularity first seen in Section 2.1 (when $\widetilde{k}_p = -k_w$ over there), implying that monetary policy cannot deliver determinacy. In that case, the force coming from our new "aspirational" transmission channel perfectly offsets the standard channel, and fluctuations in cyclical conditions are not able to affect the (model-relevant transformation of) markup aspirations of firms versus workers in a way to deliver determinacy.[17,18]

At this point it is interesting to contrast our findings to those of Layard and Nickell (1986): they favor the case of countercyclical price markups ($\eta_p < 0$, in our notation) and suggest that a situation of inconsistent aspirations (with workers preferring a higher real wage than firms) is ultimately resolved through greater unemployment (or, in terms of our model, a negative output gap). Our analysis (which captures their logic in a forward-looking new-Keynesian environment, while conducting a formal analysis of the stability issue) qualifies this point. In particular, our analysis makes clear that this is

[16] Observe that abstracting from markup cyclicality altogether (i.e., setting $\eta_p = \eta_w = 0$) yields $\det(J) = -(\phi-1)\left[\frac{\varepsilon_p-1}{\psi_p}\frac{(\varepsilon_w-1)(1+\theta)}{\psi_w}\right]$. Since the term in square brackets ("Phillips' force") is always positive in the benchmark model, this produces the standard finding that the equilibrium is determinate if monetary policy is active ($\phi > 1$).

[17] The standard new-Keynesian model encounters the exact same issue if the utility function were $\log C_{j,t} - \log N_{j,t}$. In that case, the intratemporal optimality condition would boil down to (in logs) $w_t - p_t = 0$, implying that the real wage cannot adjust in order to stabilize the system.

[18] Note that countercyclicality in the frictionless wage markup ($\eta_w < 0$) has similar implications to a countercyclical price markup: when $\eta_w$ becomes negative enough (so that (24) fails), active monetary policy fails to deliver determinacy. The intuition is similar to before: when $\eta_w < 0$ a monetary contraction raises workers' wage markup aspirations, which is inflationary when the Phillips curve is positively sloped. Since countercylical wage markups are difficult to reconcile with the standard notion that workers have less bargaining power during recessions, we see this case as of limited practical relevance.

only true if the impact of real wages on inflation (determined by the slope of the Phillips curve $(\varepsilon_p(0) - 1)/\psi_p$) is sufficiently strong relative to any countercyclicality in frictionless markups. If the Phillips curve is rather flat, countercyclical price markups ($\eta_p < 0$) may well call for a *positive* output gap (*lower* unemployment) in order to resolve the "battle of the markups" – in that case by working to lower firms' markup aspirations.

Now, let us return to the more general monetary policy rule (22) which responds to the output gap with $\phi_y > 0$. In that case, Proposition 2 generalizes to:

**Proposition 3.** *If* $\eta_p + (\varepsilon_p(0) - 1)\left(1 + \theta + \frac{\eta_w}{\varepsilon_w(0)-1}\right) > 0$ *and* $\phi_y > 0$*, determinacy of the REE requires*

$$\phi_\pi > 1 - \varrho\phi_y \left[\frac{\varepsilon_p(0) - 1}{\psi_p} + \frac{\varepsilon_w(0) - 1}{\psi_w}\right] \left[\frac{\varepsilon_w(0) - 1}{\psi_w}\frac{\eta_p}{\psi_p} + \frac{\varepsilon_p(0) - 1}{\psi_p}\frac{(\varepsilon_w(0) - 1)(1 + \theta) + \eta_w}{\psi_w}\right]^{-1}, \tag{25}$$

*and condition (37) in Appendix B if* $\eta_p > 0$ *or condition (38) in Appendix B if* $\eta_p < 0$*.*

**Corollary 3.** *If* $\eta_p + (\varepsilon_p(0) - 1)\left(1 + \theta + \frac{\eta_w}{\varepsilon_w(0)-1}\right) < 0$ *and* $\phi_y > 0$*, determinacy of the REE requires*

$$\phi_\pi < 1 - \varrho\phi_y \left[\frac{\varepsilon_p(0) - 1}{\psi_p} + \frac{\varepsilon_w(0) - 1}{\psi_w}\right] \left[\frac{\varepsilon_w(0) - 1}{\psi_w}\frac{\eta_p}{\psi_p} + \frac{\varepsilon_p(0) - 1}{\psi_p}\frac{(\varepsilon_w(0) - 1)(1 + \theta) + \eta_w}{\psi_w}\right]^{-1}, \tag{26}$$

*and condition (37) in Appendix B if* $\eta_p > 0$ *or condition (38) in Appendix B if* $\eta_p < 0$*.*

In both cases the proof is analogous to that of Proposition 2. In practice, it turns out that the additional conditions (37)-(38) in Appendix B (which only come into play when $\phi_y > 0$) are implied by (25)-(26) for all reasonable parameter values, which is why we have relegated them to the Appendix; it is only when prices become highly flexible that conditions (37)-(38) from Appendix B *may* become relevant.

If $\eta_p + (\varepsilon_p(0) - 1)\left(1 + \theta + \frac{\eta_w}{\varepsilon_w(0)-1}\right) > 0$, which includes the original EHL model where frictionless markups are acyclical ($\eta_p = \eta_w = 0$), Proposition 3 demonstrates that the central bank responding to the output gap (via $\phi_y > 0$) enables it to ensure determinacy while responding less strongly to inflation (this can also be inferred from Galí's (2008) numerical analysis, see his Figure 6.2, but Proposition 3 shows this analytically).

However, when there is strong enough countercyclicality in markups so that

$$\eta_p + (\varepsilon_p(0) - 1)\left(1 + \theta + \frac{\eta_w}{\varepsilon_w(0) - 1}\right) < 0,$$

Corollary 3 shows that the central bank responding to the output gap (via $\phi_y > 0$) creates room for it to respond more strongly to inflation (as the final term in (26) is negative in this case) – potentially even "actively" (i.e., with $\phi_\pi > 1$) which is not compatible with determinacy when $\phi_y = 0$. The intuition is the same as in our simple model presented in Section 2: the central bank's countercyclical response to the output gap puts a break on the inflation driven by the countercyclicality in firms' markup aspirations – making the conventional Taylor principle ("$\phi_\pi > 1$") more compatible with determinacy. This effect is more powerful when Phillips' force is strong (as captured by the term $\frac{\varepsilon_p(0)-1}{\psi_p} + \frac{\varepsilon_w(0)-1}{\psi_w}$ in (25)-(26), which is the sum of the slope of the Phillips curve for prices and that for wages).

We can thus conclude that countercyclicality in frictionless markups may require a central bank that wishes to avoid indeterminacy to adopt a more "dovish" approach – responding less aggressively to inflation, or more strongly to the output gap.

## 3.4 Optimal monetary policy

Thus far, we have solely been concerned with questions of determinacy in a model with wage-price dynamics alongside cyclicality of frictionless markups – thereby building on the widely accepted notion that policy makers should prevent equilibrium indeterminacy.

But even when constraining the analysis to those parts of the parameter space where the equilibrium is determinate, there is the question what optimal policy looks like in this world. Inspired by recent events, we consider optimal policy in the face of supply shocks. In particular, we enrich the Phillips curve (17) with an adverse cost-push shock "$x_t$", which we assume to follow an $AR(1)$ process with persistence parameter $\rho_x$. Following Steinsson (2003) we focus solely on the distortions arising from nominal rigidities, thus abstracting from the inefficiencies related to the deeper, underlying market structure (which is imperfectly competitive).

