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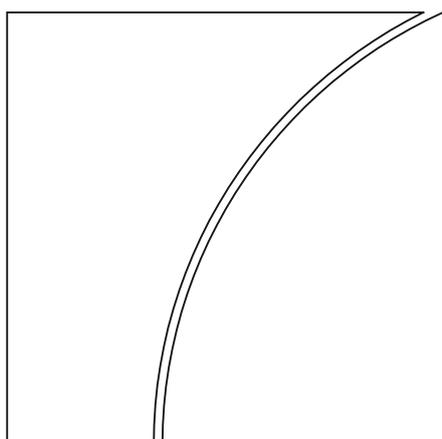
No 1341

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Monetary and Economic Department

March 2026



JEL classification: E23, E24, E31, E32, E52, J64

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ISSN 1020-0959 (print)
ISSN 1682-7678 (online)

Labour Market Flows, Unemployment and the Phillips Curve*

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March 2026

Abstract

We present empirical evidence from the United States demonstrating that labour market flows provide valuable insights into subsequent wage and price inflation. Specifically, we introduce a novel measure of the unemployment gap, defined as the difference between the unemployment rate implied by current labour market transitions—referred to as “flow-based unemployment”—and the observed, or stock-based unemployment, rate. Our findings reveal that inflationary pressures tend to subside when the unemployment gap becomes positive, i.e., when flow-based unemployment exceeds stock-based unemployment. To further investigate this relationship, we develop a search-and-matching model incorporating nominal wage rigidities and persistent (non-i.i.d.) shocks. In this framework, while firms face wage rigidities, they retain the ability to negotiate wages with new hires, making firms’ bargaining power endogenous and dependent on both stock- and flow-based unemployment. Consistent with our empirical results, the model demonstrates that a larger unemployment gap—whether driven by higher flow-based unemployment or lower stock-based unemployment—typically leads to lower wages, provided that shocks to transition probabilities exhibit sufficient persistence.

Keywords: Labour Market Flows, Unemployment Gap, Search-and-Matching, Nominal Rigidities, Inflation, Phillips Curve

JEL Classification codes: E23, E24, E31, E32, E52, J64

*We are grateful for comments and suggestions from seminar participants at the BIS and the University of Lausanne, in particular Gianluca Benigno, Simon Gilchrist, Aurélien Eyquem, Julio Leal, Benoit Mojon, Aysegül Sahin, Frank Smets, and Pascal St-Amour. We also thank conference participants at the AEA Annual Meeting 2026, the 15th BIS Consultative Council for the Americas Annual Research Conference on Labour markets, and the 40th EEA Congress. All potential errors are our own.

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1 Introduction

Inflation has returned to the forefront of economic concerns in the aftermath of the COVID-19 pandemic, as the world experienced one of the most severe episodes of price pressures in the past 40 years. In the United States, headline inflation surged from 1% in 2020 to nearly 9% in 2022, reaching levels not seen since the early 1980s. This inflationary spike created significant challenges, not only for households and firms, which faced higher costs for daily consumption and production inputs, but also for central banks, whose analytical frameworks were put to the test. Many leading central banks failed to anticipate the rapid acceleration of prices, and some initially underestimated the severity of the issue.

In this paper, we argue that paying closer attention to labour market transitions could have provided timely signals of inflationary pressures. More broadly, we provide evidence that labour market flows capture the underlying dynamics of wage and price pressures in ways that conventional measures of labour market or economic slack do not. Unlike stock-based measures, which offer static snapshots of labour market conditions, flow-based measures encode the directional momentum of labour market adjustments. We illustrate this mechanism through a stylized model, demonstrating how worker transitions between labour market states generate predictable dynamics in wages and prices.

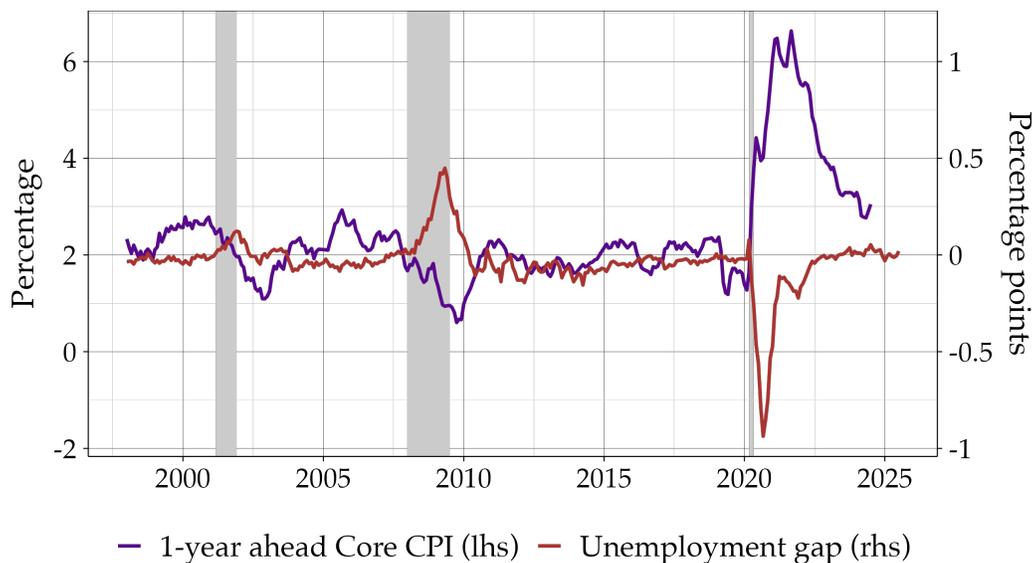
To construct our key measure—the unemployment gap—we distinguish between two perspectives on unemployment. The traditional, stock-based perspective evaluates the number (or stock) of unemployed workers relative to the total working-age population. In contrast, the flow-based perspective calculates the unemployment rate that would prevail given current labour market flows.¹ The unemployment gap, defined as the difference between flow-based and stock-based unemployment, exhibits a strikingly strong negative correlation with 12-month-ahead core CPI inflation.² This relationship is illustrated in Figure 1, where the purple line plots 12-month-ahead year-on-year core CPI inflation, and the red line shows our unemployment gap measure.

The intuition behind the unemployment gap lies in its ability to capture the directional momentum of labour market dynamics. This measure distills the complex system of worker transitions into a single indicator of whether the labour market is tightening or loosening. For example, when

¹For example, when flows out of unemployment exceed flows into unemployment, flow-based unemployment is low, regardless of the current stock-based unemployment rate. Conversely, when flows into unemployment dominate flows out, flow-based unemployment is high, irrespective of the stock-based measure.

²For instance, during the 2009 recession, the unemployment gap increased significantly as 1-year-ahead inflation dropped to near-zero levels. Conversely, during the post-COVID inflation surge, the unemployment gap turned deeply negative. The unemployment gap also correctly predicts the decline in inflation following the 2001 recession. Figure A1 in Appendix A shows that this relationship holds for wage inflation as well.

Figure 1: Higher flow-based relative to stock-based unemployment predicts lower inflation



Notes: The figure shows the time series for the 1-year ahead year-on-year core CPI inflation (consumer price index inflation excluding food and energy) and the unemployment gap. The gray areas indicate NBER recessions. *Data sources:* U.S. Bureau of labour Statistics; Authors' calculations.

the unemployment gap is positive—that is, when flow-based unemployment exceeds stock-based unemployment—the labour market dynamics point to rising future unemployment relative to current levels. This reflects labour market flows that imply a “terminal” or steady-state unemployment rate higher than the current rate.³ Conversely, a negative unemployment gap suggests that unemployment is likely to decline in the future relative to current levels. This directional information is crucial for understanding wage and price dynamics, as it is the trajectory of labour market tightness—rather than its current level alone—that drives emerging pressures on wages and prices.

1.1 The main empirical results

Our empirical analysis unfolds in two steps. First, we examine labour market flows data to establish the key statistical properties of our newly constructed unemployment gap. Second, we estimate time series regressions that link this indicator to subsequent price and wage inflation.

The labour market flows data is sourced from the Current Population Survey conducted by the U.S. Bureau of labour Statistics. Using this data, we calculate a matrix of monthly transition probabilities between employment, unemployment, and inactivity. At each point in time, we derive the corresponding steady-state distributions—i.e., the distribution of the population across employ-

³This interpretation assumes that the steady-state distribution of the labour market is both a fixed point and an attractor, meaning that the current labour market distribution, when deviating from the steady state, converges back to it over time.

ment, unemployment, and inactivity that would prevail if current transition probabilities persisted indefinitely.

The steady-state (or flow-based) unemployment rate, which reflects the fraction of the population that would be unemployed given current labour market transitions, closely tracks actual (stock-based) unemployment. On average, the unemployment gap (flow-based unemployment minus stock-based unemployment) is approximately -0.03 percentage points, with a standard deviation of 0.13 percentage points.⁴ However, there are notable periods when the two measures diverge significantly and remain apart for extended durations—most prominently during the Global Financial Crisis (positive gap) and the COVID-19 period (negative gap). Consistent with these observations, the unemployment gap exhibits counter-cyclical behavior.

Examining the peaks and troughs of the unemployment gap reveals interesting patterns. For instance, at peaks, the job-separation rate tends to rise and fall in tandem with the unemployment gap, while the job-finding rate steadily declines before and after the peak. The job-finding rate reverses and begins to increase only after a lag of approximately 10 months. This suggests that the initial decline in the unemployment gap is driven by a reduction in the separation rate. A plausible interpretation is that firms first stop laying off workers following a period of elevated separations and only later resume hiring, causing the job-finding rate to recover with a delay.

Conversely, the dynamics around unemployment gap troughs are less pronounced and often feature a period of stagnation before reversing. This asymmetry arises because peaks in the unemployment gap tend to be sharp but short-lived, whereas troughs are more gradual and prolonged. On average, positive gaps last approximately six months, while negative gaps persist for around 17 months.

At the core of our empirical analysis is evidence that the unemployment gap is a critical determinant of inflation dynamics, significantly enhancing on traditional slack measures. To establish this relationship, we estimate a series of structurally motivated predictive Phillips curve regressions, where future price and wage inflation are modeled as functions of current labour market dynamics.⁵

Our model performs particularly well during the COVID-19 period, when a sustained negative unemployment gap—indicating that observed unemployment would decline—kept upward pressure

⁴In this paper, both flow- and stock-based unemployment rates are expressed as a share of the working-age population, rather than the labour force. While reverting to the standard labour force definition would require a non-linear combination of steady-state employment and unemployment, this approach generally weakens empirical results. By contrast, our method explicitly accounts for inactivity, which is often overlooked in studies focusing on a two-state labour market. Notable exceptions include [Dixon et al. \(2015\)](#) and [Barnichon and Nekarda \(2012\)](#).

⁵These results are robust across sub-periods and hold for various alternative measures of inflation, including headline inflation, service inflation, Personal Consumption Expenditures (PCE) inflation, Unit labour Cost (ULC) inflation, and total employment cost inflation.

on wages and prices. The economic significance of fluctuations in the unemployment gap is substantial: a widening of the gap corresponding to a 1 percentage point increase in the unemployment rate over the next 12 months leads to a 1.3 percentage point decline in 12-month-ahead core CPI inflation. These results suggest that the Phillips curve slope is steeper than previously estimated.⁶

1.2 Our analytical framework

To account for our empirical findings, we develop a search-and-matching model with two states (employment and unemployment), enriched along three key dimensions. First, we incorporate sticky wages following the Calvo framework. Second, consistent with observed labour market practices, we assume that only pre-existing workers face sticky wages, while new hires can freely bargain their wages. Third, we introduce persistent shocks to transition probabilities. Using this framework, we aim to understand how shocks to the stock of unemployed workers and to flows between employment and unemployment affect equilibrium wages (and, consequently, prices).

First, considering a first-order approximation where the fraction of sticky-wage firms can be made arbitrarily small, we derive an analytical expression for equilibrium wages resulting from Nash bargaining between firms and workers. Specifically, we show that the average wage rate paid by sticky-wage firms can be expressed as the sum of: (i) the current flexible wage rate and (ii) a wage premium, which increases with (a) the fraction of old hires in the total workforce and (b) the previous period's flexible wage rate. This wage premium arises because sticky-wage firms bargain only with new hires, making them typically less conservative than firms with flexible wages. Consequently, sticky-wage firms are willing to pay a premium relative to their flexible-wage counterparts. Moreover, when the workforce has a larger fraction of old hires and fewer new hires, sticky-wage firms bargain with a smaller share of the workforce, further increasing their willingness to pay, and thereby enlarging the equilibrium wage premium.⁷

With this characterization of equilibrium wages, we now present our main results on how changes in stock- and flow-based unemployment affect equilibrium wages. Starting with stock-based unemployment, its impact on flexible wages, while initially counterintuitive, is relatively straightforward to explain. In our framework, employment is mean-reverting, meaning that higher stock-based unemployment typically predicts higher employment growth, as employment reverts to its steady

⁶For example, [Hazell et al. \(2022\)](#) estimate that a 1 percentage point increase in unemployment reduces inflation by approximately 0.34 percentage points, which is 4 to 5 times smaller than our estimates.

⁷These results imply that the dispersion of labour costs between flexible-wage and sticky-wage firms tends to increase with past flexible wages and/or with the fraction of old hires in the workforce. Both factors are typically pronounced during late expansion phases of the business cycle.

state.⁸ A match is more valuable to firms when employment growth is expected to accelerate, as higher growth increases the continuation value of a match. Firms are therefore willing to pay higher flexible wages when stock-based unemployment is high, reflecting the countercyclical value of a match for firms. For sticky-wage firms, higher unemployment reduces the fraction of old hires in the workforce, thereby lowering the equilibrium wage premium. However, legacy wages—paid to old hires—still increase, which is sufficient to push up the overall wage premium when firms’ bargaining power is sufficiently large.

Now, let us examine the impact of a fall in flow-based unemployment, which in our framework can result from either an increase in the employment retention rate or the hiring rate (corresponding to “employment-to-employment” and “unemployment-to-employment” transitions, respectively). Both transitions tend to boost employment growth—and the higher the persistence of the increase in transition probabilities, the more prolonged the impact on employment growth. Through higher employment growth, both transitions raise the continuation value of a match for firms, thereby increasing the wage rate firms are willing to pay.

However, the employment retention rate and the hiring rate also influence wages through two additional channels. First, a higher employment retention rate increases the continuation value of employment for workers, effectively *reducing* their wage demands. Conversely, a higher hiring rate raises the continuation value of unemployment for workers, thereby *increasing* their reservation wages and wage demands. As a result, shocks that raise the hiring rate typically push up flexible wages over a longer horizon than those that raise the employment retention rate.

Second, a higher employment retention rate increases the fraction of old hires, thereby *raising* the wage premium paid by sticky-wage firms. Conversely, a higher hiring rate increases the fraction of new hires, which *reduces* the wage premium paid by sticky-wage firms. As a result, shocks that raise the employment retention rate typically push up the average wage rate of sticky-wage firms over a longer horizon than shocks raising the hiring rate.

Considering these three channels together, we show that both the employment retention rate and the hiring rate tend to increase average wages for both flexible- and sticky-wage firms. This effect is more pronounced the more persistent the underlying shocks. These results align with the impact of transition probabilities on the unemployment gap, which typically decreases when the hiring rate or employment retention rate increases, with the magnitude of the effect growing as the persistence of the shocks increases.

⁸Mean-reversion reflects the fact that the employment retention rate and hiring rate cannot exceed one. Consequently, any fluctuations in the stock of employed or unemployed workers tend to dissipate over time.

1.3 Related literature

The economic literature has long debated the relationship between inflation and economic slack, i.e. the correct specification of the Phillips curve. The post-pandemic inflation surge has re-intensified this line of research. Key findings underscore the importance of inflation expectations (Hazell et al., 2022; Beaudry et al., 2024), of differentiating between the level and the change in inflation (Jørgensen and Lansing, 2019), and considering potential non-linearities in the Phillips curve with respect to the vacancy-to-unemployment (V/U) ratio (Benigno and Eggertsson, 2023) or the inflation level (Forbes et al., 2021). While Forbes et al. (2021) argue that the curve becomes nonlinear when inflation is below 3 percent, depending on whether there is positive slack (flat curve) or negative slack (steep curve), Benigno and Eggertsson (2023) famously advocate that the Phillips curve has a kink at a V/U ratio of one, suggesting that inflationary pressures rise more sharply when vacancies exceed unemployment.⁹

While the general specification of the Phillips curve remained very similar — defining inflation in terms of inflation expectations, supply shocks, and a measure of economic slack — the slack measure has varied quite a bit. Besides the output gap, the unemployment gap, or the unemployment rate, also the labour share of income (Galí and Gertler, 1999), and the V/U ratio (Benigno and Eggertsson, 2023; Ball et al., 2022; Michailat and Saez, 2024; Bernanke and Blanchard, 2023) have been used. Three other recent papers have investigated the correct specification of the economic slack measure, employing labour market factors. Crump et al. (2024) introduce a new measure of the natural unemployment rate, building on their earlier work (Crump et al., 2019). They argue that the post-pandemic inflation surge was driven by a rise in the natural rate, which stayed well above actual unemployment.¹⁰ Similarly, Michailat and Saez (2024) develop the *full-employment rate of unemployment* (FERU), defined as the unemployment rate that achieves social efficiency by minimizing unproductive labour use.¹¹ Finally, Hall and Kudlyak (2023) introduce the “anchored-inflation method” to identify a natural rate, which assumes that when inflation is at its anchored level, unemployment equals its natural rate. This implies that the natural rate of unemployment is more volatile, and closely tracks the actual rate during recoveries.¹² Heise et al. (2024) construct a new composite indicator of labour market tightness, defined as a weighted average of the quits rate and the vacancies-per-effective-searcher ratio. They use this measure to predict wage inflation, as captured by the Employment Cost Index

⁹In Benigno and Eggertsson (2024b) they look at international evidence of the L-shaped Phillips curve theory established in Benigno and Eggertsson (2023), and in Benigno and Eggertsson (2024a) they introduce the Beveridge threshold.

¹⁰Crump et al. (2024) define their measure of the natural rate of unemployment as the rate at which, after controlling for supply shocks, inflation is kept stable.

¹¹The FERU is defined as $u^* = \sqrt{uv}$, where u is the unemployment rate and v is the vacancy rate. The measure should identify the “unemployment rate that achieves the socially optimal allocation of labour”.

¹²For an analysis of various measures of the natural unemployment rate, see Bok et al. (2023).

(ECI), finding that it performs very well and is highly correlated with wage inflation. However, they do not use or look at labour market flows and rely purely on stock based data.

In a similar spirit we contribute to this literature by constructing a novel measure of economic slack. While the measures mentioned above rely on stock variables, we use flow data, and capture the dynamic aspects of the labour market.¹³ Similar to [Hall and Kudlyak \(2023\)](#), we argue that the steady state value that matters might be more volatile than assumed in previous studies.

A second strand of literature this paper contributes to is on labour market flows. While labour market flows data has been used in research on labour market developments, its application in relation to inflation has been limited.¹⁴ Some studies have examined the relationship between labour market dynamics and inflation by focusing on the on-the-job search and employment transitions ([Faccini and Melosi, 2023](#); [Fujita et al., 2024](#); [Moscarini and Postel-Vinay, 2023](#); [Pilossoph and Ryngaert, 2024](#)).¹⁵ [Elsby et al. \(2013\)](#) use data on unemployment inflows and outflows to decompose changes in the unemployment rate across OECD countries, showing that both flows contribute significantly. They construct a steady-state level of unemployment and attribute deviations from it to movements in inflow and outflow rates. In contrast to our approach, their steady-state concept relies solely on flows into and out of unemployment, without accounting for other labour market transitions. Moreover, they do not incorporate unemployment persistence as a key mechanism, nor do they explore its implications for inflation dynamics.

While most of these studies use individual labour market flows or ratios, we use all existing flows to construct a dynamic conditional steady-state measure for unemployment. The paper closest to ours is [Barnichon and Nekarda \(2012\)](#). They also construct a conditional steady-state unemployment rate, and show that it is a good leading indicator for the actual unemployment rate.¹⁶ However, compared to our paper they do not relate it to price dynamics.

