# *Comments and Discussion*

COMMENT BY

**JORDI GALÍ** Lorenzoni and Werning deal with a subject that is central to macroeconomics: the sources and mechanisms behind inflation fluctuations. Interest in that subject has only been enhanced by the recent high inflation episode. More specifically, they revisit the potential role of wage-price spirals as a factor of inflation persistence using a New Keynesian model with staggered price and wage setting à la Erceg, Henderson, and Levin (2000) as a reference framework. Their analysis yields a number of interesting results, including a connection between wage-price spirals and the concept of "conflict inflation," which they introduced in earlier work (Lorenzoni and Werning 2022). The paper contains many insights, of which I will single out the discussion of the potential role of two departures from the standard model as sources of inflation persistence, namely, the introduction of expectations de-anchoring and real rigidities.

My discussion is organized as follows. Firstly, I raise a caveat regarding the authors' characterization of the recent wage and price developments that motivate the paper. I then contrast the notion of inflation as conflict proposed in the paper with a more conventional interpretation of wage spirals. Next, I will discuss the connection between wage-price spirals and conflict inflation and relate some of the paper's normative findings to the existing literature. Finally, I will discuss the extensions of the model incorporating adaptive expectations and real rigidities.

RECENT WAGE AND PRICE DEVELOPMENTS REVISITED While the focus of Lorenzoni and Werning's paper is theoretical, its motivation is driven by the wage and price developments observed in the wake of the COVID-19

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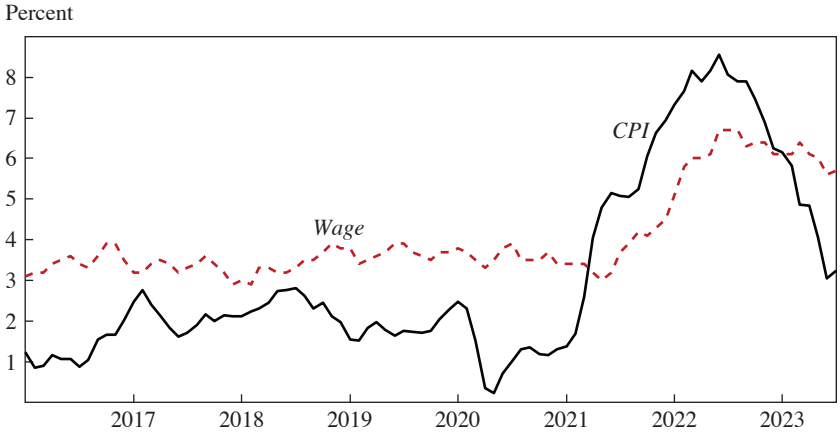
**Figure 1.** CPI and Wage Inflation

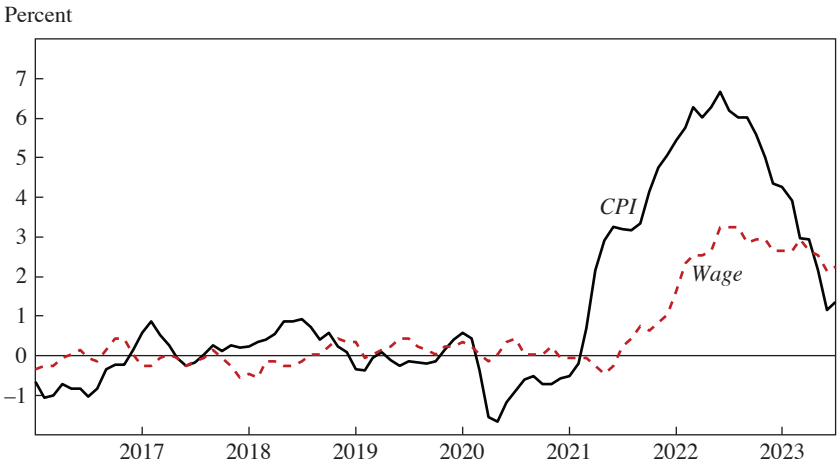



Source: CPI data from Bureau of Labor Statistics, retrieved from FRED; and wage inflation data from Wage Growth Tracker, Atlanta Fed.