The intuition for the results that are to follow are easiest to understand in the case where wages are fully flexible. That leaves us with the standard new-Keynesian model, thus featuring sticky prices, but enriched to allow for price markup cyclicality (as captured by our super-elasticity $\eta_p$). The new-Keynesian Phillips curve now reads:

$$\dot{\pi}_t = \varrho \pi_t - \left( \frac{\varepsilon_p(0) - 1 + \eta_p}{\psi_p} \right) y_t + x_t. \tag{27}$$

Given the period loss function:

$$\mathcal{L}_t = \alpha_p \pi_t^2 + \alpha_y y_t^2, \tag{28}$$

it readily follows that optimal policy under discretion is characterized by:

$$y_t = -\frac{\alpha_p}{\alpha_y}\left(\frac{\varepsilon_p(0) - 1 + \eta_p}{\psi_p}\right)\pi_t. \tag{29}$$

This shows that optimal policy following a cost-push shock looks "more dovish" when price markups are countercyclical ($\eta_p < 0$); the same conclusion follows from solving the problem assuming perfect commitment on the central bank's part.[19] From (29) we can see that the standard "hawkish" leaning-against-the-wind policy prescription is strengthened when price markups are procyclical ($\eta_p > 0$). In that case, a given increase in inflation calls for output to be reduced by *even more*. However, the opposite holds when price markups are countercyclical ($\eta_p < 0$). There, optimal policy looks more "dovish", with a reduction in $\eta_p$ having the same effect as increasing $\alpha_y$ (the weight on output stabilization in the loss function (28)). Under strong markup countercyclicality (such that $\varepsilon_p(0)-1+\eta_p < 0$), optimal policy even calls on the central bank to *boost* output following an adverse cost-push shock. The reason is that, in this case, the Phillips curve is flat relative to the degree of price markup countercyclicality. As a result, a boom in output does little to boost inflation, while the main effect of $y_t > 0$ is to lower desired price markups, which helps to bring inflation back down.

Now, let us reintroduce wage stickiness and consider the impact of cyclicality in desired markups in the EHL model. In that case we can characterize the optimal policy numerically. Following Lorenzoni and Werning (2023), taking a quadratic approximation to the social welfare function yields:

$$\mathcal{L}_t = \left(\frac{\varepsilon_p(0)}{(\varepsilon_p(0) - 1)/\psi_p}\right)\pi_t^2 + \left(\frac{\varepsilon_w(0)}{(\varepsilon_w(0) - 1)/\psi_w}\right)\pi_{w,t}^2 + (1+\theta)\, y_t^2. \tag{30}$$

Given (30) one can ask what evolution of endogenous variables minimizes the present value of the central bank's loss function, subject to the model's structure. One can again conduct this exercise either under the assumption that the central bank is perfectly able to commit itself to future policies, or by assuming that it acts under discretion. In what follows, we focus on the latter case, but the key result also arises under commitment. As in Section 3.2, we conduct the analysis with Dynare. Figure 3 shows what optimal policy looks like in response to an adverse cost-push shock $u_t$, depending on the cyclicality of price markups; for the case of price markup *pro*cyclicality we have $\eta_p = 15$, while the case of price markup *counter*cyclicality works with $\eta_p = -15$.

[19] In that case, $\pi_t$ in (29) is replaced by $(p_t - p_{-1})$, where $p_{-1}$ is an implicit price level target determined by the price level in the period before the central bank solved its optimization problem (Gali, 2008).

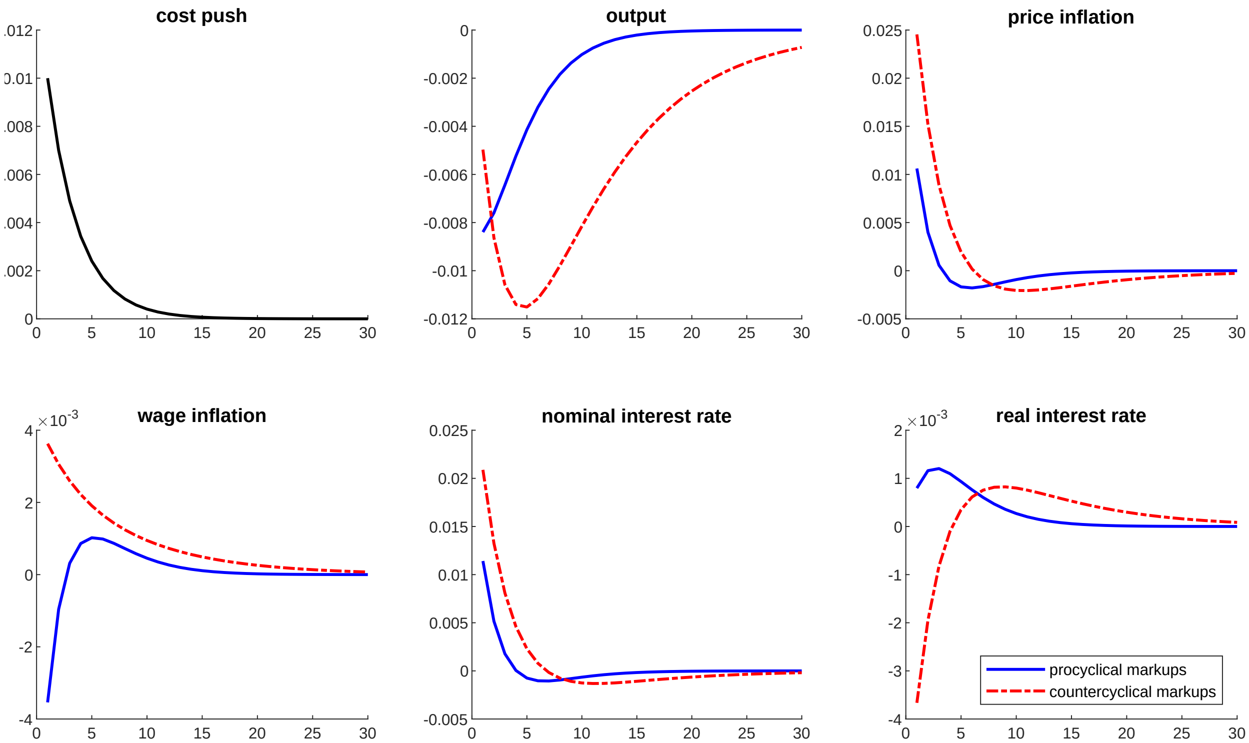



Figure 3: Optimal monetary policy under discretion in the face of cost-push shocks (calibration, at the quarterly frequency, as in Table 1; $\rho_x = 0.6$).

As can be seen from the response of the real interest rate, optimal policy continues to look “more dovish” when markups are countercyclical. The reason is that countercyclicality in the price markup means that responding strongly to inflation injects additional volatility into the economy: it lowers output further (worsening that element of the loss function), which, in turn, triggers an inflationary response from firms when $\eta_p < 0$ – only worsening the original inflationary problem. Interestingly, this also implies that when price markups are countercyclical, optimal policy can call for simultaneous price and wage inflation, even under discretion; Figure 3 shows this. As discussed in Lorenzoni and Werning (2023a) this is not possible in the standard case where markups are acyclical. In that case, price- and wage inflation should always carry opposite signs under optimal policy, so that they “cooperate” to move the real wage $\omega_t \equiv w_t - p_t$ in the desired direction.