For the theoretical part of this paper we build upon a well-established literature. Our contribution lies in how we model the search and matching framework, introduced by [Mortensen and Pissarides \(1994\)](#). [Shimer \(2005\)](#) and [Hall \(2005\)](#) later pointed out that the inclusion of wage rigidity significantly

¹³Our measure is therefore not directly comparable with the traditional meaning of a *natural* rate, as outlined in [Friedman \(1995\)](#); [Phelps \(1967, 1968\)](#) and used in early studies such as [Hall \(1974\)](#); [Hall et al. \(1970\)](#); [Gordon et al. \(1970\)](#); [Gordon \(1970\)](#).

¹⁴See e.g. [Donovan et al. \(2023\)](#); [Fallick and Fleischman \(2004\)](#); [Blanchard and Diamond \(1992\)](#); [Fontaine et al. \(2020\)](#) for studies looking at labour market flow and labour market developments.

¹⁵[Faccini and Melosi \(2023\)](#) and [Fujita et al. \(2024\)](#) investigate the correlation between *employment-to-employment* transitions and inflationary wage pressures, [Faccini and Melosi \(2023\)](#) find that a decline in on-the-job search activity contributes to easing in inflationary pressures. Expanding on this, [Moscarini and Postel-Vinay \(2023\)](#) look at misallocation of employment and wage growth. [Pilossoph and Ryngaert \(2024\)](#) argue that workers who anticipate higher inflation intensify their job search efforts, thereby exerting upward pressure on wages.

¹⁶Similarly [Şahin et al. \(2021\)](#) use labour market flows to predict the unemployment rate.

improves that framework to account for unemployment fluctuations. We will suggest a new approach on how this rigidity can be implemented. There are several papers looking at New Keynesian models with search and matching labour markets.¹⁷ Most closely related to our paper is [Gertler and Trigari \(2009\)](#). They introduce staggered multiperiod wage contracting to address the difficulty in accounting for volatile labour market activity over the business cycle. Our model builds on a similar framework and follows the same underlying logic. However, we depart from the assumption of [Gertler and Trigari \(2009\)](#) that firms with sticky wages pay the same wage to both new hires and pre-existing workers. By allowing firms to set different wages for different cohorts of workers, we provide a novel channel through which aggregate conditions affect firms bargaining power with new hires and thereby the dynamics of wages.

The paper is structured as follows. Section 2 discusses the data, the construction of flow-based unemployment, and the unemployment gap measure. In section 3, we develop the main building blocks of the empirical analysis and document the properties of the unemployment gap measure in predicting inflation. Section 4 proposes an analytical framework where wages and prices respond differently to changes in stock- and flow-based unemployment. We highlight, in particular the key role of endogenous bargaining power in replicating the empirical findings described in the previous section. Finally, conclusions are drawn in Section 8.

¹⁷See e.g. [Krause and Lubik \(2007\)](#), [Krause et al. \(2008\)](#), [Thomas \(2008\)](#), and [Blanchard and Galí \(2010\)](#).

2 Labour market flows and the unemployment gap

This section introduces the data and discusses the construction of the *flow-based unemployment rate* and the *unemployment gap* measure. We then review the key statistical properties of these two variables, comparing in particular flow- and stock-based unemployment. Finally, we establish the main business cycle properties and drivers of our unemployment gap measure.

2.1 Labour market flows

The Current Population Survey (CPS), published by the U.S. Bureau of labour Statistics (BLS) as part of the *labour Force Statistics* data, provides detailed information on labour market flows at a monthly frequency.¹⁸ The CPS covers the U.S. civilian non-institutional population aged 16 and older, with a monthly sample consisting of about 60,000 households. This survey contains a wealth of information, including current and past labour market status of individuals. Each individual can be in one of three mutually exclusive states: employed (e), unemployed (u), and inactive (i) (i.e. not in the labour force). The survey data allows to compute labour market flows between any of the three states, starting in January 1990.¹⁹ Transitions are naturally expressed as the conditional probabilities of switching to state y at date t given state x at date $t - 1$:

$$\Pr_t[y|x] = \frac{\text{date-}t \text{ flow from } x \text{ to } y}{\text{date-}t \text{ total flows out of } x}.$$

This yields a 3×3 transition matrix, which we denote M_t , and whose elements on each column sum up to one: $\Pr_t[e|x] + \Pr_t[u|x] + \Pr_t[i|x] = 1$, for $x = \{i; u; e\}$.

$$M_t = \begin{bmatrix} \Pr_t[e|e] & \Pr_t[e|u] & \Pr_t[e|i] \\ \Pr_t[u|e] & \Pr_t[u|u] & \Pr_t[u|i] \\ \Pr_t[i|e] & \Pr_t[i|u] & \Pr_t[i|i] \end{bmatrix}$$

Table 1 provides summary statistics for each transition probability. Several observations can be made. First, the probabilities for individuals to remain in the same state from one month to another, i.e. state-persistence, far exceed the probabilities to switch to another state. For example, unemployed workers typically stay unemployed with a 50% chance, while employed and inactive individuals stay so with more than 90% chance. Second, unemployed workers are almost as likely to find a

¹⁸The data can be accessed from the BLS website (www.bls.gov), or downloaded from FRED (fred.stlouisfed.org).

¹⁹Note that employment-to-employment transitions cover both workers keeping their job from one month to another and workers switching jobs, thereby ignoring on-the-job search. See [Faccini and Melosi \(2023\)](#); [Fujita et al. \(2024\)](#) for papers on this specific topic.

job next month as they are to leave the labour force and become inactive (20-25%). Third, despite the relatively high frequency of the data (monthly), transitions from employment and inactivity appear to be very stable over time, as is reflected in the very low standard deviation. Conversely, transitions from unemployment display more variability, with the job-finding probability ($\Pr_t[e|u]$) and unemployment persistence ($\Pr_t[u|u]$) being most volatile (4-5% standard deviations).²⁰ Finally, the separation rate ($\Pr_t[u|e]$) is on average very low, less than 1.5%, and never exceeds 4%.

Table 1: Summary statistics of monthly transition probabilities

Transition	Mean	S.D.	Skew.	Kurt.	10 th perc.	25 th perc.	50 th perc.	75 th perc.	90 th perc.
$\Pr_t[e e]$	95.85	0.7	-16.31	306.5	95.63	95.76	95.91	96.03	96.15
$\Pr_t[u e]$	1.351	0.56	13.48	237.3	0.98	1.17	1.32	1.5	1.66
$\Pr_t[i e]$	2.794	0.25	5.83	75.93	2.54	2.64	2.77	2.91	3.02
$\Pr_t[e u]$	25.56	4.21	-0.48	2.83	18.33	23.4	26.21	28.28	30.47
$\Pr_t[u u]$	52.09	5.55	0.51	2.52	45.75	48.17	51.14	55.75	60.52
$\Pr_t[i u]$	22.34	2.36	-0.02	5.18	19.12	20.83	22.63	24	25
$\Pr_t[e i]$	4.694	0.39	-0.02	2.62	4.15	4.42	4.72	4.95	5.2
$\Pr_t[u i]$	2.55	0.53	0.14	2.6	1.77	2.22	2.56	2.88	3.26
$\Pr_t[i i]$	92.76	0.53	0.48	3.22	92.18	92.4	92.64	93.15	93.53

Notes: Summary statistics are expressed in percent. *S.D.* stands for standard deviation. The reported numbers are based on monthly transition probabilities. *Data sources:* U.S. Bureau of labour Statistics; authors' calculations.

2.2 Flow-based unemployment & the unemployment gap

Let us now turn to the derivation of flow-based unemployment and the unemployment gap. Each transition matrix M_t has a steady-state, which corresponds to the distribution that would eventually prevail if current transitions were to perpetuate forever. Let \tilde{m}_t be the vector of steady-state employment, unemployment, and inactivity, such that $\tilde{m}_t = M_t \cdot \tilde{m}_t$. Then denoting $q_t[y|x] = \Pr_t[y|x] - \Pr_t[y|i]$, steady-state or flow-based unemployment \tilde{u}_t writes as:

$$\tilde{u}_t = \frac{(1 - q_t[e|e]) \cdot \Pr_t[u|i] + q_t[u|e] \cdot \Pr_t[e|i]}{(1 - q_t[u|u])(1 - q_t[e|e]) - q_t[e|u] \cdot q_t[u|e]}. \quad (2.1)$$

Equation (2.1) provides a very intuitive link between transition probabilities and unemployment.²¹ Flow-based unemployment \tilde{u}_t naturally increases with the transition probability from inactivity to

²⁰Appendix A looks in more details at labour market transition probabilities over different periods and business cycle phases.

²¹More details about the mathematical derivation can be found in Appendix B.

unemployment ($\Pr_t[u|i]$), but decreases with the transition probability from inactivity to employment $\Pr_t[e|i]$, given that $q_t[u|e] = \Pr_t[u|e] - \Pr_t[u|i]$ is on average negative (see Table 1). Similarly, a higher persistence of unemployment $\Pr_t[u|u]$ or a higher separation rate $\Pr_t[u|e]$, is unambiguously associated with higher flow-based unemployment \tilde{u}_t . Conversely, a higher persistence of employment $q_t[e|e]$ or a higher job-finding rate $q_t[e|u]$, are both associated with lower flow-based unemployment \tilde{u}_t . Using a similar notation, *stock-based* (or actual) unemployment is the sum of flows into unemployment. The fraction of unemployed workers in the working-age population u_t , therefore, writes as:

$$u_t = \Pr_t[u|i] + q_t[u|e] \cdot e_{t-1} + q_t[u|u] \cdot u_{t-1}. \quad (2.2)$$

As a result, the difference between flow- and stock-based unemployment, which we will refer to as the *unemployment gap*, denoted z_t , can be expressed as:

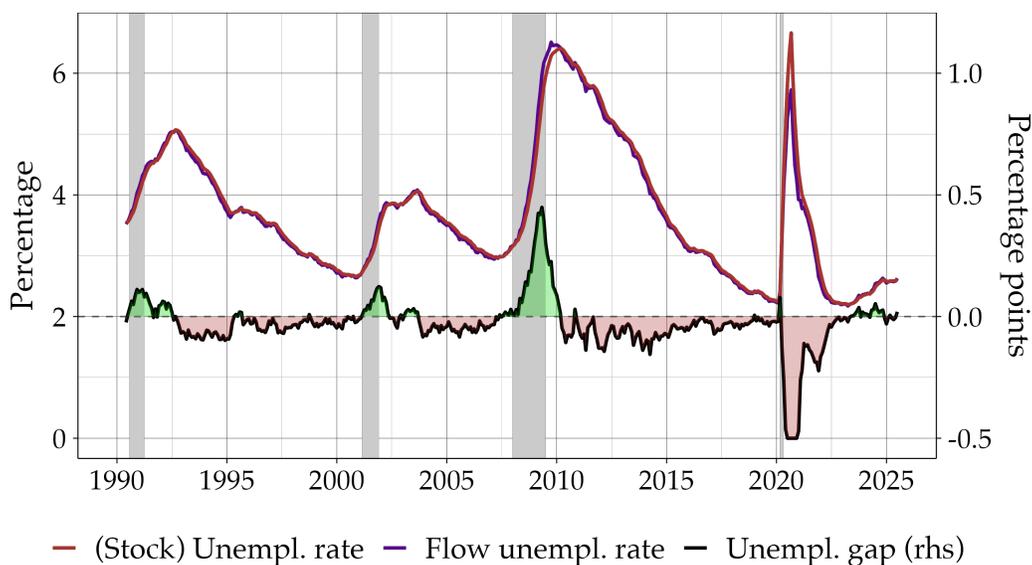
$$z_t = \tilde{u}_t - u_t = \left[\frac{(1 - q_t[e|e]) \cdot \Pr_t[u|i]}{(1 - q_t[u|u])(1 - q_t[e|e]) - q_t[e|u] \cdot q_t[u|e]} - u_{t-1} \right] q_t[u|u] + \left[\frac{\Pr_t[e|i] + q_t[e|u] \cdot \Pr_t[u|i]}{(1 - q_t[u|u])(1 - q_t[e|e]) - q_t[e|u] \cdot q_t[u|e]} - e_{t-1} \right] q_t[u|e]. \quad (2.3)$$

Expression (2.3) shows the central role of flows into unemployment in driving the unemployment gap, in particular the separation rate $\Pr_t[u|e]$ as well as unemployment persistence $\Pr_t[u|u]$, both of which are embedded in the counterpart q probabilities, $q_t[u|e]$ and $q_t[u|u]$.

Before we dive into the relationship between the unemployment gap and the different transition probabilities in more details, we analyse the unemployment gap over time. Figure 2 plots stock- and flow-based unemployment, as well as the gap as defined in Equation (2.3). For each series we use the 6-month backward looking moving average.²² The figure shows that stock- and flow-based unemployment display a striking level of similarity. The unemployment gap is therefore one to two orders of magnitude smaller than stock- or flow-based unemployment (more details in Table 2). Second, for most of the 35-year period covered in this graph, the unemployment gap has been negative with flow-based unemployment below stock-based unemployment, as indicated by the red areas. Third, periods of positive unemployment gap coincide with recession periods as labeled by the NBER, the clearest example being the Global Financial Crisis (GFC) of 2008.

²²We use a 6-month backward-looking moving average rather than, for example, the monthly gap or the gap calculated using the flow-based unemployment rate derived from compounded 3- or 6-period transition probabilities, for the following reasons. First, the moving average smooths the series and filters out short-term noise. More importantly, it requires a sustained deviation from zero to produce a significant gap. This implies that flow-based unemployment must be changing persistently for the gap to widen, reflecting the fact that flow-based unemployment is changing faster than stock-based unemployment can catch up (see Figure A4 in Appendix A for a graphical illustration of the different approaches). Besides the economic reasoning, also the empirical section will show that the 6-month moving average version performs better empirically and econometrically.

Figure 2: Unemployment rates and unemployment gap



Notes: The figure plots stock- and flow-based unemployment rates, both taken as 6-month backward-looking moving averages, as well as the unemployment gap computed as the difference between flow- and stock-based unemployment. All variables are expressed in percentages or percentage points, and the unemployment gap is truncated at -0.5 to ensure better visibility. Gray areas indicate NBER recessions. *Data sources:* U.S. Bureau of labour Statistics; authors' calculations.

Panel (a) in Table 2 provides summary statistics for the three unemployment measures and confirms previous conclusions. On average flow-based unemployment is barely different from stock-based unemployment, and the hypothesis of equal means cannot be rejected at standard confidence levels. Also, the two variables share very similar quantiles and moments.

Table 2: Summary statistics of unemployment measures

	Mean	S.D.	Skew.	Kurt.	10 th perc.	25 th perc.	50 th perc.	75 th perc.	90 th perc.
(a)									
Stock-based U	3.71	1.07	0.79	2.95	2.41	2.95	3.54	4.34	5.24
Flow-based U	3.68	1.06	0.81	3.03	2.41	2.94	3.51	4.26	5.19
U gap	-0.03	0.12	-2.47	22.82	-0.09	-0.06	-0.03	0	0.05
(b)									
Pos. gap length	5.94	7.9	2.19	7.63	1	1	2.5	7.75	14.3
Neg. gap length	16.58	24.35	2.08	7.22	1	1	6	27	39.2

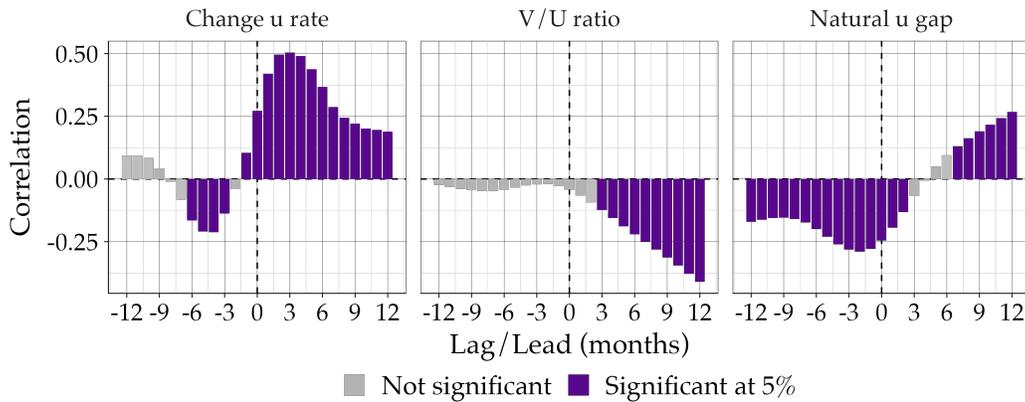
Notes: All summary statistics pertain to 6-month backward-looking moving averages of underlying variables, all expressed in percentage or in percentage points. Positive and negative gap length periods are expressed in months. S.D. stands for standard deviation, *Med.* for median. The positive and negative gap lengths are measured in months. *Data sources:* U.S. Bureau of labour Statistics; authors' calculations.

Yet, as noted above, the unemployment gap exhibits some asymmetry. Not only does it display a negative skewness, but, as panel (b) of Table 2 shows, spells of negative unemployment gaps also tend to last about 3 times longer than those of positive gaps (17 vs. 6 months). Finally, the kurtosis of the unemployment gap is very large, suggesting the existence of many extreme values, especially on the negative side.

2.2.1 Unemployment gap correlations

How does our unemployment gap measure compare with measures of labour market tightness or, broader economic slack? Figure 3 shows that contemporaneous correlations between our unemployment gap measure and standard measures of labour market tightness are low, if not insignificant altogether. For example, the contemporaneous correlation with the change in the unemployment rate is positive. An increase in the unemployment gap, i.e. an increase in flow-based unemployment relative to stock-based unemployment, is associated with rising unemployment. But the correlation only reaches 25%. Other measures, e.g. the vacancy-to-unemployment ratio, widely seen as a proxy for demand-supply imbalances on the labour market, are basically uncorrelated on a contemporaneous basis. Similarly the unemployment gap computed by the Congressional Budget Office (CBO) — calculated as the difference between actual and “natural” unemployment —, also displays a very low contemporaneous correlation.²³

Figure 3: Unemployment gap lead-lag correlations with labour market indicators



Notes: All measures are 6-month moving averages. *Change u rate* is the change over the last 6 months of the unemployment rate (measured as a share of the working age population). *V/U ratio* is the vacancy-to-unemployment ratio. The *Natural u gap* is the natural unemployment gap defined as the difference between the observed unemployment rate as a share of the labour force and the Congressional Budget Office’s *Noncyclical Rate of Unemployment*. *Data sources:* U.S. Bureau of labour Statistics; Congressional Budget Office; authors’ calculations.

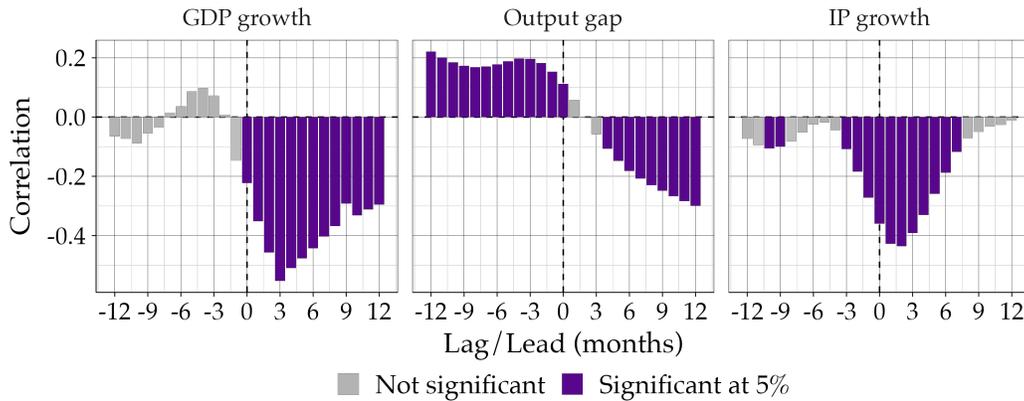
That said, when contemporaneous correlations are weak, examining leads and lags offers a very

²³Figure C5 in Appendix C.1 provides an illustration of alternative measures of gaps to the observed unemployment rate, as well as their correlation with the our unemployment gap in Table C1.

different perspective. For each of the three labour market indicators considered, an increase in our unemployment gap measure is followed by a significant loosening of labour market conditions — whether through rising unemployment or declining vacancies. For instance, an increase in the unemployment gap is typically followed, three to six months later, by higher unemployment levels, stronger unemployment growth, and a lower vacancy-to-unemployment ratio. In other words, the evidence on lead/lag correlations suggests that our unemployment gap measure is a leading indicator of the stance of the labour market.

