Wage Setting in Times of High and Low Inflation*

Maximilian Gödl, Isabel Gödl-Hanisch, and Simon Velten

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Abstract

The post-pandemic surge in inflation led many unions and firms to alter their bargaining and wage-setting policies. Using novel German firm-level survey data, we document the extent of state dependence in wage setting across firms and workers during periods of high and low inflation. We find state dependence along the extensive and intensive margins: the average duration of wage agreements shortens from 14.2 to 12.9 months, and the adjustment per pay round increases from 2-4% to 4-6%. We complement these findings with newly compiled union-level panel data on collective bargaining outcomes. We show that the observed state dependence can be rationalized in menu cost and Calvo models of wage setting with heterogeneous firms. We examine the implications of state-dependent wage setting for the long-run effects of trend inflation, the transmission of monetary policy shocks, and the slope of the Phillips curve in an otherwise standard New Keynesian model.

Keywords: State-dependent wage setting, New Keynesian model, heterogeneous firms, Phillips curve.
JEL codes: E24, E31, E50, E60.

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1 Introduction

Nominal rigidities play a key role in the propagation of economic shocks and the transmission of monetary policy. While an extensive literature has documented that price stickiness is time-varying and varies with the inflation environment (e.g., Kashyap 1995; Nakamura and Steinsson 2008; Alvarez et al. 2019; Gagnon 2009), the state dependence of wage setting has received comparatively little attention. This is despite the fact that wage rigidity seems to be quantitatively more important than price rigidity for monetary non-neutrality (e.g., Amano et al. 2009).[1] The post-pandemic surge in inflation provides an opportunity to examine whether and how wage-setting behavior adapts to changes in the inflation environment.

This paper presents novel facts about wage setting in times of high and low inflation and explores their implications for monetary policy transmission as well as the long-run effects of trend inflation on the macroeconomy. Leveraging firm-level survey data and union-level panel data from Germany, we document that wage setting is state dependent along both the extensive and intensive margins: the duration of wage agreements shortens, and the size of wage adjustments increases when inflation is high. Our empirical results can be rationalized by a menu cost model of wage setting, in which high inflation induces firms to reset wages more often and by higher increments to avoid large deviations from the optimal real wage.A Calvo-type model of wage setting, where the probability of reset is exogenous, can also replicate the empirical facts provided that the reset probability is linked to the inflation rate. Furthermore, we propose a tractable way to incorporate state-dependent wage setting into a standard New Keynesian model. Our findings indicate that state-dependent wage setting reduces the distortionary effects of inflation on output, employment, and welfare in the long run, and attenuates monetary transmission to real variables, resulting in a steeper Phillips curve.

Our firm-level evidence comes from a set of supplementary questions added to the ifo Institute's HR survey, a quarterly representative survey of about 600 firms across all industries in Germany. By questioning HR managers, this survey allows us to obtain information from the key decision-makers in hiring and wage-setting processes at the firm level. Focusing on non-performance-based, ordinary wage adjustments, we compare the size (intensive margin) and frequency (extensive margin) of wage adjustments in two periods with significantly different inflation rates: 2017-2019, with an average annual inflation rate of 1.6%; and 2022-2024, with an expected average inflation rate of 6.5%, per

[1] Fregert and Jonung (1999) and Sigurdsson and Sigurdardottir (2016) provide some evidence that the timing of wage adjustments depends on the inflation rate using data from Sweden and Iceland, respectively.

the Joint Economic Forecast.

Our survey data allow us to consider several dimensions of heterogeneity in wage-setting behavior, such as (i) heterogeneity across firms in terms of size and monopsony power in the labor market, and (ii) heterogeneity along the job ladder and skill level of workers. We examine factors influencing wage decisions, including competitors' wage-setting practices, worker availability, sales price dynamics, overall inflation, and collective bargaining agreements. We also identify constraints on wage setting, such as administrative costs, regulation, economic reasons, and wages set outside of the firm.

The results show that firms alter their wage-setting behavior in response to high inflation by resetting wages more frequently and by higher increments per pay round. On average, the duration of pay agreements decreased from 14.2 months in the low inflation period to 12.9 months in the high inflation period, with about 20% of firms planning to negotiate wages more frequently during high inflation. Wage adjustments per pay round increase during high inflation, with most firms raising nominal wages by 4-6%, compared to 2-4% in low inflation times. Converted into (semi-)elasticities, we find that the duration shortens by 0.26 months, and nominal wages increase by 0.3 percentage points for each percentage point increase in inflation. There is large heterogeneity across and within sectors, with larger firms increasing wages by less but more frequently, suggestive for the presence of monopsony power in the labor market. At the firm level, both labor market and macroeconomic factors are key for wage decisions.

The patterns from our firm-level survey data are corroborated by union-level panel data on collective bargaining outcomes, enhancing both the external and internal validity of our results. This newly compiled data spans a longer time horizon and allows us to control for potentially confounding factors (such as inflation uncertainty and labor market conditions). Based on our main sample from 1990 to 2023, we show that during periods of high inflation, negotiated wage hikes are 2.2 percentage points higher, and the duration of collective bargaining agreements is two months shorter. Panel regressions on our union-level data estimate a semi-elasticity of contract duration of -0.9 months and an elasticity of wage growth of about 0.6. Notably, the adjustment along the extensive margin in the union data during high inflation periods is approximately three times larger than in the firm-level data, while the intensive margin adjustment is about two times larger.

In the second part, we turn to models of state-dependent wage setting. First, we develop a menu cost model of wage setting in analogy to the price-setting models of Nakamura and Steinsson (2008) and Gagnon (2009). In this model, heterogeneous firms face fixed "menu costs" each time they want to reset nominal wages. As a result, the probability of a wage change in each period is endogenous and depends on both the aggregate state of the economy (which is summarized by the average price level) as well as the idiosyncratic productivity of the firm. We show that such a model can rationalize the wage-setting behavior along the extensive and intensive margin as well as the observed differences between large and small firms. We then show that a computationally simpler Calvo model with an exogenous probability of wage changes and time-varying parameters suffices to reconcile the empirical results. This point echoes the results of Auclert et al. (2024) on the price-setting side.

To explore the general-equilibrium implications of our findings, we incorporate state-dependent wage setting into a standard New Keynesian model with sticky wages based on Erceg et al. (2000). We assume that the probability of resetting the wage is an increasing function of the inflation rate. In this model, we show that state-dependent wage setting alters the "macroeconomics of trend inflation" (Ascari and Sbordone 2014). A higher wage resetting probability during high inflation mitigates the distorting effects of inflation on wage dispersion, output, and employment. When calibrated to the observed degree of state dependence, our model suggests that welfare costs of high inflation are almost neutralized.

To gauge the effect of state dependence on inflation dynamics, we analyze the propagation of an expansionary monetary shock in the neighborhood of a steady state with positive trend inflation. We find that pass-through to prices and wages is amplified and monetary transmission is dampened in a model with state-dependent wage setting, i.e., wage and price inflation become more responsive while output and employment react less to monetary shocks. This means that the Phillips curve steepens in the presence of state-dependent wage setting, resulting in a lower sacrifice ratio and a more favorable trade-off for central banks. Simulations of our calibrated model imply that state-dependent wage setting reduces the output cost of an inflation reduction policy by 20-50% relative to a model where the wage reset probability is fixed.

Related literature. The empirical literature on the frequency and size of nominal wage changes is surprisingly thin and primarily based on U.S. data. For instance, Barattieri et al. (2014) find a probability of nominal wage change of 21-27% per quarter using data from the mid-1990s — a period with a 2.5% average inflation rate comparable to our low inflation period. This is equivalent to an expected duration of about one year, slightly lower than the average duration of 14 months in our firm-level data during the low inflation period. Similar patterns were found in data from other developed economies. For example, Druant et al. (2012) find that firms adjust wages about every 15 months on average in a survey of firms in 17 European countries. Similarly, Sigurdsson and Sigurdardottir (2016) document that 90% of wage spells last one year or less using administrative data from Iceland.

The question of state dependence in wage-setting behavior has received even less attention. Grigsby et al. (2021) use administrative job-level data from the U.S. covering 2008 to 2016. They find that base wage adjustments, excluding compensation elements such as bonuses, commission, and overtime pay, are almost always positive, with the highest probability of a wage change occurring 12 months after the last adjustment. While they emphasize the dependence of wage setting on the business cycle and comovement with the unemployment rate, they are silent about the role of inflation. Sigurdsson and Sigurdardottir (2016) also address the question of state dependence, finding that the frequency of wage adjustments depends on both inflation and unemployment. However, they do not consider the impact of inflation on both the extensive and intensive margin of wage adjustments. In addition, our firm-level survey data allow a more granular look at wage-setting behavior and its heterogeneity across firm sizes, industries, and the degree of monopsony power in the labor market.

We also contribute to the burgeoning literature studying pass-through of (expected) inflation to wages and to understanding the "puzzle" of why wage growth reacts sluggishly to (expected) inflation in micro and survey data (e.g., Abberger et al. 2023; Buchheim et al. 2024; Baumann et al. 2024 for firms and Hajdini et al. 2025; Jain et al. 2024 for employees). We show that the conclusions from previous studies remain valid when simultaneously eliciting the intensive and extensive margin of wage setting.

Our paper is also closely connected to the state-dependent price-setting literature. For instance, Gagnon (2009) document that firms adjust prices more frequently in times of high inflation. The monthly price change frequency rose from an average of 22% in 1994 to a high of 62% at peak inflation in Mexico. Kashyap (1995) provides similar evidence for the US in the 1970s and 80s versus the period before and after. In a similar vein, Nakamura and Steinsson (2008) show that the frequency of price hikes correlates with inflation. Further, Alvarez et al. (2019) demonstrate that the elasticity of price change frequency to inflation is positive in data from Argentina.

Our estimates on the wage-setting side are qualitatively and quantitatively similar to the price-setting side. For example, results reported by Konieczny and Skrzypacz (2005) imply that a 1 percentage point increase in inflation increases the price-setting frequency by 0.12 percentage points. For wage setting, we find similar effects with a 1 percentage point increase in inflation, increasing the wage-setting frequency by 0.14 percentage points in the firm-level survey. In a similar fashion, Alvarez et al. (2019) estimate semi-elasticities of the frequency of price changes to inflation of roughly 0.04 during periods of similar levels of inflation.

On the theoretical side, our paper contributes to the literature on modeling wage stickiness. An extensive literature starting with Danziger (1999) has developed dynamic models in which price stickiness is due to fixed menu costs that firms have to pay whenever they adjust prices (e.g., Golosov and Lucas, 2007, Gagnon, 2009 and Gertler and Leahy, 2008). In these models, a firm will change its price whenever the existing price deviates too far from the optimal level. We apply the menu cost approach to wage setting and show that it is successful in replicating the empirical patterns found in our firm-level and union-level data. Recent work by Auclert et al. (2024) has demonstrated that the Calvo price setting model yields the same Phillips curve as a menu cost model under quite general conditions. We find a corresponding result for wage setting: a Calvo model with a state-dependent probability of wage adjustment can also replicate the empirical facts about wage setting at the extensive and intensive margins. In the final section, we introduce state-dependent wage setting into a standard New Keynesian framework with both price and wage rigidity first developed by Erceg et al. (2000). We show that state-dependent wage setting matters both for the long-run consequences of trend inflation as well as the short-run dynamics of a monetary policy shock.

The remainder of this paper is structured as follows: Section 2 describes the survey and union data sets. Section 3 presents novel facts on wage-setting behavior in times of high and low inflation. Section 4 first proposes a simple model of state-dependent wage setting and then discusses the dynamic effects of monetary shocks in a New Keynesian general equilibrium model. Section 5 concludes. Additional empirical results as well as details on the theoretical models are available in the appendices.

2 Data Sources and Summary Statistics

2.1 Firm-level survey data

Our evidence comes from two novel datasets. First, we collected survey data on firms' wage-setting behavior by adding a module of questions to the ifo Institute's HR survey. This is a quarterly survey of around 600 HR managers in German firms asking about current HR policy topics. The main advantage of the ifo HR survey for our purposes is that it elicits information directly from the key decision makers at the firm in the wage-setting process. In our sample, the number of HR employees has a median of 2 and a mean of 4.1, while the relative size of HR has a median of 3% and a mean of 4% of total employees. The panel includes companies across all sectors of the economy, covering manufacturing (37%), services (41%), trade (21%), and construction. About half of the companies are classified as medium-sized (50-249 employees), one-third as small-sized (<50 employees), and 11% as large-sized (>500 employees), which is representative of the German corporate landscape.

For more information on the survey, see Schaller et al. (2025).

We supplemented the Q4/2022 survey round with questions on wage-setting behavior in times of high and low inflation and factors and frictions impacting firms' wage-setting decisions. Specifically, we ask the following questions to assess the state dependence of wage adjustment along the extensive and intensive margins:

- *On average, how often (in months) did [does] your firm [plan to] adjust wages during 2017-2019 [2022-2024]? (excluding promotions, extraordinary wage changes, etc.)*
  Every ___ months.

- *On average, by how much (in percent) did [do] you [plan to] adjust wages per pay round during 2017-2019 [2022-2024]?*
  ☐ $< 0\%$ ☐$0-2\%$ ☐$2-4\%$ ☐$4-6\%$ ☐$6-8\%$ ☐$8-10\%$ ☐ $> 10\%$

Appendix A presents the complete survey instrument as well as a translation of the survey questions. The survey also asked to what extent firms plan to make use of one-time inflation offsetting payments (so-called "Inflationsausgleichsprämie", a tax-free bonus of up to 3,000 euros paid out between October 2022 and December 2024). In addition, we leverage questions on expected wage growth over the next year asked in Q4/2021, Q4/2022, Q4/2023, and Q4/2024 to check the consistency of our results. In Q4/2023 and Q4/2024, we asked firms about the bargaining room for new hires compared to existing hires. The survey further contains information on the firm's narrow industry, size, and other characteristics. Table 1 provides descriptive statistics on wage-setting behavior across low and high inflation periods.

The mean duration of pay agreements during the low inflation period (2017-2019) is 14.2 months compared to 12.9 months during the high inflation period (2022-2024). The mean adjustment of pay agreements during the low inflation period corresponds to category 3 (2-4%). In contrast, the mean expected adjustment of pay rounds during the high inflation period corresponds to category 4 (4-6%), slightly below the expected annual inflation rate of 6.5%. Section 3 provides more systematic evidence on state dependence and heterogeneity of wage-setting behavior across time and space.

2.2 Union-level data

While our firm-level survey provides detailed data on firms' wage-setting decisions during two specific periods of time, it does not contain direct information on actual wage changes and their duration over a longer time horizon. We therefore ask whether the results of our

Table 1: Descriptive statistics

	N	Mean	Std. dev.	p10	p25	p50	p75	p90
Duration (2017-2019)	529	14.18	5.71	12	12	12	12	24
Planned duration (2022-2024)	504	12.93	4.86	8	12	12	12	24
Realized duration (2022-2024)[a]	470	13.35	.	10	12	12	12	24
Adjustment (2017-2019)	529	3.88	2.13	1	3	3	5	7
Planned adjustment (2022-2024)	509	4.95	2.39	3	3	5	7	9
Realized adjustment (2022-2024)[a]	471	4.97	.	3	3	5	7	9
Relevance of wage competition[b]	499	0.17	0.15	0	0	0.19	0.25	0.33
Relevance of labor supply[b]	499	0.19	0.14	0	0.09	0.2	0.26	0.33
Relevance of inflation[b]	499	0.15	0.17	0	0	0.13	0.21	0.32
Relevance of coll. bargaining[b]	499	0.20	0.29	0	0	0.11	0.29	0.56
Relevance of sales prices[b]	499	0.08	0.10	0	0	0.05	0.14	0.21
Relevance of labor demand[b]	499	0.18	0.12	0	0.08	0.19	0.25	0.31
% of part-time workers[c]	428	0.16	0.15	0.02	0.05	0.10	0.22	0.36
% of temporary workers[c]	428	0.01	0.05	0	0	0	0	0.04
% of trainees[c]	428	0.05	0.05	0	0	0.03	0.07	0.12
Family business[c]	461	0.64	0.48	0	0	1	1	1
Number of employees[c]	433	253	855	17	33	74	195	411
Tenure HR manager[a]	457	18.16	11.63	4	9	17	25	35
% of minimum wage workers[c]	352	11.46	22.48	0	0	0	10	45
Payout % of one-time bonus	233	70.76	29.65	30	50	75	100	100

Notes: This table provides summary statistics for the duration of pay agreements (in months) and wage adjustment per pay round (in percent) during the periods 2017-2019 and 2022-2024, the relative relevance of labor market and macroeconomic factors for wage setting, as well as additional summary statistics on the firms' type, firm size, share of minimum wage workers, share of part-time workers, share of temporary workers, share of trainees, tenure of HR manager in years, and payout ratio of one-time bonus payments.

[a] Question was elicited in May 2025.
[b] Relative relevance reflects the firm-level importance of this factor and is calculated as the relevance of the respective factor over the sum of the relevance of all factors.
[c]Structural factors were asked in earlier survey rounds: 2019, 2020, and 2021.

ifo HR survey data are consistent with actual wage bargaining outcomes in the recent past and for a longer sample.

Sectoral collective bargaining between employer associations and labor unions plays a central role in wage determination in Germany (Jäger et al. 2022). Bargaining generally occurs at the industry level and is differentiated by region. The bargained contract contains minimum requirements for wages and working conditions (including work hours, entitlements, and promotion criteria) for all workers and firms who are members of the respective union or employer association. About half of the German labor force and a quarter of German firms are directly covered by a collective bargaining agreement; in addition, about half of non-covered firms apply the collective bargaining agreement to their employees voluntarily (Hohendanner and Kohaut 2023). The bargaining parties usually start negotiating days or weeks before the existing contract is about to expire. Failure to reach a consensus before the contract expires results in a continuation of provisions, including the wage negotiated in the old contract after the contract has expired.[2]

Individual firms covered by a sectoral wage agreement have some leeway in implementing collective bargaining agreements, either through flexibility clauses in sectoral agreements or direct negotiations between individual firms and sectoral unions. Therefore, our analysis considers not only industry-level wage agreement, but also firm-level agreements, i.e. agreements between labor unions and individual firms, such as the Deutsche Bahn AG or Volkswagen AG.

For that purpose, we collect data from collective bargaining agreements of labor unions from 1990 to 2025 in Germany. The primary source of the union data is the German Economic and Social Science Institute (Wirtschafts- und Sozialwissenschaftliches Institut, henceforth WSI), which centrally documents collective bargaining agreements in an online database and its accompanying annual report. Based on this information, we compile data on the size and duration of wage adjustments for the largest industries by union membership, focusing on the sectors such as metal, civil service, chemical, retail, construction, transport, and firms like Deutsche Post, Deutsche Bahn, and Volkswagen. Table C.1 provides summary statistics for each union on the time period covered by the database, the number of contracts, the mean duration, and the mean adjustment.

Since the availability of most of the contracts in the WSI starts in 1994, we supplement and cross-check the data with several reliable news articles about the duration and wage adjustment for most of the identifiers, at least until 1990. We attain the most comprehensive data for the metal as well as iron and steel industry, for which coverage extends back to

[2] The Collective Agreements Act (“*Tarifvertragsgesetz*”) contains all regulations on the collective bargaining process.

1956.

The main measure of wage adjustment includes all permanent wage increases for a given contract. For comparability, we focus on workers' wage increases in the so-called middle group, the lowest group for employees who have completed three years of vocational training.[3]

In total, the data on labor unions includes 317 contracts in 12 separate industries.[4] The mean duration of a contract is 19 months, and the mean adjustment is 4.8% per pay round. Our main sample starts in 1990 to ensure the availability of most union data and to prevent overweighting the metal and iron and steel industries, which have a longer coverage than others.

Compared to the ifo HR survey, we define the cutoff between high and low inflation environments to be an annual inflation rate of 3%, as measured by the Consumer Price Index for Germany. The high inflation environments in our main sample include the boom after the German unification (1991 – 1993, with inflation rates of more than 3.5%) and the post-pandemic inflation (2021 – 2024, with inflation rates between 3.1 and 5.9%). The results are not sensitive to either the definition of the sample or the choice of the inflation threshold.

3 Facts About Wage Setting During High and Low Inflation

3.1 Evidence from firm-level survey

This section establishes a set of novel facts about the wage-setting behavior of firms during periods of high and low inflation. At the firm level, we compare the intensive and extensive margin of wage adjustment in the years 2017-2019, with an underlying average annual inflation rate of 1.6%, with the period of 2022-2024, with an underlying average expected inflation rate of 6.5%.[5] The firm-level survey data also allows us to analyze potential heterogeneity across sectors and the firm size distribution.

[3]In addition, we provide a measure of wage adjustment including bonus payments (i.e., non-permanent wage increases for a given contract), and calculate annualized wage adjustment and real wage growth.

[4]Figures C.1 show the time series of the duration (converted to annual adjustment probability), the wage adjustment, and inflation. The time series of the union-level annualized wage changes is consistent with aggregate annual changes in the gross compensation of employees from the Federal Statistical Office of Germany. Their correlation is 0.69.

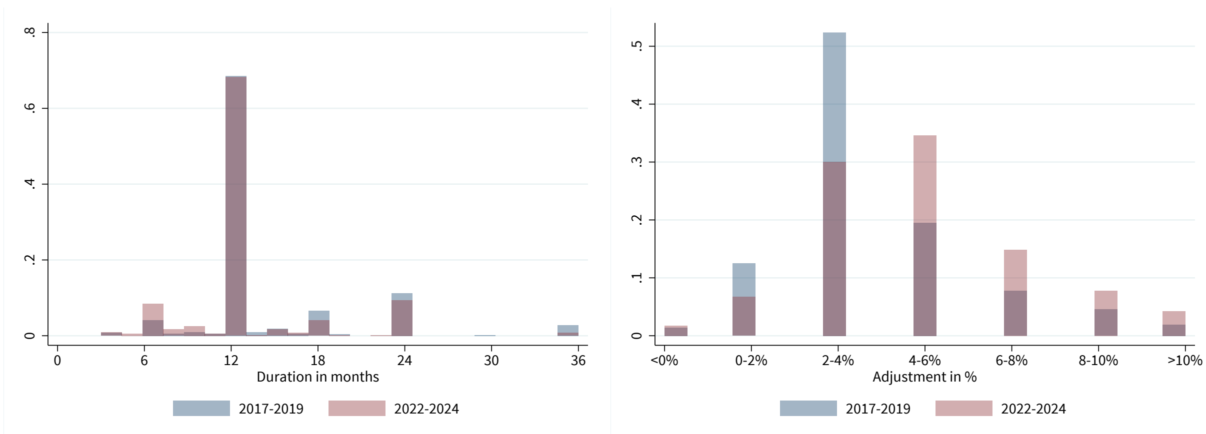
[5]The reference to average inflation for 2017-2019 and expected average inflation for 2022-2024 is consistent with firms' information set at the time of the survey. The forecast is the Joint Economic Forecast Project Group on behalf of the Federal Ministry of Economics and Technology (Gemeinschaftsdiagnose) in September 2022. Buchheim et al. (2023) show that survey-measured inflation expectations of German firms were consistent with the inflation forecasts by professional forecasters.