pandemic and the war in Ukraine. Figure 1 summarizes these developments by displaying year-on-year US price and wage inflation from 2016 onward, using the Consumer Price Index (CPI) and the Federal Reserve Bank of Atlanta's wage index, respectively. The figure reveals the temporal pattern stressed by the authors, with wage inflation lagging price inflation both on the way up—with the real wage declining as a result—and on the way down—with wage inflation remaining roughly unchanged over the past year even in the face of a marked decline in price inflation—with the consequent increase in the real wage. That observation had led, in the authors' words, to "the concern . . . that higher wage growth would prevent inflation from going back to target, or even set off an out-of-control wage-price spiral." A central message of the paper is that such a concern is likely to be unwarranted, for the observed pattern is precisely the one that a standard model, calibrated in a way consistent with the evidence on the relative stickiness of prices and wages, would predict in response to either an expansionary demand shock or an adverse supply shock (both persistent, but not permanent) in an environment in which the monetary policy rule guarantees the return of price inflation to its intended target.

Here I would like to point out a caveat in the authors' analysis: the fact that price inflation and wage inflation display different underlying trends may distort the interpretation of figure 1 and its connection with the subsequent model simulations (which abstract from those differential trends). More

**Figure 2.** CPI and Wage Inflation (Demeaned)

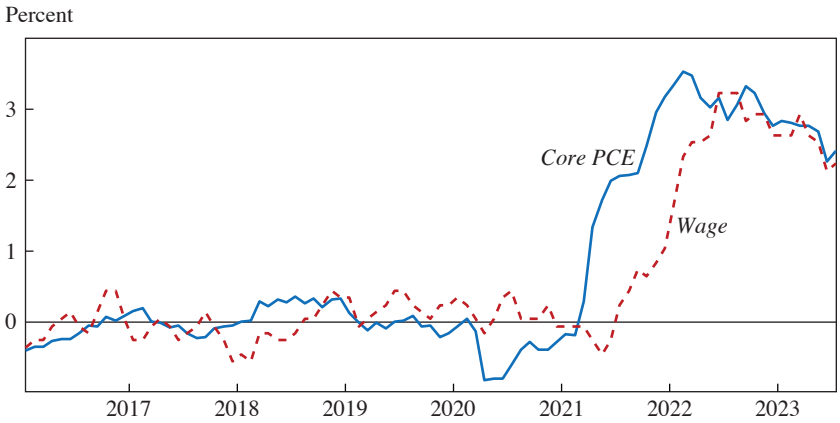



Source: CPI data from Bureau of Labor Statistics, retrieved from FRED; and wage inflation data from Wage Growth Tracker, Atlanta Fed.

specifically, and as figure 1 makes clear, wage inflation is, on average, higher than price inflation (equivalently, the real wage displays an upward trend). When using a simple plot to ascertain the impact of a shock on both variables, it is important to subtract their respective means. This is shown in figure 2, which displays the US price and wage inflation net of their (pre-COVID-19) means. The picture that emerges is significantly different, with more limited evidence of persistently higher wage inflation than price inflation (both relative to trend) at the end of the sample period. In other words, there is no evidence of a tendency for the real wage to revert back to its initial trend. That caveat appears even stronger when one uses core Personal Consumption Expenditures (PCE) data to construct the series for price inflation, as illustrated in figure 3.

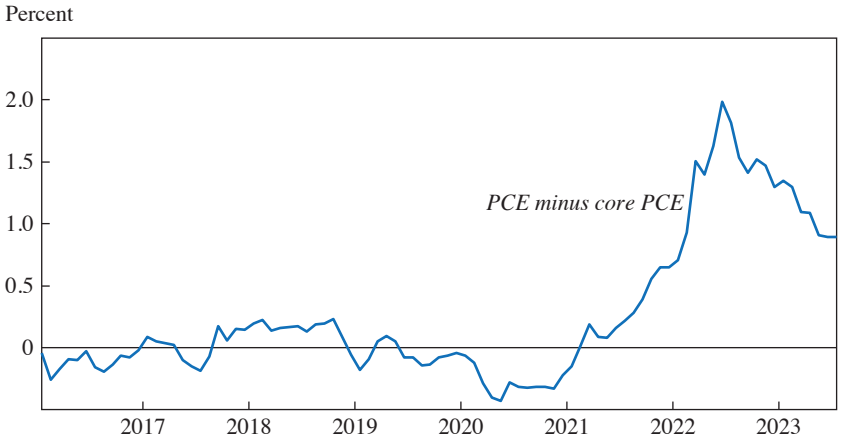
The resulting picture does not accord easily with the model simulations shown later in the paper, which imply trend reversion of the real wage. A possible explanation for the apparent absence of such trend reversion in the data is that the shock experienced by the US economy may have warranted a permanent fall in the real wage. Through the lens of the paper's model, this would be the case in the face of a permanent decline in the energy input endowment. Figure 4 displays some evidence consistent (if nothing else) with the hypothesis of a permanent supply shock: the log deviation between the PCE and core PCE indexes—which can be interpreted