Since the practical implementability of the above approach is at times questioned, it may also be of interest to consider optimal policy when constraining the central bank to a “simple, implementable rule”, responding to observable developments in output and inflation. Since one can moreover question whether central banks in practice care *directly* about wage inflation (their mandates are typically phrased in terms of consumer price, and in many cases, output stabilization), we conduct this exercise with an ad-hoc loss function featuring just price inflation and the output gap (per a “dual mandate”):

$$\widetilde{\mathcal{L}}_t = \pi_t^2 + 0.5 y_t^2. \tag{31}$$

(31) places a 2x bigger weight on inflation stabilization relative to output gap stabilization. This loss function is thought to be a reasonable approximation of actual central bank practices (Carney, 2017). When we subsequently specify the “simple rule” (22), again thought to be a reasonable approximation of central bank behavior, we can ask what values of $\phi_\pi$ and $\phi_y$ minimize the central bank's loss for various values of $\eta_p$.

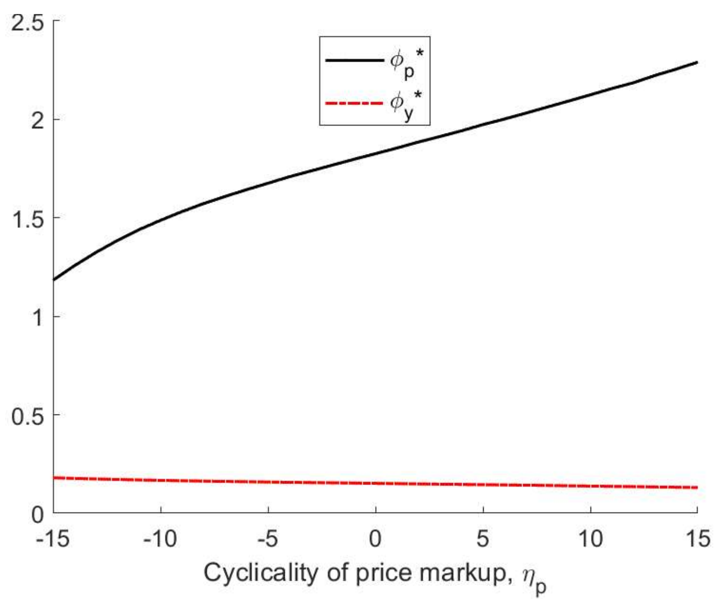



Figure 4: Optimal coefficients in the Taylor rule (22) as a function of $\eta_p$ in the face of cost-push shocks (calibration, at the quarterly frequency, as in Table 1; $\rho_x = 0.6$).

As one can see from Figure 4, the insights from our determinacy analysis again carry over to the optimal policy question: as frictionless price markups turn less procyclical (lower $\eta_p$) it becomes optimal for the central bank to respond less strongly to inflation; the optimal response to the output gap is quite stable, implying that the relative responsiveness to inflation falls as $\eta_p$ goes down. So we confirm that also the optimal “simple” policy becomes more dovish as markups turn more countercyclical.

# 4 Empirical test

Our analysis suggests that the cyclicality of markups is an important co-determinant of the ability of contractionary monetary policy to bring down inflation; recall especially Figure 2, which shows that any countercyclicality in price markups will make inflation fall by less in the short run following a contractionary monetary policy shock – potentially even generating a price puzzle. In the long run, this difference should disappear as Phillips' force kicks in (see Figure 2). This gives rise to a testable prediction:

HYPOTHESIS: *The short-run anti-inflationary effect of contractionary monetary shocks increases in the degree of procyclicality of price markups.*[20]

To investigate this hypothesis, we first need to estimate the cyclicality of price markups at the country level. To do this, we build on the approach proposed by Hall (1988) and refined by Roeger (1995); Appendix C discusses data-related details. This approach has lower data requirements relative to the method of De Loecker and Warzynski (2012), yielding greater cross-country coverage, while being more amenable to capturing cyclicality.[21] It starts from the observation that, away from the perfectly competitive benchmark, price markups are related to the Solow residual ("$SR$") via the labor share and changes in the capital-labor ratio:

$$SR_t \equiv \Delta q_t - \alpha_t \Delta n_t - (1 - \alpha_t)\Delta k_t = (\mu - 1) \cdot \alpha_t(\Delta n_t - \Delta k_t) + \Theta_t. \qquad (32)$$

Here, $\mu$ is the markup, $\Delta q$ the change in the log of output, $\alpha$ the labor share in national income, $\Delta n$ the change in the log of labor input, $\Delta k$ the change in the log of the capital stock, and $\Theta$ the true rate of technological progress (which only equals the Solow residual if $\mu = 1$, i.e., under perfect competition). The difficulty with estimating (32) is that $\Theta$ is unobserved, yet plausibly correlated with other RHS variables in (32). This gives rise to an endogeneity problem – creating a need to find a good instrument, exogenous to $\Theta$. As Hall (1988) himself notes, this is very challenging.

Roeger (1995), however, observed that one can also create a "dual" Solow residual ("$DSR$"), in price-space:

[20] While our analysis suggests that the same applies to wage markups, we do not pursue that avenue here for two reasons. Firstly, the wage markup is thought to be more decidedly procyclical (giving rise to less exploitable cross-country variation). Secondly, estimating the cyclicality of wage markups is arguably even more difficult than for price markups, which is why we limit our focus to the latter.

[21] In addition, as discussed in Hall (2018) and De Loecker, Eeckhout, and Unger (2020), the two approaches yield reasonably consistent results – at least when applied to U.S. data.

$$DSR_t \equiv \alpha_t \Delta w_t + (1-\alpha_t)\Delta r_t - \Delta p_t = (\mu - 1) \cdot \alpha_t(\Delta w_t - \Delta r_t) + \Theta_t. \tag{33}$$

Now, upon subtracting (33) from (32), the unobserved $\Theta$ drops out, which eliminates the endogeneity problem. Instead, one can proceed by estimating $\beta \equiv \mu - 1$ from the following equation via OLS:

$$SR_t - DSR_t = \beta \cdot \alpha_t(\Delta q_t + \Delta p_t - \Delta k_t - \Delta r_t) + \epsilon_t.$$

To capture any cyclicality in the price markup, we follow Haskel, Martin, and Small (1995) and estimate:

$$SR_t - DSR_t = [\beta + \eta_p \cdot CYC_t] \cdot \alpha_t(\Delta q_t + \Delta p_t - \Delta k_t - \Delta r_t) + \epsilon_t, \tag{34}$$

where $CYC_t$ measures the economy's cyclical stance at time $t$ (for which we use the cyclical residual that obtains from applying the Hamilton (2018) filter to the real GDP series) and $\epsilon_t$ is the error term. If $\eta_p > 0$, the markup goes up in booms and is thus procyclical, while $\eta_p < 0$ implies countercyclicality in the price markup.[22]

Armed with estimates of markup cyclicality at the country level ($\hat{\eta}_{pi}$, listed in Appendix C, Table 2),[23] one can subsequently estimate horizon $h$-specific panel Local Projections on the natural log of the price level (as measured by the CPI) at the monthly frequency:

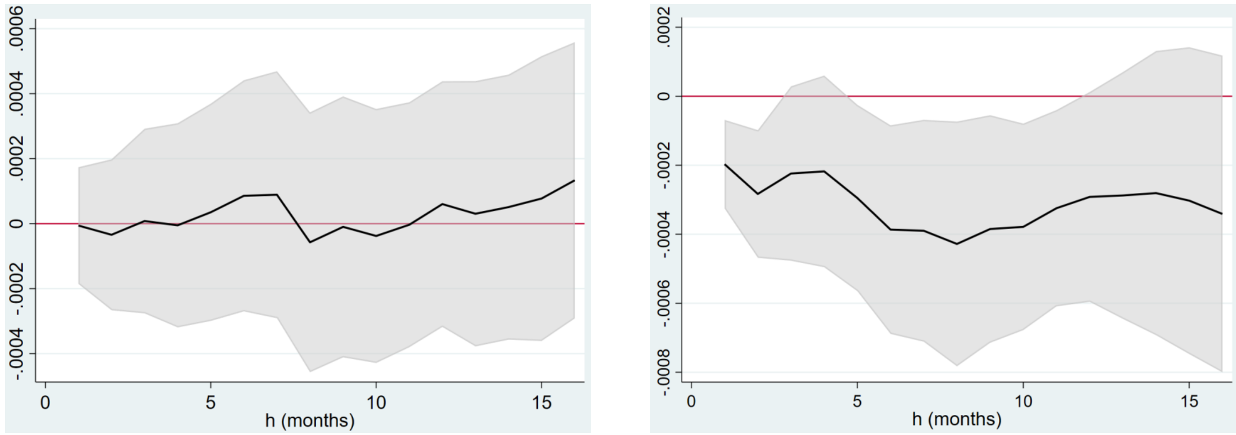
$$\ln(CPI_{it+h}) = \vartheta_i^h + \gamma_1^h MPS_{it} + \gamma_2^h \left(MPS_{it} \cdot \hat{\eta}_{pi}\right) + \gamma_3^h X_{it} + \upsilon_{it}^h, \tag{35}$$

where $MPS_{it}$ is a monetary policy shock in country $i$ at time $t$, while $X_{it}$ is a vector of standard controls (twelve lags of the logged CPI, twelve lags of the logged industrial production index, and twelve lags of the monetary policy shock). All data-related details can be found in Appendix C.

Our main interest lies with the coefficient on the interaction variable, $\gamma_2^h$, which according to our theory should be negative at short horizons – meaning that contractionary monetary policy shocks have greater anti-inflationary effects in countries where markups are more procyclical (i.e., where $\hat{\eta}_{pi}$ is higher).

[22] While technically not an elasticity (just an object with the same sign), we use "$\eta$" to point out the more general link with the eponymous object central to Section 3.

[23] Given the existince of nominal rigidities in the world generating our data, one could question whether our approach truly gets at the cyclicality of *frictionless* price markups – which is the relevant object according to our theory. This is of second-order importance to our empirical exercise though, as we are conducting a cross-country exercise – essentially looking at a difference-in-differences. If the bias coming from nominal rigidities is roughly similar across countries, it diminishes in importance upon differencing.




(a) Baseline coefficient on $MPS$ (b) Interaction coefficient on $MPS \cdot \hat{\eta}_p$

Figure 5: Panel (a) plots $\widehat{\gamma}_1^h$ in equation (35) at different horizons $h$, which is the IRF of the logged CPI to a contractionary monetary policy shock when the price markup is estimated to be acyclical ($\hat{\eta}_{pi} = 0$). Panel (b) plots $\widehat{\gamma}_2^h$ in equation (35), capturing the additional effect coming from any procyclicality in price markups. Shaded areas are 90% confidence bands, calculated via robust standard errors.

As Figure 5b shows, the data support our theory – especially at horizons shorter than 12 months, after which the difference turns insignificant.[24] This is consistent with our model's prediction, as shown in the top-center panel of Figure 2. It furthermore illustrates that it is important that central banks are aware of the cyclicality of price markups, as our empirical findings suggest that this affects the response of inflation, while our theoretical analysis makes clear that it has (optimal) policy implications as well.

Finally, we end by noting that it may well be that the cyclicality of desired markups is conditional on the type of shock hitting the economy (recall footnote 11). In that case, we would be dealing with $\eta_p(\Xi)$ where $\Xi \in$ {monetary shock; cost-push shock; technology shock, ...}. If so, our empirical estimates of $\eta_p$ should be thought of as representing $\hat{\Sigma}_\Xi \eta_p(\Xi)$,where the $\hat{\Sigma}_\Xi$-operator delivers the appropriate average across all driving shocks. One can then interpret Figure 5b as suggesting that the average cyclicality of price markups over the business cycle carries the same sign as the cyclicality following a monetary shock, i.e., that $sgn(\hat{\Sigma}\eta_p(\Xi)) = sgn(\eta_p(\text{monetary shock}))$. Importantly, this does not rule out the possibility that the cyclicality following atypical shocks (such as a pandemic accompanied by lockdowns and severe supply-chain disruptions) is of the

[24]Robustness checks in Appendix C document that this result arises consistently across specifications. The same result also obtains when following Auerbach and Gorodnichenko (2012) in running a state-dependent regression, with the degree of markup cyclicality defining the state.

opposite sign. In this respect it is interesting to note that Acharya et al. (2023) find that price markups in European countries *increased* post-Covid – which could be interpreted as markups having behaved countercyclically in this instance. Still, if $\eta_p$(monetary shock)$> 0$, as our estimates suggest is the case for most European countries, it would be appropriate for the central bank to respond by tightening monetary policy.

# 5 Conclusion

As recently shown by Lorenzoni and Werning (2023ab), conflict over relative prices can be seen as the most proximate cause of inflation. Taking this insight to a new-Keynesian environment (where workers and firms may disagree over the real wage) featuring cyclically-sensitive markups, we show that there is an important role to be played by monetary policy – provided it is able to affect macroeconomic conditions which, in turn, affect the relative markup aspirations of workers versus firms. This is our new "aspirational" channel of monetary policy transmission.