Turning to output indicators, Figure 4 shows that qualitatively similar patterns tend to hold. The figure shows that an increase in the unemployment gap is associated with subsequent lower GDP growth, weaker output gap, and lower growth in industrial production (IP). For IP the drop tends to pre-date the change in the unemployment gap. Interestingly, while correlations with subsequent GDP and IP growths tend to fade away after about 8 months, correlations with subsequent output gaps tend to build up gradually over time. This gradual build-up in forward correlations also shows up for price and wage indicators. More details on that in Section 3.

Figure 4: Unemployment gap lead-lag correlations with business cycle indicators



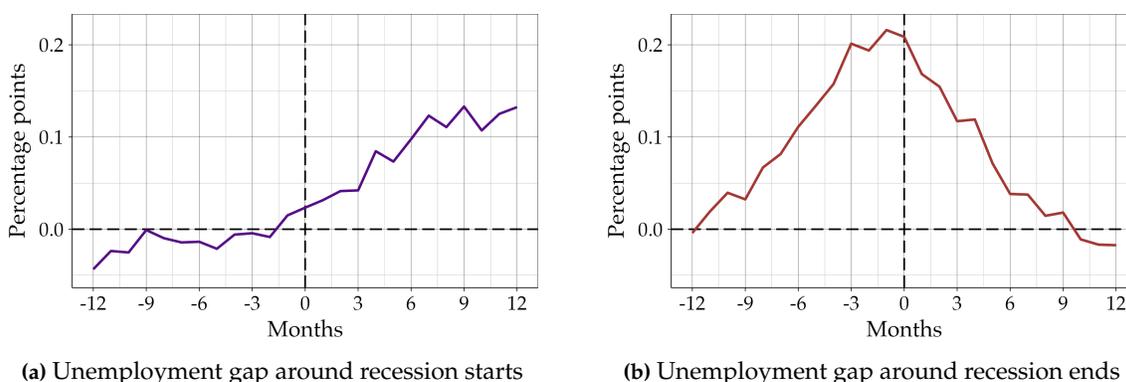
Notes: All measures are 6-month moving averages or last 6-month growth rates. The *Output gap* is calculated by the Congressional Budget Office. IP stands for industrial production. *Data sources:* U.S. Bureau of labour Statistics; Congressional Budget Office; authors' calculations.

2.2.2 The unemployment gap before, during, and after recessions

Looking at recession starts and ends — following the NBER classification of U.S. recessions — confirms the key role of flows into unemployment as cyclical drivers of the unemployment gap. Panel (a) in Figure 5 focuses on recession starts. The plot shows that the unemployment gap is stable and remains slightly negative up to two months before the start of a recession. Shortly before the start of the recession, it begins increasing in a consistent manner, first moving into positive territory and then

edging significantly higher over the 12 following months. This pattern — flat before the recession starts, then expanding once the recession has started — mainly reflects the evolution of transitions into unemployment, as can be seen in Figure 6. Each of these transitions follows a qualitatively similar pattern to that of the unemployment gap, roughly flat or slowly increasing *in the run-up* to the recession and then increasing significantly *once* the recession has started, cumulating more than a one standard deviation increase within 12 months in the case of unemployment persistence. It is worth mentioning that flows from inactivity into employment display a qualitatively similar (but opposite) evolution to that of the unemployment gap, as it cumulatively decreases by almost one and a half standard deviation over the 12 months following the start of a recession.

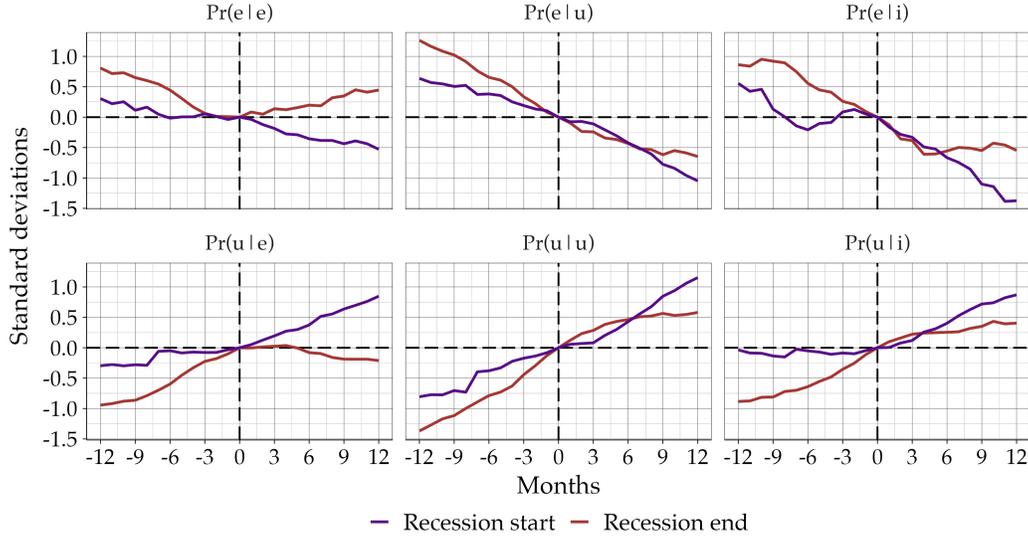
Figure 5: Unemployment gap before and after recession starts and ends



Notes: The figures plot the average unemployment gap around the start and end of (NBER-defined) recessions (excluding the COVID recession). The vertical dashed line indicates either the start or end month of the recession. *Data sources:* U.S. Bureau of labour Statistics; NBER; authors' calculations.

Conversely, Panel (b) in Figure 5 focuses on the end of recession periods. It shows that the unemployment gap follows an inverted V-shaped trajectory. The gap steadily increases in the months preceding the end of a recession, then starts falling some 2 months before the end of a recession, first very gradually and then more significantly, especially once the recession is officially over. The unemployment gap finally turns negative about 10 months after the recession ends. Looking at the evolution of transition probabilities around recession ends, we find that two opposite forces shape the dynamics of the unemployment gap. On the one hand, stickier unemployment in the form of higher “U-to-U” and lower “U-to-E” transitions contribute to push the unemployment gap up.

Figure 6: Transition probabilities around recession starts and ends



Notes: Figures plot average transition probabilities relative to the probability at the end of (NBER-defined) recession periods (excluding the COVID recession). Changes are expressed in standard deviations, based on each transition probability’s historical distribution. *Data sources:* U.S. Bureau of labour Statistics; NBER; authors’ calculations.

On the other hand, “E-to-E” and “E-to-U” transitions both display a non-monotonic pattern that is consistent with the evolution of the unemployment gap. Specifically, as the economy gears towards the end of the recession, both transitions contribute to an increase of the unemployment gap, as “E-to-E” transitions fall while “E-to-U” transitions rise. But once the end of the recession is passed, both transitions contribute to cut the unemployment gap, with “E-to-E” flows recovering, and “E-to-U” flows first stabilising and then starting a limited and gradual decrease. Importantly, the unemployment gap is quite sensitive to changes in flows from employment, i.e. “E-to-E” or “E-to-U” transitions. As noted above, “E-to-E” transitions being on average very high, even small changes in this transition probability have a large impact on flow-based unemployment. In addition, because employment tends to be relatively low around recession ends, changes in the “E-to-U” transition have little impact on stock-based unemployment but conversely have a large impact on flow-based unemployment. As a consequence, even a small reduction in “E-to-U” transitions (the separation rate) can lead to a significant fall in the unemployment gap.^{24,25}

In summary, our unemployment gap measure provides several insights. First, it summarises the

²⁴Using equation (2.1), one can easily check that flow-based unemployment \tilde{u} is increasing with the “E-to-U” transition, and more so, when flow-based unemployment \tilde{u} is higher, i.e. $\frac{\partial \tilde{u}_t}{\partial q_t(u|e)} > 0$ and $\frac{\partial^2 \tilde{u}_t}{\partial q_t(u|e) \partial \tilde{u}_t} > 0$. Similarly, using equation (2.2), it is straightforward to see that stock-based unemployment u_t is increasing with the “E-to-U” transition, and more so, when (stock-based) employment e_{t-1} is higher, i.e. $\frac{\partial u_t}{\partial q_t(u|e)} > 0$ and $\frac{\partial^2 u_t}{\partial q_t(u|e) \partial e_{t-1}} > 0$.

²⁵In Appendix A.1 the same exercise is done for peaks and troughs of the stock-based unemployment rate (Figure A2), and minima and maxima of the unemployment gap itself (Figure A3).

dynamics of the labour market in a single statistic. Second, the analysis of lead-lag correlations shows that the unemployment gap is a leading indicator for the labour market and business cycle. Last, it strongly co-moves with onsets and conclusions of recession periods. Main drivers of the unemployment gap around recession starts appear to be flows into unemployment, while improved employment prospects the fall in the gap towards the end of recessions.

2.2.3 Flow-based unemployment & unemployment gap: which transitions matter?

The goal of this section is to identify which transition probabilities matter most for our flow-based measure of unemployment as well as the unemployment gap. We proceed in two steps: First we compute a counter-factual measure of flow-based unemployment as well as the unemployment gap by sequentially holding one transition probability constant at its historical average, while allowing the remaining transition probability to vary according to the data. For both flow- and stock-based unemployment we compute six different counter-factuals, denoted as $\tilde{u}_t(y|x)$ and $u_t(y|x)$, where $y|x$ refers to the transition probability held constant (x to y) and $y = \{u; e\}$, $x = \{i; u; e\}$. Importantly, holding a transition probability constant not only affects the flow-based measure of unemployment, but also the actual employment, unemployment, and inactivity rates.

To determine which transitions matter for flow-based unemployment and the unemployment gap, we run a set of first-order approximations by plotting (regressing) the deviations of actual from counterfactual measure against deviations of the corresponding transition probability from its long-run average (defined in equations (2.4) and (2.5)).

$$\tilde{u}_t - \tilde{u}_t(y|x) = \tilde{\alpha}_{yx} + \tilde{\beta}_{yx}(\text{Pr}_t[y|x] - \text{Pr}[y|x]) + \tilde{\varepsilon}_{yx,t} \quad (2.4)$$

$$z_t - z_t(y|x) = \alpha_{yx} + \beta_{yx}(\text{Pr}_t[y|x] - \text{Pr}[y|x]) + \varepsilon_{yx,t} \quad (2.5)$$

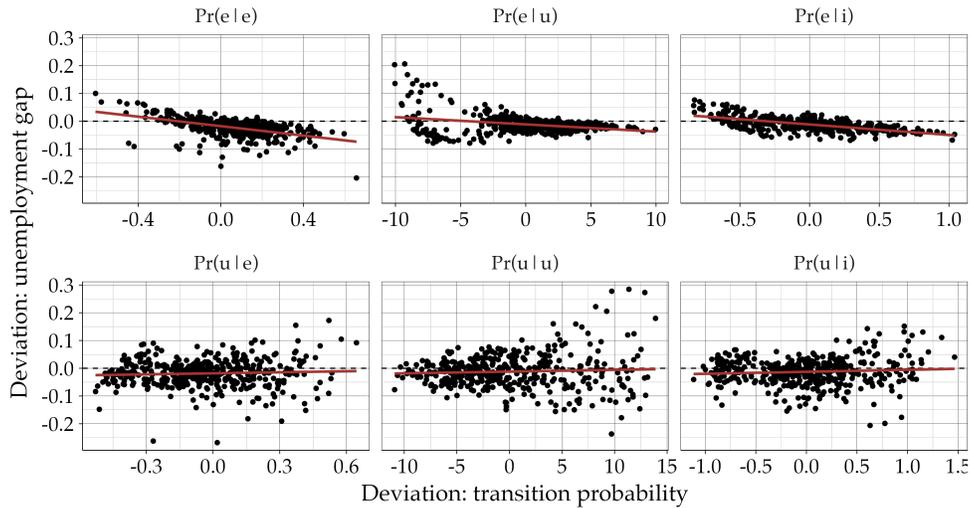
Intuitively, a transition probability $\text{Pr}_t[y|x]$ matters more for flow-based unemployment \tilde{u}_t (or for the unemployment gap z_t) when its deviations from the long-run average correlate more tightly with deviations from its counter-factual. Put differently, when changes in a transition probability provide a good (first-order) approximation of the changes in the actual measure relative to the counter-factual measure.

We find that flow-based unemployment depends first and foremost on flows into *unemployment*, i.e. "E-to-U", "I-to-U" and "U-to-U". Flows into employment are somewhat less important. By contrast, deviations are much larger when flows into *unemployment* are held constant. Therefore, abstracting from fluctuations in flows into employment does not significantly change the measure of flow-based unemployment, while ignoring fluctuations in flows into unemployment can open a

significant wedge between actual and counter-factual flow-based unemployment (see Figure C6 for a graphical illustration).

Applying the same methodology to the unemployment gap, Figure 7 suggests that flows into *employment* are the most relevant transitions. Specifically, flows into employment, in particular from employment to employment (“E-to-E”) and from inactivity to employment (“I-to-E”), matter most. By contrast, flows into *unemployment* display no correlation with the unemployment gap, as is visible from the flat red line in the lower panels of Figure 7.²⁶

Figure 7: Actual vs. counter-factual unemployment gaps



Notes: Each panel plots the difference between actual and counter-factual unemployment gaps where the counter-factual is computed assuming each transition probability is constant at its long-run average, against deviations of the actual transition probability from its long-run average. All deviations are expressed in percentage points. The red lines in each panel plot the predicted difference between actual and counter-factual flow-based unemployment based on a linear adjustment. *Data sources:* U.S. Bureau of Labour Statistics; authors’ calculations.

While the former result —flow-based unemployment primarily depends on flows into *unemployment*— is relatively intuitive, the latter —the unemployment gap essentially depends on flows into *employment*— is more surprising. Yet, the reason for it is relatively simple. The unemployment gap depends on flow- and stock-based unemployment. Yet, flows into unemployment affect both measure, while flows into employment primarily affect flow-based unemployment. For instance, transitions from inactivity to *unemployment* raise flow- and stock-based unemployment, leaving the unemployment gap barely affected. By contrast, transitions from inactivity to employment cut flow-based unemployment but do not affect stock-based unemployment, at least not instantaneously.²⁷

²⁶Especially Figure A3 in Appendix A.1 confirms the finding that the “E-to-E” transition is important in defining the unemployment gap. Figure C7 in Appendix C.1 shows the difference between the actual unemployment gap and the counterfactual gaps.

²⁷Note that we focus on contemporaneous correlations. In practice, flows into employment also influence stock-based unemployment with a lag, as current employment affects future unemployment.

3 Empirical analysis

We start this section by looking at the dynamics of unemployment and how it relates to the unemployment gap. In a nutshell, we find that an increase in the unemployment gap is associated with higher subsequent unemployment. In a second step, we run Phillips curve-like regressions, looking at how the unemployment gap impacts subsequent (nominal) wage and price inflation. The main result is that a higher unemployment gap is associated with reduced inflationary pressures, be it for wages or prices.

3.1 Unemployment rate dynamics

To test the relationship between the unemployment gap and subsequent unemployment rates, we estimate the following econometric specification.

$$u_{t+h} - u_t = \alpha_h + \beta_h u_{t,6} + \tilde{\beta}_h \tilde{u}_{t,6} + \gamma_h X_t + \epsilon_{t+h} \quad \text{for } h = \{1; \dots; 36\} \quad (3.1)$$

In Equation (3.1), u_{t+h} and u_t are (stock-based) unemployment rates, while $u_{t,6}$ and $\tilde{u}_{t,6}$ are the respective 6-month backward-looking moving averages of stock- and flow-based unemployment rates at time t . In addition, the vector X_t includes a set of control variables, e.g. alternative indicators of labour market conditions as well as standard business cycle controls, meant to test the robustness of our unemployment gap measure.

Table 3 provides the estimation results for equation (3.1) at a 12-month horizon. Column (1) confirms that unemployment displays mean reversion, as the current level of unemployment relates negatively to the subsequent change in unemployment. Quantitatively, the regression suggests that about a third of a given change in unemployment tends to dissipate after one year. Column (2) shows that flow-based unemployment provides very similar results. This is unsurprising since both variables tend to track each other very closely over time. Column (3) provides our first core result. It shows that flow-based unemployment contains valuable information for subsequent unemployment, over and above the standard mean-reversion property just described. Holding current (stock-based) unemployment constant, an increase in flow-based unemployment is followed by significantly higher unemployment 12 months down the road. Quantitatively, column (4) — which restricts the coefficients β_h and $\tilde{\beta}_h$ of equation (3.1) to sum up to zero — suggests that a one standard deviation increase in the unemployment gap tends to raise unemployment at a 12-month horizon by 0.3 - 0.4 percentage points (the *unemployment gap* coefficient in the table shows percentage point changes and is therefore an order of magnitude larger).

Table 3: Unemployment rate dynamics 12-month ahead

	12-month ahead change in unemployment rate						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Stock-unempl. rate (u)	-0.342** (0.121)		-3.323*** (0.555)	-0.300** (0.086)	-0.216** (0.105)	-0.256*** (0.071)	-0.138 (0.100)
Flow-unempl. rate (\tilde{u})		-0.302** (0.118)	3.023*** (0.539)				
Unemployment gap (z)				3.023*** (0.539)	3.412*** (0.672)	3.227*** (0.463)	2.601*** (0.421)
Change in stock-unempl.						-0.629** (0.313)	-0.604** (0.291)
Stock-empl. rate (e)					0.042 (0.052)		0.105** (0.052)
Employment gap					0.251** (0.117)		0.162 (0.178)
Labour productivity (growth rate)						0.107 (0.120)	0.095 (0.120)
Oil price (growth rate)						0.003 (0.003)	0.003 (0.003)
Industrial production (growth rate)						-0.119* (0.068)	-0.167*** (0.062)
Adj. R ²	0.146	0.112	0.299	0.299	0.336	0.374	0.400
Num. obs.	409	409	409	409	409	409	409
RMSE	0.883	0.901	0.801	0.801	0.779	0.756	0.741

Notes: Except for the change in stock-based unemployment, all other explanatory variables pertaining to the labour market are computed as 6-month backward looking moving averages while gap measures are computed as differences between flow- and stock-based measures of the corresponding variable. The change in stock-based unemployment rate, as well as the growth rates of industrial production and the oil price, are computed over the last six months, using for the latter the West Texas Intermediate (WTI) Crude Oil Price. Asterisks indicate significance at the 1%, 5%, and 10% level (** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$). Standard errors are Newey-West corrected (18 months). The constant term is omitted from the table.