Fact 1: The duration of pay agreements shortens during times of high inflation. The duration of pay agreements is shorter on average in times of high inflation. Panel (a) of Figure 1 compares the frequency distributions of the duration of pay agreements for the periods 2017-2019 and 2022-2024, respectively. On average, firms plan to reset wages every 12.9 months in times of high inflation compared to every 14.2 months in times of low inflation.[6] Figure B.1(a) presents a histogram of the firm-level wage-setting changes along the extensive margin: A mass of around 70% of firms at zero duration change and a left tail with small peaks of 10% and 5% at six and twelve months, respectively.

Figure 1: Wage-setting behavior in times of high and low inflation

(a) Extensive margin

(b) Intensive margin



Notes: This figure shows the duration of pay agreements (extensive margin) and the wage adjustment in percent (intensive margin) during the periods 2017-2019 and 2022-2024.

Looking more closely, about 60% of companies adjust wages once a year and plan to continue doing so during the period of high inflation. Another 15% will continue to adjust wages at the same (higher or lower) frequency as before. Meanwhile, about 5% expect the duration of wage agreements to increase and about 20% expect it to decrease. Specifically, 10% of the companies in our sample expect to shift from a 24-month to a 12-month duration or from a 12-month to a 6-month duration, while another 5% expect to shift from an 18-month to a 12-month duration, as shown in Table 2.

[6]The difference is significant at the 1% level.

Table 2: Frequency distribution of duration in times of high and low inflation

		Duration 2022-2024					
		1-6	7-12	13-18	19-24	>24	Total
Duration 2017-2019	1-6	3.17	1.19	0.00	0.00	0.00	4.37
	7-12	5.56	62.90	1.39	1.98	0.00	71.83
	13-18	0.40	4.96	3.77	0.60	0.00	9.72
	19-24	0.00	4.37	0.40	6.55	0.20	11.51
	>24	0.20	0.60	0.40	0.79	0.60	2.58
	Total	9.33	74.01	5.95	9.92	0.79	100.00

Notes: This table shows the frequency distribution of the duration of pay agreements (in months) during the periods 2017-2019 (rows) and 2022-2024 (columns) clustered by duration bins.

These results are qualitatively in line with Sigurdsson and Sigurdardottir (2016), although quantitatively larger. In their data, a 5 percentage point increase in the cumulative inflation rate is associated with a decrease in duration from 8.26 months to 7.94 months, implying a semi-elasticity of 0.06 months per percentage point of inflation. In our data, the implied elasticity is between -0.23 and -0.26 months per percentage point of inflation (Table B.1), depending on the specification, with or without fixed effects for firms, sectors, or size.

Fact 2: The size of wage adjustments increases during times of high inflation. In times of high inflation, most firms plan to adjust nominal wages by more per pay round, resulting in a rightward shift in the entire distribution of firms' wage adjustment in the high inflation period, as shown in Panel (b) of Figure 1.[7] In 2017-2019, the mode of wage adjustments was 2-4%. The mode shifted to the right to 4-6% in 2022-2024. Figure B.1(b) presents a histogram of the firm-level wage-setting changes along the intensive margin: A mass of around 40% of firms at zero change in adjustment and 30% and 10% of firms moving up one or two categories, respectively.[8]

About 47% of firms plan to increase the wage adjustment. More specifically, about 20% of firms in our sample plan to increase the wage adjustment from 2-4% to 4-6% per pay round in 2022-2024, as shown in Table 3. A further 6% of firms plan to increase the wage adjustment from 2-4% to 6-8% per pay round and another 4% from 4-6% to 6-8%. Also,

[7] The difference in mean wage adjustments is significant at a 1% level.

[8] As we ask about wage growth in categories, this gives a lower bound on the intensive margin. Firms may increase wages within each category.

about 5% of firms adjusted wages previously marginally by 0-2% increase adjustment to 2-4%. The table also shows that only 28% of firms try to keep real wages constant in times of high inflation, while the others adjust by less than 6% in 2022-2024. This ratio is much higher in times of low inflation, where only 13% of firms offer less than a 2% increase in wages per pay round.

We combine survey responses on the duration and size of wage adjustments to approximate annualized wage changes, defined as the product of the annual frequency of wage adjustments and the size of the adjustment per pay round.[9] We find a mean annualized wage growth of 3.8% (median of 3%) in times of low inflation and 5.3% (median of 5%) in times of high inflation. Given that expected inflation rose from 1.6% to 6.5%, this implies a drop in annualized real wage growth from 2.2% to -1.2%. Probably, the latter number slightly underestimates wage growth during periods of high inflation, as most firms planned to additionally pay out one-time bonus payments during that time (Table 1).

These results indicate an incomplete pass-through of inflation to wage growth. The implied elasticity of nominal wages with respect to inflation is around 0.1-0.2 (Table B.1 and Table B.2), depending on the specification of fixed effects and the use of annual wage growth or three-year averages. As we show below, this is broadly in line with aggregate data from collective bargaining outcomes in Germany. Consistent with the recent literature on the pass-through of wage (expectations) to inflation (expectations) (e.g., Abberger et al. 2023; Buchheim et al. 2024; Baumann et al. 2024), we document a relatively low pass-through. However, a new finding is that the extensive margin effect for annualized wages should not be ignored. The pass-through to annualized wages is close to 0.30 and is about 9 bps – or one-third – higher than the pass-through to wage growth per wage round, as the duration decreases during periods of high inflation.

[9] Since the responses on the size of pay adjustments are given in bins, we use the central value of each bin. We set a value of -1% for the lowest bin (< 0) and 11% for the highest bin, but these values do not much affect our results due to the small proportion of answers in these bins.

Table 3: Frequency distribution of adjustment in times of high and low inflation

	Adjustment in % 2022-2024							
Adjustment in % 2017-2019	<0%	0-2%	2-4%	4-6%	6-8%	8-10%	>10%	Total
<0%	0.20	0.20	0.00	0.00	0.00	0.00	0.00	0.39
0-2%	0.00	2.94	4.71	3.14	0.78	0.39	0.20	12.16
2-4%	0.39	2.55	22.16	20.00	6.08	2.35	0.78	54.31
4-6%	0.20	0.20	2.75	9.22	4.31	1.57	0.78	19.02
6-8%	0.00	0.00	0.98	1.96	2.94	1.37	0.00	7.25
8-10%	0.00	0.20	0.20	0.59	0.98	2.35	0.59	4.90
>10%	0.20	0.00	0.20	0.00	0.20	0.00	1.37	1.96
Total	0.98	6.08	30.98	34.90	15.29	8.04	3.73	100.00

Notes: This table shows the frequency distribution of pay adjustments per pay round (in percent) during the periods 2017-2019 (rows) and 2022-2024 (columns).

We further validated these results using data from the May 2025 HR survey, which repeated the questions on wage-setting patterns. The observed patterns in both wage duration and wage changes remain broadly consistent with earlier findings: the distribution continues to shift toward a shorter wage duration, and the share of firms maintaining annual adjustments remains largely stable (Figure B.6). The differences in realized values are notable: wage growth was .91 p.p. higher during the high-inflation period compared to the low-inflation period, a difference significant at the 1% level. Similarly, wage duration was 0.669 longer, a result significant at the 5% level. Realized inflation during the 2022–2024 period was lower than initially expected (5% compared to 6.5%), which may explain why the estimated effects are slightly attenuated. Nonetheless, the direction and structure of the changes remain robust.

We also ask HR managers directly about the role of inflation and other macroeconomic, firm-specific, and industry-specific factors in the survey. Table B.3 shows how inflation affects wage setting and pass-through for firms separating by the importance of: collective agreements, wage competition, labor supply, inflation, sales prices, and labor demand. Firms that attribute a greater role to inflation, on average, make higher adjustments to wage duration, wage growth, and annualized wage growth in response to inflation. Contrary to the literature on wage-price-spirals, firms attribute low importance to the dynamics of (own) sales prices, rather than limited pass-through to wage growth.[10]

[10] Blanchard (1986) documents that high demand puts pressure on wages and markups in flexible price environments. Recent policy papers, including Suthaharan and Bleakley (2022), Boissay et al. (2022) and

At the firm level, we find largely uniform wage dynamics – duration and wage growth – along the job ladder. Table B.6 shows that 65% and 56% of firms adjust wages with the same frequency and the same magnitude for unskilled, skilled, and workers in executive positions, respectively. Approximately 15% adjust wages more frequently and less frequently for executives, canceling out in the aggregate. Similarly, 20% adjust by more for executives, while 17% adjust less for executives compared to low-skilled workers. Again, similar dynamics in the aggregate. Thus, looking at the economy as a whole, one can conclude that wage dynamics are largely uniform along the job ladder.

Fact 3: Large firms change wages more frequently, but average wage adjustments are smaller. The duration of pay agreements tends to be shorter for large firms. Table 4 suggests that large firms (measured by the number of employees) adjust wages more frequently, controlling for industry-fixed effects, such as (labor) demand and supply factors.[11] A doubling of the workforce suggests a reduction in the duration of pay agreements by about 0.7 and 0.44 months in times of low and high inflation, respectively.[12] Heterogeneity along the firm size distribution could result from large firms assessing costs and wages more often and more systematically, having more resources and better technology available, or other strategic reasons (e.g., limiting uncertainty and forecast errors).

There are also large differences in wage adjustment per pay round along the firm size distribution. Large firms increase wages by less than small firms. While 40% of large firms plan to increase wages by 2-4%, only 25% of small firms plan to do so (Figure B.4 in Appendix B). Similarly, less than 2% of large firms plan to increase wages by more than 8%, while almost 20% of small firms plan to do so. Table 4 presents further evidence based on regressions for wage adjustment in percent on firm size, controlling for industry fixed effects. A doubling of the workforce implies a 0.1 percentage point lower wage growth in times of low inflation. This result points to a potential role of large firms' monopsony power in depressing wages and wage growth.

The heterogeneity of adjustment across the firm size distribution also has implications for the interpretation of our findings on duration and size of wage changes. Since large firms tend to adjust wages more frequently, the weighted average duration of wages is lower (12.9 months and 12.4 months, respectively) than the unweighted duration during both periods. Similarly, the average adjustment per pay round is slightly lower (namely

Koester et al. (2021), find that tight labor markets, the balance of bargaining power between workers and firms, wage stickiness, the prevalence and design of wage indexation schemes, the level of competition and pricing power among firms, as well as inflation expectations could influence the emergence of wage-price spirals.

[11] Figure B.2 presents similar evidence comparing the average duration and adjustment by firm size.

[12] Tables B.5 and B.4 provide robustness checks using different sets of controls.

Table 4: Extensive and intensive margin by firm size

	D_{low}	D_{high}	ΔD	$\%_{low}$	$\%_{high}$	$\Delta\%$
log(employees)	-0.70***	-0.44**	0.25	-0.10**	-0.050	0.056
	(0.24)	(0.21)	(0.21)	(0.044)	(0.051)	(0.053)
Constant	17.2***	14.8***	-2.17**	3.82***	4.14***	0.29
	(0.99)	(0.87)	(0.87)	(0.18)	(0.21)	(0.22)
Observations	405	386	386	408	390	390
R^2	0.109	0.143	0.072	0.124	0.129	0.063
Sector FE	✓	✓	✓	✓	✓	✓

Notes: This table shows the regression results for the duration of pay agreements, D, and the wage adjustment in percent, during the periods 2017-2019, *low*, and 2022-2024, *high*, as well as change between the two periods, Δ, on the log of employees controlling for sector fixed effects. Standard errors are in parentheses. * p<0.10, ** p<0.05, * * * p<0.01.

3.3% vs. 3.9%).

Overall, there remains substantial variation in the duration of pay agreements and the size of wage adjustments, both within as well as across industries.[13] Table 5 quantifies the within-industry and cross-industry standard deviation: during times of low and high inflation, the standard deviation within industries is about three times as large as across industries. Similarly, the (semi-)elasticity regressions of wage duration and wage growth on inflation show that firm-level fixed effects explain up to 80% and sector fixed effects 10% (Tables B.1 and B.2). This makes the point that industry-specific aspects such as whether workers in the industry are part of collective bargaining agreements only explain a very small proportion of differences. Instead, wage-setting patterns seem to be much more firm-specific, with firm size playing a major role.

Table 5: Variation within and across industries

	D_{low}	D_{high}	$\%_{low}$	$\%_{high}$
Within	5.91	5.09	0.99	1.08
Across	1.38	1.42	0.32	0.37

Notes: This table presents within-industry and cross-industry standard deviation of the duration of pay agreements, D, and the wage adjustment, %, during the periods 2017-2019, low, and 2022-2024, $high$.

[13] According to the Federal Statistical Office Germany, an industry at the WZ-2008 level consists of 88 divisions. Our dataset represents 62 out of the 88 divisions.

To what extent might our wage growth estimates for the aggregate economy be biased leaving out wage growth from job-to-job transitions? Pilossoph and Ryngaert (2024) find that job-to-job transitions are more frequent in periods of high inflation. Do job-to-job transitions pay off? We find some room for negotiation for new hires compared to existing hires. We directly elicited the salary range for new hires compared to existing employees in 2023Q4 and 2024Q4:

How much room is there for salary adjustments in the coming year for newly hired employees compared to the salary of existing employees (on average)?
☐ *no room* ☐ *room: ______%* ☐ *no new hires planned*

In 2024 and 2025, 28% and 25% of firms say they have room to negotiate, respectively. On average, the salary range was 8.3% and 7.8%. This indicates a slight decrease in the bargaining room along the intensive and extensive margins, possibly also influenced by the lower inflationary environment.

Table 6: Extensive and Intensive Margins of Bargaining Room by Sector and Importance of Collective Agreements

	Extensive Margin		*Intensive Margin*	
	2024	2025	2024	2025
Manufacturing	19.69	21.54	8.04	7.89
Retail	41.18	29.11	7.59	8.76
Services	29.63	25.00	8.83	7.08
Low Coll. Barg. Imp.	32.56	27.53	8.66	7.94
High Coll. Barg. Imp.	23.77	21.98	7.99	7.64
Total	27.59	24.39	8.29	7.77

Notes: This table shows the extensive and intensive margin of firms' bargaining room for 2024 and 2025 by sector and by the importance of collective bargaining agreements (low/high classified as importance $</\geq 5$), with the first two columns showing the share of firms that have room and the second two columns showing how much room in % they have.

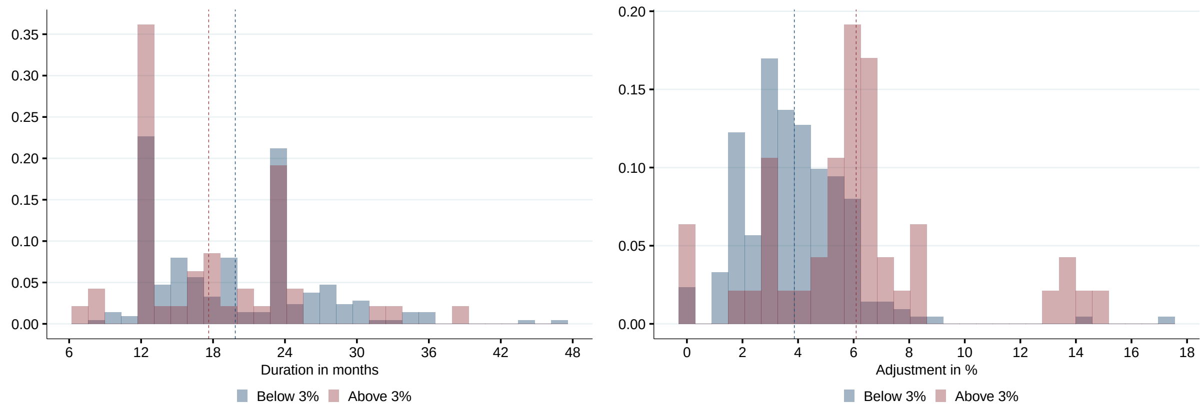
3.2 Evidence from union-level data

Are these survey results consistent with actual collective bargaining outcomes in Germany over the past decades? To answer this question we turn to our newly compiled union-level data set. The analysis confirms the firm-level survey results and demonstrates a clear pattern of larger wage hikes and shorter duration during periods of high inflation.

Figure 2: Wage-setting behavior of labor unions in times of low and high inflation

(a) Extensive margin

(b) Intensive margin



Notes: This figure shows the duration of pay agreements (extensive margin) and the wage adjustment in percent (intensive margin) for collective bargaining agreements during 1990 - 2024, split into low ($< 3\%$) and high ($> 3\%$) inflation periods. The dotted vertical lines show the mean for each inflation environment.

Figure 2 shows how the collective bargaining agreements change along the extensive and intensive margins in times of high and low inflation, similar to Figure 1 in the context of the ifo HR survey. As seen in Panel (a), the duration of pay agreements is generally shorter in high inflation periods. Specifically, the mean duration decreases from 20 months in times when inflation was below 3% to 18 months when inflation was above that threshold. The frequency distribution of the duration also shifts to the left when inflation is high: More contracts are 8 or 12 months long, while relatively fewer contracts are 24 months or longer.

As in the firm-level data, wage adjustments are higher in times of high inflation. The average size of wage adjustments increases from 3.9% to 6.1% per pay round between low and high inflation periods. Panel (b) reveals a clear rightward shift in the distribution: Most wage adjustments in high inflation periods are between 5 and 8%, while most wage adjustments in low inflation periods are between 2 and 5%.

Compared to the duration reported in the ifo HR survey, the duration of contracts in the union data is 6 months longer on average, but the difference in duration between low and high inflation periods is also larger by almost 50% (2 months compared to 1.3 months). While more than half of the firms in the ifo HR survey report a duration of 12 months, only 20% of the collective bargaining contracts are annual, implying that the distribution of the latter has longer and fatter tails. Yet, the 2.2 percentage points wage increase in the labor union data is in line with the 2 percentage points in the ifo HR survey.

Our results are robust to changes in the inflation threshold, the sample period, and alternative measures of wage adjustment. First, as Table C.2 demonstrates, choosing slightly lower or higher thresholds for times of "high inflation" does not affect the main findings on duration and size of wage adjustments. For instance, if we choose a threshold of 2.5%, duration drops from 20 to 17 months and the size of adjustments rises from 3.8% to 5.4%. Second, we find similar results when we restrict the sample to 2017–2019 and 2022–2024, exactly corresponding to the time periods referred to in the ifo HR survey. Contracts are almost 2 months shorter and have a 4.6 percentage points higher wage adjustment in times of high inflation (Table C.2 and Figure C.4).[14] Third, firm and industry collective agreements have a similar adjustment magnitude comparing high- and low inflation environments. At the same time, firm collective agreements are significantly shorter when inflation is high (17 vs. 21 months) than industry collective agreements (18 vs. 19.5 months) (see Table C.2). The difference could be due to an informational advantage in firm collective agreements since they only cover a single firm. To process this advantage, unions want to adjust contracts more quickly. Fourth, we also calculate annualized wage adjustments, include bonus payments, and provide a measure for the real wage Table C.3 and Figure C.3). Apart from the real wage, times of high inflation are always associated with higher wage adjustments.

Table 7: Inflation, duration, wage adjustments and annualized wage adjustment in labor union contracts

	Duration (in months)		Wage Increase (in Percent)		Annualized Wage (in Percent)	
	(1)	(2)	(3)	(4)	(5)	(6)
Inflation	−0.344	-0.927^{**}	0.816^{***}	0.627^{***}	0.591^{***}	0.638^{***}
	(0.327)	(0.425)	(0.103)	(0.138)	(0.062)	(0.082)
Union-region FE		✓		✓		✓
Other controls		✓		✓		✓
Observations	259	259	259	259	259	259
Adjusted R^2	0.0004	0.205	0.193	0.316	0.258	0.382

Notes: This table shows the regression results for the duration, wage increase and annualized wage of labor union contracts for data from 1990 to 2024. Panels 1, 3 and 5 give the pooled OLS results without any controls, the specifications in panels 2, 4 and 6 add union-region fixed effects and other controls such as GDP growth, unemployment rate, variance of the monthly inflation rate (all for Germany) and EPU index (for the EU) in each year. Standard errors are in parentheses. * p<0.10, ** p<0.05, *** p<0.01.

[14]The relatively high difference of 4.5 percentage points is due to contracts with simultaneously long duration and high wage adjustments in the high-inflation period. Annualizing the wage adjustment yields a difference of only 2.2 percentage points.

Table 8: Inflation, duration, wage adjustments and annualized wage adjustment in labor union contracts

	Duration (in months)		Wage Increase (in Percent)		Annualized Wage (in Percent)	
	(1)	(2)	(3)	(4)	(5)	(6)
Inflation	−0.344	−0.927**	0.816***	0.627***	0.591***	0.638***
	(0.327)	(0.425)	(0.103)	(0.138)	(0.062)	(0.082)
GDP Growth		−0.033		−0.058		−0.020
		(0.206)		(0.067)		(0.040)
Unemployment Rate		0.167		−0.348***		−0.368***
		(0.272)		(0.089)		(0.053)
Variance Inflation Yearly		0.375		0.039		−0.199*
		(0.598)		(0.195)		(0.116)
Policy Uncertainty (EU)		0.044***		0.002		−0.010***
		(0.010)		(0.003)		(0.002)
Union-region FE		✓		✓		✓
Observations	259	259	259	259	259	259
Adjusted R^2	0.0004	0.205	0.276	0.337	0.204	0.411

Notes: This table shows the regression results for the duration, wage increase and annualized wage of labor union contracts for data from 1990 to 2024. Panels 1, 3 and 5 give the pooled OLS results without any controls, the specifications in panels 2, 4 and 6 add union-region fixed effects and other controls such as GDP growth, unemployment rate, variance of the monthly inflation rate (all for Germany) and EPU index (for the EU) in each year. Standard errors are in parentheses. * $p<0.10$, ** $p<0.05$, *** $p<0.01$.

Table 9: W/ productivity growth, we loose the years 1990 and 1991

	Duration (in months)		Wage Increase (in Percent)		Annualized Wage (in Percent)	
	(1)	(2)	(3)	(4)	(5)	(6)
Inflation	−0.022	−0.327	0.782***	0.808***	0.477***	0.632***
	(0.337)	(0.484)	(0.109)	(0.155)	(0.056)	(0.087)
GDP Growth		0.641**		0.141		−0.025
		(0.318)		(0.102)		(0.057)
Unemployment Rate		−0.094		−0.177*		−0.205***
		(0.330)		(0.106)		(0.059)
Variance Inflation Yearly		−0.211		−0.235		−0.266**
		(0.661)		(0.212)		(0.119)
Policy Uncertainty (EU)		0.035***		0.008**		−0.005**
		(0.011)		(0.004)		(0.002)
Productivity		−0.938**		−0.432***		−0.090
		(0.439)		(0.141)		(0.079)
Union-region FE		✓		✓		✓
Observations	241	241	241	241	241	241
Adjusted R^2	−0.004	0.181	0.174	0.336	0.230	0.263

Notes: This table shows the regression results for the duration, wage increase and annualized wage of labor union contracts for data from 1990 to 2024. Panels 1, 3 and 5 give the pooled OLS results without any controls, the specifications in panels 2, 4 and 6 add union-region fixed effects and other controls such as GDP growth, unemployment rate, variance of the monthly inflation rate (all for Germany) and EPU index (for the EU) in each year. Standard errors are in parentheses. * p<0.10, ** p<0.05, *** p<0.01.