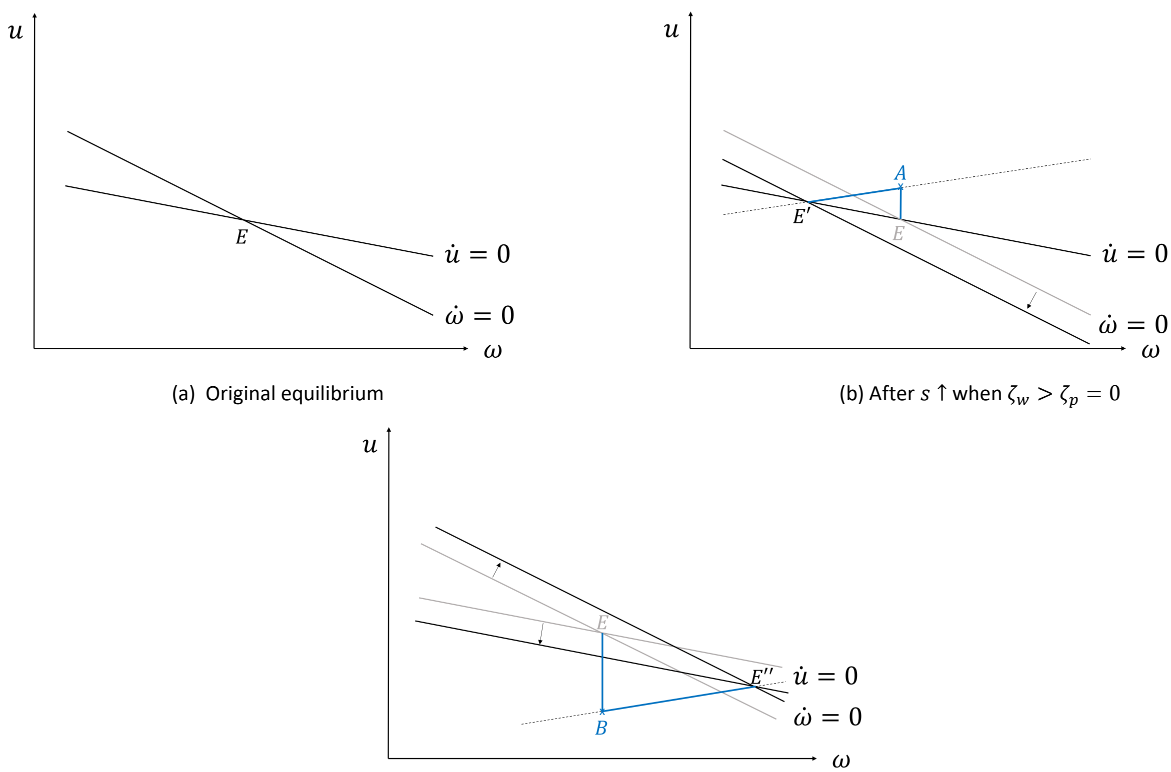
In a model where aspired markups depend on the state of the business cycle (so that the latter can moderate worker and/or firm aspirations), we show that monetary policy – through its effects on the real economy – can resolve the "conflict" between competing claimants by bringing about changes in the relative market power of workers versus firms. The direction in which monetary policy should move, however, depends crucially on the cyclicality of aspired wage- and price markups. When flexible-price markups are countercyclical, responding strongly to inflation may be undesirable (as the ensuing recession then leads firms *to increase* markups, giving rise to renewed inflationary pressures). This concern is particularly acute when the Phillips curve is rather flat, implying that a reduction of wage pressures does relatively little to bring down inflation – leaving the countervailing force exerted by rising markups as the dominant one. In such cases monetary policy may need to take a more passive stance towards inflation, or place a bigger weight on the output gap – i.e., conduct monetary policy in a more "dovish" way. This implication follows from considerations related to ensuring equilibrium determinacy, as well as from an optimal policy perspective.

Our model furthermore points to the importance of knowing the direction and degree of cyclicality in frictionless markups when conducting monetary policy. Estimating price markup cyclicality across a panel of countries, and subsequently deploying that information to generate Impulse Response Functions to a monetary policy shock, we find that monetary contractions have stronger short-term anti-inflationary effects in countries where the markup is found to be more procyclical. This is in line with our model's prediction that monetary contractions are more likely to succeed in bringing inflation down when desired markups are procyclical.

Finally, this paper leaves important questions for future work – particularly when it comes to linking the state of the business cycle to desired frictionless markups. Here, we have taken a reduced-form approach, sticking with the Dixit-Stiglitz setup where the optimal markup is narrowly pinned down by the elasticity of substitution between varieties $\varepsilon$ (putting the desired markup at $\varepsilon/(\varepsilon-1)$). We have furthermore remained agnostic as to which exact theoretical channel gives rise to aspired markups being cyclically sensitive (and whether this suggests that the degree of cyclicality depends on the driving shock). It could however be interesting to consider alternative settings, placing less focus on the elasticity of substitution between varieties. For example: if markets are modelled in a frictional way, this would give rise to a matching surplus that needs to be split in some way between firms and workers – which could provide a role for outside options, habit formation, or social norms (e.g., notions of "fairness" *a la* Eyster, Madarász, and Michaillat (2020)).

# Appendix A

Section 2.2.2 of the main text discusses dynamics following a terms-of-trade shock when the $\dot{u} = 0$ locus slopes up. It is however also possible to have a stable equilibrium when both loci are downward sloping – just with the $\dot{\omega} = 0$ locus carrying the steeper slope, as shown in Figure 6a (which illustrates the case for $\widetilde{k}_p < k_w = \phi_u = 0$). Dynamics are different in this case. If $\zeta_w > \zeta_p = 0$ (implying that only workers carry direct exposure to the shock, Figure 6b) a worsening in the terms-of-trade still increases unemployment on impact (as well as in the long run) but in this case the real wage falls along the transition path. Consumers not only see their real consumption wage $(W/[P^{1-\zeta_w} P_f^{\zeta_w}])$ fall, but their real wage in terms of the domestic price level $(W/P)$ falls as well, implying *negative* pass-through: firms, who carry no direct exposure to the shock when $\zeta_p = 0$, end up *benefitting* from an adverse terms-of-trade shock. In this case, the pain is not shared between workers and firms, but stays with the workers (who carry the original exposure to the shock) and multiplies there due to the countercyclicality of price markups ($\widetilde{k}_p < 0$, meaning that the rise in unemployment makes firms charge higher markups).




(a) Original equilibrium

(b) After $s \uparrow$ when $\zeta_w > \zeta_p = 0$

(c) After $s \uparrow$ when $\zeta_p > \zeta_w = 0$

Figure 6: Phase diagrams for $\widetilde{k}_p < k_w = \phi_u = 0$.

If $\zeta_p > \zeta_w = 0$ (implying that only firms carry direct exposure to the energy shock, Figure 6c) workers see the unemployment rate fall and their real wage rise – again stemming from negative pass-through, now on the part of firms.

This illustrates how markup countercyclicality implies "burden concentration and multiplication", instead of burden sharing between workers and firms.

# Appendix B

**Lemma 1.** *The REE is determinate if* $\det(J) < 0$.

*Proof.* Our model can be cast into the following state-space form:

$$\begin{bmatrix} \dot{y}_t \\ \dot{\pi}_t \\ \dot{\pi}_{w,t} \\ \dot{\omega}_t \end{bmatrix} = \underbrace{\begin{bmatrix} \phi_y & (\phi_\pi - 1) & 0 & 0 \\ -\frac{\eta_p}{\psi_p} & \varrho & 0 & -\frac{\varepsilon_p(0)-1}{\psi_p} \\ -\frac{(\varepsilon_w(0)-1)(1+\theta)}{\psi_w} - \frac{\eta_w}{\psi_w} & 0 & \varrho & \frac{\varepsilon_w(0)-1}{\psi_w} \\ 0 & -1 & 1 & 0 \end{bmatrix}}_{J} \begin{bmatrix} y_t \\ \pi_t \\ \pi_{w,t} \\ \omega_t \end{bmatrix}. \tag{36}$$

This matrix structure is like that for the standard EHL-model, except for the blue terms: they are equal to 0 for the standard model, but do feature here because of the cyclicality of frictionless markups when $\eta_p, \eta_w \neq 0$.