Let us now turn to the extended regressions in columns (5) - (7). The regression in column (5) introduces the current employment rate as well as the employment gap, which is computed as the difference between flow- and stock-based employment rates. As is clear from the transition matrix M_t defined in Section 2, the dynamics of the unemployment rate $u_{t+h} - u_t$ depend on both the unemployment gap $\tilde{u}_t - u_t$ and the employment gap $\tilde{e}_t - e_t$. The result shows that although the employment gap correlates significantly with the subsequent change in the unemployment, the coefficient is counter-intuitively positive. A positive coefficient implies would imply that an increase in flow-based employment above actual employment — an indication of a stronger labour market — would be followed by higher unemployment. Moreover, the regression fit barely improves and, upon including additional controls in column (7), it does not seem to be very robust.²⁸

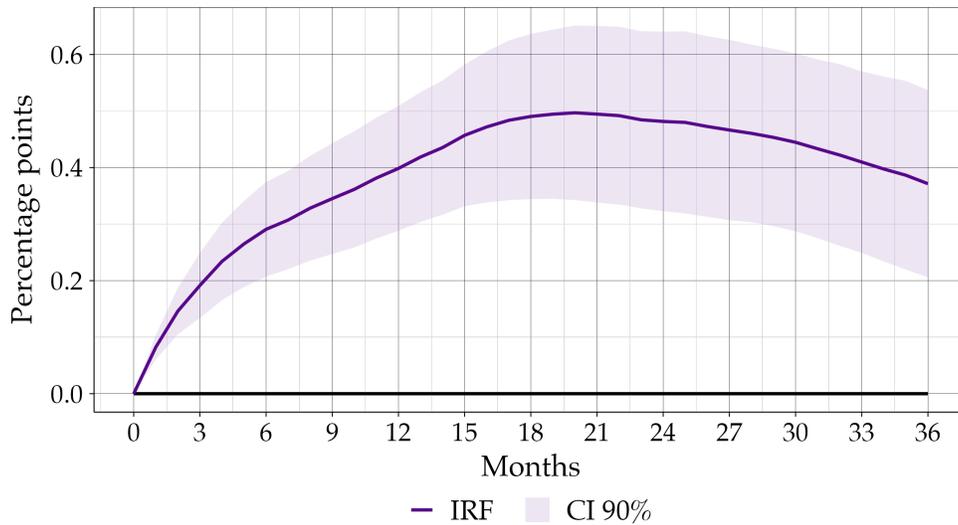
Finally, columns (6) and (7) show that the correlation between the current unemployment gap and subsequent changes in unemployment is robust to controlling for past changes in unemployment as well as industrial production. In addition, the two latter variables do correlate significantly with subsequent unemployment, the correlation of both being, as would be expected, negative. Labour

²⁸Table D3 in appendix D introduces these control variables one by one.

productivity and oil price inflation are not significant.

In order to get a better understanding of the dynamics of the unemployment rate, we estimate Equation (3.1) over a horizon h of 36 months, using the set of controls introduced in column (6) in Table 3. Figure 8 below plots the change in the unemployment rate following a one-standard deviation increase in the unemployment gap. The effect peaks around 19 months after the (standardised) increase in the unemployment gap. Figure 8 also suggest that the unemployment rate stays elevated even up to 30 months ahead, highlighting that changes in the unemployment gap tend to be followed by long-lasting changes in actual unemployment.²⁹

Figure 8: The dynamic response of the unemployment rate to the unemployment gap



Notes: The figure shows the dynamic effect of a one-standard deviation increase in the unemployment gap on the cumulative change of the unemployment rate. The model controls for the level and the change in stock-unemployment, productivity, oil price, and industrial production (column (6) in Table 3). The shaded area shows the 90% confidence bands, the errors are Newey-West corrected. The underlying model is described in Section 3.1. *Data sources:* Authors' calculations.

Before turning to the relationship between the unemployment gap and inflation, we look into the possibility of reverse causality. While the timing difference between the change in the unemployment rate and the unemployment gap should limit the likelihood that the unemployment gap responds to changes in subsequent unemployment, it is still possible that firms and workers take their labour market decisions according to their expectations about future labour market conditions. In this case, the current unemployment gap may respond to future expected changes in unemployment.

To address this possibility, we estimate to what extent the current unemployment gap depends on expectations of future activity and prices. We therefore estimate a specification where the unemploy-

²⁹Appendix D shows additional regression results related to alternative labour market tightness measures (Table D2).

ment gap relates to 1-year ahead forecasts of inflation and GDP growth. In addition, we include the 1-year forward rate as well as the slope of the yield curve, considering the difference between the 10- and the 2-year yields, as both these indicators may indicate how financial markets expect future activity to develop. We do not find this relationship to be significant, and can confidently disregard the possibility that the unemployment gap may reflect agents' expectations about future economic developments.³⁰

3.2 Inflation dynamics

The core of the empirical analysis examines the relationship between the unemployment gap and subsequent price dynamics, with a primary focus on core CPI and unit labour cost.³¹ We start by estimating a hybrid Phillips curve with monthly data, where inflation between t and $t+h$ — denoted as π_{t+h}^i , where $h = \{1; \dots; 36\}$ and $i \in \{p, w\}$ denotes price and wage inflation, respectively — depends on past inflation between t and $t-n$ — denoted π_{t-n}^i with $n = \{6; 12\}$ — and future expected price inflation for the next year — denoted π_{t+12}^e . Moreover, we include measures of stock- and flow-based unemployment, respectively denoted as $u_{t,6}$ and $\tilde{u}_{t,6}$, to proxy for the direction of the labour market. Finally, we augment the specification with a set of control variables X_t , which include alternative measures of (labour market or wider economic) slack, e.g. employment (the rate and the gap to the steady-state rate), the change in the unemployment rate, the growth rate of industrial production and, oil price inflation.³² The resulting regression specification takes the following form:

$$\pi_{t+h}^i = \alpha_{i,h} + \beta_h^i u_{t,6} + \tilde{\beta}_h^i \tilde{u}_{t,6} + \gamma_h^i \pi_{t-n}^i + \delta_h^i \pi_{t+12}^e + \theta_h^i X_t + \epsilon_{i,t+h}. \quad (3.2)$$

Tables 4 and 5 respectively present estimation results for price and wage inflation. Following the structure outlined above, the *unemployment gap* measure is introduced step by step into the Phillips curve specification. Columns (1) to (3) each use a different slack measure: stock-based unemployment, flow-based unemployment, or the change in the unemployment rate. Column (4) then includes both stock- and flow-based unemployment rates, as specified in equation (3.2). The coefficients of both variables become highly significant, and the regression fit increases by 20 percentage points when estimating price inflation (by about 30 percentage points when estimating wage inflation). Moreover, since the estimated coefficients are similar in absolute size but opposite in sign, makes it a natural choice to introduce the difference between the two. Column (5) shows that the unemployment gap contains all the relevant information, and the coefficient remains highly significant. Column (6)

³⁰Table D4 in the appendix shows the results.

³¹For robustness, we also perform the same regressions using headline CPI inflation and other price measures. The results of these robustness checks are provided in Appendix E.

³²Tables E5 and E6 in Appendix E.1 provide summary statistics for all variables used in the regression.

includes the (stock-based) employment rate and employment gap. Finally, column (7) and (8) present specifications with additional controls, further testing the robustness of the results.

For core CPI inflation, the unemployment gap is not only a statistically significant, but also quantitatively important. Based on estimation results in column (5) of Table 4, a one-standard-deviation increase in the unemployment gap is followed by core CPI inflation falling by 45 basis points, at a one-year horizon (the *unemployment gap* coefficient in the table shows percentage point changes and is therefore an order of magnitude larger). Among the additional control variables in columns (8), only industrial production is significant. Its inclusion slightly increases the economic magnitude of the unemployment gap (from 45 to 53 basis points) but does not alter its overall significance.³³ The employment gap is also significant in column (6), but it enters with the wrong sign. Its significance disappears once additional controls are included. The dynamic response of core CPI inflation over time can be seen in the left panel in Figure 9. The effect builds up gradually and remains persistent for a long time.

In addition to testing several control variables, we also test the robustness of our results over specific sub-periods, such as the period preceding the COVID crisis or the period running up to the Global Financial Crisis. Regression results reported in Table E9 in Appendix E.2. show that empirical results remain broadly unchanged. Finally, a natural question is how our measure compares to alternative slack indicators commonly used in the literature. These include the change in the unemployment rate, the vacancy-to-unemployment ratio, the output gap, or the so-called “natural” unemployment gap derived from the *natural rate of unemployment*, both of which are calculated by the Congressional Budget Office (CBO). While the V/U ratio and the natural unemployment gap are statistically significant, they have a R^2 of 10-15% less and do not alter the economic or statistical significance of our unemployment gap measure.³⁴

For wage inflation, as measured by the unit labour cost, the qualitative findings closely mirror those for price inflation. Quantitatively the change in ULC upon a one-standard-deviation increase in the unemployment gap is one-and-a-half times the change in core CPI (76 vs. 53 basis points) (column (7) in Table 5; again the *unemployment gap* coefficient shows percentage point changes and not standard deviations). Unlike the price inflation regressions, however, several control variables are statistically significant here.³⁵ Higher past oil price inflation increases wage inflation, and an increase over the past six months in industrial production also shifts inflationary pressures up. The right panel in

³³Regression results in which the additional control variables are introduced sequentially can be found in Table E7 in Appendix E.2.

³⁴See Table E11 in Appendix E.2 for the full set of results.

³⁵Regression results in which the additional control variables are introduced sequentially can be found in Table E8 in Appendix E.2.

Table 4: Core consumer price index inflation

	Core CPI inflation - 12-months ahead							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Stock-unempl. rate (u)	0.070 (0.097)			3.576*** (0.513)	0.030 (0.047)	-0.038 (0.055)	0.046 (0.044)	-0.007 (0.059)
Flow-unempl. rate (\hat{u})		0.019 (0.085)		-3.546*** (0.511)				
Unemployment gap (z)					-3.546*** (0.511)	-3.716*** (0.408)	-4.148*** (0.335)	-3.851*** (0.352)
Change in stock-unempl.			-0.009 (0.203)					
Lagged core infl.	0.669*** (0.129)	0.658*** (0.127)	0.653*** (0.115)	0.613*** (0.086)	0.613*** (0.086)	0.584*** (0.100)	0.588*** (0.079)	0.521*** (0.098)
Infl. expectation (1y)	-0.120 (0.230)	-0.131 (0.238)	-0.133 (0.247)	0.026 (0.136)	0.026 (0.136)	0.146 (0.172)	0.130 (0.124)	0.285* (0.171)
Stock-empl. rate (e)						-0.062 (0.054)		-0.072 (0.052)
Employment gap						-0.161*** (0.058)		-0.001 (0.107)
Labour productivity (growth rate)							0.008 (0.053)	0.020 (0.062)
Oil price (growth rate)							0.003 (0.003)	0.004 (0.003)
Industrial production (growth rate)							-0.074*** (0.017)	-0.070*** (0.024)
Adj. R ²	0.512	0.508	0.507	0.691	0.691	0.707	0.717	0.720
Num. obs.	409	409	409	409	409	409	409	409
RMSE	0.712	0.715	0.715	0.566	0.566	0.551	0.542	0.539

Notes: *Inflation expectation (1y)* are the 1-year expectations of inflation calculated by the [Federal Reserve Bank of Cleveland](#). *Labour productivity* is using the *Nonfarm Business labour productivity output per hour* index. *Oil price* is calculated using the West Texas Intermediate (WTI) Crude Oil Price. All variables enter the regression as either 6-month growth rates, changes or backward looking moving averages, lagged core inflation is annualised. Asteriks indicate significance at the 1%, 5%, and 10% level (***) $p < 0.01$; (**) $p < 0.05$; (*) $p < 0.1$). Standard errors are Newey-West corrected (18 months). The constant term is omitted from the table.

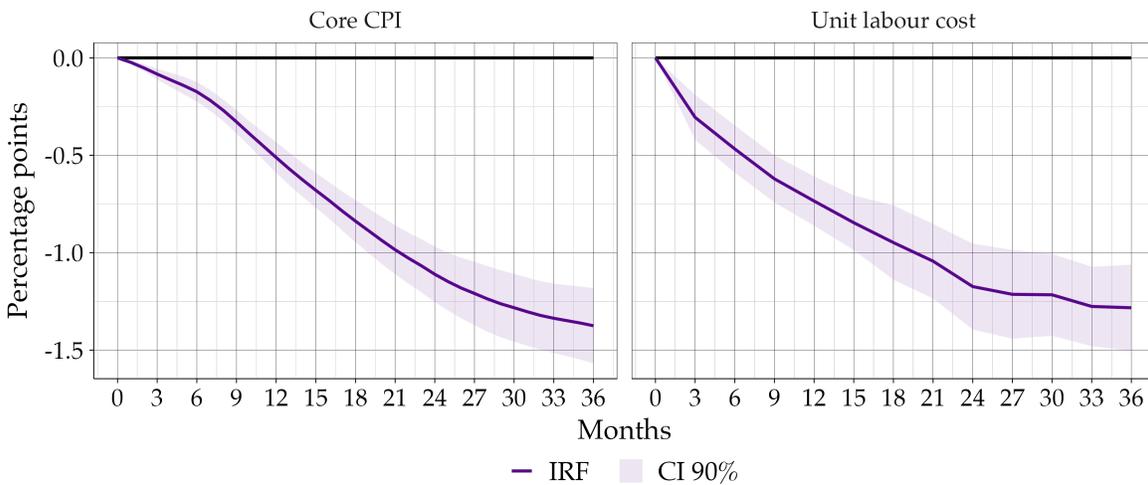
Figure 9 shows the dynamic response of ECI inflation over time. The effect is equally persistent as for price inflation.

Table 5: Unit labour cost inflation

	Unit labor cost inflation - 12-months ahead							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Stock-unempl. rate (u)	-0.246** (0.110)			7.515*** (1.444)	-0.391*** (0.134)	-0.424*** (0.091)	-0.412*** (0.116)	-0.586*** (0.092)
Flow-unempl. rate (\bar{u})		-0.369*** (0.111)		-7.906*** (1.378)				
Unemployment gap (z)					-7.906*** (1.378)	-6.006*** (0.965)	-5.960*** (0.592)	-3.920*** (0.806)
Change in stock-unempl.			-0.874 (0.566)					
Lagged ULC infl.	-0.019 (0.067)	-0.036 (0.064)	0.001 (0.069)	-0.100 (0.074)	-0.100 (0.074)	-0.128* (0.072)	-0.027 (0.080)	-0.032 (0.080)
Infl. expectation (1y)	-0.017 (0.272)	-0.039 (0.272)	0.011 (0.343)	0.245 (0.180)	0.245 (0.180)	0.575** (0.226)	-0.036 (0.263)	0.446** (0.224)
Stock-empl. rate (e)						-0.234** (0.095)		-0.345*** (0.081)
Employment gap						0.518*** (0.164)		0.163 (0.177)
Labour productivity (growth rate)							0.094 (0.084)	0.269** (0.110)
Oil price (growth rate)							0.013** (0.006)	0.012** (0.005)
Industrial production (growth rate)							0.191** (0.074)	0.207*** (0.074)
Adj. R ²	-0.001	0.024	0.076	0.321	0.321	0.386	0.428	0.492
Num. obs.	136	136	136	136	136	136	136	136
RMSE	1.728	1.706	1.660	1.423	1.423	1.353	1.306	1.231

Notes: *Inflation expectation (1y)* are the 1-year expectations of inflation calculated by the [Federal Reserve Bank of Cleveland](#). *Labour productivity* is using the *Nonfarm Business labour productivity output per hour* index. *Oil price* is calculated using the West Texas Intermediate (WTI) Crude Oil Price. All variables enter the regression as either 6-month growth rates, changes or backward looking moving averages, lagged core inflation is annualised. Asterisks indicate significance at the 1%, 5%, and 10% level (***) $p < 0.01$; ** $p < 0.05$; * $p < 0.1$). Standard errors are Newey-West corrected (18 months). The constant term is omitted from the table.

Figure 9: Change in inflation upon a 1 standard deviation increase in the u gap



Notes: This figure shows the dynamic response (local projection) of core CPI and ULC inflation to a one-standard deviation increase in the unemployment gap. The line shows the response for our baseline model, which controls for inflation expectation, productivity, oil price, labour participation, industrial production and lagged inflation (column (7) in tables 4 and 5). The shaded area represents the Newey-West corrected 90% confidence interval. *Data sources:* Authors' calculations.

We also conduct the same robustness checks as above, considering various subperiods and alternative slack measures. Since wage inflation is only observed at a quarterly frequency, the number of observations is roughly one-third compared to monthly price inflation, making subperiod analysis less reliable. Indeed, for the ULC-based measure, some subperiods yield insignificant coefficients. Nevertheless, the findings regarding alternative slack measures remain robust: they attain a lower R^2 and do not alter the coefficient or significance of the unemployment gap.³⁶

As mentioned above, we also examine alternative measures of inflation beyond core CPI and ULC. On the price side, we include headline CPI, core goods and core services CPI, as well as PCE inflation. On the wage side, we additionally consider the wage component of the Employment Cost Index (ECI) and total ECI inflation. For all measures, we estimate the fully specified regression model that includes the complete set of control variables as given in column (7) of the tables above.

Interestingly, the effect of the unemployment gap on headline CPI inflation is slightly stronger than on core CPI inflation — 63 basis points compared to 53. The response is particularly pronounced for core goods inflation, with an estimated effect exceeding 1 percentage point. This may be due to the fact that goods prices, especially in tradable sectors, are more responsive to cost pressures and inventory adjustments that are closely tied to labour market expectations. In contrast, core services CPI reacts similarly to core PCE (40 basis points). Services prices tend to be more sticky and less sensitive to short-term fluctuations in labour market slack. On the wage side, the unemployment gap has a smaller effect on the the wage component of the ECI and total ECI with 17 and 28 basis points. The fact that total compensation (ECI) reacts less than the wage component could indicate that broader compensation costs, including benefits, are more cyclically sensitive than base wages.³⁷ The effect of the unemployment gap is not immediate but builds gradually over time. Using local projection methods, we find that the peak response of inflation occurs roughly 20 months after the initial shock.³⁸

Finally, the unemployment gap does indeed seem to serve as a sufficient statistic for labour market dynamics. In baseline specifications without the unemployment gap, nearly every individual transition probability enters significantly in explaining inflation (Tables E15 and E16), reflecting the rich information contained in worker flows. However, once the unemployment gap is included, the significance of individual transition probabilities diminishes dramatically. This demonstrates that the gap effectively captures the essential dynamics embedded across all nine transition probabilities,

³⁶Regression results are provided in Tables E10 and E12 in Appendix E.2.

³⁷Table E13 presents the regression results for alternative inflation measures, while Table E14 summarizes the findings for other wage inflation indicators, both in Appendix E.2

³⁸For the local projection graph, see Figure E8 in Appendix E.6.

compressing them into a single parsimonious measure. Rather than requiring separate tracking of each flow, the gap provides a sufficient summary of the directional forces.³⁹

4 The model

Let us now turn to the analytical part of the paper, whose road-map is as follows. We first derive, in a simple 2-state framework with otherwise minimal assumptions, how the unemployment gap, as defined in the empirical section, responds to changes in transition probabilities. We show that the persistence of shocks affecting transition probabilities plays a key role in shaping this response: the higher the persistence of shocks affecting the "E-to-E" or "U-to-E" transition probability, the longer the time spell over which the unemployment gap turns negative in response to a positive shocks to each of these transition probabilities.

We then follow up with a (two-state) search-and-matching model with sticky wages, where we focus on the response of equilibrium wages to changes in unemployment flows and stocks. We then show that the very same logic applies: a fall in the unemployment gap driven by an increase in the "E-to-E" or "U-to-E" transition probability tends to raise wages over a longer time spell, the higher the persistence of the original shock. Meanwhile, a fall in the unemployment gap, driven by an increase in the stock of unemployed workers, is always associated with higher wages and hence prices.

In other words, in line with the empirical findings, the analytical framework shows that a fall in the unemployment gap raises wages and prices. Moreover the model suggests that this impact tends to last longer when changes in transition probabilities are more persistent.

4.1 Main assumptions and timing

Consider a continuum of infinitely-lived firms and a continuum of infinitely-lived workers, of equal mass. Both workers and firms have preferences u over their life-time consumption stream $\{c_t\}_{t \geq 0}$:

$$u = \mathbb{E}_0 \sum_{t \geq 0} \beta^t c_t \tag{4.1}$$

where \mathbb{E}_0 denotes the expectation operator and β the discount factor. At any period, firms can hire unemployed workers while employed workers can either stay employed or become unemployed. Employed workers earn a wage w while unemployed workers receive unemployment benefits b .

³⁹Further robustness test include sensitivity to different inflation expectation measures (tables E17 and E18); alternative measures from the literature (tables E19 and E20 in appendix E.5), and an IV approach using monetary policy shocks (Table E21).