Table 10: Last adjustment

	Duration (in months)		Wage Increase (in Percent)		Annualized Wage (in Percent)	
	(1)	(2)	(3)	(4)	(5)	(6)
Inflation	0.543***	0.209	0.600***	0.525***	0.267***	0.306***
	(0.157)	(0.178)	(0.042)	(0.049)	(0.031)	(0.032)
Union-region FE		✓		✓		✓
Other controls		✓		✓		✓
Observations	254	254	254	254	254	254
Adjusted R^2	0.041	0.191	0.443	0.507	0.228	0.443

Notes: This table shows the regression results for the duration, wage increase and annualized wage of labor union contracts for data from 1990 to 2024. Panels 1, 3 and 5 give the pooled OLS results without any controls, the specifications in panels 2, 4 and 6 add union-region fixed effects and other controls such as GDP growth, unemployment rate, variance of the monthly inflation rate (all for Germany) and EPU index (for the EU) in each year. Standard errors are in parentheses. * $p<0.10$, ** $p<0.05$, *** $p<0.01$.

The union-level data allow us to directly quantify the relationship between inflation, duration, and wage adjustments by exploiting the panel dimension. Our interest lies in the (semi-)elasticities of contract duration, wage increases, and annualized wage increases to the underlying inflation rate. Moreover, we can include a rich set of controls such as GDP growth, unemployment, the variance of the inflation rate, as well as an economic policy uncertainty index. Table 10 shows the results. A 5 percentage point increase in the inflation rate is associated with a 1.7 to 4.6 months shorter duration, a 2.9 to 3.6 percentage points higher nominal wage adjustment, and 2.7 to 3.1 percentage points higher nominal annualized wage adjustment.[15] This is broadly in line with the firm-level evidence.

Again, we check whether these results are robust to alternative specifications and sample splits. Higher inflation also increases annualized wage adjustments and wage adjustments including bonus payments but decreases the real wage (Table C.4). Lastly, inflation in the preceding and coming years individually show qualitatively similar results for the duration and wage increase (Table C.5). One explanation for the negative relation between future inflation and wage adjustments could be due to the assumption that the inflation rate in period $t + 1$ is perfectly known in period t, which is not necessarily true. Joint estimation of inflation in years t, $t - 1$, and $t + 1$ shows that inflation in the past year is the strongest predictor for the duration and wage increase.

[15] The pass-through of less than one does not imply real wages are shrinking. Contrarily, Figure C.2 shows that workers are more than fully compensated for inflation, but wages do not respond one-to-one to changes in inflation.

4 Models of State-Dependent Wage Setting

We now ask how the empirical evidence about wage setting in times of high and low inflation can be rationalized and examine the implications for macroeconomic dynamics and the transmission of monetary shocks.

In the spirit of Nakamura and Steinsson (2008), we begin with a partial equilibrium model of the wage-setting decision faced by an individual firm to demonstrate the intuition of the relationship between wage setting and inflation. We then show that this basic intuition carries over to a menu cost model in which firms face both idiosyncratic and aggregate uncertainty. This model is analogous to the price-setting models developed by Danziger (1999), Golosov and Lucas (2007), and Gagnon (2009). We show that it can match the facts about wage setting found in our firm-level and union data at both the extensive and intensive margins. We then argue that a computationally simpler Calvo model with a state-dependent probability of wage adjustment performs as well as the menu cost model. Finally, we incorporate state-dependent wage setting into an otherwise standard New Keynesian model to study the implications for monetary policy and the slope of the Phillips curve.

4.1 Basic intuition: wage setting and inflation

Consider an individual firm that operates under perfect competition in the product market but has monopsony power in the labor market. It runs a linear production technology using labor as the only input factor:

$$y_t = al_t, \tag{1}$$

where y_t is output, a is idiosyncratic productivity and l_t is labor input at time t. The labor supply curve facing the firm is upward sloping and takes the iso-elastic form:

$$l_t = \left(\frac{W_t}{P_t}\right)^{\epsilon}, \tag{2}$$

where W_t is the individual firm's nominal wage and P_t is the price level. ϵ denotes the elasticity of the labor supply and reflects the degree of the firm's monopsony power in the labor market. The firm's real profit in period t can then be written as:

$$div(a, W_t/P_t) = \left(a - \frac{W_t}{P_t}\right)\left(\frac{W_t}{P_t}\right)^{\epsilon}. \tag{3}$$

In the absence of any adjustment costs, the firm would set the real wage to:

$$\frac{W_t^*}{P_t} = \frac{\epsilon}{1+\epsilon}a, \tag{4}$$

implying a mark-down, $\frac{\epsilon}{1+\epsilon} < 1$, on the marginal product of labor, a. Note that the optimal nominal wage W_t^* increases proportionally with the price level.

Now suppose that changing the wage is subject to a fixed cost γ. This creates a basic trade-off for the firm between the cost of resetting the wage and allowing the wage to deviate from the optimal level W_t^* over time. Intuitively, the higher the rate of inflation, the faster the actual wage drifts away from the optimum, which causes the firm to reset wages more frequently and by larger increments.

To see this analytically, assume that the price level P_t increases at the trend inflation rate μ. Then the real wage paid in period t by a firm that last changed its wage at time 0 is given by:

$$\ln(W_t/P_t) = \ln(W_0/P_0) - \mu t. \tag{5}$$

Hence, the deviation of the actual real wage from the optimal wage at time t is:

$$\ln(W_t/P_t) - \ln(W_t^*/P_t) = \ln(W_0) - \ln(W_0^*) - \mu t, \tag{6}$$

where $\ln(W_0^*) = \ln(P_0) + \ln(a\epsilon/(1+\epsilon))$ is the optimal nominal wage at time 0. Following Auclert et al. (2024), we take a second-order approximation of the firm's profit function around the optimal real wage (in logs):

$$div_t - div^* \approx -\alpha(\ln(W_t/P_t) - \ln(W_t^*/P_t))^2, \tag{7}$$

with $\alpha = \frac{1}{2}(a\epsilon)(W_0^*/P_0)^{\epsilon}$ and is, therefore, a decreasing function of the squared log deviation of the actual real wage from the optimum. Note that the constant α is increasing in the firm's productivity level a. Let the duration of wage changes be d such that the firm adjusts wages in period 0, d, $2d$, $3d$, etc. Since each of these intervals is identical, we can restrict attention to $0 \leq t \leq d$. At time $t = 0$, the firm sets the wage W_0 and chooses the duration d such as to minimize its average loss per period during which the wage is fixed:

$$L(W_0, d) = \frac{1}{d}\left[\gamma + \int_0^d \alpha(\ln(W_0) - \ln(W_0^*) - \mu t)^2 \mathrm{d}t\right]. \tag{8}$$

Thus, the firm is trading off the per-period cost of adjusting the wage $\frac{\gamma}{d}$ against the per-period loss of not adjusting the wage between 0 and d — the second term in (8). This optimization problem is a version of the optimal contracting problem studied by Gray (1978) and Dye (1985). The optimal reset wage, given duration d, is midway between the optimal wage at the beginning ($\ln(W_0^*)$) and at the end of the interval ($\ln(W_0^*) + \mu d$):

$$\ln(W_0) = \ln(W_0^*) + \frac{\mu}{2}d. \tag{9}$$

Intuitively, $\ln(W_0)$ is increasing in μ for a given duration d.[16] Thus, in times of high inflation, the optimal reset wage is correspondingly higher.

Plugging the optimal reset wage into (8) yields the firm's loss as a function of duration only:

$$\begin{aligned} L(W_0(d), d) &= \frac{\gamma}{d} + \frac{\alpha\mu^2}{d}\int_0^d \left(\frac{d}{2} - t\right)^2 \mathrm{d}t \\ &= \frac{\gamma}{d} + \frac{\alpha\mu^2}{12}d^2 \end{aligned} \tag{10a}$$

The first-order condition for a minimum of $L(w_0(d), d)$ is:

$$\frac{\gamma}{d^2} = \frac{\alpha\mu^2}{6}d, \tag{11}$$

which can be readily interpreted as equating the marginal benefit (left-hand side) to the marginal cost (right-hand side) of changing duration by a small amount. The solution is illustrated graphically in (3). The optimal choice of the reset wage and duration is given by:

$$\ln(W_0) = \ln(W_0^*) + \sqrt[3]{\frac{3\gamma\mu}{4\alpha}}, \tag{12a}$$

$$d = \sqrt[3]{\frac{6\gamma}{\alpha\mu^2}}. \tag{12b}$$

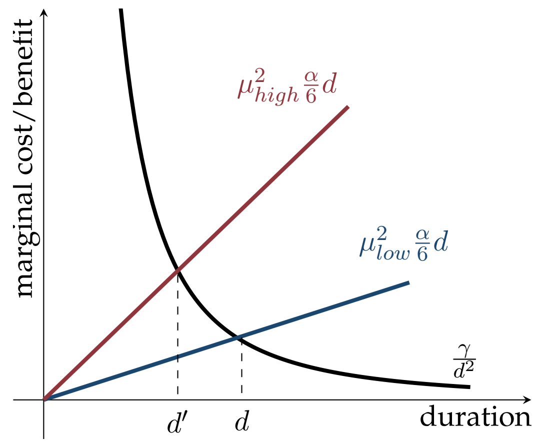
Two properties of this solution should be noted. First, duration is lower if trend inflation μ is higher. This effect is shown in Figure 3, where a higher trend inflation rate increases the loss to the firm from keeping the wage fixed for a little longer. Note, however, that the elasticity of wage adjustments with respect to inflation is less than one (here the elasticity of wages is 1/3 and the elasticity of duration is 2/3). This is due to the fact that

[16] The formal derivation is as follows: Solve the integral inside the loss function and ignore irrelevant constants:

$$\frac{1}{3}\mu^2 d^3 - \mu d^2(\ln(W_0) - \ln(W_0^*)) + d(\ln(W_0) - \ln(W_0^*))^2.$$

Now minimize this expression with respect to $\ln(W_0) - \ln(W_0^*)$ and rearrange.

Figure 3: Optimal duration in times of high and low inflation



Notes: This figure shows the marginal benefit (black curve) as well as the marginal cost (blue and red curves) of the duration of wage adjustments in a partial-equilibrium menu cost model under low (μ_{low}) and high (μ_{high}) trend inflation rates.

the firm responds to higher inflation on both the intensive margin by increasing the size of wage adjustments and the extensive margin by shortening the duration. Second, as one would expect, higher menu costs γ lead to a higher size and duration of wage adjustments. Furthermore, both the size and duration of wage adjustments decrease with α, which in turn positively depends on the firm's productivity level. Higher productivity also implies a larger firm size in terms of employment and output. Therefore, the menu cost model is consistent with our finding that larger firms tend to reset wages more frequently and by smaller amounts.

4.2 Menu cost vs. Calvo models

Now assume that there is a continuum of firms of the type just analyzed. Each firm in each period is given productivity a_t, which evolves according to an auto-regressive process:[17]

$$\ln(a_t) = \rho_a \ln(a_{t-1}) + \epsilon_t^a, \quad \epsilon_t^a \sim \mathcal{N}(0, \sigma_a^2), \tag{13}$$

where ρ_a measures the persistence and σ_a the standard deviation of idiosyncratic productivity shocks. Further, assume that the (log) aggregate price level follows a random walk with drift:

$$\ln(P_t) = \mu + \ln(P_{t-1}) + \epsilon_t^{\mu}, \quad \epsilon_t^{\mu} \sim \mathcal{N}(0, \sigma_{\mu}^2), \tag{14}$$

[17] We suppress the firm-specific index to simplify the notation. We also switch to discrete time for computational reasons.

where μ denotes the trend inflation rate and ϵ_t^μ is a shock to inflation.

Within this framework, we compare two approaches to modeling the wage-setting process: (1) a menu cost model in which firms can decide to change the wage each period subject to a fixed cost; (2) a Calvo model in which, at each point in time, a randomly chosen fraction of firms is allowed to reset its wage.

The menu cost model. In the menu cost model, the firm enters period t with its pre-existing nominal wage W_{t-1}, draws a new productivity level ϵ_t^a and learns about the price level in the goods market P_t. It then decides whether to keep the existing wage or reset it. Resetting the wage is subject to a fixed cost of γ units of labor such that the total cost of changing the wage is $\gamma \frac{W_{t-1}}{P_t}$. The firm then hires the amount of labor the market supplies at the chosen wage.

In order to state the firm's problem recursively, we define two value functions: the value of *changing* the wage V_c and the value of *not changing* V_{nc}. Both are functions in two state variables a_t and W_{t-1}/P_t. Let V be the value of the firm, which is the maximum of the value of changing and not changing the wage:

$$V\left(a_t, \frac{W_{t-1}}{P_t}\right) = \max\left[V_c\left(a_t, \frac{W_{t-1}}{P_t}\right), V_{nc}\left(a_t, \frac{W_{t-1}}{P_t}\right)\right]. \tag{15}$$

The values of changing and not changing the wage show the following Bellman equations:

$$V_{nc}\left(a_t, \frac{W_{t-1}}{P_t}\right) = \left(a_t - \frac{W_{t-1}}{P_t}\right)\left(\frac{W_{t-1}}{P_t}\right)^{\epsilon} + \beta \mathbb{E}_t\left[V\left(a_{t+1}, \frac{W_t}{P_{t+1}}\right)\right] \tag{16a}$$

$$V_c\left(a_t, \frac{W_{t-1}}{P_t}\right) = \max_{W_t^*}\left[V_{nc}\left(a_t, \frac{W_{t-1}}{P_t}\right) - \gamma \frac{W_{t-1}}{P_t}\right]. \tag{16b}$$

Clearly, the firm resets its wage whenever the difference between the net value of changing the wage exceeds the menu cost:

$$V_c\left(a_t, \frac{W_{t-1}}{P_t}\right) - V_{nc}\left(a_t, \frac{W_{t-1}}{P_t}\right) \geq \gamma \frac{W_{t-1}}{P_t}. \tag{17}$$

Note that the right-hand side of this inequality is an increasing function of the current wage. Thus, firms currently paying a high real wage face higher costs of resetting the wage.

We solve the model by value function iteration on a grid of real wage and productivity values.[18] We start with initial guesses for the value functions V_{nc} and V_c, solve the firm's problem by iterating on the value functions (16a) and (16b) until convergence.

We calibrate the model to match the average frequency, duration, and size of wage changes found in our firm-level survey data. We set the discount factor β to $0.9943^{1/3}$ and the labor supply elasticity ϵ to 5, implying that the frictionless optimal wage is a 20% markdown on the marginal productivity of labor. The parameters of the money growth process are chosen to match the periods of low and high inflation in Germany during the time of our survey. We set σ_μ to 0.015 for the standard deviation of the price level disturbance. For the idiosyncratic productivity shock, we set $\rho_a = 0.8$ and $\sigma_a = 0.053$. Setting the menu cost parameter to $\gamma = 0.056$ yields the closest match between the model and the data. Table D.1 summarizes the calibrated parameters. We simulate data for 500 firms for 500 periods and compute summary statistics to compare them to the empirical results.

The Calvo model. While the menu model delivers a microfounded model of state-dependent wage setting, it is hard to integrate into a larger macro model. Therefore, we ask whether the computationally simpler Calvo model of wage setting can also replicate our empirical findings. In this model, a randomly chosen fraction of firms is allowed to reset wages in each period. In addition to receiving its productivity shock and observing the aggregate price level P_t, the firm also learns whether it is allowed to change its wage or not. The probability of changing the wage is equal to $1 - \theta^w$ and constant across time and firms. The expected duration of a wage change is then $1/(1 - \theta^w)$.

As before, we need to keep track of the two value functions (16a) and (16b). In contrast to the menu cost model, the value function in the Calvo model is a weighted average of the value of no change and the value of change:

$$V\left(a_t, \frac{W_{t-1}}{P_t}\right) = \theta^w V_{nc}\left(a_t, \frac{W_{t-1}}{P_t}\right) + (1 - \theta^w) V_c\left(a_t, \frac{W_{t-1}}{P_t}\right). \tag{18}$$

To solve the Calvo model, we use the same approach as before.

The setup of the Calvo model allows us to calibrate the probability of wage changes directly to the average duration of wage changes observed in the data. Since the probability of wage changes is exogenous in this model, the only way to match the facts about wage setting in times of low and high inflation is to choose different values for θ^w in the two regimes. We thus set θ^w to $(1 - {}^1\!/_{14.2}) = 0.93$ and $(1 - {}^1\!/_{12.9}) = 0.92$ in the low and high

[18] We use 150 grid points for the real wage and 30 nodes for productivity. We approximate the AR(1) process for productivity using the method of Farmer and Toda (2017).

regimes, respectively.

Targeted and untargeted moments. Table 11 presents the summary statistics for the model simulations of the menu cost model and Calvo models along with the empirical analogs in the firm-level data from the ifo HR survey. In the low inflation regime, the duration of wage agreements is 14.3 in the menu cost model and 14.2 in the Calvo model, closely matching the data. The average size of wage changes is 1.9% per pay round, slightly lower than the modal answer (2-4%) in the survey data. In the high inflation regime, the duration of wage agreements drops to 12.5 months in the menu cost model and to 12.9 months in the Calvo model. While in the Calvo model, we directly target the frequency of wage setting in periods of high and low inflation, these moments are untargeted in the menu cost model, where we only target the average duration across all times. Both models predict the size of wage changes per pay round to increase - to 6.5% and 6.8%, respectively.

Table 11: Summary statistics of simulated wage changes

	Menu cost model	Calvo model	Data
Low inflation regime:			
Inflation rate (percent annualized)	1.6	1.6	1.6
Duration of wage changes (in months)	14.3	14.2	14.2
Size of wage changes (percent)	1.9	1.9	2-4
High inflation regime:			
Inflation rate (percent annualized)	6.5	6.5	6.5
Duration of wage changes (in months)	12.5	12.9	12.9
Size of wage change (percent)	6.5	6.8	4-6

Notes: Summary statistics based on model simulations (500 firms for 500 periods) and survey data from the ifo HR survey November 2022 with roughly 600 participating firms.

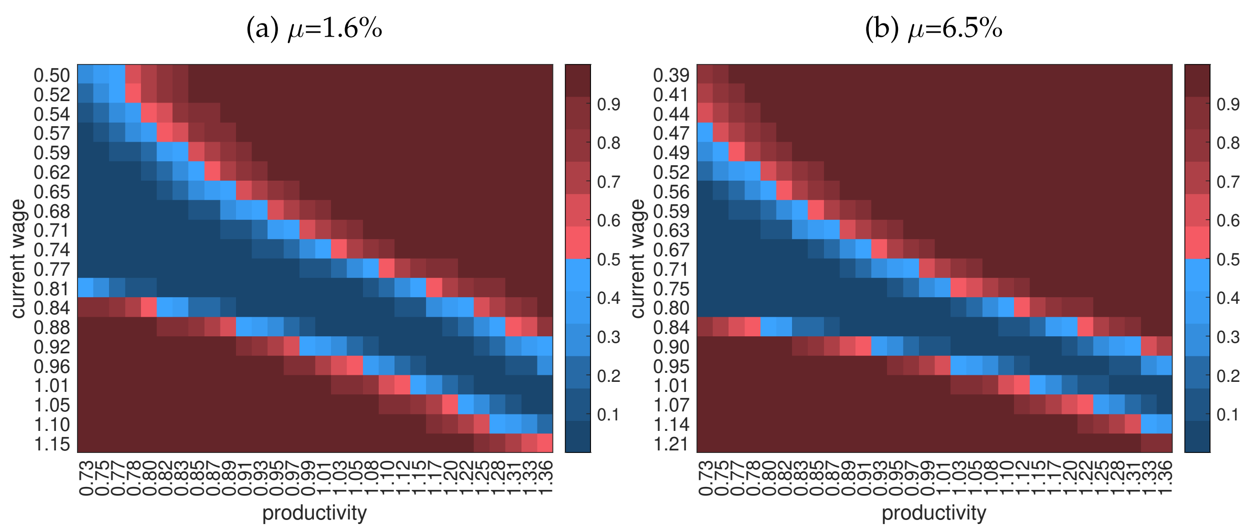
We next shed light on the mechanisms of the two models and assess their success in matching the empirical facts about wage setting in our data.

The probability of wage adjustment increases in times of high inflation. In the Calvo model, the probability of a wage adjustment is constant across firms and therefore independent of the a firm's current real wage and productivity level. By contrast, in the menu cost model, the likelihood of a wage change varies across the state space. Panels (a) and (b) of Figure 4 present the probability of wage adjustments as a function of the firm's productivity level and current real wage for the low and high inflation regimes.

The probability of adjustment is high whenever the firm finds itself far off the diagonal in the wage-productivity space, i.e. whenever there is a significant mismatch between the firm's productivity draw and the current real wage. In contrast, for any points close to the diagonal, i.e. whenever the productivity draw and current real wage are close to each other, the probability of adjusting the wage is small. The dark blue area around the diagonal represents the region where the probability of a wage change is zero, which we call the inaction area.

Comparing Panels (a) and (b) shows that the probability of wage change is higher in the high inflation regime or, put differently, the inaction area is smaller in the high inflation regime. In times of slightly higher and lower productivity draws a larger fraction of firms decides to adjust wages. Hence, introducing menu costs on wage setting leads to an *endogenous* wage-setting probability that depends not only on firm-specific productivity draws and initial positions but also on the aggregate inflation rate.[19]

Figure 4: Probability of wage change



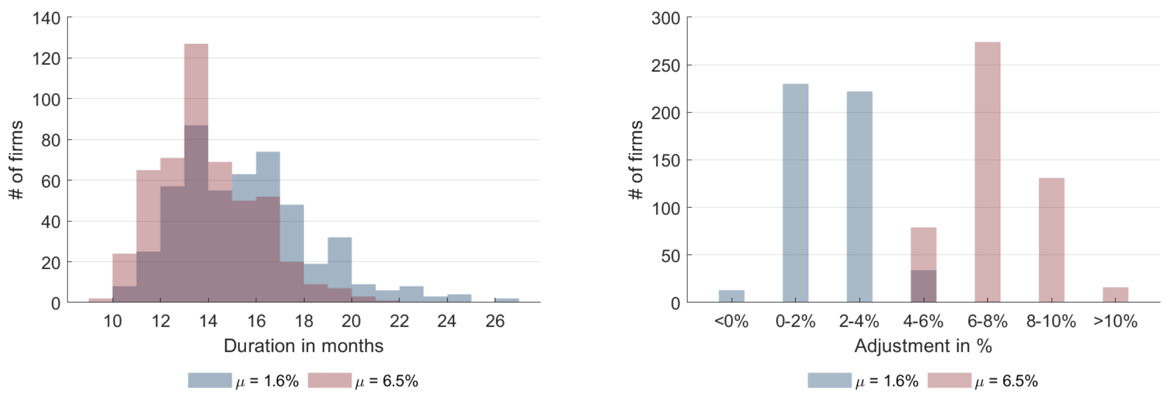
Notes: Conditional probability to change future wage depending on the current wage (x-axis) and productivity draw (y-axis).