**Figure 3.** Core PCE and Wage Inflation (Demeaned)




Source: Core PCE data from Bureau of Economic Analysis, retrieved from FRED; and wage inflation data from Wage Growth Tracker, Atlanta Fed.

**Figure 4.** Transitory or Permanent Shocks?




Source: Bureau of Economic Analysis, retrieved from FRED.

as a proxy for the relative price of noncore components (energy and food)—displays a seemingly permanent increase in the post-COVID-19 period relative to its stable pre-COVID-19 values.

A correct diagnosis of the forces behind the evidence is key to assess the challenges posed by wage developments in the near future, and in particular, by an eventual persistent above-trend wage inflation, possibly motivated by workers' resistance to seeing their real wage eroded. If the hypothesis of a permanent adverse supply shock is correct, that resistance should indeed be a source of concern since, ceteris paribus, it would be inconsistent with the attainment of the Federal Reserve's inflation target. Bringing back inflation to target would require, in that scenario, a recession strong enough to break the downward rigidity in real wages. The extension of the New Keynesian model allowing for real rigidities, developed in section V of the paper, would seem to provide the right framework for analyzing the options facing a central bank in that environment.

ON INFLATION AS CONFLICT As shown in the paper, aggregation of price-setting decisions in the continuous time version of a New Keynesian model yields the following expression for price inflation $\pi_t \equiv \dot{p}_t$:

$$\pi_t = \Lambda_p \int_t^{\infty} e^{-\rho(s-t)} \left[ \left( w_s - p_s \right) - \left( mpl_s - \mu^p \right) \right] ds, \tag{1}$$

where $w_s$ is the (log) average nominal wage, $p_s$ is the (log) price level, $mpl_s$ is the (log) marginal product of labor, and $\mu^p$ is the desired (or natural) price markup, assumed to be constant. Note that in contrast with equation (13) in the paper, I do not use demeaned variables, instead showing the constant term explicitly. Coefficient $\Lambda_p$, formally defined in the paper, is inversely related to the degree of price stickiness. Parameter $\rho > 0$ is the representative household's time discount rate.

Lorenzoni and Werning use equation (1) as a reference when putting forward their notion of inflation as conflict. Under that perspective, a rise in (price) inflation emerges when firms' real wage aspirations, defined by $mpl_s - \mu^p$, lie below actual real wages, either currently or anticipated. In that case, firms that get a chance to adjust their prices will tend to raise the latter, generating positive inflation.

A similar reasoning carries over to wage inflation, $\pi_t^w \equiv \dot{w}_t$, which is given by

$$\pi_t^w = \Lambda_w \int_t^{\infty} e^{-\rho(s-t)} \left[ \left( mrs_s + \mu^w \right) - \left( w_s - p_s \right) \right] ds, \tag{2}$$

where coefficient $\Lambda_w$ is inversely related to the degree of wage stickiness. Note that wage inflation is driven by current or anticipated gaps between workers' real wage aspiration, given by the (log) marginal rate of substitution augmented with the desired wage markup, $mrs_s + \mu^w$, and the actual average real wage $w_s - p_s$.

Accordingly, whenever firms' and workers' real wage aspirations are mutually inconsistent, this will necessarily be manifested in either price or wage inflation (or both), thus leading to the authors' view of inflation as conflict. In particular, whenever the path of real wages lies below that of workers' wage aspirations but above that of firms' corresponding aspirations, the implied upward pressure on wages and prices will reinforce each other, giving rise to a wage-price spiral, the focus of the paper.

The previous interpretation of inflation as conflict raises a number of questions, at least when applied to the New Keynesian model. In particular, I believe it gives a somewhat misleading impression about *individual* firms' motives. What drives the pricing decisions of an individual firm is the maximization of its value, which under the model's assumptions is attained by keeping its markup as close as possible (on average) to the optimal (flexible price) markup $\mu^p$. In order to set its price optimally, the individual firm only needs to know its own nominal marginal cost, current and expected. Once that path is known, the real wage of its workers (defined relative to the entire consumption basket) is not of relevance to the price-setting firm. In particular, it does not care if the real wage of its workers goes up as a result of a reduction in other firms' prices.