Transition probabilities and the unemployment gap In line with a large part of the literature, (see for instance Crump et al. (2019); Shimer (2005, 2012); Elsby et al. (2010); Hall (2005); Elsby et al. (2009)), the labour market is modeled as having two rather than three states, and workers can be either employed (e) or unemployed (u). This gives four possible transitions, and two independent conditional transition probabilities.

time t	time $t + 1$	
	Employment	Unemployment
Employment	p_t^e	$p_t^f = 1 - p_t^e$
Unemployment	p_t^h	$p_t^u = 1 - p_t^h$

Let us consider the job-finding probability or hiring rate, p_t^h , and the employment persistence probability or employment retention rate p_t^e , as the independent transitions probabilities. Moreover, let us assume that both the hiring rate and the employment retention rate are subject to the aggregate shock s , and the effect has some persistence. Specifically,

$$p_j = \mathbb{E} [p_t^j] \quad \text{and} \quad \frac{dp_{t+n}^j}{dp_t^j} = (\rho_j)^n \quad \text{with} \quad j = \{e; h\} \quad \text{and} \quad 0 < \rho_j < 1 \quad \text{and} \quad n \geq 0 \quad (4.2)$$

where ρ_j is the autocorrelation parameter of transition probability j . Using this notation, the expression for the unemployment gap — defined as in the empirical part as $z_t = \tilde{u}_t - u_t$ — simplifies in this two-state framework to:

$$z_{t+1} = \tilde{u}_{t+1} - u_{t+1} = \frac{1 - p_t^e}{1 - p_t^e + p_t^h} - \left[u_t (1 - p_t^h) + (1 - u_t) (1 - p_t^e) \right] \quad (4.3)$$

Denoting $\delta = p_e - p_h$ as the difference between the unconditional average employment retention rate and hiring rate, with $\delta > 0$, we can derive the following lemma:

Lemma 1 *An increase in the employment retention rate p_{t-1}^e (or in the hiring rate p_{t-1}^h) cuts all unemployment gaps z from t to $t + n$, if and only if the auto-correlation parameter ρ_e (or ρ_h) is sufficiently large, i.e:*

$$\mathcal{S}_n(\rho_j) \leq \frac{1}{1 - \delta} \quad \text{for} \quad j = \{e; h\} \quad \text{with} \quad \mathcal{S}_n(\rho_j) \equiv \sum_{i=0}^n \left(\frac{\delta}{\rho_j} \right)^i \quad (4.4)$$

Proof 1 *Consider an economy initially at the steady-state facing a change in the transition probability j at time t ($j = \{e; h\}$). Then, given the expression for flow-based unemployment, we have:*

$$\frac{\partial \tilde{u}_{t+n}}{\partial p_{t-1}^e} = -(\rho_e)^n \frac{(1-u)u}{1-p_e} \quad \text{and} \quad \frac{\partial \tilde{u}_{t+n}}{\partial p_{t-1}^h} = -(\rho_h)^n \frac{(1-u)u}{p_h} \quad \text{for any} \quad n \geq 0.$$

where u denotes steady-state unemployment. The law of motion for unemployment then implies:

$$\frac{\partial u_{t+n}}{\partial p_{t-1}^e} = \delta \frac{\partial u_{t+n-1}}{\partial p_{t-1}^e} - (1-u)\rho_e^n \quad \text{and} \quad \frac{\partial u_{t+n}}{\partial p_{t-1}^h} = \delta \frac{\partial u_{t+n-1}}{\partial p_{t-1}^h} - u\rho_h^n \quad \text{for any } n \geq 0.$$

Iterating backward the last expressions, changes in the unemployment gap write as:

$$\frac{\partial z_{t+n}}{\partial p_{t-1}^e} = (1-u)\rho_e^{n-1} \left[\mathcal{S}_{n-1}(\rho_e) - \frac{\rho_e}{1-\delta} \right] \quad \text{and} \quad \frac{\partial z_{t+n}}{\partial p_{t-1}^h} = u(\rho_h)^{n-1} \left[\mathcal{S}_{n-1}(\rho_h) - \frac{\rho_h}{1-\delta} \right] \quad \text{for any } n \geq 0$$

where $\mathcal{S}_{-1}(\rho) = 0$. Solving for $\frac{\partial z_{t+n}}{\partial p_{t-1}^e} \leq 0$ and $\frac{\partial z_{t+n}}{\partial p_{t-1}^h} \leq 0$ then yields the condition (4.4). Finally, given that \mathcal{S}_n increases in n and condition (4.4) is fulfilled, all unemployment gaps between t and $t+n$ are decreasing in p_t^e and p_t^h .

An increase in the hiring rate p_{t-1}^h or in the employment retention rate p_{t-1}^e always cuts the unemployment gap z_t (condition (4.4) always holds for $n = 0$). When the hiring rate p_{t-1}^h or the employment retention rate p_{t-1}^e go up, both flow- and stock-based unemployment \tilde{u}_t and u_t fall, but the latter typically falls less than the former. To see this, consider an economy initially at the steady state where $\tilde{u}_{t-1} = u_{t-1}$, facing an increase in the hiring rate p_{t-1}^h . It is straightforward to note that the sensitivity of *actual* unemployment to the hiring rate is equal to the unemployment rate itself, while the sensitivity of *steady-state* unemployment to the hiring rate is a *multiple* of the unemployment rate, provided $p_t^e - p_t^h > 0$, which is in line with the empirical regularities described in Table 1 in the empirical section.

$$\frac{\partial u_t}{\partial p_{t-1}^h} = -u_{t-1} \quad \text{and} \quad \frac{\partial \tilde{u}_t}{\partial p_{t-1}^h} = -\frac{\tilde{u}_{t-1}}{1 - p_{t-1}^e + p_{t-1}^h} \implies \left| \frac{\partial p_t^u}{\partial h_{t-1}} \right| \leq \left| \frac{\partial \tilde{u}_t}{\partial p_{t-1}^h} \right|$$

An increase in the hiring rate p_{t-1}^h therefore tends to cut flow-based unemployment \tilde{u}_t below stock-based unemployment u_t , pushing down the unemployment gap z_t .

Then from time $t+1$ onwards, two forces are at play. First, shocks to the hiring rate typically fade over time, which implies that the decline in both flow- and stock-based unemployment gradually slows down. Second, although flow-based unemployment drops more on impact than stock-based unemployment, it also tends to die out at a faster pace than the fall in stock-based unemployment.⁴⁰ How fast depends on persistence: the more persistent the increase in the hiring rate, the longer it takes for the drop in stock-based unemployment to catch up with the drop in flow-based unemployment,

⁴⁰This is because actual unemployment being an AR(1), lower unemployment in the past implies lower unemployment in the future.

and the longer the unemployment gap keeps falling after a given increase in the hiring rate.⁴¹

Wage setting Let us now come back to the description of the model and focus on wage setting. Firms set wages through Nash bargaining with workers, but wages are subject to nominal rigidities. Firms can reset nominal wages with a probability $1 - \theta$. Conversely, with a probability θ , firms have to keep paying the previous period's nominal wage.⁴² Finally, we make the important — albeit realistic — assumption, that wage stickiness only applies to workers already employed with the firm. Hence, firms and newly hired workers can always freely bargain over the wage rate, regardless of whether the firm faces rigid or flexible wages. This assumption has an important implication: the degree of nominal wage stickiness in the economy depends on aggregate conditions, specifically, the flow of workers from unemployment to employment, which in turn depends on the stock of unemployed workers in the economy u_t and the hiring rate h_t . In other words, the higher the unemployment rate u_t and/or the hiring rate p_t^h , the lower the degree of wage stickiness.

4.2 Value functions

The case of firms. Consider a firm in state s_t employing ℓ_t workers and paying the flexible wage rate $w_t^{(0)}$ to all staff, the superscript (0) indicating the length of the current wage rigidity spell. Then the continuation value of the firm $\Pi(w_t^{(0)}; n_t; s_t)$ can be expressed as:

$$\begin{aligned} \Pi(w_t^{(0)}; \ell_t; s_t) = \max_{k_t} \left\{ A(s_t) k_t^\alpha \ell_t^{1-\alpha} - r_t k_t - w_t^{(0)} \ell_t + \beta(1 - \theta) \int \Pi(w_{t+1}^{(0)}; \ell_{t+1}; s_{t+1}) dF(s_{t+1}) \right. \\ \left. + \beta\theta \int \Pi(w_{t+1}^{(1)}; \ell_{t+1}; s_{t+1}) dF(s_{t+1}) \right\}. \end{aligned} \quad (4.5)$$

A firm holding a capital stock k_t and employing ℓ_t workers, enjoys output $A(s_t)k_t^\alpha \ell_t^{1-\alpha}$ in state s_t , where A is technology. In addition, it pays a rental rate r_t on capital and the flexible wage $w_t^{(0)}$ to all workers. With a probability $1 - \theta$, wages are still flexible at the next period. The firm can then freely adjust the next period's wage $w_{t+1}^{(0)}$ in light of the shock s_{t+1} and enjoy an average continuation value $\int \Pi(w_{t+1}^{(0)}; \ell_{t+1}; s_{t+1}) dF(s_{t+1})$, where $F(\cdot)$ is the c.d.f. for the aggregate shock s . Conversely, with a probability θ , the firm faces rigid wages for old hires and can only adjust the wage of new hires. The firm then earns the average continuation value $\int \Pi(w_{t+1}^{(1)}; \ell_{t+1}; s_{t+1}) dF(s_{t+1})$, where $w_{t+1}^{(1)}$ refers to the wage rate paid to date- $t + 1$ new hires by firms whose wages have been rigid for one period.

⁴¹From Lemma 1, it is straightforward to note that the persistence parameter ρ_j ($j = \{e; h\}$) for which condition (4.4) holds with equality is increasing in the horizon n .

⁴²The wage rigidity shock is i.i.d. across firms and over time, so that there is always a fraction $1 - \theta$ of firms with flexible wages and a fraction θ of firms with rigid wages. We relax in Section 5 the assumption that wage rigidity history does not bear any implication for subsequent wage rigidity risks. This will help simplify the model's exposition and clarify the main forces at play in the model.

Let $y(k, s)$ denote the output net of the rental cost of capital of a firm with capital k employing a single worker in state s .⁴³ Then solving for the optimal capital stock per worker and denoting $y(s)$ the corresponding value of output net of the rental cost of capital in state s , the per worker-value of the firm $V_f(w_t, s_t) = \Pi(w_t, \ell_t, s_t) / \ell_t$ satisfies:

$$V_f(w_t^{(0)}, s_t) = y(s_t) - w_t^{(0)} + \beta \frac{\ell_{t+1}}{\ell_t} \left[(1 - \theta) \int V_f(w_{t+1}^{(0)}, s_{t+1}) dF(s_{t+1}) + \theta \int V_f(w_{t+1}^{(1)}, s_{t+1}) dF(s_{t+1}) \right]. \quad (4.6)$$

A flexible-wage firm employing one worker enjoys output net of rental cost of capital $y(s_t)$ in state s_t , and pays the flexible wage $w_t^{(0)}$. Moreover, it also enjoys the continuation value of profits at time $t + 1$, which is a weighted average of the continuation value when wages are flexible $V_f(w_{t+1}^{(0)}, s_{t+1})$ and the continuation value when wages turn rigid $V_f(w_{t+1}^{(1)}, s_{t+1})$. Specifically, given that rigid wages only apply to previously hired workers, and denoting λ the fraction of new hires in the labour force, the firm's continuation value under rigid wages satisfies:

$$V_f(w_t^{(1)}, s_t) = y(s_t) - (1 - \lambda_t)w_{t-1}^{(0)} - \lambda_t w_t^{(1)} + \beta \frac{\ell_{t+1}}{\ell_t} \left[(1 - \theta) \int V_f(w_{t+1}^{(0)}, s_{t+1}) dF(s_{t+1}) + \theta \int V_f(w_{t+1}^{(2)}, s_{t+1}) dF(s_{t+1}) \right]. \quad (4.7)$$

A firm whose wages turn rigid at time t keeps paying the wage rate $w_{t-1}^{(0)}$ to workers already employed with the firm at time $t - 1$. However, the firm can still bargain with new hires over the wage rate $w_t^{(1)}$, which may differ not only from the previous periods' wage $w_{t-1}^{(0)}$, but also from the wage rate $w_t^{(0)}$ paid at time t by flexible wage-firms.⁴⁴ Then considering a firm whose wages have been rigid for i consecutive periods up to time t , i.e. $t - i$ was the last period the firm had flexible wages, the continuation value for such a firm writes as:

$$V_f(w_t^{(i)}; s_t) = y(s_t) - \sum_{j=0}^i \lambda_{t,j}^{(i)} w_{t-j}^{(i-j)} + \beta \frac{\ell_{t+1}}{\ell_t} \left[(1 - \theta) \int V_f(w_{t+1}^{(0)}; s_{t+1}) dF(s_{t+1}) + \theta \int V_f(w_{t+1}^{(i+1)}; s_{t+1}) dF(s_{t+1}) \right] \quad (4.8)$$

Expression (4.8) is similar to (4.7), but with one difference: the firm pays $i + 1$ (possibly) different wage rates, reflecting that wages have been rigid for i consecutive periods. Specifically, the firm pays a (flexible) wage rate, $w_t^{(i)}$, to new hires, who account for a fraction, $\lambda_{t,0}^{(i)}$, of the total workforce, while it pays the wage rate $w_{t-j}^{(i-j)}$ to workers hired at time $t - j$ (with $j \leq i$) who have been working for the

⁴³The k notation refers to capital stock per worker. Given that the production function exhibits constant returns to scale, deriving the equations for firms in terms of per worker quantities implies no loss of generality.

⁴⁴Note that because the transition probabilities are the same for all firms irrespective of their wage rigidity histories, firms are all equally sized, hence the absence of a superscript on the employment notation. In other words, if $\ell_t^{(j)}$ denoted employment at firm with j consecutive periods of rigid wages up to date t , then we assume $\ell_t^{(j)} = \ell_t$.

firm without interruption, and who make up for a fraction $\lambda_{t,j}^{(i)}$ of the total workforce at time t . Then given that employment at time t is the sum of workers employed at time $t - 1$ who keep working at time t and workers unemployed at time $t - 1$ who take a job at time t : $\ell_t = p_{t-1}^e \cdot \ell_{t-1} + p_{t-1}^h \cdot (1 - \ell_{t-1})$, and denoting $p_{t,i}^e$ the probability for a worker to stay employed from $t - i$ to t , i.e. $p_{t,i}^e = \prod_{k=i}^{t-1} [p_{t-k}^e]$, the λ shares satisfy:

$$\lambda_{t,i}^{(i)} = \frac{\ell_{t-i}}{\ell_t} p_{t,i}^e \quad \text{and} \quad \lambda_{t,j}^{(i)} = \frac{\ell_{t-j}}{\ell_t} \lambda_{t-j} p_{t,j}^e \quad \text{if } j \leq i - 1 \quad \text{with} \quad \lambda_{t-j} = \frac{1 - \ell_{t-j-1}}{\ell_{t-j}} p_{t-j-1}^h \quad (4.9)$$

The case of workers. Workers earn a wage w_t when employed. With a probability $1 - p_t^e$, the worker loses her job and becomes unemployed, enjoying utility $U(s_{t+1})$ in state s_{t+1} . Conversely, with a probability p_t^e , the worker stays in her job at time $t + 1$, where with a probability $1 - \theta$ it is paid a flexible wage and gets utility $V_w(w_{t+1}^{(0)}, s_{t+1})$ in state s_{t+1} . But, with a probability θ , the firm faces rigid wages. The worker keeps the wage rate w_t and enjoys a value $V_w(w_t, s_{t+1})$ in state s_{t+1} . The value function V_w for a worker at time t therefore writes as:

$$V_w(w_t, s_t) = w_t + \beta(1 - p_t^e) \int U(s_{t+1}) dF(s_{t+1}) \\ + \beta p_t^e \left[(1 - \theta) \int V_w(w_{t+1}^{(0)}, s_{t+1}) dF(s_{t+1}) + \theta \int V_w(w_t, s_{t+1}) dF(s_{t+1}) \right] \quad (4.10)$$

Finally, consider the case of an unemployed worker, the continuation value of unemployment U depends on three terms. First, a worker who is unemployed, receives unemployment benefits b . Second, a worker unemployed at time t remains unemployed at time $t + 1$ with a probability $1 - p_t^h$ and earns the continuation value of unemployment $U(s_{t+1})$ in state s_{t+1} . Last, a worker unemployed at time t gets a job offer at time $t + 1$ with a probability p_t^h . In this case, it ends up working for a firm whose wages have been rigid for i periods with a probability $(1 - \theta)\theta^i$, in which case, it gets paid the (newly negotiated) wage rate $w_{t+1}^{(i)}$ and earns the continuation value $V_w(w_{t+1}^{(i)}, s_{t+1})$ in state s_{t+1} :

$$U(s_t) = b + \beta(1 - p_t^h) \int U(s_{t+1}) dF(s_{t+1}) + \beta p_t^h \sum_{i \geq 0} (1 - \theta)\theta^i \int V_w(w_{t+1}^{(i)}, s_{t+1}) dF(s_{t+1}) \quad (4.11)$$

5 Equilibrium Wages

While both flexible- and rigid-wage firms can set wages freely for new hires, they are likely to end up paying different wages. One obvious reason is differences in histories: flexible-wage firms start with a "blank" sheet while rigid-wage firms carry the legacy of past wage agreements. Another is that flexible-wage firms negotiate wages for their entire labour force, making them more wary of paying

high wages. To make these points, let us first investigate wage determination by flexible-wage firms and then turn to the case of rigid-wage firms.

5.1 The case of firms with flexible wages

Let us denote η the bargaining power of firms and assume wages are set period-by-period. The equilibrium wage rate $w_t^{(0)}$ set by flexible wage-firms maximises the geometric average of the continuation value of a match for firms, and the continuation value of a match for workers net of the value of unemployment, each being weighted by the corresponding bargaining power.

$$\max_{w_t^{(0)}} \eta \log V_f(w_t^{(0)}, s_t) + (1 - \eta) \log [V_w(w_t^{(0)}, s_t) - U(s_t)] \quad (5.1)$$

One can then derive the following result:

Proposition 2 *Nash bargaining between a worker and a firm with flexible wages takes place "as if" there were no risk of wage rigidity:*

$$\frac{V_f(w^{(0)}(s), s)}{\eta} = \frac{V_w(w^{(0)}(s), s) - U(s)}{1 - \eta} \quad (5.2)$$

Proof 2 *Based on problem (5.1), the wage rate that comes out of the Nash bargaining game between a firm with flexible wages and a worker satisfies:*

$$\eta \frac{\partial V_f^{(0)}(w, s_t) / \partial w}{V_f^{(0)}(w, s_t)} + (1 - \eta) \frac{\partial V_w^{(0)}(w, s_t) / \partial w}{V_w^{(0)}(s_t) - U(s_t)} = 0 \quad (5.3)$$

Then, isolating the terms in $w^{(0)}$, the continuation value of a match for a worker and a firm respectively write as:

$$V_f(w_t^{(0)}, s_t) = y(s_t) - \frac{1}{1 - \beta\theta p_e} w_t^{(0)} + V_f \quad \text{and} \quad V_w(w_t^{(0)}, s_t) = \frac{1}{1 - \beta\theta p_e} w_t^{(0)} + V_w \quad (5.4)$$

where V_f and V_w are terms that are independent of the wage rate $w^{(0)}$. Using the expressions from (5.4) in equation (5.3), yields the optimality condition (5.2).