The duration of pay agreements shortens during times of high inflation. Given the firm's policy function, we simulate long time series for inflation, productivity, and nominal wages and calculate the average duration of a wage adjustment as well as the size of adjustments. Panel (a) of Figure 5 resembles the model analog for the extensive margin result in Figure 1. The duration of pay agreements shortens during periods of high inflation.

[19]The span of the current real wage in Panels (a) and (b) of Figure 4 is different across both regimes as the higher dispersion widens the range of real wages.

Figure 5: Wage-setting behavior in times of low and high inflation (menu cost model)

(a) Extensive margin (b) Intensive margin



Notes: This figure shows the duration of pay agreements (extensive margin) and the wage adjustment in % (intensive margin) for the simulated data (500 firms for 500 periods) varying the mean inflation rate, μ. The blue shaded bars reflect the low inflation period, with μ set to 1.6%, and the red shaded bars reflect the high inflation period, with μ set to 6.5%. Values are grouped into seven categories in the right panel.

On average, the duration decreases from close to 14.3 to 12.5 months. Again, we see that the duration is *endogenous* and varies with the level of the inflation rate.

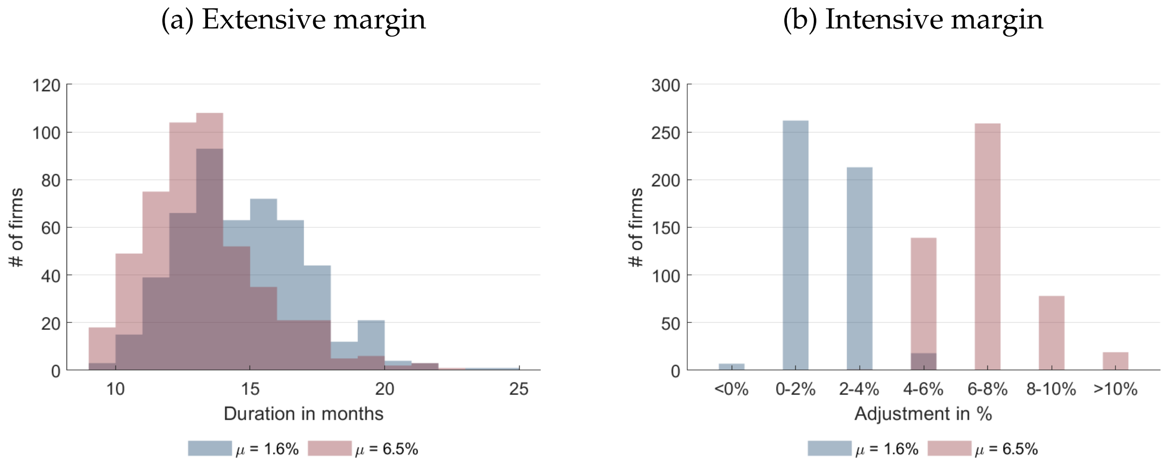
Similar to the menu cost model, the Calvo model also shows a reduction in the duration of pay agreements during high inflation periods, as reflected by the leftward shift in the distribution (Figure 6). Of course, unlike in the menu cost model, this shift is mechanical since we can directly control the duration through θ^w.

The implied semi-elasticity of duration to inflation is 0.36 months in the menu cost model, closely matching the estimates from our survey data. Of course, in the Calvo model, the elasticity of duration perfectly matches the data by design.

The size of wage adjustments increases during times of high inflation. As in the simple deterministic model, the firms in the menu cost model respond to a higher inflation environment on both extensive and intensive margins. Panel (b) of Figure 5 is the model analog for the firm-level results shown in Figure 1 and shows the distribution of the size of wage adjustment in the simulated times series. On average, the size of wage adjustments per pay round increases from close to 1.9 to 6.5% in the menu cost model.

Similarly, the Calvo model also yields a larger size of wage adjustment in times of high inflation (Figure 6). The intuition behind this is the similar to the menu cost model: If given the chance, the firm wants to adjust wages by larger increments so as to protect its real wage from being eroded by future inflation. Thus, we can conclude that the Calvo

Figure 6: Wage-setting behavior in times of low and high inflation (Calvo model)



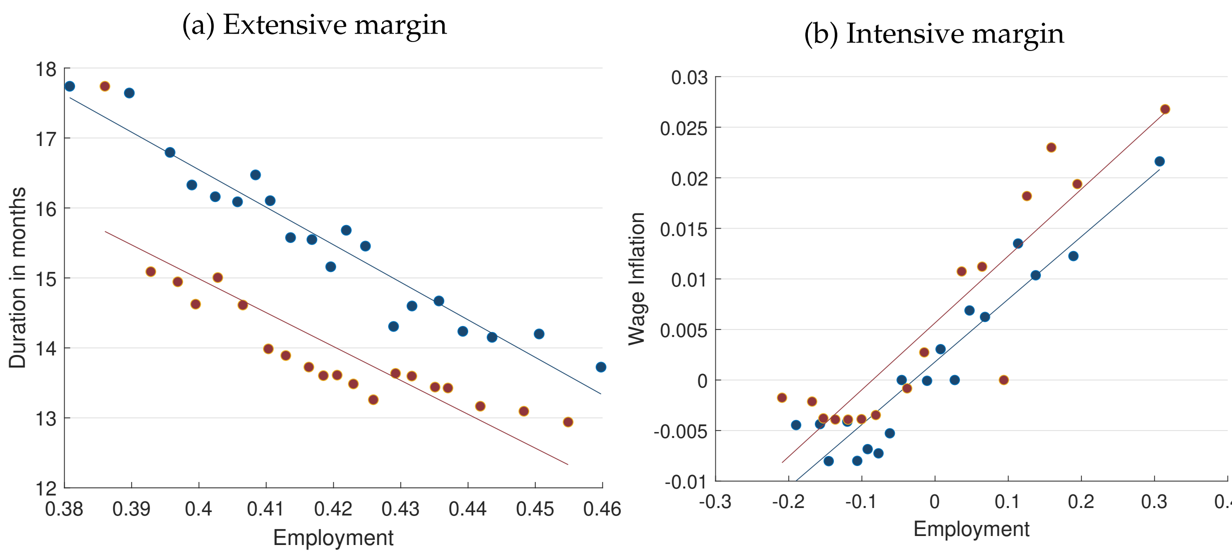
Notes: This figure shows the duration of pay agreements (extensive margin) and the wage adjustment in % (intensive margin) for the simulated data (500 firms for 500 periods) varying the mean inflation rate, μ. The blue shaded bars reflect the low inflation period, with μ set to 1.6%, and the red shaded bars reflect the high inflation period, with μ set to 6.5%. Values are grouped into seven categories in the right panel.

model with a state-dependent reset probability is successful in replicating the empirical facts about wage setting both on the extensive and intensive margins. This result echoes Auclert et al. (2024)'s work on price setting.

In both models, the increase in the intensive margin of wage adjustment is larger than in the data, with the implied inflation elasticity of nominal wages being 0.94 and 1, respectively. This is likely due to the fact that the firms in the model "know" that trend inflation permanently moves from 1.6% to 6.5%, whereas the firms in our survey could not be sure how long the inflation spell would last. Indeed, how permanent the post-pandemic surge in inflation would be was subject to lively debate at the time the survey was conducted.

Duration is shorter for larger firms. So far, we have examined wage-setting behavior in high and low inflation environments by averaging across firms. In addition, we can also examine the cross-section of firms within each inflation environment in our simulated data. Firms that receive a favorable productivity draw are larger both in terms of employment and output. In the Calvo model, this makes no difference to the frequency of wage changes. On the other hand, in the menu cost model, we find a negative relationship between the number of employees and duration, consistent with the firm-level survey data (see Figure 7(a)). Firms with a large number of employees (and high output) have a lower average duration, i.e. they reset their wages more often compared to small firms. The reason is that large firms have more to lose by allowing their real wages to deviate from the optimal level, while the fixed reset costs are lower relative to their total costs. Note that in our model it is not differences in monopsony power but differences in idiosyncratic productivity that drive differences in employment and ultimately differences in wage setting.

Figure 7: Wage-setting behavior across firm size

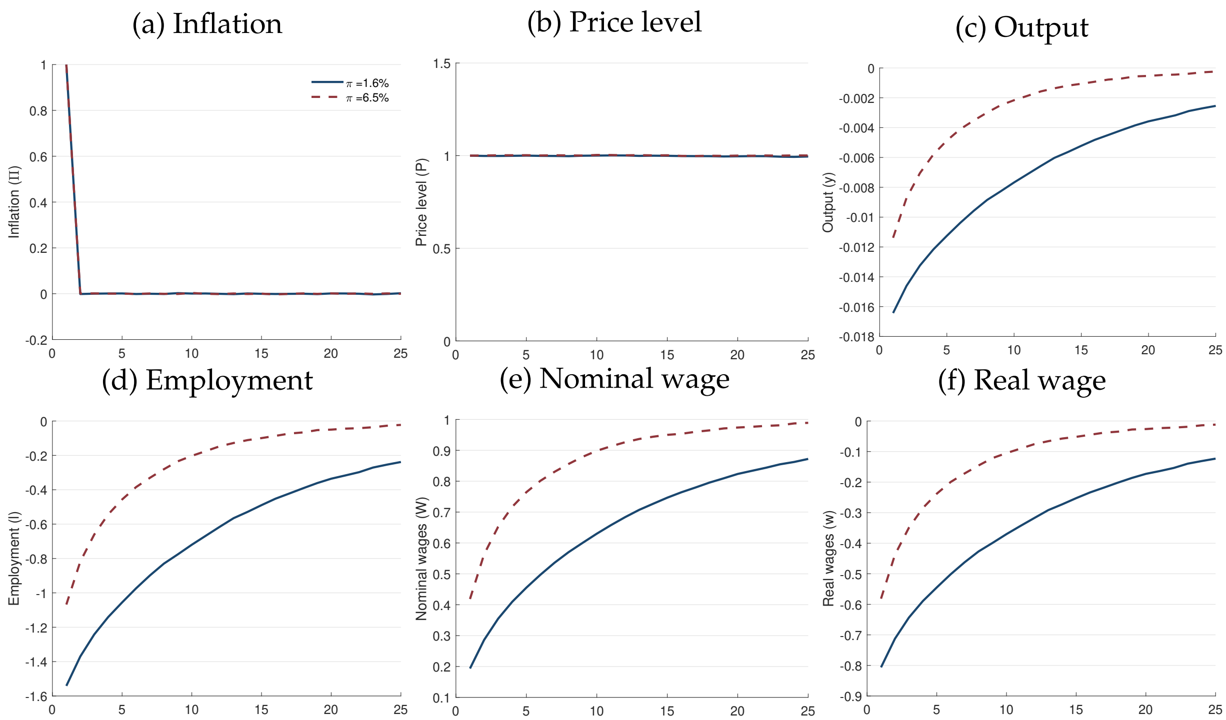


Notes: The left and right panels show binned scatter plots contrasting the duration of wage agreement and size of employment, and wage inflation and size of employment for the simulated data varying the mean inflation rate, μ, (20 bins). The blue, dotted markers reflect the low inflation period, with μ set to 1.6%, and the red, dotted markers reflect the high inflation period, with μ set to 6.5%. The level of employment is demeaned.

An alternative way to characterize the wage-setting behavior of firms is to consider the implied wage Phillips curves motivated by the original work of Phillips (1958). In the menu cost model, wage inflation is high when employment or employment growth is high, as shown in Figure 7(b). The wage Phillips curve shifts outwards in times of high inflation; that is, in times of high inflation, wage inflation is higher for any given level of employment.

Transmission of an inflationary shock. The state-dependent wage-setting behavior also has implications for the transmission of shocks to the macroeconomy. As suggested by the wage Phillips curve in Figure 7(b), wage inflation is more responsive in an environment with high trend inflation. To further explore the implications of this, we examine the transmission of a shock to the inflation rate under high and low inflation regimes. We run local projections on the simulated data from the high and low inflation regimes and trace out the impulse responses to a one percent increase in inflation shown in Figure 8. Note

Figure 8: Transmission of an inflationary shock given high and low inflation



Notes: This figure shows the impulse response function to a permanent price level shock under the two inflation regimes. We apply local projection methods for the simulated data varying the trend inflation rate, μ. The blue solid lines reflect the low inflation period, with μ set to 1.6%, and the red dashed lines reflect the high inflation period, with μ set to 6.5%.

that a shock in (14) has a permanent effect on *price level* but a purely temporary effect on *inflation*.

Firms respond to an inflationary shock by raising the nominal wage, but the adjustment is less than one-for-one and takes time due to the presence of menu costs. As a result, the real wage falls on impact which causes a contraction in the supply of labor and a decline in output. The level of trend inflation changes the transmission of the inflation shock. As firms change their wage setting at both the extensive and intensive margins, the nominal wage rises faster. Therefore, the real wage declines less and recovers more quickly, leading to a smaller decline in output and employment than in the low-inflation environment. Thus, the menu cost model predicts that high levels of trend inflation alter the transmission of shocks to the inflation rate. In particular, during periods of high inflation, the nominal wage is more responsive to an inflationary shock, while the response of real variables is muted.

As a robustness check, we repeat the same exercise as above, but instead of changing the trend inflation rate μ, we change the volatility of inflation shocks σ_μ in Figure D.1. An increase in inflation volatility has a similar effect on the extensive margin of wage change.

As inflation becomes harder to predict, firms reset wages more often. However, as might be expected, a higher σ_μ without changing the trend level of inflation does not affect the size of wage changes.

We end this comparison by pointing out some limitations of our exercise. First, both the menu cost model and the Calvo model cannot replicate every feature of the micro data. Importantly, the clustering of the duration distribution around 12 and 24 months visible in both the firm-level and union-level data is hard to reproduce with these models. One possible solution would be to make the menu cost parameter γ (or the Calvo parameter θ) time-dependent to force a peak in the hazard function of wage changes at 12 and 24 months. However, such a change would be too ad-hoc to shed more light on the timing of wage changes. We thus prefer to leave this problem to future work. Second, in this section, we have modeled the two inflation regimes as a shift in the trend level of inflation. Given that the recent surge in inflation seems to have been more temporary (ex-post), one may question the applicability of this exercise to recent events. However, as shown in the Figure D.1(a), the basic results still hold when we allow inflation volatility to increase instead.

4.3 New Keynesian model with state-dependent wage setting

The models in the previous section abstract from the rest of the economy to focus squarely on the firms' wage-setting behavior. We now turn to a general equilibrium model, which features both price and wage stickiness and a fully specified demand side. This model is an adapted version of the New Keynesian model of Erceg et al. (2000), where we introduce state-dependent wage setting. In contrast to the models discussed in the preceding section, in this model wages are not set by firms but by unions who provide differentiated labor services to producers.[20] We use this model to discuss the effects of state-dependent wage setting on the steady state as well as the transmission of monetary policy shocks. Since the basic model is well-known, we defer to Appendix E for the full derivation of the model equations and focus on the dynamics of wage setting.

4.3.1 Wage-setting dynamics

At any point t, nominal wages remain unchanged with probability θ_t^w and are reset with probability $1 - \theta_t^w$. The key innovation is that the wage-setting probability is time-varying

[20]There are two reasons for this modeling choice. First, splitting the wage-setting and price-setting decisions makes the model more tractable. Second, we want to stay as close as possible to Erceg et al. (2000) and the literature building on them.

and a function of the inflation rate, π_t, and thus an endogenous object.[21]

Specifically, we assume that the wage reset probability follows a sigmoid function of the form:

$$(1-\theta_t^w) = \frac{\gamma e^{\eta \pi_t^2}}{1+\gamma e^{\eta \pi_t^2}}, \tag{19}$$

where η is the parameter that governs the degree of state dependence and γ controls the steady-state reset probability. This functional choice assumes that the reset probability rises with the square of the inflation rate, implying that wage setting accelerates both at high rates of inflation and deflation. Setting $\eta = 0$ yields the baseline case with a constant wage resetting probability of $\gamma/(1+\gamma)$. We will calibrate γ and η to match the empirical duration of wage changes during high and low inflation found in our data.

Since the wage-resetting probability is now endogenous, so is the expected duration of wage changes d_t, which is defined as:

$$d_t = \mathbb{E}_t \left[(1-\theta_t^w) + \theta_t^w (1-\theta_{t+1}^w) 2 + \theta_t^w \theta_{t+1}^w (1-\theta_{t+2}^w) 3 + ... \right]. \tag{20}$$

As we show in Appendix E, expected duration can be expressed recursively as follows:

$$d_t = (1-\theta_t^w) + 2\theta_t^w \mathbb{E}_t d_{t+1} - \theta_t^w \mathbb{E}_t \theta_{t+1}^w d_{t+2} \tag{21}$$

In the steady state, this simplifies to the familiar formula, where variables without subscript t denote steady-state values:

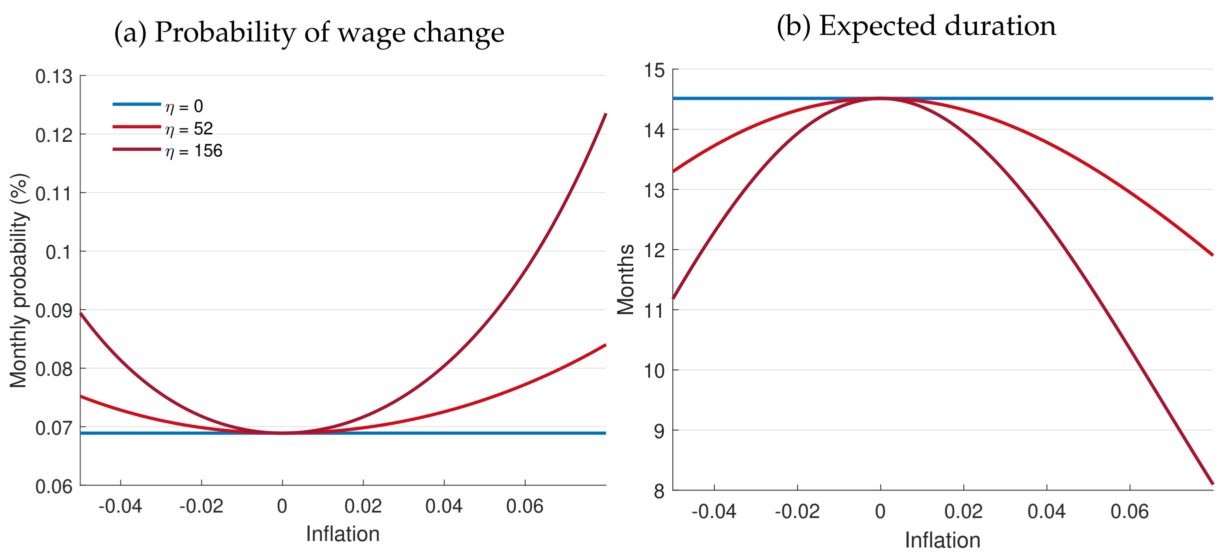
$$\begin{aligned} d &= (1-\theta^w) + 2\theta^w d - (\theta^w)^2 d \\ &= \frac{1}{1-\theta^w}. \end{aligned}$$

Figure 9 shows the shape of the wage reset probability function as well as the implied expected duration in the steady state for different degrees of state dependence η. To match the results from our firm-level data, we set $\gamma = 0.074$ and $\eta = 5,200$, which ensures that the expected duration is 14.2 months when trend inflation is 1.6% and the implied semi-elasticity of duration with respect to inflation is 0.26. Since the semi-elasticity in the union data is about 3 times higher, we also report results based on $\eta = 15,600$. This calibration implies that, in a zero-inflation steady state, the wage reset probability is 6.9% per month and the expected duration is 14.5 months. As inflation rises (or falls below zero), the frequency of wage changes increases. At very high rates of inflation or deflation, the wage reset probability $(1-\theta^w)$ rises to one, and the economy approaches the flexible

[21] The results are similar if we use the expected or lagged inflation rate.

wage equilibrium.

Figure 9: Probability of wage change and expected duration as a function of inflation



Notes: This figure plots the monthly reset probability of wages θ^w and the expected duration of wage contracts in the steady state d against the annualized inflation rate μ, for different degrees of state dependence in wage setting η. The coefficient η was scaled down by a factor of 100.

Wage setting in this model is done by unions who obtain labor from households at the marginal rate of substitution between consumption and leisure and sell a differentiated labor service to intermediaries ("labor aggregators") who in turn provide a labor index to the production sector. The labor index takes the familiar CES form:

$$L_t = \left[\int_0^1 L_t(i)^{\epsilon^w - 1} di \right]^{1/(\epsilon^w - 1)}, \tag{22}$$

where ϵ^w is the elasticity of substitution between varieties of labor. Each union faces a downward-sloping demand for its labor service and thus has wage-setting power. The labor demand facing household i is given by:

$$L_t(i) = \left(\frac{W_t(i)}{W_t} \right)^{-\epsilon^w} L_t, \tag{23}$$

where the nominal wage index is defined as:

$$W_t = \left[\int_0^1 W_t(i)^{1-\epsilon^w} di \right]^{1/(1-\epsilon^w)}. \tag{24}$$

Given the dynamics of the wage setting probability, the wage setting behavior is governed by the following equations:

$$w_t^{\#} = \frac{\epsilon^w}{\epsilon^w - 1} \frac{f_{1,t}}{f_{2,t}}, \tag{25}$$

$$f_{1,t} = mrs_t w_t^{\epsilon^w} L_t^d + \mathbb{E}_t \theta_{t+1}^w \Lambda_{t,t+1} \Pi_{t+1}^{\epsilon^w} f_{1,t+1}, \tag{26}$$

$$f_{2,t} = w_t^{\epsilon^w} L_t^d + \mathbb{E}_t \theta_{t+1}^w \Lambda_{t,t+1} \Pi_{t+1}^{\epsilon^w - 1} f_{2,t+1}. \tag{27}$$

Here (25) determines the real reset wage $w_t^{\#}$ by means of the two auxiliary variables $f_{1,t}$ and $f_{2,t}$, which are determined recursively by (26) and (27). Again, note that θ_t^w is endogenous and time-varying instead of fixed as in the standard model. The other variables impacting wage setting are the marginal rate of substitution between consumption and leisure mrs_t, the gross rate of inflation Π_t, and the stochastic discount factor $\Lambda_{t,t+1}$. Intuitively, the optimal reset wage is the present discounted value of future marginal rates of substitution between consumption and leisure. Notice that an increase in expected inflation has a bigger effect on the numerator $f_{1,t}$ than on the denominator $f_{2,t}$ in (25) and thus raises the optimal reset wage.