The markup-based interpretation of an individual firm's motives, which can be read directly from the first-order condition associated with its optimal price-setting decision, is also reflected in inflation equation (1) once we rewrite it as follows:

$$\pi_t = \Lambda_p \int_t^\infty e^{-\rho(s-t)} \left[ \mu^p - \left\{ p_s - \left( w_s - mpl_s \right) \right\} \right] ds$$

$$= \Lambda_p \int_t^\infty e^{-\rho(s-t)} \left( \mu^p - \mu_s^p \right) ds,$$

where $\mu_s^p \equiv p_s - (w_s - mpl_s)$ is the average price markup (with $w_s - mpl_s$ measuring the average marginal cost). Similarly, for wage inflation one can write

$$\pi_t^w = \Lambda_w \int_t^\infty e^{-\rho(s-t)} \left( \mu^w - \mu_s^w \right) ds,$$

where $\mu_s^w \equiv (w_s - p_s) - mrs_s$ is the average wage markup. Through this lens, price and wage inflation have a natural interpretation as the result of misalignments between actual and desired price and wage markups, respectively, and the consequent decisions by firms and workers in order to minimize those misalignments (at least in an expected sense), when allowed to do so.[1]

To be clear, the model is what it is, independent of the stories one can tell about its underlying mechanisms, and the wage-price block of the authors' model is fully standard. But to the extent that those stories help us understand the workings of the model, I can see two advantages of the interpretation based on markup misalignments relative to inflation as conflict advocated by the authors. First, while inflation is driven by deviations of a particular variable from some reference target in both cases, under the authors' interpretation that variable is the real wage whose target varies continuously over time and may even be nonstationary. By contrast, under the interpretation I prefer, the driving variable is the markup whose target is constant under standard assumptions. Second, as argued above, the markup misalignment interpretation seems to capture better the perspective of individual firms when making their price-setting decisions.

Finally, it is worth noting that the markup-based interpretation of inflation also provides a simple narrative for wage-price spirals. To see this, consider an adverse supply shock which raises firms' marginal costs and, as a result, lowers price markups relative to target. Firms that have a chance to adjust their prices will, on average, raise them, thus generating positive price inflation. Workers' real wages will be eroded as a result, thus lowering their average wage markup relative to target and inducing nominal wage increases among those workers who have a chance to reset their wage. The resulting wage inflation will in turn raise firms' marginal costs, leading to a second round of upward price adjustments, and so on.

CONFLICT INFLATION AND WAGE-PRICE SPIRALS Lorenzoni and Werning introduce the concept of conflict inflation as a component of price and wage inflation that results from a conflict between the wage aspirations of firms and workers. Formally, they define conflict inflation as follows:

$$\Pi_t^C \equiv \frac{\Lambda_p \Lambda_w}{\Lambda_p + \Lambda_w} \int_t^\infty e^{-\rho(s-t)} \left[ \left( mrs_s + \mu^w \right) - \left( mpl_s - \mu^p \right) \right] ds, \tag{3}$$

1. See, for example, Galí (2015) for a textbook treatment of the New Keynesian model that stresses this interpretation.

where, once again, I am making explicit the constant terms in the expression. Note that conflict inflation is a discounted integral of current and future gaps between workers' real wage aspirations, $mrs_s + \mu^w$, and the corresponding aspirations for firms, $mpl_s - \mu^p$. A central theme in the paper is the connection between conflict inflation, thus defined, and the presence of a wage-price spiral. What is the nature of that connection?

Note that by combining equations (1) and (2) with the above definition of conflict inflation, one can show:

$$\Pi_t^C = \alpha\pi_t + \left(1-\alpha\right)\pi_t^w, \tag{4}$$

where $\alpha \equiv \dfrac{\Lambda_w}{\Lambda_w + \Lambda_p} \in \left[0,1\right]$. In words, conflict inflation can be expressed as a particular weighted average of price inflation and wage inflation, with the weight of each variable increasing in its relative stickiness.