The wage rate $w_t^{(0)}$ equally affects the pay-off of firms and workers: whatever goes to workers means less for firms, and vice-versa. In addition, both workers and flexible wage-firms face the same likelihood θp_e , that the current wage extends to the next period. For a firm, wages turn rigid at the next period with a probability θ , while a fraction e of the labour force at time t remains on the firm's payroll at the next period and is paid the previous period's wage. Similarly, a worker faces a probability θ that her firm will have rigid wages in period $t + 1$, and she keeps her job with probability p_e . The wage rate $w_t^{(0)}$ therefore still matters for the firm and the worker with the same probability

θp_e . From date $t + 2$ onward, a similar argument holds: both the firm and the worker evaluate the probability that the wage rate $w_t^{(0)}$ that was agreed upon initially, extends from one period to the next at θp_e . And given that both firms and workers discount the future at a rate β , a higher wage rate $w_t^{(0)}$ raises the continuation value of employment for workers by $1/(1 - \beta\theta p_e)$, but cuts the continuation value of a match for firms by the same $1/(1 - \beta\theta p_e)$. Denoting $W = (1 - \eta)V_f - \eta V_w$, the equilibrium wage rate $w_t^{(0)}$ can be written as $w_t^{(0)}(s_t) = (1 - \eta)y(s_t) + \eta U(s_t) + W$. This expression shows that the wage rate $w_t^{(0)}$ is the sum of two main terms. The first is standard: it represents the average of the output of a match $y(s_t)$ and workers' outside option $U(s_t)$, weighted by the bargaining powers of workers and firms. In addition, because the value of a match depends on expected future benefits, the equilibrium wage rate $w_t^{(0)}$ also depends on an additional term W , which decreases with the firms' bargaining power η . Hence, when wage rigidity applies only to pre-existing staff, a firm with flexible wages agrees with workers on a wage rate that splits the value of the current surplus and workers' outside option, exactly as in the absence of wage rigidity risk.

5.2 The case of firms with rigid wages

Does this result extend to firms with rigid wages? As it turns out, wage rigidity makes a difference. To see this, consider a firm whose wages have been rigid for i periods, and it is bargaining at time t with a new hire over the wage $w_t^{(i)}$. We can then derive the following proposition.

Proposition 3 *Nash bargaining between a new hire and a firm whose wages have been rigid for i periods up to time t takes place “as-if” the firm’s bargaining power was not η but $\mu_t^{(i)}$ with:*

$$\mu_t^{(i)} = \frac{\eta \lambda_{t,0}^{(i)}}{1 - \eta + \eta \lambda_{t,0}^{(i)}} \quad (5.5)$$

Proof 3 *Consider a worker which gets matched at time t with a firm whose wages have been rigid for i periods. We can then write — as in the case of a match with a flexible wage firm — the continuation value for such worker as the sum of the present discounted value of the wage rate $w_t^{(i)}$ and another term, denoted V_w :*

$$V_w(w_t^{(i)}, s_t) = \frac{1}{1 - \beta\theta p_e} w_t^{(i)} + V_w^{(i)}$$

The second term $V_w^{(i)}$ stands for the present discounted value of unemployment and the continuation value of employment under flexible wages, after i periods of rigid wages. Similarly, the continuation value for the firm

can be simplified as:

$$V_f(w_t^{(i)}; s_t) = y(s_t) - \frac{\lambda_{t,0}^{(i)}}{1 - \beta\theta p_e} w_t^{(i)} + V_f^{(i)}$$

Here the last term $V_f^{(i)}$ stands for the present discounted value of the future continuation values of the match (under flexible or rigid wages), excluding wage payments made to workers hired at time t . Then the first-order condition which determines the wage rate $w_t^{(i)}$ can be simplified, as $(1 - \mu_t^{(i)})V_f(w_t^{(i)}; s_t) = \mu_t^{(i)} [V_w(w_t^{(i)}; s_t) - U(s_t)]$, which is identical to the first-order condition where firm's bargaining power would be $\mu_t^{(i)}$.

Firms with rigid wages only bargain over a fraction of their wage bill as the rigid part is given. Therefore, an increase in the wage rate cuts firms' profits by less. Maximising the joint surplus from the match therefore implies a higher wage rate, as the benefits for workers tend to outweigh the cost for firms. This is why wage rigidity typically acts "as-if" firms had a lower bargaining power.

6 A simplified framework

Let us apply this model to a simplified framework where wages can be rigid for at most one period. Wages therefore necessarily turn flexible if they were rigid at the previous period, i.e. with a probability of 1. Otherwise, if wages are flexible this period, the probability that they turn rigid next period is still θ (they stay flexible with probability $1 - \theta$). In addition to making the model more tractable, this framework is also more realistic. Not only do wages indeed get renegotiated at regular intervals, but there can also be renegotiations on an ad-hoc basis when firms or workers perceive wage conditions to be too unfavourable.

6.1 Firms' and workers' value functions

Given that wage rigidity spells last for one period at most, expressions (4.6) and (4.7) for the value functions of firms with flexible and rigid wages, respectively denoted $V_f^{(0)}$ and $V_f^{(1)}$, simplify as:

$$\begin{aligned} V_f^{(0)}(w_t^{(0)}; s_t) &= y(s_t) - w_t^{(0)} + \beta \frac{\ell_{t+1}}{\ell_t} \int \left[(1 - \theta)V_f^{(0)}(w_{t+1}^{(0)}; s_{t+1}) + \theta V_f^{(1)}(w_{t+1}^{(1)}; s_{t+1}) \right] dF(s_{t+1}) \\ V_f^{(1)}(w_t^{(1)}; s_t) &= y(s_t) - [\lambda_t w_t^{(1)} + (1 - \lambda_t)w_{t-1}^{(0)}] + \beta \frac{\ell_{t+1}}{\ell_t} \int V_f^{(0)}(w_{t+1}^{(0)}; s_{t+1}) dF(s_{t+1}) \end{aligned} \quad (6.1)$$

with λ_t being the fraction of new hires in the workforce at time t . Similarly, the value functions $V_w^{(0)}$ and $V_w^{(1)}$ for workers who take a job with a firm with flexible or rigid wages write as:

$$\begin{aligned} V_w^{(0)}(w_t^{(0)}; s_t) &= w_t^{(0)} + \beta(1 - p_t^e) \int U(s_{t+1}) dF(s_{t+1}) + \beta p_t^e \int \left[(1 - \theta) V_w^{(0)}(w_{t+1}^{(0)}; s_{t+1}) + \theta V_w^{(1)}(w_t^{(0)}; s_{t+1}) \right] dF(s_{t+1}) \\ V_w^{(1)}(w_t^{(i)}; s_t) &= w_t^{(i)} + \beta(1 - p_t^e) \int U(s_{t+1}) dF(s_{t+1}) + \beta p_t^e \int V_w^{(0)}(w_{t+1}^{(0)}; s_{t+1}) dF(s_{t+1}) \text{ for } i = \{0; 1\} \end{aligned} \quad (6.2)$$

Note that the expression for a rigid-wage firm $V_w^{(1)}(w_t^{(i)}; s_t)$ in (6.2) is the same, no matter if the worker is a new hire or already part of the workforce, hence the superscript i in the argument $w_t^{(i)}$. A worker who stays with the rigid-wage firm today, will necessarily be paid the flexible-wage $w_{t+1}^{(0)}$ next period, since wage-rigidity only lasts for one period. Finally, given there are $1/(1 + \theta)$ flexible wage-firms at any point in time, the value of unemployment $U(s_t)$ satisfies:

$$U(s_t) = b + \beta(1 - p_t^h) \int U(s_{t+1}) dF(s_{t+1}) + \beta p_t^h \int \left[\frac{1}{1 + \theta} V_w^{(0)}(w_{t+1}^{(0)}; s_{t+1}) + \frac{\theta}{1 + \theta} V_w^{(1)}(w_{t+1}^{(1)}; s_{t+1}) \right] dF(s_{t+1}) \quad (6.3)$$

Given these expressions, we can now derive the equilibrium wage rates and their main properties. Before we do so, we will simplify the notation. First, let w_t and w_t^s respectively denote the average wage rate for flexible- and rigid-wage firms:

$$w_t = \int w_t^{(0)}(s_t) dF(s_t) \text{ and } w_t^s = \lambda_t \int w_t^{(1)}(s_t) dF(s_t) + (1 - \lambda_t) \int w_{t-1}^{(0)} dF(s_{t-1})$$

In addition, let V_t denote the time- t average continuation value of a match for a flexible-wage firm and y the average output from a match:

$$V_t = \int V_f^{(0)}(w_t^{(0)}; s_t) dF(s_t) \text{ and } y = \int y(s_t) dF(s_t)$$

Denoting $x_t = p_t^e - p_t^h + \eta p_t^h / \ell_t$, we can then derive the following proposition.

Proposition 4 *Assuming $\theta \approx 0$, the average wage rates w_t and w_t^s satisfy at the equilibrium:*

$$\boxed{w_t = \omega + \Omega_t \text{ and } w_t^s = w_t + \mathcal{P}_t} \quad (6.4)$$

where $\omega = (1 - \eta)y + \eta b$ and the terms Ω and \mathcal{P} satisfy

$$\Omega_t = \beta(1 - \eta) \frac{p_t^h}{\ell_t} V_{t+1} \quad \text{and} \quad \mathcal{P}_t = (1 - \lambda_t) \left[\beta(1 - \eta)(p_t^e - p_t^h) V_{t+1} + \eta(w_{t-1} - b) \right] \quad (6.5)$$

while the value V_t of a match for a flexible-wage firm, satisfies the recursive relationship:

$$V_t = \eta(y - b) + \beta x_t V_{t+1} \quad (6.6)$$

Proof 4 cf. appendix F.1

Firms are exclusively forward-looking when setting the flexible wage rate w_t , consistent with the fact that these firms, unlike those with sticky wages, are free of any legacy. Specifically, the flexible wage w_t writes as the sum of two terms. The first is the standard static surplus sharing $\omega = (1 - \eta)y + \eta b$, where ηb stands for the current component of workers' outside option $U(s_t)$. The second, which depends on the continuation values of a match V_{t+1} is as follows. On the one hand, firms pay a fraction $1 - \eta$ of their continuation value of the match to workers. But on the other hand, workers give up a fraction η of their continuation value of a match. Altogether, workers matched with flexible-wage firms get paid at the equilibrium $\beta(1 - \eta)(p_t^h/\ell_t)V_{t+1}$ on top of the standard surplus sharing.

Conversely, the expression for the equilibrium average wage bill w_t^s of sticky-wage firms has two components. The first one is the forward-looking flexible wage rate w_t . The second, \mathcal{P}_t is akin to a wage premium and is both forward and backward-looking. The forward-looking part is the continuation value of a match V_{t+1} . The backward-looking part consists of the legacy wage w_{t-1} , as well as past transition probabilities, which affect the fraction $1 - \lambda_t$ of old hires in the total workforce.

Differences between the wage rate set by sticky- and flexible-wage firms lie on two levels. First, firms with sticky wages always carry the legacy of past wages. As is visible in (6.4) and (6.5), the average wage bill of sticky-wage firms w_t^s is always increasing with the legacy wage rate w_{t-1} . Second, expressions (6.4) and (6.5) also show that the average wage bill of sticky-wage firms always carries a *positive* premium, i.e. $w_t^s \geq w_t$, irrespective of the legacy wage w_{t-1} , the premium \mathcal{P}_t typically increasing with the fraction $1 - \lambda_t$ of old hires.

6.2 Unemployment, transition probabilities, and wages

Let us now look into how changes in unemployment affect wages. To do so, we consider two thought experiments. First, we consider the effect of a change in the *stock* of unemployed workers, specifically, the response of wages to a fall in unemployment u_t when transition probabilities are held constant. Second, we look at the implications of a change in the *flow* of unemployed workers, considering a change in the hiring rate p_t^h when (stock-)unemployment is held constant.

6.2.1 Wages and stock-based unemployment

When the stock of unemployed workers goes up, two long-lasting changes take place. On the one hand, employment ℓ_{t+n} falls at any horizon n . Yet, because of mean reversion, employment reverts back to the steady state, implying that the continuation value of a match for firms $\beta(\ell_{t+n+1}/\ell_{t+n})V_{t+n+1}$ increases at any horizon n following an increase in the stock of unemployed workers. On the other hand, the fraction λ of new hires in the total workforce goes up, since for a given hiring rate p_t^h , higher unemployment implies a larger pool of workers available to take jobs. Because of this, the wage premium, i.e. the difference between the average wage rate paid by flexible- and sticky-wage firms, tends to shrink. The next proposition details the conditions under which the latter effect is dominated by the former effect.

Proposition 5 *Provided firms' bargaining power η is sufficiently large, an increase in the stock of unemployment workers u_t , holding transition probabilities $\{p_t^e, p_t^h\}$ constant, raises the average wage rates w_{t+n} and w_{t+n}^s paid by flexible- and stick-wage firms at any horizon n :*

$$\eta \geq \left[\frac{1}{\beta} - \frac{\delta}{e} \right] \left[1 + \delta \frac{1 - \delta + \beta\delta^2}{1 - \beta\delta^2} \right]^{-1} \implies \frac{\partial w_{t+n}}{\partial u_t}; \frac{\partial w_{t+n}^s}{\partial u_t} \geq 0 \quad (6.7)$$

Proof 5 *cf. appendix F.2*

As noted above, the flexible wage rate w_{t+n} is always increasing in stock-based unemployment u_t . This essentially reflects the counter-cyclical property of the value of a match for a firm: When unemployment is high and the economy and the labour market are in a downturn, firms expect employment to grow going forward. This raises the continuation value of match and incentivises firms to pay higher wages. Conversely, when unemployment is low and the economy and the labour market are in an upturn, firms expect employment to grow more slowly if not to contract altogether. This mechanically reduces the continuation value of a match and hence the wage rate firms are willing to pay.

While this latter property also holds true for sticky-wage firms, a large bargaining power η on the side of firms is still needed to ensure that wages paid by such (sticky-wage) firms are increasing with the stock of unemployed workers. Why is that? The explanation turns out to be relatively simple: firms with sticky wages pay a wage premium relative to firms with flexible wages which is subject to opposite forces. On the one hand, the wage premium depends positively on the fraction of pre-existing workers in the total workforce, which decreases with stock-based unemployment. Hence when unemployment goes up, the wage premium falls and sticky-wage firms would pay lower wages. But on the other hand, two effects, both of which depend positively on firms' bargaining power η , play in the opposite direction. First, an increase in the stock of unemployed workers produces a larger increase in the value of a match for firms, when firms' bargaining power η is larger. Denoting $x = \delta + \eta(1 - \delta)$, this is indeed visible in the expressions below:

$$\frac{1}{V} \frac{\partial V_{t+n}}{\partial u_t} = \beta \frac{\partial x_{t+n}}{\partial u_t} + \beta x \frac{1}{V} \frac{\partial V_{t+n+1}}{\partial u_t} \quad \text{with} \quad \frac{\partial x_{t+n}}{\partial u_t} > 0 \quad \text{and} \quad \frac{\partial^2 x_{t+n}}{\partial \eta \partial u_t} > 0$$

In a nutshell, the value of match for firms is counter-cyclical—it is high when unemployment is high and low when unemployment is low—and the more so, the higher the bargaining power η of firms. Second, the wage premium \mathcal{P}_t is more sensitive to the legacy wage w_{t-1} when the bargaining power η of firms is larger. Hence, when η is large, the average wage bill of sticky-wage firms depends more heavily on legacy wages and, as a result, is more likely to be counter-cyclical, i.e. high when the stock of unemployed workers is large, and low when the stock of unemployed workers is low.

Taken together, these effects imply that the positive impact of stock-based unemployment on the equilibrium average wage paid by sticky-wage firms (through a higher value V of matches) is more likely to dominate the negative impact of stock-based unemployment (through a lower fraction $1 - \lambda$ of pre-existing workers), the higher the bargaining power η of firms.

6.2.2 Wages and flow-based unemployment

The employment retention rate Flow-based unemployment \tilde{u} essentially depends on the hiring rate h and the employment retention rate e . Hence to find out how changes in flow-based unemployment \tilde{u}_t affect current and subsequent wages paid by flexible- and sticky-wage firms $\{w_{t+n}; w_{t+n}^s\}_{n \geq 0}$, we focus in this section on the impact of changes in these two transition probabilities. For this, let us consider in turn an increase in the employment retention rate p_t^e , as well as an increase in the hiring rate p_t^h , and investigate how they affect current and subsequent wages. Starting with the employment retention rate p_t^e , we can derive the following proposition.

Proposition 6 *An increase in the employment retention rate p_t^e raises the average wage rates w_{t+n} and w_{t+n}^s*

paid by flexible- and sticky-wage firms if and only if the auto-correlation parameter ρ_e is sufficiently large:

$$\boxed{\mathcal{S}_n(\rho_e) + \frac{\beta x \delta}{1 - \beta x \delta} \left(\frac{\delta}{\rho_e} \right)^n \leq \frac{1}{1 - \beta \delta^2} [1 + \beta \delta \rho_e] \iff \frac{\partial w_{t+n}}{\partial p_t^e}; \frac{\partial w_{t+n}^s}{\partial p_t^e} \geq 0} \quad (6.8)$$

Proof 6 cf. appendix E.3

The employment retention rate p_t^e affects current and subsequent wages w_{t+n} and w_{t+n}^s in several ways. First, a higher employment retention rate raises subsequent employment and hence employment growth. This raises the continuation value of a match for firms, which pushes up wages, as firms are willing to forego some of the increase in the continuation value of a match in the form of higher wages. However, this effect depends critically on how persistent the increase in the employment retention rate is: The higher the persistence parameter ρ_e , the longer the increase in the employment retention rate. A higher employment retention rate therefore raises equilibrium wages over a longer time span.

Second, a higher employment retention rate raises the value of a match for workers since the risk for a worker of losing her job and reverting to unemployment falls. Because unemployment is less valuable than employment, workers are typically willing to accept a *lower* wage rate when the employment retention rate is higher. Again the higher the persistence parameter ρ_e , the longer workers are willing to accept lower wages following an increase in the employment retention rate.

Altogether, an increase in the employment retention rate raises the value of a match for firms to a larger extent than the value of a match for workers, the higher the auto-correlation ρ_e . This is because as the growth rate of employment has a tendency to fall after an increase in the employment retention rate, as employment naturally goes back, absent further shocks, to its steady state. As a result, conditional on a given increase in the employment retention rate, higher persistence has a larger positive impact on the value of a match for firms than on the value of a match for workers. This is why condition (6.8) states that wages at a given horizon are more likely to be increasing in the employment retention rate, the higher the persistence parameter ρ_e .

In addition, when the employment retention rate goes up, more workers are able to remain in employment, implying that new hires then account for a smaller fraction of the workforce. For firms facing sticky wages, this means that they need to bargain over a smaller fraction of their overall wage bill. In this case, such firms typically decide to pay higher wages than they would have otherwise, which pushes their overall wage bill up. One can actually show that the wage premium, i.e. the difference between the average wage rate paid by firms with sticky wages and firms with flexible

wages, is indeed increasing with the employment retention rate, confirming that as long as flexible wages are increasing in the employment retention rate, the same holds true of the average wage bill of firms facing sticky wages.

An important implication of this result relates to the efficiency properties of shocks to the employment retention rate. Because condition (6.8) ensures that the wage premium moves in line with the employment retention rate, changes in the latter can be considered as proxies for cross-sectional dispersion in wages. However, to the extent that firms are symmetric, this dispersion is typically inefficient as it would translate (in a macro model) into price dispersion and hence inefficiently high output for some firms and inefficiently low output for others.

The hiring rate Let us now turn the case of an increase in the hiring rate p_t^h . Such a change affects equilibrium wages through three channels. First, the value of unemployment increases with the hiring rate, which raises the lower bound on equilibrium wages, be it for flexible- or sticky-wage firms. Second, a higher hiring rate raises the growth rate of employment ℓ_{t+1}/ℓ_t which raises the continuation value of a match for firms and hence the wage rate firms are willing to pay. Last, the hiring rate changes the composition of the workforce by increasing the fraction of new hires versus incumbent employees in the economy, which tends to make sticky-wage firms more cautious, and weighs on the wage rate w^s paid by these firms. However, because changes in the hiring rate display some persistence, and because employment and unemployment are naturally auto-correlated, assessing the impact of a change in the hiring rate requires factoring in the direct contemporaneous effect and also the differed ones. This is what we do in the next proposition.