In each period t, a fraction $(1 - \theta_t^w)$ of unions resets their wage to the optimal level $w_t^{\#}$, while the remaining fraction θ_t^w is stuck with the old nominal wage. Their real wage is thus eroded by inflation to w_{t-1}/Π_t. Taking the integral gives the aggregate index of real wages:

$$w_t = \frac{W_t}{P_t} = \left[(1 - \theta_t^w)(w_t^{\#})^{1-\epsilon^w} + \theta_t^w \Pi_t^{\epsilon^w - 1} w_{t-1}^{1-\epsilon^w} \right]^{1/(1-\epsilon^w)}. \tag{28}$$

The staggered nature of wage setting implies that wages will differ between wage setters at any point in time. We define a wage dispersion index v_t^w as follows:

$$v_t^w = \int_0^1 \left(\frac{W_t(l)}{W_t} \right)^{-\epsilon^w} dl, \tag{29}$$

which, as shown in Appendix E can be written recursively as:

$$v_t^w = (1 - \theta_t^w) \left(\frac{w_t^{\#}}{w_t} \right)^{-\epsilon^w} + \theta_t^w \Pi_t^{\epsilon^w} \left(\frac{w_{t-1}}{w_t} \right)^{-\epsilon^w} v_{t-1}^w \tag{30}$$

Wage dispersion is a key variable in Calvo-type models as it provides a summary measure of the distortions created by nominal rigidities. As we will show, state-dependent wage setting has important implications on wage dispersion, which in turn affects output, employment, and welfare.

4.3.2 Closing the model and calibration

Before turning to the numerical simulation exercises, we briefly discuss the other key equations in the model:

$$\psi L_t^{\chi} = C_t^{-\sigma} mrs_t, \tag{31}$$

$$1 = R_t \mathbb{E}_t \Lambda_{t,t+1} \Pi_{t+1}^{-1}, \tag{32}$$

$$\Lambda_{t,t+1} = \beta \left(\frac{C_{t+1}}{C_t} \right)^{-\sigma}, \tag{33}$$

$$\Pi_t^{\#} = \frac{\epsilon^p}{(\epsilon^p - 1)} \frac{x_{1,t}}{x_{2,t}}, \tag{34}$$

$$x_{1,t} = w_t Y_t + \theta^p \mathbb{E}_t \Lambda_{t,t+1} \Pi_{t+1}^{\epsilon^p} x_{1,t+1}, \tag{35}$$

$$x_{2,t} = Y_t + \theta^p \mathbb{E}_t \Lambda_{t,t+1} \Pi_{t+1}^{\epsilon^p - 1} x_{2,t+1}, \tag{36}$$

$$\Pi_t^{1-\epsilon^p} = (1 - \theta^p)(\Pi_t^{\#})^{1-\epsilon^p} + \theta^p, \tag{37}$$

$$v_t^p = (1 - \theta^p)(\Pi_t^{\#})^{-\epsilon^p} + \theta^p \Pi_t^{\epsilon^p} v_{t-1}^p, \tag{38}$$

$$L_t = Y_t v_t^p v_t^w, \tag{39}$$

$$Y_t = C_t, \tag{40}$$

$$\log R_t = (1 - \rho^r) \log R + \log \rho^r R_{t-1} + (1 - \rho^r)\phi(\log \Pi_t - \mu) + \epsilon_t^r. \tag{41}$$

The household side is standard and consists of a labor supply equation (31), defining the marginal rate of substitution between consumption and leisure, and an Euler equation (32) along with a definition of the stochastic discount factor (33). The production side is split into wholesale and retail sectors. Wholesale firms turn one unit of labor into one unit of an intermediate product. Since wholesale is competitive, the price of intermediate goods is equal to the marginal cost which equals the real wage rate. Retail firms turn intermediate goods into final goods facing a Calvo pricing friction allowing price changes with a fixed probability $1 - \theta^p$ per period. Denoting the ratio of the reset price to the average price level by $\Pi_t^{\#}$ and average (gross) inflation by Π_t, (37)-(36) determine the price setting behavior of retail firms. Similar to wage setters, they set prices to a markup times the present discounted value of future marginal costs. The model is closed by a monetary policy rule (41), and market clearing conditions for the goods and labor markets which are summarized by (39) and (40).

The model is calibrated to match the state dependence of wage setting documented in our empirical section. Table E.1 summarizes the calibration strategy. The standard parameters are based on estimates from Gerali et al. (2010) for the euro area. The disutility of labor, ψ, is chosen such that output is equal to 1 in the zero-inflation steady state. Labor market power implies a wage markup of 25% above the marginal rate of substitution, and goods market power a markup of 20% above marginal costs. The Calvo probability of price adjustment is set to 0.083 per month, such that goods prices are changed once per year in expectation (i.e. the expected duration of prices is 12 months). We report results based on two values for the state-dependence parameter η, corresponding to the plausible range of state dependence seen in our data. The lower value of $5,200$ implies a semi-elasticity of duration of 0.3 months as in our firm-level data, while $\eta = 15,600$ corresponds to the higher elasticity estimated from the union data.

4.3.3 State-dependent wage setting and the long-run costs of inflation

Nominal rigidities tend to amplify the distortions created by monopolistic competition when trend inflation is non-zero (Ascari and Sbordone, 2014). The reason is that higher trend inflation increases the difference between those prices and wages that are reset and those that remain constant. This price and wage dispersion, in turn, leads to an inefficient allocation of resources across firms and thus reduces welfare.

To see how state-dependent wage setting alters the distortions in the long run, we solve for a steady state with different values of trend inflation μ. We then show how output, employment, wage dispersion, and welfare depend on μ for different degrees of state dependence η.

In the steady state, the probability to reset the wage $(1-\theta^w)$ and the probability to remain with the current wage θ^w are given by:

$$(1-\theta^w) = \frac{\gamma e^{\eta\mu^2}}{1+\gamma e^{\eta\mu^2}} \qquad \text{and} \qquad \theta^w = \frac{1}{1+\gamma e^{\eta\mu^2}}. \tag{42}$$

In the presence of state dependence (i.e., $\eta > 0$), the reset probability $(1-\theta^w)$ increases with the square of the trend inflation rate μ^2, while, conversely, the probability of remaining with the current wage falls with μ^2. In (25), the optimal real reset wage becomes:

$$w^{\#} = \frac{\epsilon^w}{\epsilon^w - 1}\left(\frac{1-\beta\theta^w(1+\mu)^{\epsilon^w-1}}{1-\beta\theta^w(1+\mu)^{\epsilon^w}}\right) mrs. \tag{43}$$

So those firms who can, set real wages equal to a markdown times the marginal rate of substitution between consumption and labor. (43) shows that the markdown depends on trend inflation through two channels. For a given θ^w, a higher μ raises the reset wage, as wage setters want to protect their real wage from getting eroded by future inflation. This channel is described for the price-setting side by Ascari and Sbordone (2014) and can be called the "standard channel". In addition, a new offsetting channel arises from the state dependence: as θ^w decreases with μ, an erosion of the real wage is less of a concern in times of high inflation because wages can be reset more often. Which of these channels dominates hinges on the degree of state dependence as well as on the level of trend inflation.

From (28), the aggregate real wage turns out to be:

$$w = \left(\frac{1 - \theta^w (1+\mu)^{\epsilon^w - 1}}{1 - \theta^w} \right)^{1/(\epsilon^w - 1)} w^{\#}. \tag{44}$$

Again, we see that trend inflation has two competing effects with state-dependent wage setting. Conditional on a wage resetting probability, trend inflation causes the average real wage to lag behind the reset wage. But the higher wage resetting probability in times of high inflation means that the share of wages that remain constant each period is smaller, thus reducing the difference between the average wage and the reset wage. This, in turn, implies that wage dispersion in the steady state is also lower with state-dependent wage setting. In the steady state, (30) yields:

$$v^w = \frac{1 - \theta^w}{1 - \theta^w (1+\mu)^{\epsilon^w}} \left(\frac{w^{\#}}{w} \right)^{-\epsilon^w}. \tag{45}$$

As can be seen in Figure 10(c), in the baseline model with a fixed reset probability, wage dispersion increases disproportionately once trend inflation exceeds a threshold around 4%. By contrast, in the state-dependent case, wage dispersion rises only slightly relative to the zero-inflation steady state even at very high inflation rates.

This neutralizing tendency of state-dependent wage setting on wage dispersion has consequences for the impact of trend inflation on output, employment, and welfare. This is most easily seen in the case without price stickiness, i.e. $\theta^p = 0$.[22] Then, (34)-(37) boil down in the steady state to

$$w = \frac{\epsilon^p - 1}{\epsilon^p}. \tag{46}$$

Combining (43), (44) and (46) pins down the marginal rate of substitution as a function of trend inflation μ:

$$mrs = \frac{\epsilon^w - 1}{\epsilon^w} \frac{\epsilon^p - 1}{\epsilon^p} \left(\frac{1 - \beta\theta^w (1+\mu)^{\epsilon^w}}{1 - \beta\theta^w (1+\mu)^{\epsilon^w - 1}} \right) \left(\frac{1 - \theta^w}{1 - \theta^w (1+\mu)^{\epsilon^w - 1}} \right)^{1/(\epsilon^w - 1)}. \tag{47}$$

Conditional on θ^w, the marginal rate of substitution falls with the trend inflation rate. The

[22]In the steady-state without price stickiness, (37) implies $\Pi^{\#} = 1$. Plugging this into (38) yields $v^p = 1$.

reason is that inflation increases the wedge between the real wage producers are willing to pay and the marginal rate of substitution at which wage setters (unions) obtain labor from households. However, linking θ^w to inflation reduces this wedge and therefore offsets the decreasing effect of inflation on the marginal rate of substitution.

Combining (31) with (39) and (40), gives steady-state output and employment:

$$Y = \left(\frac{mrs}{\psi(v^w v^p)^\chi}\right)^{1/(\sigma+\chi)}, \qquad \text{and} \quad L = \left(\frac{mrs(v^w v^p)^\sigma}{\psi}\right)^{1/(\sigma+\chi)}. \tag{48}$$

Since mrs is decreasing and v^w is increasing in trend inflation, the effect on output is unambiguously negative, while the effect on employment is unclear a priori. In our calibrated model, rising trend inflation reduces output and raises employment as seen in the upper panel of Figure 10. State-dependent wage setting dampens both the negative effect on output as well as the positive effect on employment. Even with a relatively low degree of state dependence, the negative impact of high inflation is significantly reduced. For instance, at 8% trend inflation ($\mu = 0.08$), output would fall by about 4% relative to the zero-inflation steady state if θ^w is fixed. With a variable θ^w, the decline in output is only about 2% when the degree of state-dependence η is calibrated to the firm-level data. When η is calibrated to the union data, we find that the output cost of inflation is virtually eliminated. For employment, we see very small positive effects of trend inflation under $\eta = 0$ and even smaller effects for $\eta > 0$.

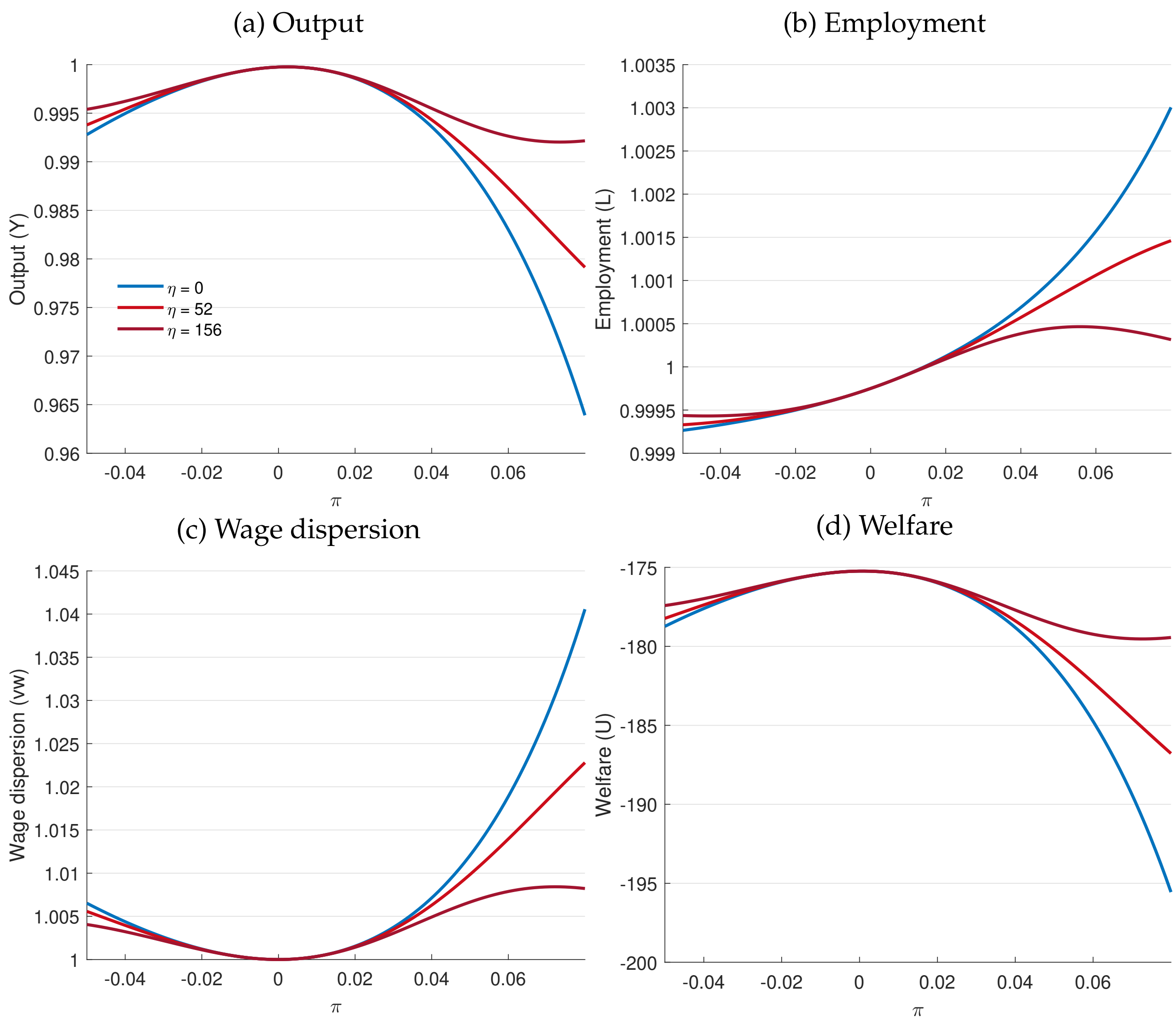
Finally, steady-state welfare is given by:

$$U = \frac{1}{1-\beta}\left[\frac{1}{1-\sigma}Y^{1-\sigma} - \frac{\psi}{1+\chi}L^{1+\chi}\right], \tag{49}$$

and is increasing in output Y and decreasing in employment L. Since trend inflation decreases the former and increases the latter, welfare declines unambiguously with higher μ. As Figure 10(d) shows, the welfare costs of inflation become substantial under a fixed θ^w, but are mitigated when state dependence is present.

It should be noted that, while this paper is only concerned with state-dependent wage setting, there are strong theoretical reasons and some empirical evidence that price rigidity (e.g., Alvarez et al. 2019) is also lower in times of high inflation. If, in addition to θ^w, we would link the reset probability of price setting θ^p to inflation in a similar way, the long-run effects of trend inflation would be reduced even further.

Figure 10: Steady state implications of trend inflation under state-dependent wage setting



Notes: This figure plots the steady-state values of output, employment, wage dispersion, and welfare for different levels of trend inflation under different degrees of state dependence in wage setting η. The coefficient η was scaled down by a factor of 100.

4.3.4 The impact of state-dependent wage setting on monetary transmission

State-dependent wage setting not only affects the long-run consequences of inflation but also has implications for the transmission and propagation of a monetary policy shock. To show this, we compare the impulse responses of macroeconomic variables to an expansionary monetary shock in our model with those of a benchmark model without state dependence — a constant reset probability $1 - \theta^w$ — in an environment with positive trend inflation. As the preceding section has demonstrated, the effects of state dependence are rather small under low levels of trend inflation but increase disproportionally with the level of trend inflation. Therefore, we log-linearize our model around a steady state with $\mu = 0.04$. We calibrate the policy shock in such a way as to create an (annualized) inflation rate of 6.5% on impact in the model with a moderate degree of state-dependence ($\eta = 5,200$).

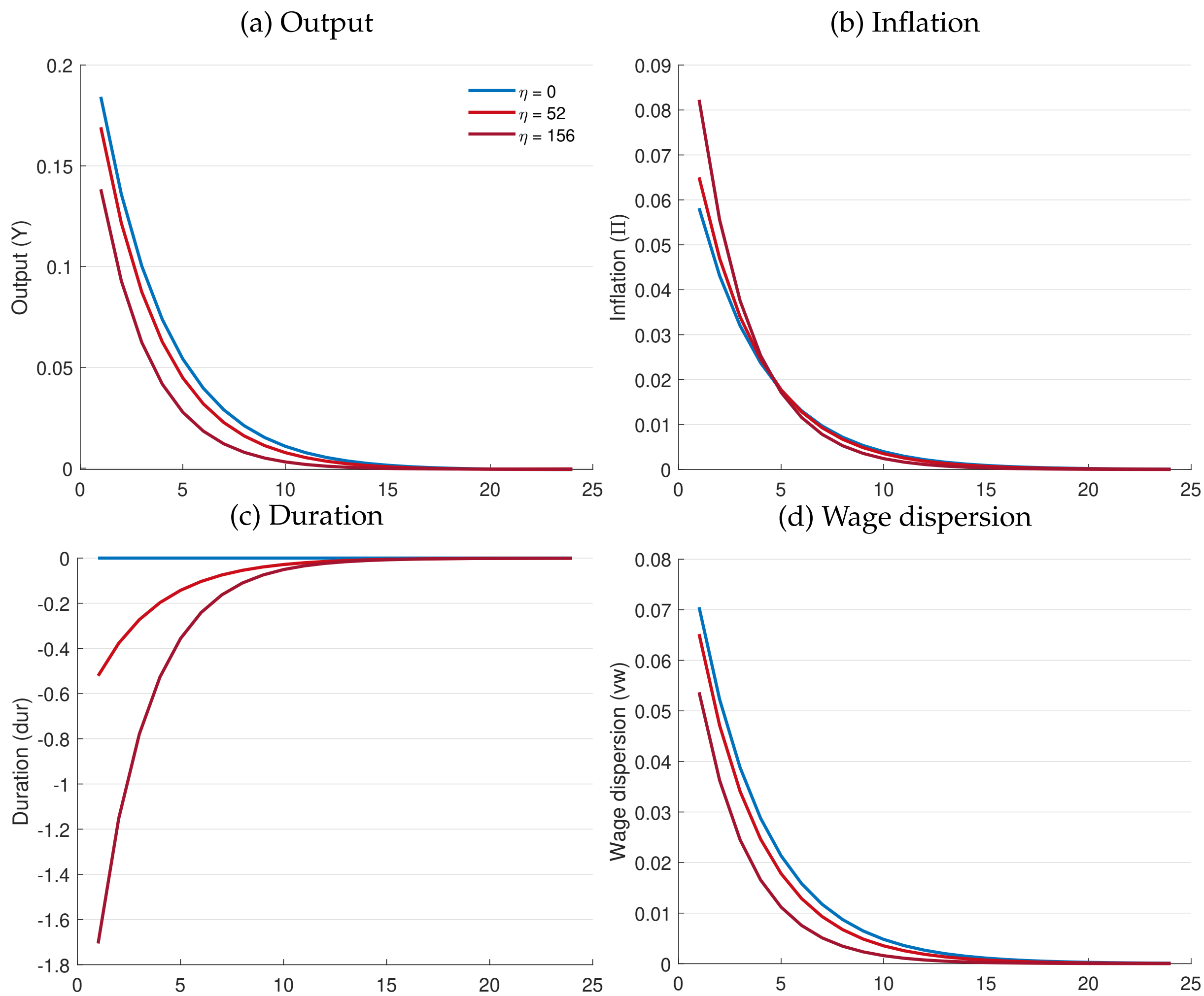
As Figure 11 above shows such an expansionary monetary shock causes the duration of wage adjustment to drop on impact by half a month (or, conversely, the probability of wage adjustments $1 - \theta_t^w$ to rise) in the scenario with $\eta = 5,200$. With $\eta = 15,600$, the same monetary shock would drive annualized inflation to 8% and duration would drop by about 1.7 months. Thus, state-dependent wage setting causes both wage and price inflation to react more strongly to a monetary stimulus than in the benchmark model with a fixed reset probability. On the flip side, the real effects are smaller: Output and employment expand less on impact and return faster to their steady-state levels.[23] Intuitively, if inflation causes firms to reset wages more frequently, the economy is pushed toward the flexible-price equilibrium. In this equilibrium, the "classical dichotomy" holds, i.e. monetary shocks affect only nominal variables.

The upshot of these results is that state-dependent wage setting leads to a steepening of the Phillips curve. This finding has important implications for the efficacy of monetary policy and the welfare cost of disinflation. A steeper Phillips curve implies that the sacrifice ratio is low, i.e. that any given reduction in inflation can be achieved at a lower cost in terms of the output gap and unemployment.

To quantify the effect of state-dependent wage setting on the short-run inflation dynamics, we run a simple regression of inflation on the output gap on the simulated data from both our model and the benchmark model. Figure 12 shows the result of this exercise. In the simulated data, the estimated slope of the Phillips curve rises from 0.33 in the model without state dependence to 0.4 and 0.62 in the scenarios with low ($\eta = 5,200$) and high ($\eta = 15,600$) state dependence respectively. This implies a decrease in the sacrifice

[23]The employment response is similar to that of output since labor is the only input in production.

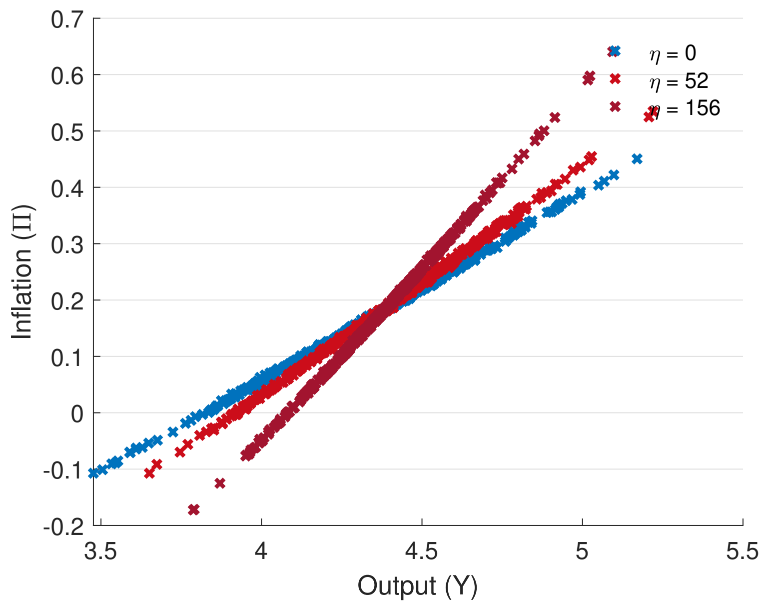
Figure 11: Impulse responses to a monetary shock with and without state-dependent wage setting



Notes: This figure plots the impulse response functions of output, inflation, duration, and wage dispersion to a one standard deviation expansionary monetary shock for the model with different degrees of state dependence in wage setting η. The coefficient η was scaled down by a factor of 100.

ratio from 3 in the benchmark model to 2.5 and 1.6 in our model with positive η. Thus, state-dependent wage setting cuts the output cost of an inflation-reducing monetary policy in our model by about 20 to 50% relative to a world with a fixed wage resetting probability.