A straightforward algebraic manipulation of equation (4) allows the authors to obtain the following expressions for price and wage inflation:

$$\pi_t = \Pi_t^C - \left(1-\alpha\right)\dot{\omega}_t \text{ and} \tag{5}$$

$$\pi_t^w = \Pi_t^C + \alpha\dot{\omega}_t, \tag{6}$$

where $\dot{\omega}_t \equiv \pi_t^w - \pi_t$ is the change in the real wage. Equations (5) and (6) motivate the authors' intended connection between conflict inflation and wage-price spirals, since $\Pi_t^C$ can be interpreted, in their words, as the "underlying common component of price and wage inflation due to the gap between the aspirations on the two sides of the market."

However, establishing a rigorous connection between conflict inflation and wage-price spirals requires a formal definition of the latter. What is a wage-price spiral, after all? How can one measure its intensity?

While macroeconomists likely share at least a vague notion of what a wage-price spiral is, as far as I can tell there is no consensus on a formal definition of that phenomenon.[2] A possible definition, and one that the authors adhere to in several instances throughout their paper, is an episode

2. A recent paper by International Monetary Fund economists (Alvàrez and others 2022) seeks to identify wage-price spiral episodes throughout history. They use as a definition the observation of three successive quarters with accelerating price and wage inflation.

in which both price and wage inflation are positive.[3] Note, however, that conflict inflation would not seem to be a good indicator of the intensity of a wage-price spiral under such a definition, for any positive value of conflict inflation is consistent with wage and price inflation values of different sign.[4]

Furthermore, it is not obvious why any arbitrary weighted average of price and wage inflation (defined by a weight $\alpha$ different from $\frac{\Lambda_w}{\Lambda_w + \Lambda_p}$) could not also be thought of as a plausible wage-price spiral indicator, since equations (5) and (6) would also hold for that alternative measure. That measure, however, would bear no simple relation with conflict inflation.

So the question remains: what makes the particular weighted average of price and wage inflation defined by equation (4) with $\alpha = \frac{\Lambda_w}{\Lambda_w + \Lambda_p}$ (and which corresponds to conflict inflation) special or particularly desirable as a measure of wage-price spirals?

To address that question, the authors first propose a formal measure of the intensity of wage-price spirals, which they refer to as "spiral inflation." Formally, they define spiral inflation (in response to a shock at time zero) as:

$$\Pi_0^S = \int_0^\infty \pi_s ds,$$

that is, the cumulative change in price inflation. To the extent that the shock under consideration does not have a long-run effect on the real wage (as assumed by the authors), it follows $\int_0^\infty \pi_s ds = \int_0^\infty \pi_s^w ds$, that is, the cumulative change in wage inflation must equal that of price inflation, with their common value corresponding to spiral inflation, the authors' proposed wage-price spiral indicator.

Next the authors move on to show that, in the particular case that conflict inflation decays exponentially, spiral inflation will be proportional to conflict inflation. To see this, note that

3. More generally, one could define a wage-price spiral episode as one displaying price and wage inflation above their corresponding steady-state values. In the authors' model, those steady-state values are zero by assumption.

4. On the other hand, positive conflict inflation is a necessary condition for a wage-price spiral under that proposed definition. As the authors argue, however, positive conflict inflation necessarily implies positive cumulative price and wage inflation through the adjustment to the steady state, under certain assumptions.

$$\begin{aligned}\Pi_0^S &= \int_0^\infty \pi_s ds \\ &= \int_0^\infty \Pi_s^C ds - \left(1-\alpha\right)\int_0^\infty \dot{\omega}_s ds \\ &= \int_0^\infty \Pi_0^C e^{-\delta s} ds - 0 \\ &= \frac{1}{\delta}\Pi_0^C,\end{aligned}$$

where $\delta$ is the rate of decay of conflict inflation and $\int_0^\infty \dot{\omega}_s ds = 0$ follows from the stationarity of the real wage. The previous finding is interpreted by the authors as implying that "conflict inflation at date zero fully captures the underlying forces that lead to a protracted period of joint price and wage inflation," thus establishing the desired connection between conflict inflation and wage-price spirals.