First consider the case where $\phi_y = 0$. Given that (36) is a four-dimensional system, and given that the determinant of $J$ is equal to the product of its eigenvalues, $\det(J) < 0$ either implies three positive eigenvalues and one negative one, or three negative eigenvalues and one positive one. Since the model has three forward-looking variables $(y, \pi, \pi_w)$, determinacy requires three positive ("unstable") eigenvalues. Having $\det(J) > 0$ can thus never deliver determinacy, as it implies all eigenvalues being positive, all of them being negative, or a situation of two positive/two negative – all of which are inconsistent with the eigenvalue-requirement of three positive/one negative.

Now that we have ruled out $\det(J) > 0$ as a possibility, we still need to show that $\det(J) < 0$ delivers three positive eigenvalues, and one negative one (as opposed to the other way round). From Descartes' Rule of Signs we know that the number of positive eigenvalues is *at most* the number of sign changes in the sequence of the characteristic polynomial's coefficients. The characteristic polynomial of $J$ reads:

$$\lambda^4 - b_3\lambda^3 + b_2\lambda^2 - b_1\lambda - b_0 = 0,$$

with:

$$b_3 = 2\varrho,$$
$$b_2 = (\phi_\pi - 1)\frac{\eta_p}{\psi_p} + \varrho^2 - \left(\frac{\varepsilon_p(0) - 1}{\psi_p} + \frac{\varepsilon_w(0) - 1}{\psi_w}\right),$$
$$b_1 = (\phi_\pi - 1)\frac{\eta_p}{\psi_p}\varrho - \varrho\left(\frac{\varepsilon_p(0) - 1}{\psi_p} + \frac{\varepsilon_w(0) - 1}{\psi_w}\right),$$
$$b_0 = (\phi_\pi - 1)\left[\frac{\varepsilon_w(0) - 1}{\psi_w}\frac{\eta_p}{\psi_p} + \frac{\varepsilon_p(0) - 1}{\psi_p}\frac{(\varepsilon_w(0) - 1)(1 + \theta) + \eta_w}{\psi_w}\right].$$

Note that it is obvious that $b_3 > 0$ and $b_0 > 0$ (with $b_0$ being the negative of the determinant of $J$, i.e., $b_0 = -\det(J)$). The coefficients $b_2$ and $b_1$ cannot be signed unambiguously, but there are only three possibilities: (i) both $b_1, b_2 > 0$; (ii) both $b_1, b_2 < 0$; or (iii) $b_1 < 0$ and $b_2 > 0$. The remaining option ($b_1 > 0$ and $b_2 < 0$) is not possible, since $b_2 < 0$ immediately implies $b_1 < 0$, which puts us back in case (ii). To see this, note that $b_1 > 0$ requires $(\phi_\pi - 1)\frac{\eta_p}{\psi_p} > \left(\frac{\varepsilon_p(0)-1}{\psi_p} + \frac{\varepsilon_w(0)-1}{\psi_w}\right)$ while $b_2 < 0$ requires $(\phi_\pi - 1)\frac{\eta_p}{\psi_p} + \varrho^2 < \left(\frac{\varepsilon_p(0)-1}{\psi_p} + \frac{\varepsilon_w(0)-1}{\psi_w}\right)$. But since $(\phi_\pi - 1)\frac{\eta_p}{\psi_p} < (\phi_\pi - 1)\frac{\eta_p}{\psi_p} + \varrho^2$, this implies $b_1 < b_2$ thus yielding a contraction and ruling out the remaining combination of $b_1 > 0$ and $b_2 < 0$.

Note that in all three possible cases ((i), (ii), and (iii)), the number of sign changes in the sequence of the characteristic polynomial's coefficients always equals three. By Descartes' Rule, this means that there are at most three positive eigenvalues – yet it does not rule out fewer than three (e.g., one).

But we can also apply the corollary of Descartes' Rule, which states that the number of negative roots equals the number of sign changes after multiplying the coefficients of odd-powered terms by $-1$, *or fewer than it by an even number.* After multiplying the odd-powered terms by -1, we are always left with only one sign change, meaning that the original polynomial has only one negative root (as "fewer than it by an even number" is not possible). Consequently, it follows that $\det(J) < 0$ implies that the model has three positive eigenvalues, and one negative one – yielding saddle-point stability.

If $\phi_y > 0$ the proof has the same structure, but the analysis is slightly more involved. In that case the coefficients of the characteristic polynomial are equal to:

$$
\begin{aligned}
b_3 &= \phi_y + 2\varrho, \\
b_2 &= (\phi_\pi - 1)\frac{\eta_p}{\psi_p} + \varrho^2 + 2\phi_y\varrho - \left(\frac{\varepsilon_p(0)-1}{\psi_p} + \frac{\varepsilon_w(0)-1}{\psi_w}\right), \\
b_1 &= \phi_y\varrho^2 + (\phi_\pi - 1)\frac{\eta_p}{\psi_p}\varrho - (\phi_y + \varrho)\left(\frac{\varepsilon_p(0)-1}{\psi_p} + \frac{\varepsilon_w(0)-1}{\psi_w}\right), \\
b_0 &= (\phi_\pi - 1)\left[\frac{\varepsilon_w(0)-1}{\psi_w}\frac{\eta_p}{\psi_p} + \frac{\varepsilon_p(0)-1}{\psi_p}\frac{(\varepsilon_w(0)-1)(1+\theta)+\eta_w}{\psi_w}\right] - \phi_y\varrho\left[\frac{\varepsilon_p(0)-1}{\psi_p} + \frac{\varepsilon_w(0)-1}{\psi_w}\right].
\end{aligned}
$$

As before, we need to rule out the case where $b_1 > 0$ and $b_2 < 0$ (as that combination would produce three negative eigenvalues and one positive one – the exact opposite of what we need). This now requires:

$$
\phi_\pi > 1 - \frac{2\varrho^2 + 2\phi_y\varrho + \varrho^3}{\eta_p/\psi_p} \quad for \;\; \eta_p > 0, \tag{37}
$$

$$
\phi_\pi < 1 - \frac{2\varrho^2 + 2\phi_y\varrho + \varrho^3}{\eta_p/\psi_p} \quad for \;\; \eta_p < 0. \tag{38}
$$

These form additional determinacy conditions (complementing (25) and (26) from the main text).■

In practice it however turns out that – for all reasonable parameter values – (25) and (26) are actually stricter than (37) and (38), meaning that if the former are satisfied, the latter will automatically hold as well (except in the extreme flexible price limit case where $\psi_p \searrow 0$).

# Appendix C

This appendix details the data underlying our empirical exercise in Section 4. As that exercise spans two exercises (first estimating price markup cyclicality and subsequently running Local Projections), we discuss each element in turn.

## Estimating the cyclicality of price markups

We estimate the degree of price markup cyclicality by estimating equation (34) of the main text. All of its inputs are readily available from the Penn World Tables (PWT, version 10.01) which contains data through 2019; for most countries, the data start in 1970.

The only variable that requires some non-trivial calculations is $R$, the Hall-Jorgenson rental price of capital. It can be calculated from the PWT as follows:[25]

$$R = (IRR + DEPR) \cdot INVDEFL,$$

where "$IRR$" is the internal rate of return (directly available in the PWT under the variable name "irr"), "$DEPR$" the depreciation rate (directly available in the PWT under the variable name "delta"), while "$INVDEFL$" is the deflator for investment. The latter can be calculated from the National Accounts data accompanying the PWT, as v_gfcf/q_gfcf (i.e., the value of gross fixed capital formation divided by its volume).