Proposition 7 *An increase in the hiring rate at time p_t^h raises the average wage rates w_{t+n} and w_{t+n}^s paid by flexible- and sticky-wage firms if and only if the auto-correlation parameter ρ_h is sufficiently large:*

$$\mathcal{S}_n(\rho_h) + \frac{\beta x \delta}{1 - \beta x \delta} \left(\frac{\delta}{\rho_h} \right)^n \leq \frac{1}{1 - \beta \delta^2} \left[1 + \frac{\delta}{1 - p_e} [1 - \beta p_e \rho_h] \right] - \mathcal{H}_n(\rho_h) \iff \frac{\partial w_{t+n}}{\partial p_t^h}; \frac{\partial w_{t+n}^s}{\partial p_t^h} \geq 0 \quad (6.9)$$

where

$$\mathcal{H}_n(\rho_h) = \Phi(\rho_h) \cdot \mathcal{W}_n(\rho_h) \quad \text{with} \quad \Phi(\rho_h) = \frac{1 - \beta x \rho_h}{\varphi_0 + \varphi_1 \rho_h} \quad \text{and}$$

$$\mathcal{W}_n(\rho_h) = \max \left\{ 1 + \omega_2 \rho_h - \omega_0 \mathcal{S}_{n-1}(\rho_h) - \omega_1 \left(\frac{\delta}{\rho_h} \right)^n; 0 \right\}$$

while $(\varphi; \varphi_0; \varphi_1)$ and $(\omega_0; \omega_1; \omega_2)$ are all positive scalars.

Proof 7 cf. appendix F.4

Similar to the employment retention rate p_t^e , a higher hiring rate p_t^h leads to higher subsequent employment growth, and therefore a higher continuation value of a match for firms. This *pushes up* wages, since firms pay a fraction of future pay-offs already in today's wages. In addition, a higher hiring rate p_t^h raises the value of unemployment for workers, since unemployed workers are more likely to switch to employment. Due to the higher continuation value of unemployment and the increased reservation wage, workers demand *higher wages* to participate in a match. Because employment has a natural tendency to revert back to its steady state, an increase in the hiring rate is more likely to raise the flexible wage at a given horizon, when the auto-correlation ρ_h is higher, as this tends to delay the point at which employment growth turns negative to bring employment back to its steady state.

What about sticky wages? Since sticky wages are the sum of flexible-wages and a wage premium, they share some similarities with flexible wages. But they also face additional forces, because of the wage premium. On the one hand, the wage premium increases with the continuation value of a match V_{t+n+1} , as well with past flexible wages w_{t+n-1} . Hence, to the extent that a higher hiring rate is associated with higher flexible wages and higher continuation value of match for firms, the wage premium would also go up with the hiring rate. On the other hand, however, a higher hiring rate is associated with a lower wage premium, as new hires then account for a larger fraction of the workforce, leading sticky-wage firms and workers to agree on a lower wage premium.

Condition (6.9) shows that the net effect of these two forces can go either way. For example, the wage premium is more likely to increase with the hiring rate, — the term $\Phi(\rho_h)\mathcal{W}_k(\rho_h)$ is then positive — the higher the bargaining power η of firms. This is very intuitive since a large bargaining power on the side of firms makes the wage premium typically more sensitive to past flexible wages. By contrast, the wage premium is more likely to fall with the hiring rate when the auto-correlation parameter ρ_h is large — the term $\Phi(\rho_h)\mathcal{W}_n(\rho_h)$ is decreasing in ρ_h . Again the reason is fairly intuitive: the higher the persistence parameter ρ_h , the longer an increase in the hiring rate will raise the fraction of new hires in the total workforce, thereby weighing on the wage premium over a longer time span.

This last point illustrates a key difference between the employment retention rate p_t^e and the hiring rate p_t^h . While both affect the unemployment gap and flexible wages in a qualitatively similar way, — raising flexible wages while turning the unemployment gap negative — things are different for sticky wages. This is because changes in the employment retention rate move flexible and sticky wages in the same way, as the wage premium move in line with flexible wages. By contrast, the hiring rate can move flexible wages and the wage premium in opposite directions, so that flexible and sticky wages may not respond similarly to a given change in the hiring rate.

This property of the model sheds lights on some of our empirical findings. In particular, the property that the employment retention rate, i.e. "E-to-E" transitions, appears to be crucial for our unemployment gap, followed by the hiring rate, i.e. "U-to-E" transitions. This is consistent with the comparative statics results described above. To the extent that the unemployment gap is a good predictor of subsequent wage and cost pressures, it makes sense within our model, that "E-to-E" transitions have an un-ambiguous impact on aggregate wages (as both flexible and sticky wages move in the same direction), while the impact of "U-to-E" transitions is more blurred given the possibly opposite effects on flexible and sticky wages.

7 Wrapping-up the main results.

Our analytical framework has delivered two main results as follows. First, according to condition (6.7), there exists a lower bound $\underline{\eta}$ such that wages paid by flexible- and sticky-wage firms are increasing with the stock of unemployed workers u_t if firms' bargaining power η satisfies $\eta \geq \underline{\eta}$:

$$\eta \geq \underline{\eta} \Rightarrow \frac{\partial w_{t+i}}{\partial u_t} \geq 0 \text{ and } \frac{\partial w_{t+i}^s}{\partial u_t} \geq 0 \text{ for any } i \geq 0 \quad (7.1)$$

Second, according to conditions (6.8) and (6.9), there exist lower bounds $\underline{\rho}_j(n)$ ($j = \{e; h\}$) such that all wage rates up to n periods ahead are increasing in the transition probability p_t^j if the persistence parameter satisfies $\rho_j \geq \underline{\rho}_j(n)$:

$$\rho_j \geq \underline{\rho}_j(n) \Rightarrow \frac{\partial w_{t+i}}{\partial p_t^j} \geq 0 \text{ and } \frac{\partial w_{t+i}^s}{\partial p_t^j} \geq 0 \text{ for any } 0 \leq i \leq n \quad (7.2)$$

Hence, denoting $\rho(n) = \max\{\rho_e(n); \rho_h(n)\}$, we can derive the final proposition below, which sets a set of sufficient conditions for how the unemployment gap affect subsequent wages.

Proposition 8 *An increase in the unemployment gap $z_t = \tilde{u}_t - u_t$ cuts the series of equilibrium average wage rates $\{w_{t+i}; w_{t+i}^s\}_{0 \leq i \leq n}$ up to n periods ahead, when firms' bargaining power η and the persistence parameters ρ_e and ρ_h are sufficiently large and satisfy:*

$$\eta \geq \underline{\eta} \text{ and } \rho_e; \rho_h \geq \rho(n) \quad (7.3)$$

Proof 8 See propositions (5), (6) and (7).

8 Conclusion

This paper introduces a novel measure to capture momentum in the labour market: the unemployment gap, defined as the difference between the flow-based steady-state unemployment rate and the actual stock-based unemployment rate. Unlike traditional measures of labour market tightness, the unemployment gap captures the dynamics of the labour market and proves to be a robust indicator of both subsequent wage and price inflation.

Our analysis demonstrates that the unemployment gap contains valuable information that standard stock-based measures often overlook. Specifically, a positive unemployment gap—where flow-based unemployment exceeds actual unemployment—signals easing inflationary pressures, while a negative gap is associated with higher wage and price inflation in the future. Furthermore, we find that flows into employment are the primary drivers of the unemployment gap, with the employment retention rate and the hiring rate playing the most significant roles.

To rationalize these empirical findings, we extend the standard search-and-matching model by incorporating partial nominal wage rigidities. By distinguishing between sticky wages for existing workers and flexible bargaining for new hires, our model reveals that firms' effective bargaining power becomes endogenous to labour market stocks and flows. For instance, an increase in the employment retention rate makes firms more willing to pay higher wages, as the pool of new hires shrinks, reducing firms' sensitivity to negotiated wages. Additionally, a higher retention rate raises employment growth, which increases the value of a match for firms. These effects are amplified when the shocks to transition probabilities are persistent. Similarly, an increase in the hiring rate also boosts employment growth and firms' valuation of matches, but its impact on wages is moderated as new hires represent a larger group, prompting firms to keep newly bargained wages in check. Overall, our model underscores the importance of the persistence of shocks to transition probabilities in explaining the observed empirical patterns.

Looking ahead, these findings offer a fresh perspective on the relationship between labour market dynamics and wage inflation. The evidence suggests that prices and wages are highly sensitive to the velocity of the labour market—that is, the flows and transitions—rather than just the level of unemployment. Shifting the analytical focus from the stock of unemployment to the flows governing its trajectory provides critical insights into price pressures. This underscores the importance of the “direction of travel” in labour market dynamics, which can be as, if not more, informative than the destination (the stock of unemployment) itself.

References

- Ball, L., D. Leigh, and P. Mishra (2022). Understanding us inflation during the covid-19 era. *Brookings Papers on Economic Activity* 2022(2), 1–80.
- Barnichon, R. (2010). Building a composite help-wanted index. *Economics Letters* 109(3), 175–178.
- Barnichon, R. and G. Mesters (2020). Identifying modern macro equations with old shocks. *The Quarterly Journal of Economics* 135(4), 2255–2298.
- Barnichon, R. and C. J. Nekarda (2012). The ins and outs of forecasting unemployment: Using labor force flows to forecast the labor market. *Brookings Papers on Economic Activity*, 83–131.
- Bauer, M. D. and E. T. Swanson (2023). A reassessment of monetary policy surprises and high-frequency identification. *NBER Macroeconomics Annual* 37(1), 87–155.
- Beaudry, P., C. Hou, and F. Portier (2024). The dominant role of expectations and broad-based supply shocks in driving inflation. Technical report, National Bureau of Economic Research.
- Benigno, G., J. Di Giovanni, J. J. Groen, and A. I. Noble (2022). The gscpi: a new barometer of global supply chain pressures. *FRB of New York Staff Report* (1017).
- Benigno, P. and G. B. Eggertsson (2023). It's baaack: The surge in inflation in the 2020s and the return of the non-linear phillips curve. *National Bureau of Economic Research Working Paper*.
- Benigno, P. and G. B. Eggertsson (2024a). Revisiting the phillips and beveridge curves: Insights from the 2020s inflation surge. *National Bureau of Economic Research Working Paper*.
- Benigno, P. and G. B. Eggertsson (2024b). Slanted-l phillips curve. In *AEA Papers and Proceedings*, Volume 114, pp. 84–89. American Economic Association 2014 Broadway, Suite 305, Nashville, TN 37203.
- Bernanke, B. and O. Blanchard (2023). What caused the us pandemic-era inflation? *Peterson Institute for International Economics Working Paper* (23-4).
- Blanchard, O. and J. Galí (2010). Labor markets and monetary policy: A new keynesian model with unemployment. *American economic journal: macroeconomics* 2(2), 1–30.
- Blanchard, O. J. and P. A. Diamond (1992). The flow approach to labor markets.
- Bok, B., R. K. Crump, C. J. Nekarda, and N. Petrosky-Nadeau (2023). Estimating natural rates of unemployment: A primer. Federal Reserve Bank of San Francisco.

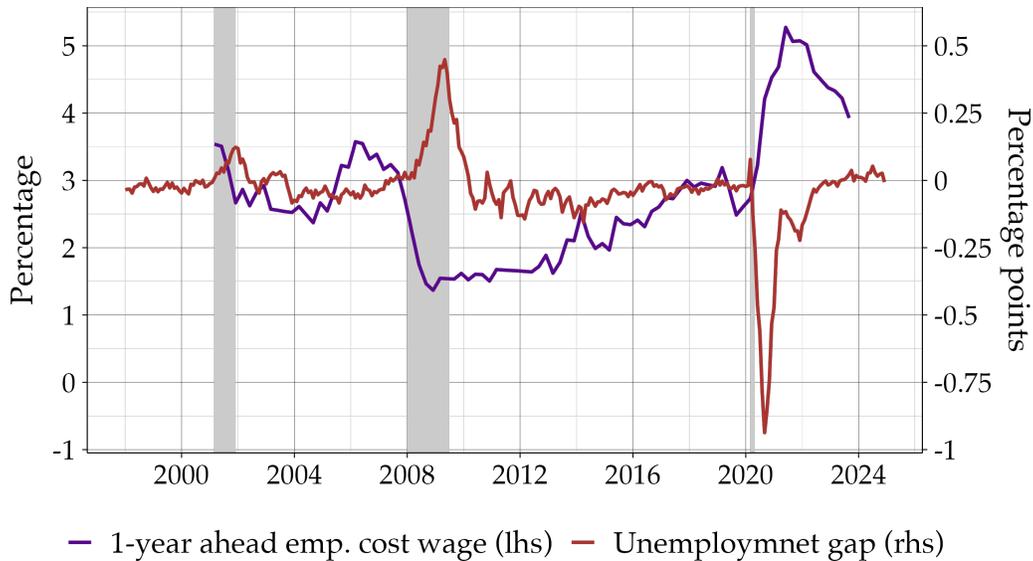
- Crump, R. K., S. Eusepi, M. Giannoni, and A. Şahin (2019). A unified approach to measuring u. Technical report, National Bureau of Economic Research.
- Crump, R. K., S. Eusepi, M. Giannoni, and A. Şahin (2024). The unemployment-inflation trade-off revisited: The phillips curve in covid times. *Journal of Monetary Economics*, 103580.
- Dixon, R., G. C. Lim, and J. C. van Ours (2015). The effect of shocks to labour market flows on unemployment and participation rates. *Applied Economics* 47(24), 2523–2539.
- Donovan, K., W. J. Lu, and T. Schoellman (2023). Labor market dynamics and development. *The Quarterly Journal of Economics* 138(4), 2287–2325.
- Elsby, M. W., B. Hobijn, and A. Sahin (2010). The labor market in the great recession. Technical report, National Bureau of Economic Research.
- Elsby, M. W., B. Hobijn, and A. Şahin (2013). Unemployment dynamics in the oecd. *Review of Economics and Statistics* 95(2), 530–548.
- Elsby, M. W. L., R. Michaels, and G. Solon (2009). The ins and outs of cyclical unemployment. *American Economic Journal: Macroeconomics* 1(1), 84–110.
- Faccini, R. and L. Melosi (2023). Job-to-job mobility and inflation. *Review of Economics and Statistics*, 1–45.
- Fallick, B. and C. A. Fleischman (2004). Employer-to-employer flows in the us labor market: The complete picture of gross worker flows. *Available at SSRN* 594824.
- Fontaine, I., I. Galvez-Iniesta, P. Gomes, and D. Vila-Martin (2020). Labour market flows: Accounting for the public sector. *Labour Economics* 62, 101770.
- Forbes, K., J. Gagnon, and C. G. Collins (2021). Low inflation bends the phillips curve around the world. Technical report, National Bureau of Economic Research.
- Friedman, M. (1995). *The role of monetary policy*. Springer.
- Fujita, S., G. Moscarini, and F. Postel-Vinay (2024). Measuring employer-to-employer reallocation. *American Economic Journal: Macroeconomics* 16(3).
- Gali, J. and M. Gertler (1999). Inflation dynamics: A structural econometric analysis. *Journal of monetary Economics* 44(2), 195–222.
- Gertler, M. and A. Trigari (2009). Unemployment fluctuations with staggered nash wage bargaining. *Journal of political Economy* 117(1), 38–86.

- Gordon, R. J. (1970). Prices in 1970: The horizontal phillips curve? *Brookings Papers on Economic Activity* 1970(3), 449–458.
- Gordon, R. J., R. Solow, G. Perry, and R. Gordon (1970). The recent acceleration of inflation and its lessons for the future. *Brookings Papers on Economic Activity* 1970(1), 8–47.
- Hall, R. E. (1974). The process of inflation in the labor market. *Brookings Papers on Economic Activity* 1974(2), 343–393.
- Hall, R. E. (2005). Employment fluctuations with equilibrium wage stickiness. *American economic review* 95(1), 50–65.
- Hall, R. E., R. Gordon, and C. Holt (1970). Why is the unemployment rate so high at full employment? *Brookings papers on economic activity* 1970(3), 369–410.
- Hall, R. E. and M. Kudlyak (2023). The active role of the natural rate of unemployment during cyclical recoveries. Technical report, National Bureau of Economic Research.
- Hazell, J., J. Herreno, E. Nakamura, and J. Steinsson (2022). The slope of the phillips curve: evidence from us states. *The Quarterly Journal of Economics* 137(3), 1299–1344.
- Heise, S., J. Pearce, and J. P. Weber (2024, October). Wage growth and labor market tightness. Staff report, Federal Reserve Bank of New York. Revised March 2025.
- Jørgensen, P. L. and K. J. Lansing (2019). Anchored inflation expectations and the slope of the phillips curve. *Federal Reserve Bank of San Francisco Working Paper* 27.
- Krause, M. U., D. Lopez-Salido, and T. A. Lubik (2008). Inflation dynamics with search frictions: A structural econometric analysis. *Journal of Monetary Economics* 55(5), 892–916.
- Krause, M. U. and T. A. Lubik (2007). The (ir) relevance of real wage rigidity in the new keynesian model with search frictions. *Journal of Monetary Economics* 54(3), 706–727.
- Michaillat, P. and E. Saez (2024). $u^* = \sqrt{uv}$: The full-employment rate of unemployment in the united states. *Brookings Papers on Economic Activity* 55(2).
- Mortensen, D. T. and C. A. Pissarides (1994). Job creation and job destruction in the theory of unemployment. *The review of economic studies* 61(3), 397–415.
- Moscarini, G. and F. Postel-Vinay (2023). The job ladder: Inflation vs. reallocation. Technical report, National Bureau of Economic Research.

- Phelps, E. S. (1967). Phillips curves, expectations of inflation and optimal unemployment over time. *Economica*, 254–281.
- Phelps, E. S. (1968). Money-wage dynamics and labor-market equilibrium. *Journal of political economy* 76(4, Part 2), 678–711.
- Pilossof, L. and J. M. Ryngaert (2024). Job search, wages, and inflation. Technical report, National Bureau of Economic Research.
- Şahin, A., M. Tasci, and J. Yan (2021). Unemployment in the time of covid-19: a flow-based approach to real-time unemployment projections. Technical report, National Bureau of Economic Research.
- Sahm, C. (2019). Chapter 3: Direct stimulus payments to individuals. In H. Shambaugh, R. Boushey, and J. Nunn (Eds.), *Recession Ready: Fiscal Policies to Stabilize the American Economy*. Brookings Institute.
- Shimer, R. (2005). The cyclical behavior of equilibrium unemployment and vacancies. *American economic review* 95(1), 25–49.
- Shimer, R. (2012). Reassessing the ins and outs of unemployment. *Review of Economic Dynamics* 15(2), 127–148.
- Thomas, C. (2008). Search and matching frictions and optimal monetary policy. *Journal of Monetary Economics* 55(5), 936–956.

A Additional descriptives

Appendix Figure A1: Employment cost inflation and the unemployment gap



Notes: This figure shows the time series for the 1-year ahead employment cost (wage) inflation and the unemployment gap. The gray areas indicate NBER recessions. *Data source:* Bureau of labour Statistics; authors' calculations.

A.1 Transition probabilities around key events

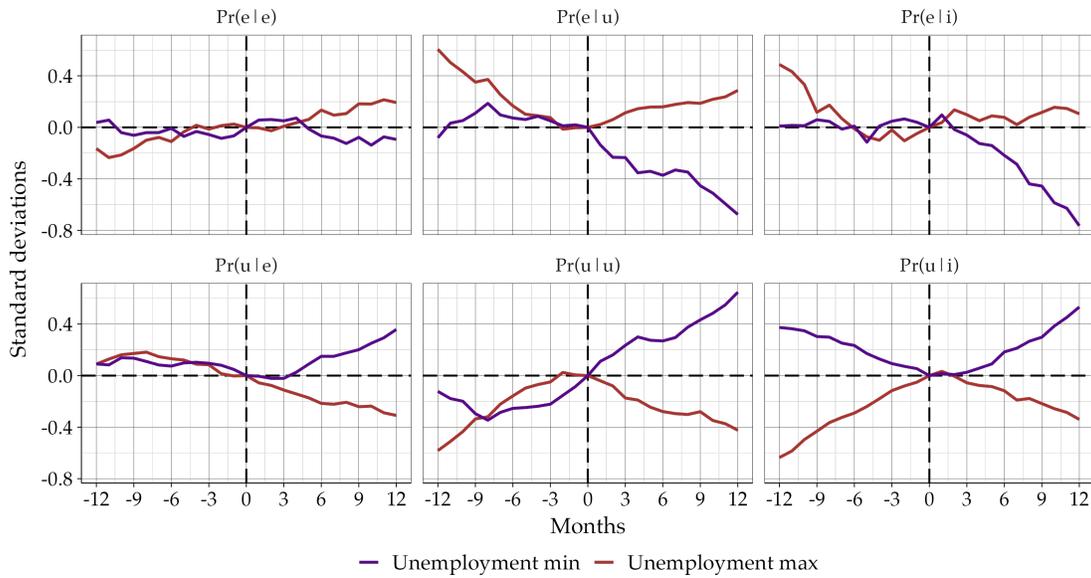
The figures below illustrate the dynamics of transition probabilities around local minima and maxima of the (stock-based) unemployment rate and the unemployment gap. This analysis parallels the exercise in Section 2.2.1.