The interest of the previous result notwithstanding, it is important to point out some caveats. First, the proportionality between spiral inflation $\Pi_0^S$ and conflict inflation $\Pi_0^C$ holds in the particular case of exponential decay, but it will not hold more generally. While such an exponential decay may be supported by an appropriate choice of monetary policy, it is generally not a property of the equilibrium. Furthermore, the coefficient of proportionality between the two variables depends on the rate of decay, which will not be invariant to the persistence of the shock or the policy rule in place. Accordingly, similar readings of conflict inflation at different points in time (or for different economies) may correspond to different levels of spiral inflation. Second, the tight relation between conflict inflation and spiral inflation hinges on the assumption of a stationary real wage, which is needed for $\int_0^\infty \dot{\omega}_s ds = 0$ to hold. Accordingly, the simple relation between spiral inflation and conflict inflation will vanish in the face of shocks with permanent effects on the real wage. Third, and perhaps most important, even in the case of a stationary real wage, the link between spiral inflation and conflict inflation uncovered above holds at time zero, that is, the time of the shock, when the real wage is still at its steady-state level, but it fails to do so on an arbitrary period $t > 0$ when that variable is away from the steady state, for in that case $\int_0^\infty \dot{\omega}_s ds \neq 0$.

CONFLICT, SPIRALS, AND THE DESIGN OF MONETARY POLICY Section IV of Lorenzoni and Werning's paper revisits the problem of optimal policy in the face of supply shocks. Given that the analysis of optimal policy in the New Keynesian model with staggered prices and wages, tracing back to

Erceg, Henderson, and Levin (2000), is generally well understood, some of the authors' findings are not entirely novel, though they are recast here in terms of conflict inflation and, more generally, they are related to the notion of a wage-price spiral. In particular, there are two well-established results in the literature on optimal policy in the model in Erceg, Henderson, and Levin (2000).[5] First, there exists a specific weighted average of wage inflation and price inflation, referred to as "composite inflation" in Galí (2015), for which the divine coincidence holds, that is, full stabilization of that variable implies full stabilization of the output gap. Second, there is a knife-edge parameter configuration for which the optimal policy calls for a full stabilization of the output gap and, hence, of composite inflation. More generally, and for a broad range of parameter values, such a policy is nearly optimal.

The connection between the previous results and some of the findings in the paper becomes clear once we recognize that the weighted average defining conflict inflation in equation (4) matches exactly the one that defines composite inflation in the existing literature. In particular, the symmetric case considered by the authors in their example 1 corresponds to the knife-edge case referred to above, while examples 2 and 3 can be viewed as an illustration of the near optimality of stabilization of the output gap more generally as reflected in the tiny response of that variable (once the scale of the plot is taken into account) under the optimal policy, as displayed in figures 10 and 11 in the paper.

Beyond the connection with the existing literature, the authors' analysis uncovers some results that shed light on a number of issues and that, in my opinion, are not sufficiently stressed in the paper.

First, the authors derive the second-order approximation to the welfare losses for the case of continuous time. The resulting expression is similar to the one for the discrete time case, originally derived in Erceg, Henderson, and Levin (2000). It is worth noting a difference, not emphasized by the authors, related to their use of a CES production function: the coefficient on the output gap $\Phi_y$ is inversely related to the elasticity of substitution between energy and labor. Thus, ceteris paribus, a low value for that elasticity will be associated with a higher weight on output gap stability in the central bank's loss function. That result, in a model in which the divine coincidence does not hold, is of great interest and its implications would seem to deserve some further discussion.

5. See proposition 3.9 and section 4.4 in Woodford (2004) and section 6.4.3 in Galí (2015).

Second, the authors note the following result, which follows from equation (4): with a zero output gap (and, hence, zero conflict/composite inflation), the adjustment in the real wage never requires positive inflation for *both* wages and prices. A slight generalization of that result, based on the near-optimality findings mentioned above, would run as follows: the fact that the optimal policy involves, at most, tiny deviations of conflict inflation from zero, rules out non-negligible positive inflation for both wages and prices as an optimal outcome. In their example 3, the authors uncover an instance of coexistence of positive wage and price inflation for a very brief period during the adjustment, but one should note that wage inflation is almost zero during that brief episode.