Estimating our proxy for markup cyclicality on these data, via equation (34) of the main text, yields country-level estimates of $\eta_p$ as shown in Table 2. From there, one can see that we estimate markups to be procyclical for most countries, though there are some notable exceptions (highlighted in red).

Table 2: country-level estimates of cyclicality in price markups ($\hat{\eta}_p$ in equation (34))

| Country | $\hat{\eta}_p$ | Country | $\hat{\eta}_p$ | Country | $\hat{\eta}_p$ | Country | $\hat{\eta}_p$ |
|---|---|---|---|---|---|---|---|
| Austria | 0.648 | Denmark | 0.889 | Israel | -0.203 | Poland | -0.667 |
| Belgium | 1.893 | Ecuador | -0.620 | Italy | 0.504 | Portugal | 0.031 |
| Brazil | -0.228 | Estonia | 0.074 | Japan | 0.209 | Romania | 0.520 |
| Bulgaria | 3.274 | Finland | 0.005 | Korea | 0.249 | Russia | 0.233 |
| Canada | -0.067 | France | 0.650 | Latvia | 0.275 | Slovakia | 0.751 |
| Chile | -0.590 | Germany | 0.446 | Lithuania | 0.296 | Slovenia | 0.694 |
| Colombia | -0.016 | Greece | -0.334 | Luxembourg | 0.747 | Spain | 0.106 |
| Costa Rica | -2.786 | Hungary | -0.006 | Malta | 0.728 | Sweden | 0.161 |
| Croatia | 0.491 | Iceland | 1.007 | Mexico | 2.074 | Türkiye | 0.501 |
| Cyprus | 0.321 | India | 0.026 | Netherlands | 0.524 | United Kingdom | 0.652 |
| Czech Rep. | -0.839 | Ireland | -0.012 | Norway | 0.181 | United States | 1.532 |

While data coverage in the PWT is such that we can obtain $\eta_p$ estimates for more countries than the 44 listed in Table 2, the sample shown here is the sample on which the Local Projections are estimated (as data requirements are more binding there, in particular when it comes to the availability of monetary policy shock estimates; see the next sub-section).

[25] We thank Robert Inklaar for his help on this.

## Local Projections

The Local Projections (recall equation (35) of the main text) use monthly data on the (natural log of) CPI, (natural log of) industrial production, as well as monetary policy shocks. The former two are taken from the IMF's IFS database. Data on monetary policy shocks are constructed based on Choi, Willems, and Yoo (2023), pursuing the following strategy:

1. Where available, we take pre-existing estimates from studies deploying high-frequency methods. For the U.S., we use the estimates of Bauer and Swanson (2022); for the Eurozone, we use the target shock of Andrade and Ferroni (2021); for the U.K., we use Cesa-Bianchi, Thwaites, and Vicondoa (2020); for Canada, we use Champagne and Sekkel (2018); for Norway, we use Holm, Paul, and Tischbirek (2021); for Sweden, we use Amberg et al. (2022), for Brazil, we use Alberola et al. (2021); for India, we use Lakdawala and Sengupta (forthcoming); for Japan, we use Kubota and Shintani (2022); for Korea, we use and Ahn, Kim, and Lee (2021).

2. If 1 is not available, the monetary policy shock is proxied by the one-day change in the 3-month swap yield around monetary policy decision days.

3. If 1 and 2 are not available, the monetary policy shock is proxied by the one-day change in the short-term domestic government bond yield around monetary policy decision days.

4. If 1, 2, and 3 are not available, the monetary policy shock is proxied by relying on Bloomberg's survey of financial market participants to obtain prior (i.e., pre-decision) expectations for each rate decision. The shock is subsequently estimated by subtracting this prior expectation from the realization.

5. (*Only for countries with a pegged currency:*) If 1, 2, 3, and 4 are not available, we import the estimated monetary policy shock from the anchor country (accounting for capital account openness, in line with Trilemma logic).

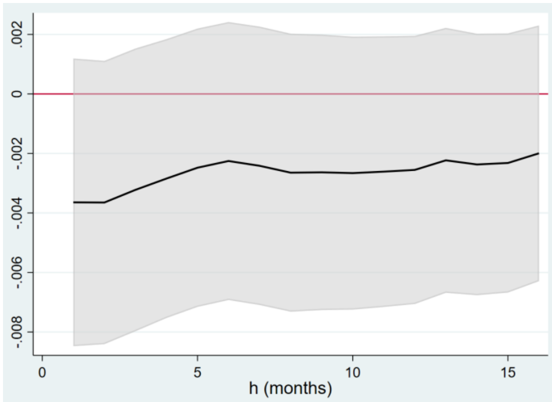
To ensure comparability of units across countries, we normalize each series at the country level by dividing by its standard deviation.

Though the exact coverage period varies by country (typically depending on the availability of monetary policy shock estimates) the estimation sample spans 1980M1-2019M12, with the end date ensuring that our analysis is not distorted by the 2020 Covid shock.

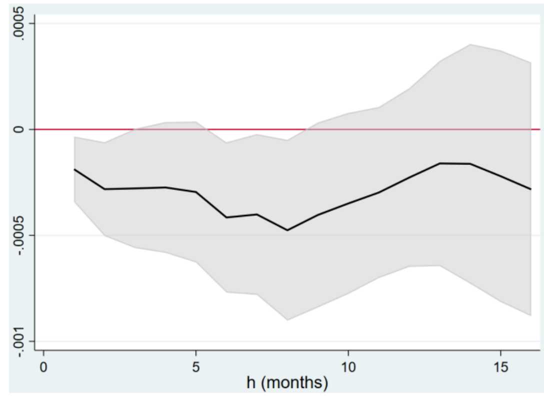
## Robustness

The baseline results depicted in Figure 5 were generated with a fairly standard specification for (35), with the regression controlling for 12 monthly lags of the logged CPI, 12 lags of logged industrial production, as well as 12 lags of the monetary policy shock. However, what exact controls to include is somewhat ambiguous. Figure 7 therefore documents that our main finding is robust to different regression specifications. All panels plot $\widehat{\gamma}_2^h$ in equation (35) (capturing the additional effect coming from any procyclicality in price markups) for different horizons, $h$. The underlying regression specification however differs. In particular, panel (a) includes no controls (so $X_t = \{\}$ in equation (35)).[26] In this case, the point estimate remains negative over the entire horizon, but the effect is no longer statistically significant (but, as argued in Inoue, Jordà, and Kuersteiner (2023), the fact that the point estimate is *consistently* negative across horizons is informative too). It is also important, however, to examine richer specifications – featuring more controls than our baseline. In this regard, panel (b) augments the baseline specification featured in the main text with 12 lags of the level of the short-term interest rate (either the monetary policy rate or the yield on short-term government debt) as a control; panel (c) uses lagged levels of short-term interest rates *instead of* lagged monetary policy shocks as a control; panel (d) augments the baseline specification featured in the main text with 12 lags of the interaction term ($MPS_{it} \cdot \hat{\eta}_{pi}$) as a control; panel (e), which features the richest specification, controls for *both* 12 lags of the short-term interest rate and 12 lags of the interaction term (in addition to the controls present in the baseline specification featuring in the main text). Panel (f) shows estimates when estimating our baseline specification in a pooled way (dropping the country fixed effects).