Figure 12: Phillips curve with and without state-dependent wage setting



Notes: Phillips curves estimated from simulated data for output and inflation from the model under different degrees of state dependence in wage setting η. The coefficient η was scaled down by a factor of 100.

It should be stressed that the effect of state-dependent wage setting strongly interacts with trend inflation. For small levels of trend inflation ($\mu < 2\%$), the impulse response functions in the model with time-varying θ_t^w would be very close to the standard model with a fixed θ^w. Indeed, one can easily show that, in the neighborhood of a zero-inflation steady state, the state-dependent terms drop out of the log-linearized model equations.[24]

5 Conclusion

This paper provides novel evidence on wage-setting behavior using comprehensive firm- and union-level data from Germany. Exploiting the historical rise in inflation in the post-pandemic economy, we document changes in wage-setting dynamics as inflation rises from below 2% to nearly 7%: wage agreement duration shortened by approximately 1.5 months, and wage adjustments increased by 2 to 4 percentage points per pay round. Larger firms tend to implement smaller but more frequent wage increases. Similarly, in collective

[24]For example, a log-linear approximation of (19) gives: $\tilde{\theta}_t^w = 2(1-\theta^w)\eta\mu^2\tilde{\pi}_t$, which implies $\tilde{\theta}_t^w = 0$ when $\mu = 0$.

bargaining outcomes, periods of high inflation are associated with negotiated wage hikes that are about 5 percentage points higher, while the duration of collective bargaining agreements is 2 months shorter.

We demonstrate that these empirical patterns can be rationalized by macroeconomic models in which wage setters have monopsony power. Specifically, we show that a menu cost model with heterogeneous firms and monopsony power in the labor market can replicate our empirical findings. The basic intuition is that firms want to protect their real wages from getting eroded by inflation. Thus, when inflation is high, they will adjust wages more frequently and by larger increments per pay round. In addition, consistent with our data, firms who receive favorable productivity draws and are therefore large in terms of output and employment adjust wages more frequently. We also show that a Calvo-type model of wage setting behaves similarly to the menu cost model when the Calvo probability of wage changes depends on the inflation rate.

Embedding such a mechanism in a calibrated New Keynesian model a la Erceg et al. (2000) reveals that state-dependent wage setting changes the economics of inflation both in the long run and the short run. In the long run, realistic degrees of state dependence in wage setting greatly reduce the negative effects of inflation on output and welfare. In the short run, state-dependent wage setting amplifies the impact of a monetary policy shock on nominal variables while dampening its effect on real variables, implying a steepening of the Phillips curve. In the calibrated model, we find that the slope of the Phillips curve increases by about 30% to 120% depending on the elasticity of the wage-resetting frequency to inflation. This also implies that the welfare cost of reducing inflation (the sacrifice ratio) is significantly lower when wage setting depends on the inflation rate.

Overall, this paper provides reasons to be cautious when extrapolating results obtained in a low-inflation regime to periods of higher inflation. Models that do not take into account the state dependence of wage setting and are estimated on, or calibrated to, data from low-inflation environments may be misleading guides to policy when inflation rises.

While the menu cost and Calvo models discussed in this paper are successful in explaining some features of the micro data, there is clearly room for improvement. In particular, the bunching of the distribution of wage duration at 12 and 24 months visible in both the firm-level survey data and the collective bargaining data is difficult to capture with existing models. This feature of the data might have additional implications for the welfare costs of inflation as well as for monetary policy transmission.

References

Abberger, K., Funk, A. K., Lamla, M., Lein, S., and Siegris, S. (2023). Firms' inflation expectation pass-through into prices and wages: Evidence from an RCT survey. Technical report, Unpublished manuscript.

Alvarez, F., Beraja, M., Gonzalez-Rozada, M., and Neumeyer, P. A. (2019). From hyperinflation to stable prices: Argentina's evidence on menu cost models. *The Quarterly Journal of Economics*, 134(1):451–505.

Amano, R., Moran, K., Murchison, S., and Rennison, A. (2009). Trend inflation, wage and price rigidities, and productivity growth. *Journal of Monetary Economics*, 56(3):353–364.

Ascari, G. and Sbordone, A. M. (2014). The macroeconomics of trend inflation. *Journal of Economic Literature*, 52(3):679–739.

Auclert, A., Rigato, R., Rognlie, M., and Straub, L. (2024). New pricing models, same old phillips curves? *The Quarterly Journal of Economics*, 139(1):121–186.

Barattieri, A., Basu, S., and Gottschalk, P. (2014). Some evidence on the importance of sticky wages. *American Economic Journal: Macroeconomics*, 6(1):70–101.

Baumann, U., Ferrando, A., Georgarakos, D., Gorodnichenko, Y., and Reinelt, T. (2024). Safe to update inflation expectations? new survey evidence on euro area firms. Technical report, National Bureau of Economic Research.

Blanchard, O. J. (1986). The wage price spiral. *The Quarterly Journal of Economics*, 101(3):543–565.

Boissay, F., De Fiore, F., Igan, D., Tejada, A. P., and Rees, D. (2022). Are major advanced economies on the verge of a wage-price spiral? Technical report, Bank for International Settlements.

Buchheim, L., Link, S., and Möhrle, S. (2024). Inflation and wage expectations of firms and employees. *Available at SSRN 4943991*.

Buchheim, L., Link, S., and Möhrle, S. (2023). Wage expectations of firms and employees. Technical report, Unpublished manuscript.

Danziger, L. (1999). A dynamic economy with costly price adjustments. *American Economic Review*, 89(4):878–901.

Druant, M., Fabiani, S., Kezdi, G., Lamo, A., Martins, F., and Sabbatini, R. (2012). Firms' price and wage adjustment in Europe: Survey evidence on nominal stickiness. *Labour Economics*, 19(5):772–782.

Dye, R. A. (1985). Optimal length of labor contracts. *International Economic Review*, 26(1):251–270.

Erceg, C. J., Henderson, D. W., and Levin, A. T. (2000). Optimal monetary policy with staggered wage and price contracts. *Journal of Monetary Economics*, 46(2):281–313.

Farmer, L. E. and Toda, A. A. (2017). Discretizing nonlinear, non-gaussian markov processes with exact conditional moments. *Quantitative Economics*, 8(2):651–683.

Fregert, K. and Jonung, L. (1999). Monetary regimes and endogenous wage contracts: Sweden 1908-1995. Technical report, Lund University, Department of Economics.

Gagnon, E. (2009). Price setting during low and high inflation: Evidence from Mexico. *The Quarterly Journal of Economics*, 124(3):1221–1263.

Gerali, A., Neri, S., Sessa, L., and Signoretti, F. M. (2010). Credit and banking in a dsge model of the euro area. *Journal of Money, Credit and Banking*, 42:107–141.

Gertler, M. and Leahy, J. (2008). A Phillips curve with an Ss foundation. *Journal of Political Economy*, 116(3):533–572.

Golosov, M. and Lucas, R. E. (2007). Menu costs and Phillips curves. *Journal of Political Economy*, 115(2):171–199.

Gray, J. A. (1978). On indexation and contract length. *Journal of Political Economy*, 86(1):1–18.

Grigsby, J., Hurst, E., and Yildirmaz, A. (2021). Aggregate nominal wage adjustments: New evidence from administrative payroll data. *American Economic Review*, 111(2):428–71.

Hajdini, I., Knotek, E. S., Leer, J., Pedemonte, M., Rich, R., and Schoenle, R. (2025). Low pass-through from inflation expectations to income growth expectations: Why people dislike inflation.

Hohendanner, C. and Kohaut, S. (2023). Tarifbindung und Mitbestimmung: Keine Trendumkehr in Westdeutschland, Stabilisierung in Ostdeutschland. IAB-Forum, online. Accessed: 10 March 2025.

Jäger, S., Noy, S., and Schoefer, B. (2022). The German Model of Industrial Relations: Balancing Flexibility and Collective Action. *Journal of Economic Perspectives*, 36(4):53–80.

Jain, M., Kostyshyna, O., and Zhang, X. (2024). How do people view wage and price inflation? *Journal of Monetary Economics*, page 103552.

Kashyap, A. K. (1995). Sticky prices: New evidence from retail catalogs. *The Quarterly Journal of Economics*, 110(1):245–274.

Koester, G., Grapow, H., et al. (2021). The prevalence of private sector wage indexation in the euro area and its potential role for the impact of inflation on wages. *Economic Bulletin Boxes*, 7.

Konieczny, J. D. and Skrzypacz, A. (2005). Inflation and price setting in a natural experiment. *Journal of Monetary Economics*, 52(3):621–632.

Nakamura, E. and Steinsson, J. (2008). Five facts about prices: A reevaluation of menu cost models. *The Quarterly Journal of Economics*, 123(4):1415–1464.

Phillips, A. W. (1958). The relation between unemployment and the rate of change of money wage rates in the United Kingdom, 1861-1957. *Economica*, 25(100):283–299.

Pilossoph, L. and Ryngaert, J. M. (2024). Job search, wages, and inflation. Technical report, National Bureau of Economic Research.

Schaller, D., Hennrich, J., and Wohlrabe, K. (2025). The ifo human resources survey. *Jahrbücher für Nationalökonomie und Statistik*.

Sigurdsson, J. and Sigurdardottir, R. (2016). Time-dependent or state-dependent wage-setting? Evidence from periods of macroeconomic instability. *Journal of Monetary Economics*, 78:50–66.

Suthaharan, N. and Bleakley, J. (2022). Wage-price dynamics in a high-inflation environment: the international evidence. *The Reserve Bank's Liaison Program*, page 51.

A Survey Instrument

ifo Personalleiterbefragung

Sonderfragen: Lohnsetzung

1) In welchem zeitlichen Abstand (in Monaten) wurden in Ihrem Unternehmen in den Jahren 2017-2019 die Mitarbeiterlöhne durchschnittlich angepasst? (exklusive Beförderungen, außerordentliche Gehaltsänderungen, etc.)

Alle _______ Monate

2) Um wie viel Prozent wurden die Mitarbeiterlöhne bei einer Lohnanpassung in den Jahren 2017-2019 im Durchschnitt verändert?

☐ < 0% ☐ 0-2% ☐ 2-4% ☐ 4-6% ☐ 6-8% ☐ 8-10% ☐ >10%

3) Wie wichtig waren die folgenden Faktoren für die vergangenen Lohnentscheidungen in Ihrem Unternehmen Bitte tragen Sie einen Wert von 0 (= gar keine Bedeutung) bis 10 (= sehr hohe Bedeutung) ein.

___ Lohnwettbewerb von Konkurrenten
___ Erwartetes Arbeitskräfteangebot/Angebot von Fachkräften
___ Orientierung an der Inflationsrate
___ Anpassung durch Tarifvertrag
___ Veränderung der Verkaufspreise
___Veränderung der Nachfrage nach Arbeitskräften

___ Sonstiges: ____

4) Auswirkungen einer hohen Inflation auf Lohnverhandlungen

a) In welchem zeitlichen Abstand (in Monaten) wurden bzw. werden in Ihrem Unternehmen in den Jahren 2022-2024 die Mitarbeiterlöhne durchschnittlich angepasst? (exklusive Beförderungen, außerordentliche Gehaltänderungen, etc.)

Alle _______ Monate

b) Um wie viel Prozent wurden bzw. werden die Mitarbeiterlöhne bei einer Lohnanpassung in den Jahren 2022-2024 im Durchschnitt verändert?

☐ < 0% ☐ 0-2% ☐ 2-4% ☐ 4-6% ☐ 6-8% ☐ 8-10% ☐ >10%

5) Welche Faktoren schränken Ihr Unternehmen in der Lohnsetzung ein? (Mehrfachnennung möglich)

☐ administrativer Aufwand
☐ Regulierung
☐ Lohnsetzung liegt nicht beim Unternehmen
☐ wirtschaftliche Faktoren/Existenzbedrohung

☐ Sonstiges: ____

6) Inwieweit variiert die Lohnanpassung in Ihrem Unternehmen nach Beschäftigungsgruppen im Vergleich zum Durchschnitt der drei Beschäftigungsgruppen?
→ Zeitlicher Abstand der Anpassung (häufiger, gleich, weniger häufig)
→ Höhe der Anpassung der Mitarbeiterlöhne in % (höher, gleich, niedriger)

	Zeitlicher Abstand der Anpassung			**Höhe der Anpassung in %**		
	häufiger	gleich	weniger häufig	höher	gleich	niedriger
Ungelernte Beschäftigte	☐	☐	☐	☐	☐	☐
Fachkräfte ohne Leitungsposition	☐	☐	☐	☐	☐	☐
Führungskräfte	☐	☐	☐	☐	☐	☐

PL 79.406.079.579

Rücksendung bitte bis Montag, 21. November 2022
Fax: (089) 9224-1463, E-Mail: PL-Umfrage@ifo.de

Supplementary questions: wage setting (English translation)

A.1.: On average, how often (in months) did your firm adjust wages during 2017-2019? (excluding promotions, extraordinary wage changes, etc.)
Every ____ months.

A.2.: On average, by how much (in percent) did you adjust wages during 2017-2019?
☐ $< 0\%$ ☐$0 - 2\%$ ☐$2 - 4\%$ ☐$4 - 6\%$ ☐$6 - 8\%$ ☐$8 - 10\%$ ☐ $> 10\%$

A.3.: How important were the following factors for past wage decisions? Enter a value from 0 (= no importance) to 10 (= very high importance).

- Wage competition by other firms
- Expected labor supply/supply of skilled workers
- Focus on the inflation rate
- Adjustment due to a collective agreement
- Changes in sales prices
- Changes in labor demand
- Other factors:

Impact of high inflation on wage-setting practices at your firm

A.4a.: On average, how often (in months) does your firm plan to adjust wages during 2022-2024? (excluding promotions, extraordinary wage changes, etc.)
Every ____ months.

A.4b.: On average, by how much (in percent) do you plan to adjust wages during 2022-2024?
☐ $< 0\%$ ☐$0 - 2\%$ ☐$2 - 4\%$ ☐$4 - 6\%$ ☐$6 - 8\%$ ☐$8 - 10\%$ ☐ $> 10\%$

A.5.: What factors limit wage-setting practices at your firm? (Multiple answers possible)

- Administrative burden
- Regulation
- Wage decision outside of the firm
- Economic reasons/ threat to firm's existence
- Other factors:

A.6.: Do wage-setting practices vary at your firm by occupation group relative to the average?
→ Frequency of adjustment (more often, same, less often)
→ Extent of adjustment in percent (more often, same, less often)

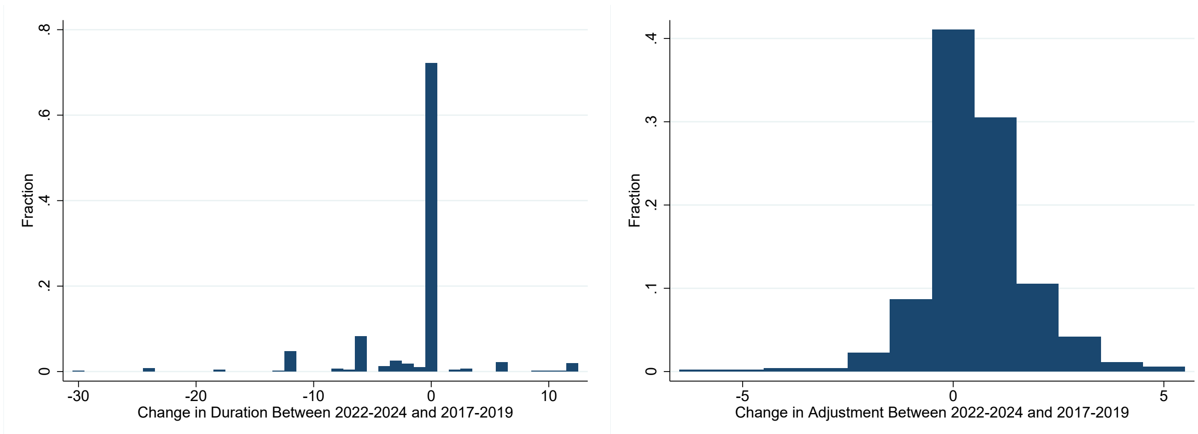
- Unskilled workers
- Skilled workers without executive position
- Executives

B Firm-Level Data Appendix

B.1 Additional figures

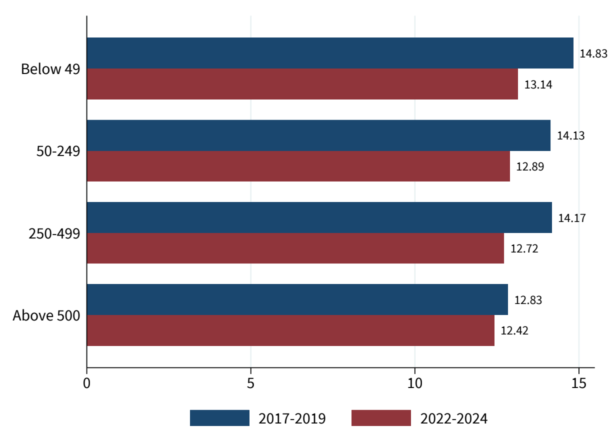
Figure B.1: Firm-level changes in wage-setting behavior

(a) Extensive margin (b) Intensive margin



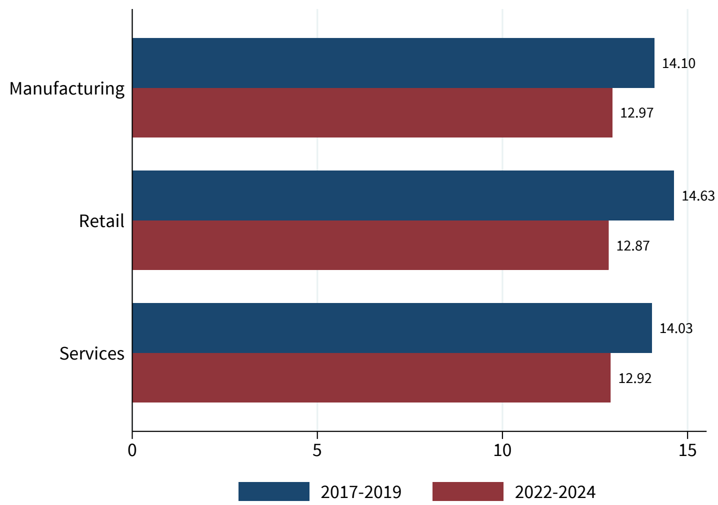
Notes: This figure shows firm-level changes in the duration of pay agreements (extensive margin) and the wage adjustment in percent (intensive margin) between the periods 2017-2019 and 2022-2024.

Figure B.2: Extensive margin by size: 2017-2019 vs. 2022-2024



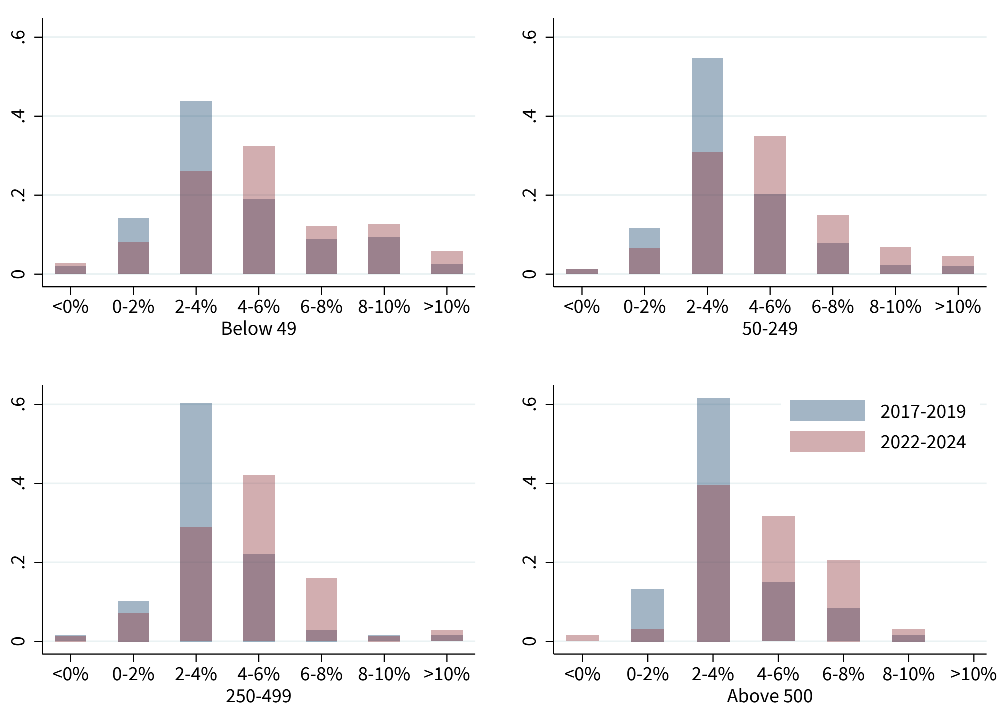
Notes: Average duration of pay agreements by firm size in terms of employees. Four buckets: Below 50, 50-249, 250-499, and above 500 employees.

Figure B.3: Extensive margin by sector: 2017-2019 vs. 2022-2024



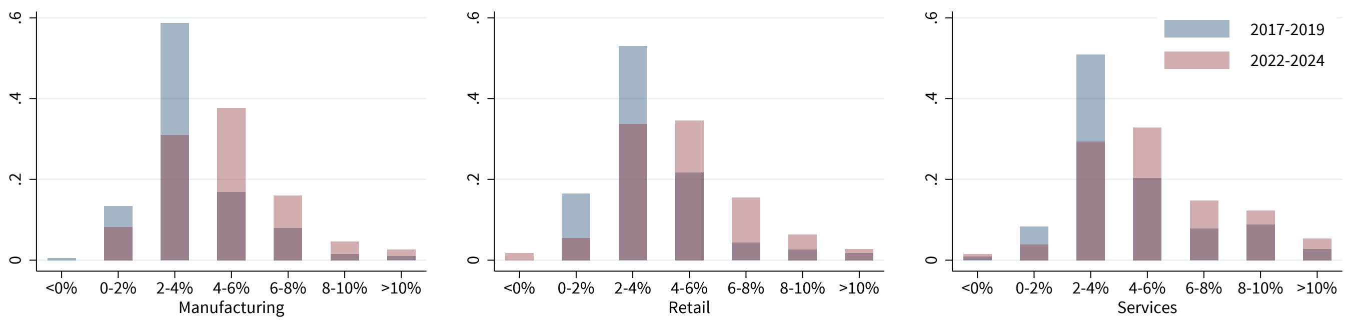
Notes: Average duration of pay agreements by sector by time period (2017-2019 vs. 2022-2024).

Figure B.4: Intensive margin by size: 2017-2019 vs. 2022-2024



Notes: Histogram of average wage growth by firm size. Four buckets: Below 49, 50-249, 250-499, and above 500 employees.