Under a definition of wage-price spirals as episodes with (non-negligible) positive inflation in wages and prices, the previous discussion would establish an interesting connection between optimal policy and the subject that is the focus of this paper, namely, the observation that wage-price spirals are (almost) always suboptimal. But, as discussed above, this is not the definition of wage-price spirals adopted by the authors, who instead focus on the concept of spiral inflation as an indicator of the intensity of wage-price spiral episodes. Unfortunately, the usefulness of spiral inflation in the context of the authors' optimal policy exercise is limited, since the real wage is permanently affected by the shock considered, implying that the mapping between conflict and spiral inflation is lost. In fact, under the optimal policy, and given the discussion above, we have

$$\Pi_0^S \simeq -\left(1-\alpha\right)\int_0^\infty \dot{\omega}_s ds,$$

which may take a large positive value in response to an adverse supply shock even if wage inflation and price inflation co-move negatively during the adjustment period (as in the three examples considered). It is clear that, in that instance, spiral inflation would not be a good indicator of a wage-price spiral.

ADAPTIVE EXPECTATIONS AND REAL RIGIDITIES Section V departs from the standard model in Erceg, Henderson, and Levin (2000) by exploring the implications of two potential sources of inertia, namely, a form of adaptive expectations that implies de-anchoring and the presence of real rigidities. The former is modeled by assuming that firms and workers expect constant inflation at all horizons (at a level that may be different from the steady state, thus the interpretation as a form of de-anchoring), with that variable adjusting slowly in response to variations in realized inflation. The latter

assumes that the real wage targets of workers and firms adjust sluggishly in response to changes in $mrs_s$ and $mpl_s$.

Lorenzoni and Werning show that the introduction of de-anchoring leads to both greater inertia and higher persistence in both price and wage inflation relative to the baseline model, as a result of a strong underlying wage-price spiral mechanism. That prediction is enhanced when real rigidities are added.

Unfortunately, the authors do not carry out an analysis of optimal policy using the modified model. I believe it would be interesting to explore whether the two sources of inertia considered in this section could overturn the result derived for their baseline model, regarding the impossibility of non-negligible positive inflation coexisting for both wages and prices as an optimal outcome. I hope the authors (or someone else) undertake that analysis in future work.

Here is a minor quibble I have on this section: when considering the calibration with real rigidities (the second source of inertia), the authors maintain the assumption of adaptive expectations (the first source of inertia), but they lower the setting of $\gamma$ from 1 to 0.1, which is justified on the grounds that "inflation expectations play a more limited role." This may be somewhat confusing to the reader since, as far as I understand, lowering $\gamma$ makes inflation expectation even more sluggish (and thus further from rational expectations than in their first exercise where they only considered adaptive expectations as a source of inertia). In any event, I believe the authors should have gone back to rational expectations when studying real rigidities, in order to insulate the independent role played by this second source of inertia.

As a final comment, I would encourage the authors to discuss the connection between the two sources of inertia and wage indexation, a feature that is often incorporated in estimated versions of the standard model.[6] Wage indexation is typically modeled by having the nominal wages that are not re-optimized to be adjusted automatically in proportion to past price inflation. That mechanism is a source of real wage rigidity whose implications would be worth contrasting with the type of real rigidity assumed by the authors.

CONCLUDING REMARKS Recent price and wage developments in the United States and other advanced economies have rekindled fears of a wage-price spiral that may hinder central banks' efforts to control inflation. Lorenzoni and Werning's paper seeks to understand those developments through the lens of a New Keynesian model with sticky prices and wages. The first

6. See, for example, Smets and Wouters (2007).

challenge is to come up with an operational definition and measure of a wage-price spiral. The authors' proposed measure, spiral inflation, seems to be useful under certain conditions but not generally. The authors also explore the usefulness of conflict inflation, a concept they introduced in earlier work (Lorenzoni and Werning 2022), in accounting for wage-price spirals, and its connection with spiral inflation. In the context of the New Keynesian model, conflict inflation turns out to coincide with the particular weighted average of price and wage inflation (composite inflation), the stabilization of which implies the stabilization of the output gap; thus, conflict inflation inherits all the normative implications associated with composite inflation. Furthermore, conflict inflation is shown to be proportional to spiral inflation under certain conditions. In my discussion, I have raised some caveats about the usefulness of both conflict inflation and spiral inflation to help us understand and measure wage-price spirals. That skepticism notwithstanding, I found the paper to be thought-provoking and insightful along many dimensions. The likely inefficiency of wage-price spirals is an implication of their analysis that I found particularly interesting. It would be interesting to explore the type of changes in the environment that would allow that result to be overturned. An analysis of the normative implications of the sources of inertia introduced by Lorenzoni and Werning would seem to be a natural starting point in that endeavor.

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