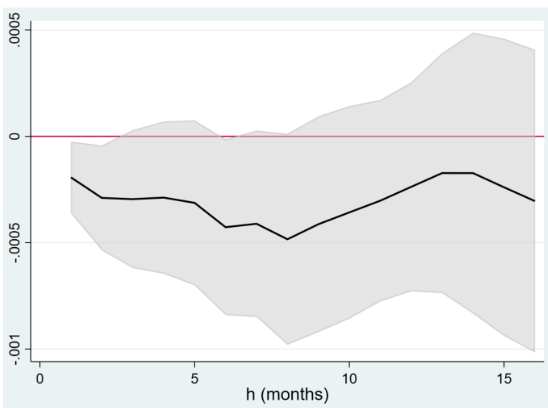
[26] For this specification we report Newey-West standard errors, which are not needed when (35) includes lags of the dependent variable (Montiel Olea and Plagborg-Møller, 2021).



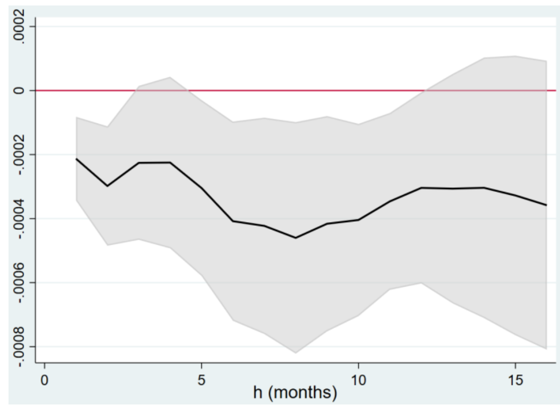

(a) No controls



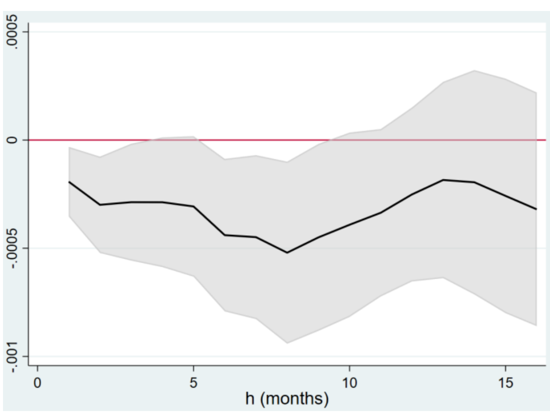

(b) Controlling for lags of short-term rate



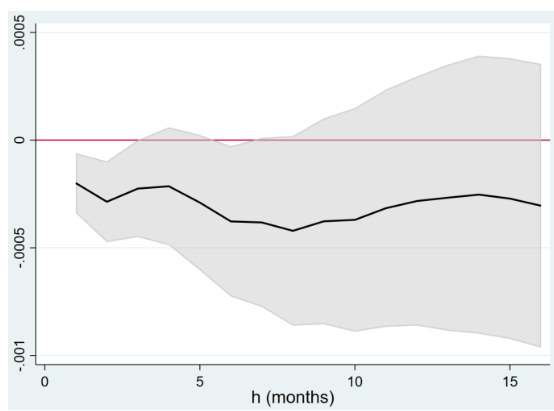

(c) Controlling for lags of short-term rate instead of lags of $MPS$




(d) Controlling for lags of the interaction term




(e) Controlling for lags of short-term rate and interaction term




(f) Baseline specification estimated in a pooled way

Figure 7: Robustness checks: estimates of $\widehat{\gamma}_2^h$ for different regression specifications.

Finally, one can also take an alternative econometric approach. In particular, one can follow Auerbach and Gorodnichenko (2012) and Tenreyro and Thwaites (2016) and let the impact of monetary policy shocks vary with a certain state indicator $q_i$. Here, we take $q_i = \hat{\eta}_{pi}$ (i.e., the estimated degree of price markup cyclicality for each country $i$). One can subsequently employ the logistic function $F(\hat{\eta}_{pi}) = \exp(\hat{\eta}_{pi}/\sigma_\eta)/\left[1 + \exp(\hat{\eta}_{pi}/\sigma_\eta)\right]$, with $\sigma_\eta$ being the standard deviation of $\hat{\eta}_{pi}$ across countries, and estimate:

$$\ln(CPI_{it+h}) = \vartheta_i^h + F(\hat{\eta}_{pi})\left[\gamma_{1,pro}^h MPS_{it} + \gamma_{2,pro}^h X_{it}\right] + (1 - F(\hat{\eta}_{pi}))\left[\gamma_{1,count}^h MPS_{it} + \gamma_{2,count}^h X_{it}\right] + \upsilon_{it}^h,$$

where $F(\hat{\eta}_{pi})$ essentially attaches a probability to country $i$'s price markup being procyclical (which, naturally, is increasing in $\hat{\eta}_{pi}$). The estimated coefficients $\hat{\gamma}_{1,pro}^h$ and $\hat{\gamma}_{1,count}^h$ trace out the average IRFs (to monetary policy shocks) for countries with decidedly pro- and countercyclical markups, respectively (i.e., $F(\hat{\eta}_{pi}) \approx 1$ and $F(\hat{\eta}_{pi}) \approx 0$). Figure 8 shows the results of this exercise, where the set of controls in $X_{it}$ is the same as in the main text (but the $\gamma_2^h$-coefficients are now state-dependent, allowing the controls to play a different role between the two regimes).

Since all resulting IRFs are consistently very similar to our baseline finding (depicted in Figure 5, panel (b)), we conclude that the prediction of our theory – monetary contractions having stronger anti-inflationary effects in countries where price markups are procyclical – finds robust support in the data.

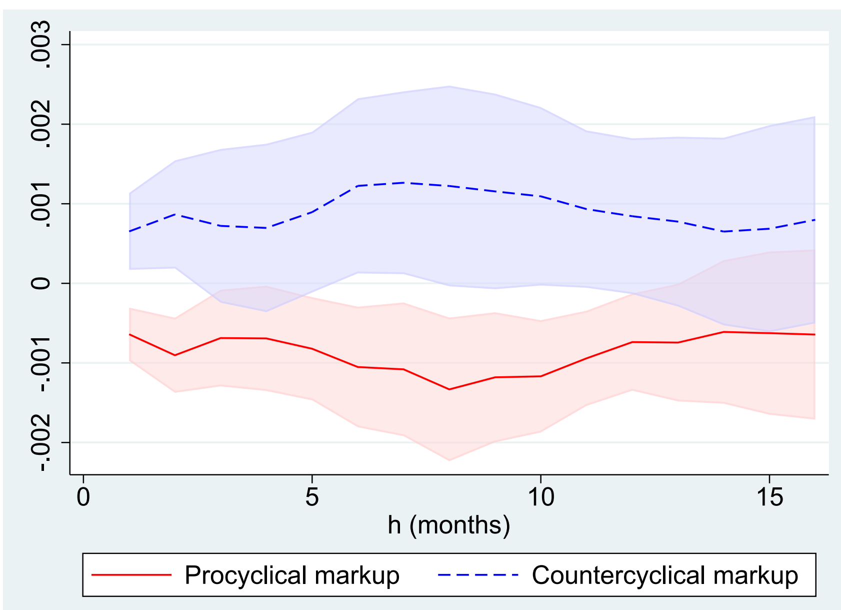



Figure 8: Robustness check: response of $\ln(CPI)$ in a state-dependent local projection. Shaded areas are 90% confidence bands, calculated via robust standard errors.

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