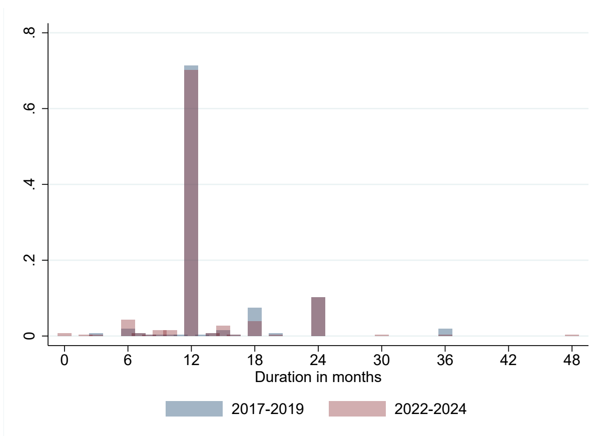
Figure B.5: Intensive margin by sector: 2017-2019 vs. 2022-2024



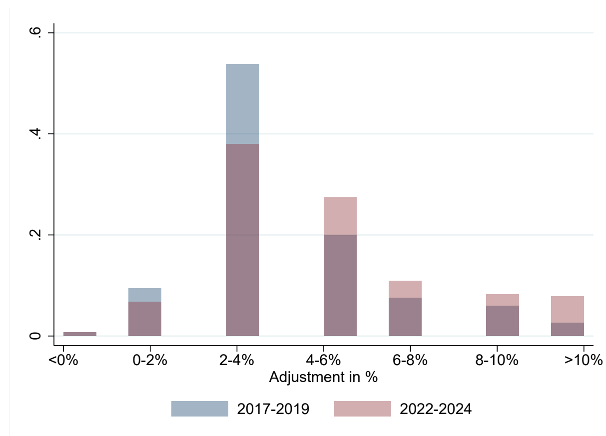
Notes: Histogram of average wage growth by sector.

Figure B.6: Wage-setting behavior in times of high and low inflation (realized)

(a) Extensive margin



(b) Intensive margin



Notes: This figure shows the duration of pay agreements (extensive margin) and the wage adjustment in percent (intensive margin) during the periods 2017-2019 and 2022-2024 (asked in 2025).

B.2 Additional tables

Table B.1: (Semi-)Elasticity regressions with controls

	(1)	(2)	(3)	(4)
Panel A: Wage Duration (3-year avg)				
Inflation	-0.251***	-0.231***	-0.255***	-0.252***
	(-4.01)	(-5.82)	(-4.11)	(-4.03)
Constant	14.64***	14.52***	14.65***	14.65***
	(46.46)	(72.66)	(46.97)	(46.53)
N	1068	1014	1065	1068
R^2	0.015	0.807	0.091	0.020
Fixed Effects		Firm	Sector	Size
Panel B: Wage Growth (3-year avg)				
Inflation	0.204***	0.206***	0.204***	0.204***
	(7.54)	(9.98)	(7.77)	(7.59)
Constant	3.494***	3.517***	3.493***	3.493***
	(25.79)	(33.96)	(26.52)	(25.88)
N	1114	1062	1111	1114
R^2	0.049	0.739	0.155	0.059
Fixed Effects		Firm	Sector	Size
Panel C: Annual Wage Growth (3-year avg)				
Inflation	0.291***	0.279***	0.294***	0.291***
	(6.76)	(8.06)	(6.94)	(6.77)
Constant	3.341***	3.368***	3.323***	3.341***
	(15.45)	(19.39)	(15.62)	(15.47)
N	1057	996	1052	1057
R^2	0.042	0.677	0.130	0.047
Fixed Effects		Firm	Sector	Size

Notes: Panel regressions of duration, wage growth per pay round and annualized wage growth on inflation information available at the survey in November 2022 (realized inflation until 2021 and inflation expectations from the Gemeinschaftsdiagnose after 2021). Averages for three years 2017-2019 and 2021-2024. Different sets of controls: (1) no controls, (2) firm-fixed effects, (3) sector/industry-fixed effects, (3) size-fixed effects (four groups: < 50 employees, 50-249, 250-499, > 500).

Table B.2: Elasticity regressions with controls - yearly data

	(1)	(2)	(3)	(4)
Panel A: Pass-through of realized inflation				
Inflation	0.223***	0.205***	0.227***	0.233***
	(6.10)	(6.10)	(6.10)	(6.13)
Constant	2.554***	2.591***	2.528***	2.501***
	(13.95)	(15.45)	(13.05)	(12.67)
N	1927	1738	1677	1677
R^2	0.019	0.504	0.096	0.024
Fixed Effects		Firm	Sector	Size
Panel B: Pass-through of expected inflation				
Inflation	0.142***	0.130***	0.143***	0.144***
	(5.90)	(5.85)	(5.97)	(5.89)
Constant	2.970***	2.988***	2.962***	2.958***
	(23.55)	(26.34)	(22.34)	(21.89)
N	1927	1738	1677	1677
R^2	0.018	0.503	0.095	0.022
Fixed Effects		Firm	Sector	Size

Notes: Panel regressions of expected wage growth over the next year on realized inflation (previous year) and inflation expectations over the next year (from Gemeinschaftsdiagnose). Different sets of controls: (1) no controls, (2) firm-fixed effects, (3) sector/industry-fixed effects, (3) size-fixed effects (four groups: < 50 employees, 50-249, 250-499, > 500).

Table B.3: (Semi-)Elasticities by factor

	Coll. agreem.	Competition	Labor supply	Inflation	Prices	Labor demand
			Panel A: Wage Duration (3-year avg)			
Inflation	-0.168*	-0.289***	-0.258***	-0.273**	-0.220	-0.223**
	(-2.06)	(-3.51)	(-3.31)	(-2.93)	(-1.90)	(-2.86)
Constant	13.94***	14.87***	14.82***	14.97***	14.37***	14.48***
	(33.98)	(35.77)	(37.80)	(31.67)	(24.31)	(36.95)
N	519	668	735	542	360	703
R^2	0.008	0.018	0.015	0.016	0.010	0.012
			Panel B: Wage Growth (3-year avg)			
Inflation	0.227***	0.198***	0.216***	0.229***	0.171***	0.219***
	(5.96)	(5.77)	(6.88)	(6.12)	(3.48)	(6.88)
Constant	3.299***	3.588***	3.515***	3.421***	3.668***	3.448***
	(17.22)	(20.80)	(22.31)	(18.11)	(14.80)	(21.49)
N	547	690	764	565	384	728
R^2	0.061	0.046	0.058	0.062	0.031	0.061
			Panel C: Annual Wage Growth (3-year avg)			
Inflation	0.268***	0.295***	0.285***	0.301***	0.179*	0.283***
	(4.91)	(5.11)	(6.03)	(5.76)	(2.20)	(5.63)
Constant	3.359***	3.459***	3.361***	3.251***	4.019***	3.406***
	(12.22)	(11.92)	(14.16)	(12.25)	(9.72)	(13.48)
N	513	659	726	534	353	694
R^2	0.045	0.038	0.048	0.059	0.014	0.044

Notes: Panel regressions of duration, wage growth per pay round and annualized wage growth on inflation information available at the survey in November 2022 (realized inflation until 2021 and inflation expectations from the Gemeinschaftsdiagnose after 2021). Averages for three years 2017-2019 and 2021-2024. Regressions by factor: adjustment due to collective agreements, wage competition by other firms, expected labor supply/supply of skilled workers, focus on the inflation rate, changes in sales prices, and changes in labor demand. Importance of factors elicited on a scale from 0 (no importance) to 10 (very high importance). Corresponding columns include firms that responded with a value of five or more.

Table B.4: Extensive margin and firm size: robustness checks

	2017-2019				2022-2024			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
log(employees)	-0.54***	-0.69***	-0.70***	-0.68***	-0.30*	-0.41**	-0.44**	-0.078
	(0.19)	(0.21)	(0.24)	(0.24)	(0.17)	(0.19)	(0.21)	(0.25)
Observations	423	421	405	394	403	400	386	301
R^2	0.018	0.091	0.109	0.121	0.007	0.098	0.143	0.153
1-Digit Sector FE		✓				✓		
2-Digit Sector FE			✓	✓			✓	✓
Add. Controls				✓				✓

Notes: This table shows the regression results for the duration of pay agreements in the periods 2017-2019 and 2022-2024 on firm size with different sets of controls: no controls, 1-Digit sector fixed effects, 2-Digit sector fixed effects, 2-Digit sector fixed effects and controlling for the share of part-time workers, share of temporary workers, share of trainees, and a dummy for family business. Standard errors are in parentheses. * p<0.10, ** p<0.05, * * * p<0.01.

Table B.5: Intensive margin and size: robustness checks

	2017-2019				2022-2024			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
log(employees)	-0.13***	-0.098**	-0.10**	-0.083*	-0.075*	-0.049	-0.050	-0.032
	(0.037)	(0.041)	(0.044)	(0.045)	(0.043)	(0.048)	(0.051)	(0.054)
Observations	427	425	408	397	407	404	390	380
R^2	0.028	0.114	0.124	0.165	0.007	0.083	0.129	0.135
1-Digit Sector FE		✓				✓		
2-Digit Sector FE			✓	✓			✓	✓
Add. Controls				✓				✓

Notes: This table shows the regression results for wage adjustment in percent in the periods 2017-2019 and 2022-2024 on firm size with different sets of controls: no controls, 1-Digit sector fixed effects, 2-Digit sector fixed effects, 2-Digit sector fixed effects and controlling for the share of part-time workers, share of temporary workers, share of trainees, and a dummy for family business. Standard errors are in parentheses. * p<0.10, ** p<0.05, * * * p<0.01.

Table B.6: Comparison of Wage Duration and Wage Growth Paths

	Wage Duration Path (%)	Wage Growth Path (%)
Flat	65.0	56.0
U-Shape	0.0	1.0
Inv. U-Shape	3.0	5.0
Increase	15.0	20.0
Decrease	15.0	17.0

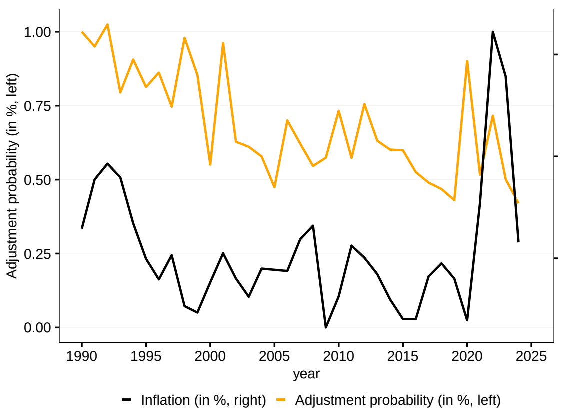
Notes: Wage duration and wage growth paths across groups of workers: unskilled workers, skilled workers without executive positions, and executives. *Flat* refers to the same duration/wage adjustment across workers, *U-Shape* to lower duration/lower wage adjustment for unskilled workers and executives, *Inverse U-Shape* to higher duration/wage adjustment for unskilled workers and executives, *Increase* to lower duration/wage adjustment for executives, and *Decrease* to lower duration/wage adjustment for low-skilled workers.

C Union Data Appendix

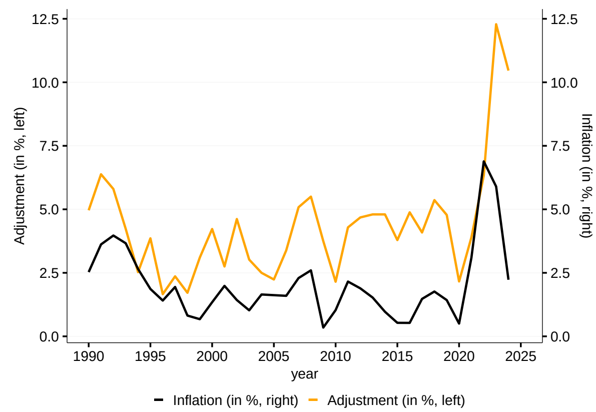
C.1 Additional figures

Figure C.1: Time series of adjustment probability, wage growth and inflation

(a) Extensive margin



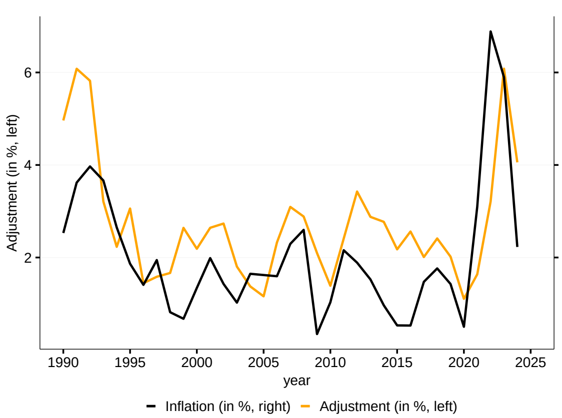
(b) Intensive margin



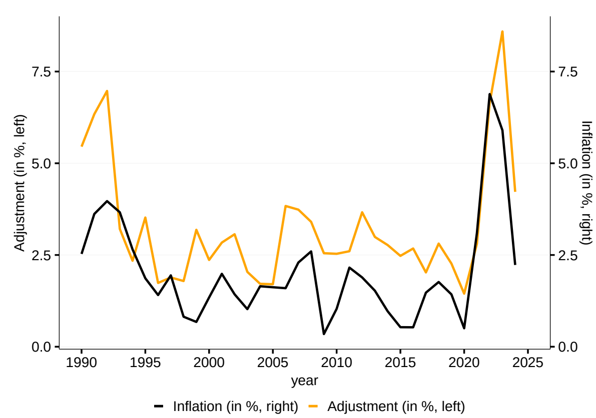
Notes: This figure shows the relation between the extensive margin (adjustment probability) and inflation and the intensive margin (wage adjustment) and inflation. In Panel (a), the orange line reflects the adjustment probability (calculated as $12/duration\,in\,months$) and the black line reflects the inflation rate in %; in Panel (b), the orange line reflects the wage adjustment in % and the black line reflects the inflation rate in %.

Figure C.2: Time series of annualized wage growth (with and without bonus payments) and inflation

(a) Annualized wage growth (without bonus payments)



(b) Annualized wage growth (with bonus payments)

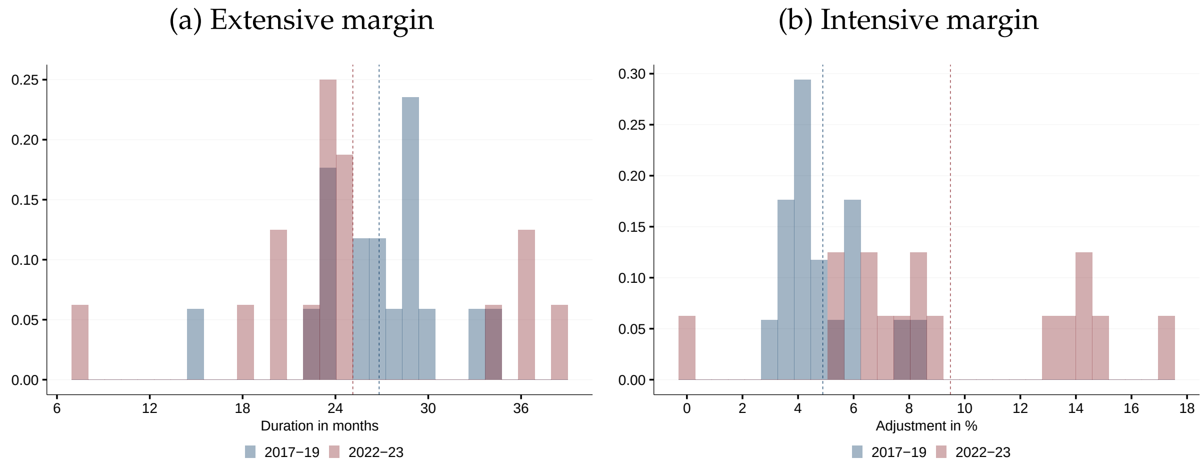


Notes: This figure shows the relation between annualized wage growth and inflation. In Panel (a), the orange line reflects the annualized wage growth excluding bonus payments in % and the black line reflects the inflation rate in %; in Panel (b), the orange line reflects the annualized wage growth including bonus payments in % and the black line reflects the inflation rate in %.

Figure C.3: Different measures of wage adjustments in times of low ($< 3\%$) and high ($> 3\%$) inflation

Notes: This figure shows different measures of wage adjustments (annualized wage, wage with bonus payments, and real wage) for collective bargaining agreements, split into environments of low inflation ($< 3\%$) in blue and high inflation ($> 3\%$) in red. The dotted vertical lines show the mean adjustment for each inflation environment.

Figure C.4: Wage setting behavior of labor unions in times of low (2017-19) and high inflation (2022-23)



Notes: This figure shows the duration of pay agreements (extensive margin) and the wage adjustment in percent (intensive margin) for collective bargaining agreements, split in times of low inflation (2017-19) in blue and high inflation (2022-24) in red. The dotted vertical lines show the mean adjustment for each inflation environment.

C.2 Additional tables

Table C.1: Summary statistics by union

	Union	Size (year)	Availability	Number of contracts	Mean Duration	Mean Adjustment
1	Metal industry	3,726,800 (2024)	1956 - 2024	49	17.2	5.8
2	Civil service, federal and local level	2,385,200 (2023)	1990 - 2023	20	21.0	4.3
3	Civil service, state level	1,100,000 (2023)	1990 - 2023	20	21.5	4.2
4	Chemical industry	586,800 (2024)	1990 - 2024	27	15.9	3.7
5	Retail sector	573,500 (2024)	1989 - 2024	23	19.3	4.1
6	Main construction industry	425,100 (2024)	1988 - 2024	24	19.5	4.8
7	Private transport and traffic industry	175,900 (2024)	1994 - 2024	17	23.2	5.0
8	Insurance sector	169,600 (2022)	1990 - 2022	21	19.7	4.0
9	Deutsche Post AG	160,000 (2023)	1987 - 2023	21	21.7	4.8
10	Deutsche Bahn AG	134,000 (2023)	1987 - 2023	22	20.9	4.4
11	Volkswagen AG	100,100 (2022)	1987 - 2022	23	19.3	4.4
12	Iron and steel industry	85,500 (2023)	1958 - 2023	50	16.2	5.7
$\boldsymbol{\Sigma}$ / $\tilde{x}$				317	19	4.8

Notes: This table presents summary statistics derived from the labor union data. The data comprises eleven distinct unions. The "size" column provides the number of union members for the most recent year, presented within parentheses. The "availability" column specifies the time duration during which the data captures collective agreements, along with the corresponding number of contracts recorded, as well as the mean duration and mean wage adjustment for each union. The last row presents the number of contracts, as well as the mean duration and mean wage adjustment in the full data.

Table C.2: Descriptive statistics for union data

	N	Mean	Std. dev.	Min	p25	p75	Max
Panel A: Main sample (1990 - 2024)							
Duration	259	19.5	7.0	7	13	24	47
Adjustment	259	4.3	2.5	0.0	2.9	5.4	17.3
Duration ($\pi < 3\%$)	212	19.9	7.0	8	13	24	47
Duration ($\pi > 3\%$)	47	17.6	7.0	7	12	24	38
Adjustment ($\pi < 3\%$)	212	3.9	2.0	0.0	2.8	4.8	17.3
Adjustment ($\pi > 3\%$)	47	6.1	3.4	0.0	4.4	6.7	14.7
Duration ($\pi < 2.5\%$)	187	20.4	6.8	8	14	24	47
Duration ($\pi > 2.5\%$)	72	17.1	7.1	7	12	23.2	44
Adjustment ($\pi < 2.5\%$)	187	3.8	2.0	0.0	2.8	4.8	17.3
Adjustment ($\pi > 2.5\%$)	72	5.4	3.2	0.0	3.0	6.5	14.7
Duration ($\pi < 3.5\%$)	220	20.0	7.0	8	14	24	47
Duration ($\pi > 3.5\%$)	39	16.2	6.4	7	12	20.5	38
Adjustment ($\pi < 3.5\%$)	220	3.9	2.1	0.0	2.7	4.8	17.3
Adjustment ($\pi > 3.5\%$)	39	6.5	3.1	0.0	5.4	6.8	14.7
Panel B: Full sample (1956 - 2024)							
Duration	317	19.0	7.1	7.0	12.0	24.0	47.0
Adjustment	317	4.8	2.8	0.0	3.0	5.9	18.3
Duration ($\pi < 3\%$)	244	19.8	7.1	8	13	24	47
Duration ($\pi > 3\%$)	73	16.2	6.4	7.0	12.0	21.0	38.0
Adjustment ($\pi < 3\%$)	244	4.3	2.4	0.0	2.9	5.3	18.3
Adjustment ($\pi > 3\%$)	73	6.5	3.3	0.0	4.8	7.5	15.3
Panel C: Comparison between 2017 – 2019 and 2022–2024							
Duration	33	26.0	6.3	7	24	29	38
Adjustment	33	7.1	4.0	0.0	4.3	8.5	17.3
Duration (2017–2019)	17	26.8	4.4	15	24	29	34
Duration (2022–2024)	16	25.1	7.9	7	21.5	27.2	38
Adjustment (2017–2019)	17	4.9	1.4	2.8	4.0	5.7	8.1
Adjustment (2022–2024)	16	9.5	4.6	0.0	6.5	14.0	17.3
Panel D: Industry collective agreements							
Duration	198	19.2	7.0	7	13	24	47
Adjustment	198	4.2	2.4	0.0	2.8	5.4	17.3
Duration ($\pi < 3\%$)	164	19.5	7.0	9	13	24	47
Duration ($\pi > 3\%$)	34	18.0	7.3	7	12	23.5	38
Adjustment ($\pi < 3\%$)	164	3.8	2.1	0.0	2.6	4.8	17.3
Adjustment ($\pi > 3\%$)	34	6.0	3.2	0.0	4.8	6.7	14.0
Panel E: Firm collective agreements							
Duration	61	20.1	6.9	8	14	24	44
Adjustment	61	4.5	2.5	0.0	3.2	5.6	14.7
Duration ($\pi < 3\%$)	48	21.0	6.9	8	15	25.2	44
Duration ($\pi > 3\%$)	13	16.8	6.0	12	12	24	25
Adjustment ($\pi < 3\%$)	48	4.0	1.6	0.0	3.2	5.1	7.0
Adjustment ($\pi > 3\%$)	13	6.3	4.1	1.5	3.0	6.5	14.7

Notes: This table presents summary statistics for the duration of pay agreements (in months) and wage adjustment per contract (in percent). Panel A shows the main sample (1990 – 2024), Panel B refers to the full sample (1956 – 2024), Panel C compares the periods from 2017–2019 and 2022–2024, and Panels D and E respectively focus on industry- and firm collective agreements.

Table C.3: Alternative measures of adjustment

	N	Mean	Std. dev.	Min	p25	p75	Max
Panel A: Baseline Adjustment							
Baseline Adjustment	259	4.3	2.5	0.0	2.9	5.4	17.3
Adjustment ($\pi < 3\%$)	212	3.9	2.0	0.0	2.8	4.8	17.3
Adjustment ($\pi > 3\%$)	47	6.1	3.4	0.0	4.4	6.7	14.7
Panel B: Annualized Adjustment							
Annualized Adjustment	259	2.8	1.5	0.0	1.8	3.1	8.1
Annualized Adjustment ($\pi < 3\%$)	212	2.4	1.1	0.0	1.7	2.8	6.5
Annualized Adjustment ($\pi > 3\%$)	47	4.4	2.2	0.0	3.0	6.1	8.1
Panel C: Adjustment with bonus payments							
Adjustment with bonus payments	259	5.0	2.9	0.0	3.3	6.0	19.4
Adjustment with bonus payments ($\pi < 3$)	212	4.4	2.1	0.0	3.2	5.4	17.3
Adjustment with bonus payments ($\pi > 3$)	47	7.7	4.3	1.4	5.0	8.7	19.4
Bonus payments (in %)	259	0.7	1.2	0.0	0.0	0.9	6.9
Panel D: Real Wage							
Real Wage	259	2.3	2.2	-6.9	1.2	3.4	15.0
Real Wage ($\pi < 3$)	212	2.4	2.0	-1.6	1.3	3.5	15.0
Real Wage ($\pi > 3$)	47	1.8	3.1	-6.9	-0.3	2.9	10.6

Notes: This table provides summary statistics for alternative measures of adjustment. Panel A shows the baseline adjustment, Panel B the annualized adjustment (i.e. the baseline adjustment that is normalized to a duration of 12 months), Panel C the adjustments with the amount of bonus payments, with the bonus payments given in an additional row, and Panel D the real wage (i.e. the difference between baseline adjustment and inflation),

Table C.4: Regressions of alternative measures of adjustment on inflation

	Baseline	Annualized	Bonus	Real
	(1)	(2)	(3)	(4)
Inflation	0.627***	0.638***	0.696***	−0.373***
	(0.138)	(0.082)	(0.145)	(0.138)
Union-region FE	✓	✓	✓	✓
Other controls	✓	✓	✓	✓
Observations	259	259	259	259
Adjusted R^2	0.316	0.382	0.468	0.160

Notes: This table shows regression results for alternative measures of adjustment of labor union contracts for data from 1990 to 2024. All columns include union-region fixed effects and other controls such as GDP growth, unemployment rate, variance of the monthly inflation rate (all for Germany) and EPU index (for the EU) in each year. Standard errors are in parentheses. * p<0.10, ** p<0.05, *** p<0.01.

Table C.5: Regressions of duration and wage increase on inflation in $t-1$, t, and $t+1$

	Duration (in Months)			Wage Increase (in percent)		
	(1)	(2)	(3)	(4)	(5)	(6)
Inflation	-0.927^{**}			0.627^{***}		
	(0.425)			(0.138)		
Inflation t-1		-1.124^{***}			0.804^{***}	
		(0.330)			(0.101)	
Inflation t+1			-2.099^{***}			0.372^{**}
			(0.494)			(0.171)
Union-region FE	✓	✓	✓	✓	✓	✓
Other controls	✓	✓	✓	✓	✓	✓
Observations	259	259	259	259	259	259
Adjusted R^2	0.205	0.227	0.246	0.316	0.412	0.272

Notes: This table shows regression results for the duration (in months, panels 1 to 3), and the wage increase (in percent, panels 4 to 6) of labor union contracts for data from 1990 to 2024. Panels 1 and 4 give the baseline pooled OLS results, panels 2 and 5 (3 and 6) use inflation in the preceding (subsequent) year as the main predictor. All columns include union-region fixed effects and other controls such as GDP growth, unemployment rate, variance of the monthly inflation rate (all for Germany) and EPU index (for the EU) in each year. Standard errors are in parentheses. * $p<0.10$, ** $p<0.05$, *** $p<0.01$.

D Modeling Wage Stickiness: Details

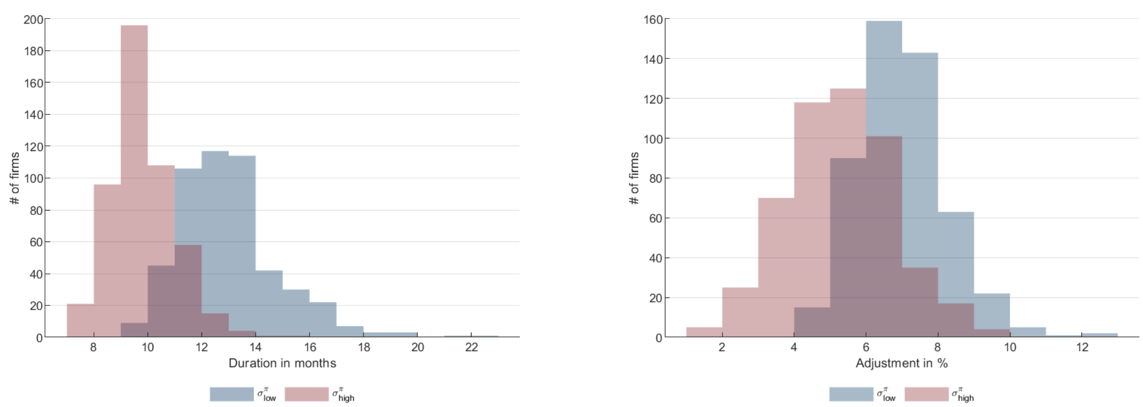
Table D.1: Calibration of model parameters

Parameter	Description	Value
β	Discount factor of household	$0.9943^{(1/3)}$
ϵ	Elasticity of labor supply	5
γ	Menu cost of resetting wage	0.056
ρ_a	Persistence of productivity shock	0.8
σ_a	Standard deviation of productivity shock	0.053
σ_μ	Standard deviation of monetary shock	0.015

Figure D.1: Wage-setting behavior in times of low and high volatility (menu cost model)

(a) Extensive margin

(b) Intensive margin



Notes: This figure shows the duration of pay agreements (extensive margin) and the wage adjustment in % (intensive margin) for the simulated data (500 firms for 500 periods) varying the standard deviation of the inflation rate, σ_μ. The blue shaded bars reflect the low volatility period, with σ_μ set to 0.32%, and the red shaded bars reflect the high volatility period, with σ_μ set to 0.64%.

E New Keynesian Model: Details

Here we provide the derivation of the New Keynesian model with state-dependent wage setting.

Households

Consider a continuum of identical households, each deriving utility from consumption C_t and disutility from labor supply L_t. The flow utility function is given by:

$$U(C_t, L_t) = \frac{C_t^{1-\sigma}}{1-\sigma} - \psi \frac{L_t^{1+\chi}}{1+\chi},$$

where σ is the intertemporal elasticity of substitution, and χ represents the inverse of the Frisch elasticity of labor supply. The parameter β denotes the household's discount factor applied to future utility. The households budget constraint in real terms is:

$$C_t + B_t \leq mrs_t L_t + R_{t-1}\Pi_t^{-1} B_{t-1} + Div_t, \tag{50}$$

requiring that expenditures on consumption and savings, B_t, cannot exceed the sum of labor income, $mrs_t L_t$, the real return on last period's savings, $R_{t-1}\Pi_t^{-1}B_{t-1}$, and dividend income, Div_t. Π_t is gross inflation defined as the change in the price of consumption goods between period t and $t-1$.

Solving the household's maximization problem yields the following first-order conditions:

$$\psi L_t^{\chi} = C_t^{-\sigma} mrs_t \tag{51}$$

$$1 = R_t \mathbb{E}_t \Lambda_{t,t+1} \Pi_{t+1}^{-1} \tag{52}$$

$$\Lambda_{t,t+1} = \beta \left(\frac{C_{t+1}}{C_t} \right)^{-\sigma}. \tag{53}$$

Labor Markets

Households sell their labor to unions at the marginal rate of substitution mrs_t. The unions provide differentiated labor services to labor aggregators who, in turn, sell aggregate labor input to wholesale firms. The unions thus act as the wage setters in this model, taking both the mrs_t as well as the demand curve for their labor as given. We start with deriving the labor demand curve and then discuss wage setting by the unions.

Labor aggregators. The labor aggregators bundle differentiated union labor l into a final labor input using a CES technology, where ϵ^w is the elasticity of substitution across different types of labor:

$$L_t^d = \left[\int_0^1 L_t^d(l)^{\frac{\epsilon^w - 1}{\epsilon^w}} dl \right]^{\frac{\epsilon^w}{\epsilon^w - 1}}$$

Profit maximization of the labor aggregators yields a demand curve for each union's labor and an aggregate wage index:

$$L_t^d(l) = \left(\frac{W_t(l)}{W_t} \right)^{-\epsilon^w} L_t^d$$

$$W_t^{1-\epsilon^w} = \int_0^1 W_t(l)^{1-\epsilon^w} dl$$

Unions. Unions repackage differentiated labor from the households for resale to the labor aggregator. The unions maximize income subject to the labor aggregator's demand function, expressed in real terms:

$$div_t^u(l) = W_t(l) \left(\frac{W_t(l)}{W_t} \right)^{-\epsilon^w} P_t^{-1} L_t^d - mrs_t \left(\frac{W_t(l)}{W_t} \right)^{-\epsilon^w} L_t^d,$$

where mrs_t denotes the worker's marginal rate of substitution between labor and consumption.

The unions face a nominal rigidity and can only adjust their wage with a probability of $(1 - \theta_t^w)$ in any given period t. This makes their wage decision problem dynamic, accounting for the fact that the wage might remain effective for multiple periods. The unions' optimization problem is to maximize future real dividends discounted by the stochastic discount factor, $\Lambda_{t,t+j}$. The union has to take into account the probability that the wage set at time t will remain in place $t + j$ periods later, which we will denote by $\Theta_{t,t+j}^w$ and is given by:

$$\Theta_{t,t+j}^w = \theta_{t+1}^w \theta_{t+2}^w ... \theta_{t+j}^w.$$

We also define $\Theta_{t,t}^w = 1$. Note that with a fixed probability θ^w, as in the baseline model, we would have: $\Theta_{t,t+j}^w = (\theta^w)^j$.

The union's optimization problem is:

$$\max_{W_t(l)} \mathbb{E}_t \sum_{j=0}^{\infty} \Theta_{t,t+j}^w \Lambda_{t,t+j} \{ W_t(l)^{1-\epsilon^w} W_{t+j}^{\epsilon^w} P_{t+j}^{-1} L_{t+j}^d - mrs_{t+j} W_t(l)^{-\epsilon^w} W_{t+j}^{\epsilon^w} L_{t+j}^d \}$$

The first-order condition for this problem is:

$$(1-\epsilon^w)W_t(l)^{-\epsilon^w}\mathbb{E}_t\sum_{j=0}^{\infty}\Theta^w_{t,t+j}\Lambda_{t,t+j}W^{\epsilon^w}_{t+j}P^{-1}_{t+j}L^d_{t+j}+\epsilon^w W_t(l)^{-\epsilon^w-1}\mathbb{E}_t\sum_{j=0}^{\infty}\Theta^w_{t,t+j}\Lambda_{t,t+j}mrs_{t+j}W^{\epsilon^w}_{t+j}L^d_{t+j}=0$$

The reset wage, $W_t^{\#}$ is independent of l and can be rewritten as:

$$W_t^{\#}=\frac{\epsilon^w}{(1-\epsilon^w)}\frac{\mathbb{E}_t\sum_{j=0}^{\infty}\Theta^w_{t,t+j}\Lambda_{t,t+j}mrs_{t+j}W^{\epsilon^w}_{t+j}L^d_{t+j}}{\mathbb{E}_t\sum_{j=0}^{\infty}\Theta^w_{t,t+j}\Lambda_{t,t+j}W^{\epsilon^w}_{t+j}P^{-1}_{t+j}L^d_{t+j}}$$

The reset wage is determined by the present discounted sum of future marginal rates of substitution. Note that the reset wage positively depends on expected inflation, which is consistent with our evidence. We can write the wage-setting problem recursively as follows:

$$w_t^{\#}=\frac{\epsilon^w}{(1-\epsilon^w)}\frac{f_{1,t}}{f_{2,t}}, \tag{54}$$

$$f_{1,t}=mrs_t w_t^{\epsilon^w}L_t^d+\theta_t^w\mathbb{E}_t\Lambda_{t,t+1}\Pi_{t+1}^{\epsilon^w}f_{1,t+1}, \tag{55}$$

$$f_{2,t}=w_t^{\epsilon^w}L_t^d+\theta_t^w\mathbb{E}_t\Lambda_{t,t+1}\Pi_{t+1}^{\epsilon^w-1}f_{2,t+1}, \tag{56}$$

where we define the real reset wage as $w_t^{\#}=W_t^{\#}/P_t$ and the gross inflation rate as $\Pi_t=P_t/P_{t-1}$.

The expected duration of a wage change conditional of information at time t is given by

$$d_t=\mathbb{E}_t\left[(1-\theta_t^w)+\theta_t^w(1-\theta_{t+1}^w)2+\theta_t^w\theta_{t+1}^w(1-\theta_{t+2}^w)3+...\right]. \tag{57}$$

Expected duration one period ahead is then given by

$$\mathbb{E}_t d_{t+1}=\mathbb{E}_t\left[(1-\theta_{t+1}^w)+\theta_{t+1}^w(1-\theta_{t+2}^w)2+\theta_{t+1}^w\theta_{t+2}^w(1-\theta_{t+3}^w)3+...\right].$$

Let us define the auxiliary variable ζ_t as follows:

$$\begin{aligned}\zeta_t &\equiv d_t-\theta_t^w\mathbb{E}_t d_{t+1}\\ &=\mathbb{E}_t\left[(1-\theta_t^w)+\theta_t^w(1-\theta_{t+1}^w)+\theta_t^w\theta_{t+1}^w(1-\theta_{t+2}^w)+...\right]\\ &=(1-\theta_t^w)+\theta_t^w\mathbb{E}_t\zeta_{t+1}\end{aligned}$$

Now re-insert the definition of ζ_t in the last equation and use the law of iterated expectations, i.e., $\mathbb{E}_t\mathbb{E}_{t+1}d_{t+j}=\mathbb{E}_t d_{t+j}$:

$$d_t-\theta_t^w\mathbb{E}_t d_{t+1}=(1-\theta_t^w)+\theta_t^w\mathbb{E}_t(d_{t+1}-\theta_{t+1}^w d_{t+2})$$

Rearranging this expression leads to

$$d_t = (1-\theta_t^w) + 2\theta_t^w \mathbb{E}_t d_{t+1} - \theta_t^w \mathbb{E}_t \theta_{t+1}^w d_{t+2},$$

which is (21) shown in the main text.

Production

The goods production process is split into three sectors: a representative wholesale firm, retail firms, and a final goods firm. We start by describing the production model blocks backward along the supply chain.

Final goods firm. The competitive final goods firm combines differentiated input goods, $Y_t(f)$, from the wholesale firms, bundles and repackages them into a homogeneous final good sold to the households, where the different varieties are denoted by f. The final goods firm's technology is:

$$Y_t = \left[\int_0^1 Y_t(f)^{\frac{\epsilon_p - 1}{\epsilon_p}} df\right]^{\frac{\epsilon_p}{\epsilon_p - 1}}$$

where ϵ_p reflects the elasticity of substitution across intermediate inputs. The final goods firms first-order condition in real terms is:

$$Y(f)_t = \left(\frac{P_t(f)}{P_t}\right)^{-\epsilon_p} Y_t$$

$$P_t^{1-\epsilon_p} = \int_0^1 P_t(f)^{1-\epsilon_p} df$$

Retail firms. The retail firms buy differentiated wholesale goods from the wholesale firm at price, MC_t, and transform them into a final good and sell it to a competitive final goods at price, $P_t(f)$, taking into account the demand function of the final goods firm:

$$DIV_t^r(f) = P_t(f)\left(\frac{P_t(f)}{P_t}\right)^{-\epsilon_p} Y_t - MC_t \left(\frac{P_t(f)}{P_t}\right)^{-\epsilon_p} Y_t$$

Retailers face a nominal rigidity and can only adjust their price with a probability of $(1-\theta^p)$. This makes their price decision problem dynamic, accounting for the fact that the price might remain effective for multiple periods. The retailers' maximization problem is to maximize future real dividends discounted by the stochastic discount factor, $\Lambda_{t,t+1}$:

$$\max_{P_t(f)} = \mathbb{E}_t \sum_{j=0}^{\infty} \theta^{p,j} \Lambda_{t,t+j} \{P_t(f)^{1-\epsilon^p} P_{t+j}^{\epsilon^p - 1} Y_{t+j} - MC_{t+j} P(f)_t^{-\epsilon^p} P_{t+j}^{\epsilon^p-1} Y_{t+j}\} \tag{58}$$

The first-order condition is:

$$(1-\epsilon^p) P_t(f)^{-\epsilon^p} \mathbb{E}_t \sum_{j=0}^{\infty} \theta^{p,j} \Lambda_{t,t+j} P_{t+j}^{\epsilon^p-1} Y_{t+j} + \epsilon^p P_t(f)^{-\epsilon^p-1} \mathbb{E}_t \sum_{j=0}^{\infty} \theta^{p,j} \Lambda_{t,t+j} MC_{t+j} P_{t+j}^{\epsilon^p-1} Y_{t+j} = 0 \tag{59}$$

The optimal reset price, $P_t^{\#}$, is independent of f allowing us to simplify the equation to:

$$P_t^{\#} = \frac{\epsilon^p}{(1-\epsilon^p)} \frac{\mathbb{E}_t \sum_{j=0}^{\infty} \theta^{p,j} \Lambda_{t,t+j} MC_{t+j} P_{t+j}^{\epsilon^p-1} Y_{t+j}}{\mathbb{E}_t \sum_{j=0}^{\infty} \theta^{p,j} \Lambda_{t,t+j} P_{t+j}^{\epsilon^p-1} Y_{t+j}} \tag{60}$$

This can be simplified and expressed recursively:

$$P_t^{\#} = \frac{\epsilon^p}{(1-\epsilon^p)} \frac{X_{1,t}}{X_{2,t}}$$

$$X_{1,t} = MC_t P_t^{\epsilon^p-1} Y_t + \theta^p \Lambda_{t,t+j} X_{1,t+1}$$

$$X_{2,t} = P_t^{\epsilon^p-1} Y_t + \theta^p \Lambda_{t,t+j} X_{2,t+1}$$

To transform this into real variables, $x_{1,t}$ and $x_{2,t}$ are defined as $x_{1,t} = \frac{X_{1,t}}{P_t^{\epsilon^p}}$ and $x_{2,t} = \frac{X_{2,t}}{P_t^{\epsilon^p-1}}$. Then the last expression becomes:

$$x_{1,t} = mc_t Y_t + \theta^p \mathbb{E}_t \Lambda_{t,t+1} \Pi_{t+1}^{\epsilon^p} x_{1,t+1} \tag{61}$$

$$x_{2,t} = Y_t + \theta^p \mathbb{E}_t \Lambda_{t,t+1} \Pi_{t+1}^{\epsilon^p-1} x_{2,t+1} \tag{62}$$

$$\Pi_t^{\#} = \frac{\epsilon^p}{(1-\epsilon^p)} \frac{x_{1,t}}{x_{2,t}} \tag{63}$$

Wholesale firms. The representative wholesale firm hires labor from the labor aggregator to produce output, Y_t^w, and sells it to the retail firms at price, mc_t, where the superscript w stands for wholesale. The production function of the firm is linear:

$$Y_t^w = L_t^d \tag{64}$$

The representative wholesale firm maximizes dividends subject to the production function and taking wages and prices as given:

$$DIV_t^w = MC_t Y_t^w - W_t L_t^d$$

The wholesale firm's first-order condition in real terms is:

$$w_t = mc_t, \tag{65}$$

where $w_t = W_t/P_t$ and $mc_t = MC_t/P_t$.

Monetary Policy.

The central bank sets the gross nominal interest rate, R_t, according to a standard Taylor rule:

$$\log R_t = (1-\rho^r)\log R + \log \rho^r R_{t-1} + (1-\rho^r)\rho^\pi(\log \Pi_t - \mu) + s_r \epsilon_t^r \tag{66}$$

where ρ^r determines the persistence of a monetary policy shock, and ρ^π governs the response to deviations of inflation from the steady-state rate, μ.

Aggregation and Market Clearing.

Given that in each period, a fraction $1-\theta_t^w$ of unions reset their wage to $W_t^{\#}$, while a fraction θ_t^w keeps the old wage, the aggregate wage index becomes:

$$W_t^{1-\epsilon^w} = (1-\theta_t^w)(W_t^{\#})^{1-\epsilon^w} + \theta_t^w W_{t-1}^{1-\epsilon^w},$$

which, expressed in real terms, turns out to be:

$$w_t^{1-\epsilon^w} = (1-\theta_t^w)(w_t^{\#})^{1-\epsilon^w} + \theta_t^w \Pi_t^{\epsilon^w-1} w_{t-1}^{1-\epsilon^w}.$$

Similarly, since a fraction $(1-\theta^p)$ of retailers reset their price while a fraction θ^p is stuck with the old price, the aggregate price index is:

$$P_t^{1-\epsilon^p} = (1-\theta^p)(P_t^{\#})^{1-\epsilon^p} + \theta^p P_{t-1}^{1-\epsilon^p}.$$

Defining reset inflation as $\Pi_t^{\#} = P_t^{\#}/P_t$ and the gross inflation rate $\Pi_t = P_t/P_{t-1}$, we can rewrite the last equation as follows:

$$\Pi_t^{1-\epsilon^p} = (1-\theta^p)(\Pi_t^{\#})^{1-\epsilon^p}\Pi_t^{\epsilon^p-1} + \theta^p,$$

.

Market clearing in the labor market requires that households' labor supply equal total labor demanded by unions, i.e.:

$$L_t = \int_0^1 L_t^d(l)dl.$$

Taking into account the labor demand function derived above, this becomes:

$$L_t = L_t^d v_t^w,$$

where v_t^w is a measure of wage dispersion which is defined recursively as:

$$v_t^w = (1-\theta_t^w)\left(\frac{W_t^{\#}}{W_t}\right)^{-\epsilon^w} + \theta_t^w \left(\frac{W_{t-1}}{W_t}\right)^{-\epsilon^w} v_{t-1}^w.$$

Wage dispersion can be stated in terms of real wages as follows:

$$v_t^w = (1-\theta_t^w)\left(\frac{w_t^{\#}}{w_t}\right)^{-\epsilon^w} + \theta_t^w \Pi_t^{\epsilon^w} \left(\frac{w_{t-1}}{w_t}\right)^{-\epsilon^w} v_{t-1}^w.$$

Likewise, clearing of the market for final goods implies:

$$Y_t = Y_t^w / v_t^p,$$

with the price dispersion measure v_t^p defined analogously:

$$v_t^p = (1-\theta^p)(\Pi_t^{\#})^{-\epsilon^p} + \theta^p \Pi_t^{\epsilon^p} v_{t-1}^p.$$

Table E.1: Calibration for New Keynesian model with state-dependent wage setting

Parameter	Description	Value
β	Discount factor	$0.9943^{1/3*}$
σ	Elast. of intertemporal substitution	1
ϵ^p	Price elasticity of demand for goods	6^*
ϵ^w	Wage elasticity of labor supply	5^*
χ	Frisch elasticity of labor supply	1^*
ψ	Disutility of labor supply	0.8
θ^p	$1-$ Prob. of price change	0.917
σ_R	Standard dev. of monetary policy shock	0.0124
ρ_R	Taylor rule coefficient on interest rate	0.9^*
ρ_π	Taylor rule coefficient on inflation	2^*

Notes: Parameter values denoted with an asterisk are taken from Gerali et al. (2010) and converted to a monthly frequency.