For stock-based unemployment, Figure A2, local minima often precede the onset of recessions, while the unemployment rate typically peaks after the recession has already begun (see Figure 2 in the main part). Following a local minimum, the most pronounced changes are observed in the job-finding rate—which declines — and unemployment persistence — which rises. Notably, unemployment persistence begins to edge up as early as nine months prior to the trough. Around maxima, the dynamics largely mirror those at minima, but the leading indicators now shift: the employment persistence and the job-separation rate begin to deteriorate roughly nine months before the peak.

Similar patterns arise around turning points in the unemployment gap itself, see Figure A3. A maximum in the unemployment gap, which typically occurs shortly before the end of a recession, is followed by a lagged reversal in the job-separation rate and unemployment persistence, both of which begin to decline only about nine months after the peak. In contrast, employment persistence and the job-finding rate start to improve already around the peak. This pattern is economically intuitive:

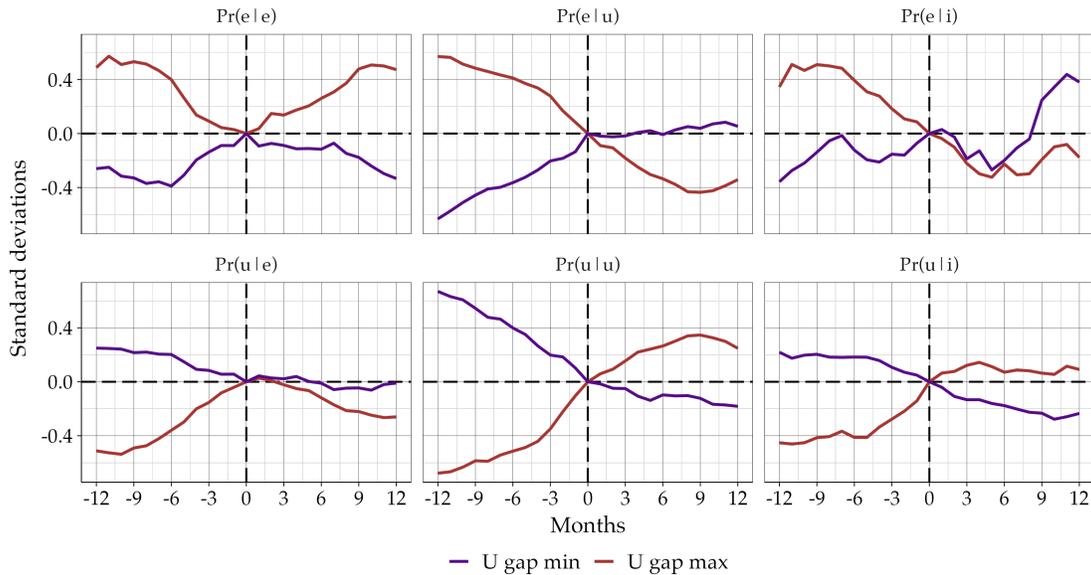
firms tend to stop firing first, while hiring resumes only with some delay.

Appendix Figure A2: Average change in transition probabilities around (stock) unemployment min/max



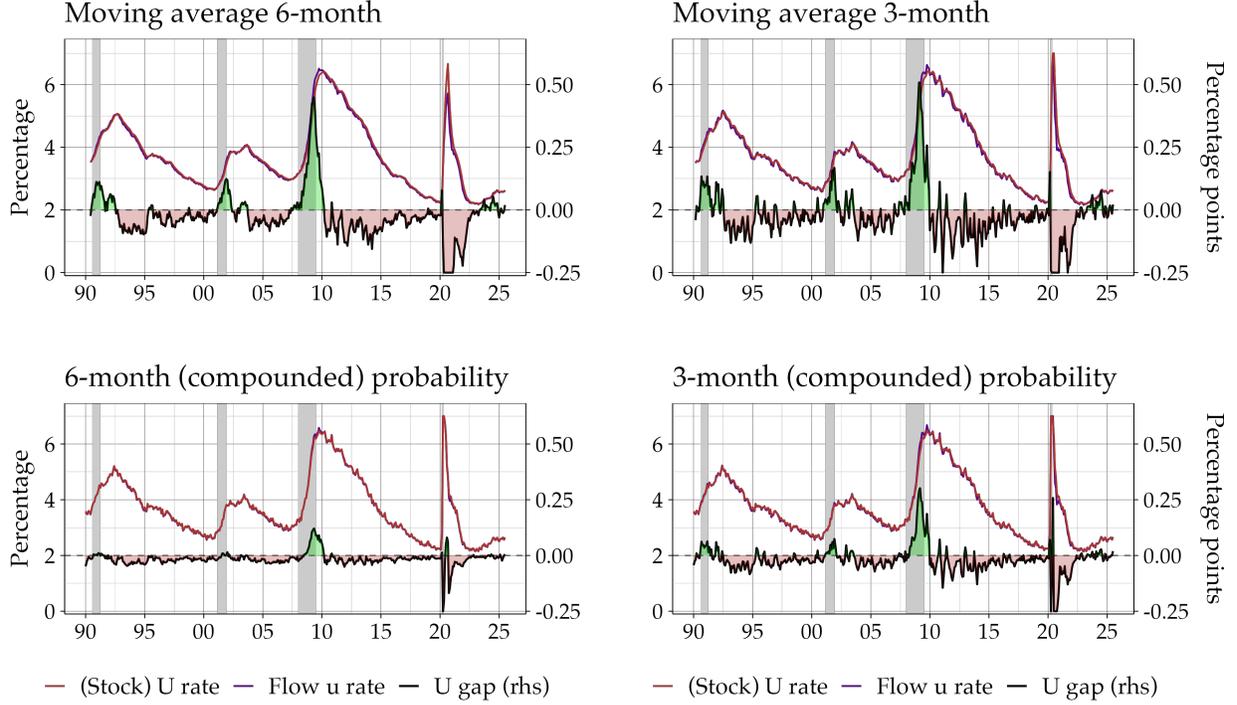
Notes: The figure shows the mean development of individual transition probabilities around the minimum and maximum of stock-based unemployment fluctuations (excluding the COVID period). *Data sources:* U.S. Bureau of labour Statistics; authors' calculations.

Appendix Figure A3: Average change in transition probabilities around unemployment gap min/max



Notes: The figure shows the mean development of individual transition probabilities around the minimum and maximum of unemployment gap fluctuations (excluding the COVID period). *Data sources:* U.S. Bureau of labour Statistics; authors' calculations.

Appendix Figure A4: Alternative calculations for the unemployment gap



Notes: The figure illustrates different approaches to calculating the unemployment gap. This paper uses the 6-month backward-looking moving average, shown in the top-left panel. Compounded probabilities refer to transition probabilities calculated over the respective 3- and 6-month periods. Note that the right-hand scale is different compared to Figure 2. Unemployment rates are cut at 7, the gap is cut at -0.25 . *Data sources:* U.S. Bureau of labour Statistics; authors' calculations.

B Mathematical derivation of the flow-based conditional steady state unemployment rate

Consider an economy where agents can be either employed (e), unemployed (u) or inactive (i). Moreover, let M_{t+1} denote the matrix for labour market transition probabilities between date t and date $t + 1$ where the probability to switch from state x at date t to state y at date $t + 1$ is denoted by $\Pr[y_{t+1}|x_t]$. The transition matrix M_{t+1} therefore writes as:

$$M_{t+1} = \begin{bmatrix} \Pr[e_{t+1}|e_t] & \Pr[e_{t+1}|u_t] & \Pr[e_{t+1}|i_t] \\ \Pr[u_{t+1}|e_t] & \Pr[u_{t+1}|u_t] & \Pr[u_{t+1}|i_t] \\ \Pr[i_{t+1}|e_t] & \Pr[i_{t+1}|u_t] & \Pr[i_{t+1}|i_t] \end{bmatrix}$$

Let $m_t = (e_t, u_t, i_t)'$ denote the vector describing the labour market at date t , with e_t , u_t , and i_t denoting the fraction of the population that is respectively employed, unemployed, and inactive at date t . Then

the dynamics of the labour market writes as

$$m_{t+1} = M_{t+1} \cdot m_t$$

Given that at any point in time, the employed, unemployed and the inactive make up for the total population, i.e. $e_t + u_t + i_t = 1$, the different probabilities conditional on a given initial state x_t also sum up to one:

$$\Pr[e_{t+1}|x_t] + \Pr[u_{t+1}|x_t] + \Pr[i_{t+1}|x_t] = 1$$

We compute the steady-state unemployment, employment, and inactivity rates that would prevail under the currently observed transition probabilities. Specifically, we calculate the conditional (flow-based) steady state, \tilde{m}_{t+1} , such that given the transition matrix M_{t+1} , \tilde{m}_{t+1} is the eigenvector of the matrix M_{t+1} associated with the eigenvalue one:

$$\tilde{m}_{t+1} = M_{t+1} \cdot \tilde{m}_{t+1}$$

where $\tilde{m}_t = (\tilde{e}_t, \tilde{u}_t, \tilde{i}_t)'$ represents the steady-state rates of employment, unemployment, and inactivity. This calculation is performed for each transition matrix M at any time t , yielding a time series of the conditional employment, unemployment and inactivity rates that would hold if observed transition probabilities remained unchanged indefinitely.

Based on these relationships, let $q[y_{t+1}|x_t] = \Pr[y_{t+1}|x_t] - \Pr[i_{t+1}|x_t]$, denote the probability to switch from x_t to y_{t+1} relative to the probability to switch from x_t to inactivity. Then, the law of motion for the dynamics of the labour market satisfies:

$$\begin{bmatrix} e_{t+1} \\ u_{t+1} \end{bmatrix} = \begin{bmatrix} q[e_{t+1}|e_t] & q[e_{t+1}|u_t] \\ q[u_{t+1}|e_t] & q[u_{t+1}|u_t] \end{bmatrix} \begin{bmatrix} e_t \\ u_t \end{bmatrix} + \begin{bmatrix} \Pr[e_{t+1}|i_t] \\ \Pr[u_{t+1}|i_t] \end{bmatrix}$$

Let Q_{t+1} denote the above 2-by-2 transition matrix. Then, given this transition matrix Q_{t+1} , the fraction $\tilde{x}_{t+1} = \{\tilde{e}_{t+1}; \tilde{u}_{t+1}\}$ of the population that is in state x at the steady state, conditional on the transition matrix q_{t+1} write as:

$$\tilde{x}_{t+1} = \Gamma_{t+1}^x \Pr[x_{t+1}|i_t] + \Lambda_{t+1}^x \Pr[-x_{t+1}|i_t] \text{ for } x = \{e; u\}$$

where the parameters Γ_{t+1} and Λ_{t+1} are non-linear expressions of the probabilities included in the matrix q_{t+1} . Specifically, the parameters that link steady-state employment \tilde{e}_{t+1} to the probabilities to

switch out of inactivity $\Pr[e_{t+1}|i_t]$ and $\Pr[u_{t+1}|i_t]$, satisfy:

$$\Gamma_{t+1}^e = \frac{1 - q[u_{t+1}|u_t]}{\det(I - Q_{t+1})} \text{ and } \Lambda_{t+1}^e = \frac{q[e_{t+1}|u_t]}{\det(I - Q_{t+1})}$$

Similarly, the parameters that link steady-state unemployment \tilde{u}_{t+1} to the probabilities to switch out of inactivity $\Pr[u_{t+1}|i_t]$ and $\Pr[i_{t+1}|i_t]$, satisfy:

$$\Gamma_{t+1}^u = \frac{1 - q[e_{t+1}|e_t]}{\det(I - Q_{t+1})} \text{ and } \Lambda_{t+1}^u = \frac{q[u_{t+1}|e_t]}{\det(I - Q_{t+1})}$$

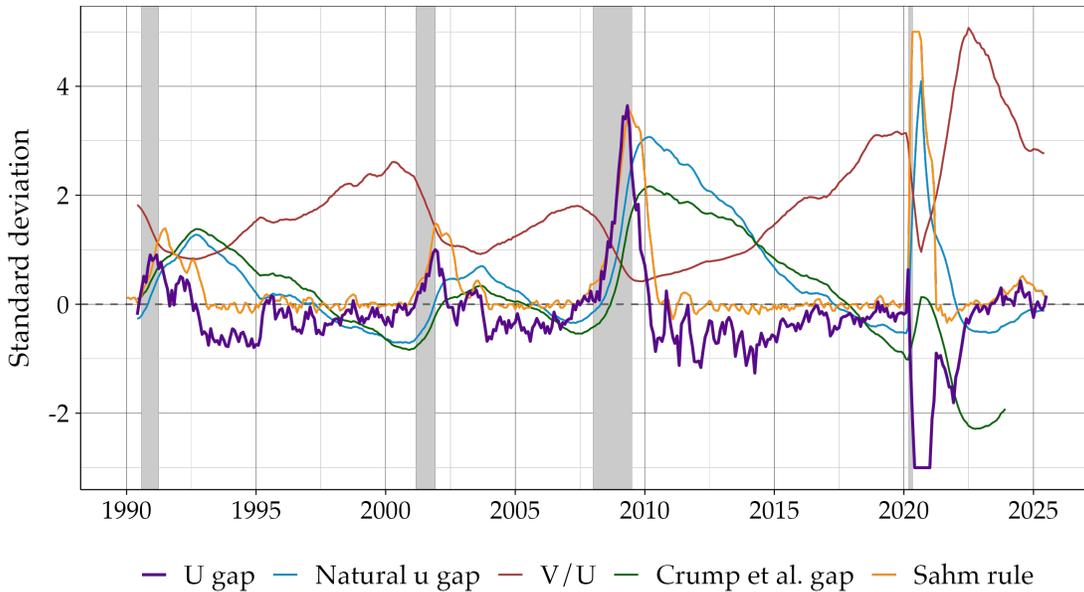
Finally assuming the matrix q can be diagonalised, i.e. it has two eigenvalues, the speed σ_{t+1} at which the labour market converges to its conditional steady state $\tilde{x}_{t+1} = \{\tilde{e}_{t+1}; \tilde{u}_{t+1}\}$ simply depends on the trace of the matrix q_{t+1} , i.e.

$$\sigma_{t+1} = 1 - \frac{1}{2} \text{Tr}[Q_{t+1}]$$

C Unemployment rates & transition probabilities

C.1 Alternative unemployment rate & gap measures

Appendix Figure C5: Traditional measures for the unemployment gap / economic slack



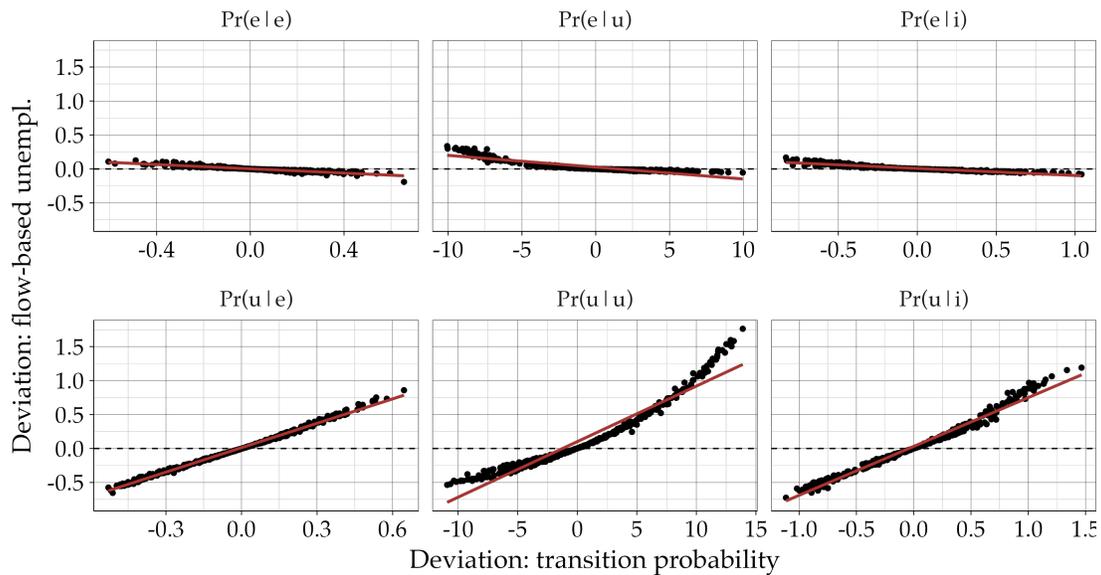
Notes: The figure shows different measure of some kind of unemployment gap. The *Natural u gap* is the natural unemployment gap defined as the difference between the observed unemployment rate as a share of the labour force and the Congressional Budget Office's *Noncyclical Rate of Unemployment*. *V/U* is the vacancy-to-unemployment ratio. *Crump et al. gap* is the gap based on [Crump et al. \(2019\)](#) measure of steady state unemployment. *Sahm rule* shows the measure defined in [Sahm \(2019\)](#). The *U gap* and the *Sahm rule* are truncated at the bottom and top, respectively. *Data source:* Bureau of labour Statistics; Congressional Budget Office; [Crump et al. \(2019\)](#); [Sahm \(2019\)](#); authors' calculations.

Appendix Table C1

	Natural u gap	V/U	Crump et al. gap	Sahm rule
Unemployment gap	-0.25	-0.04	0.06	-0.16

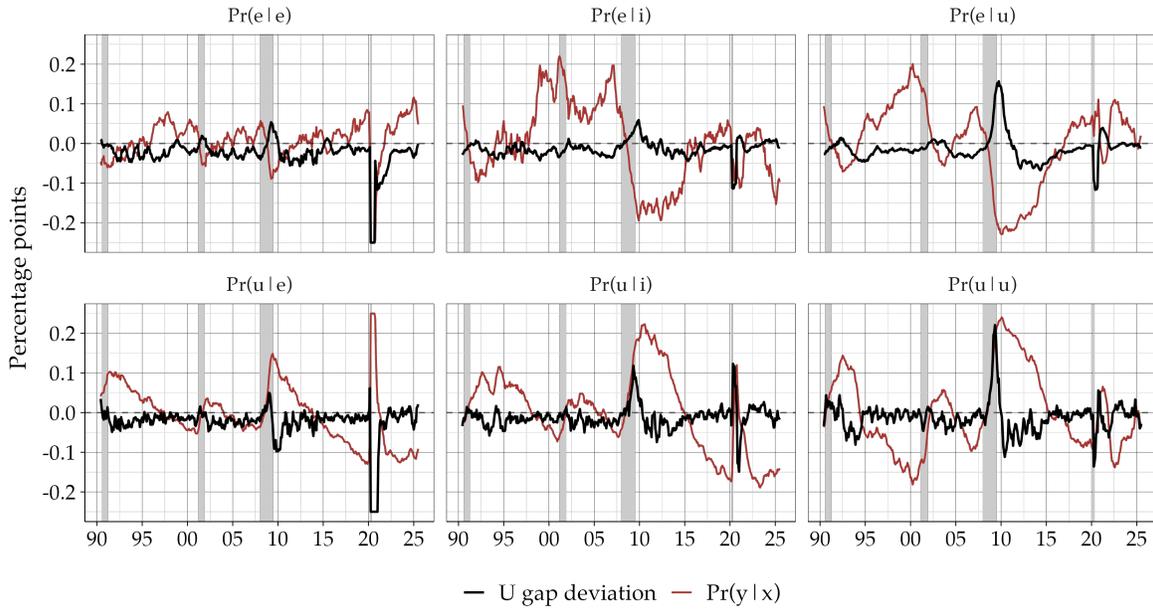
Notes: This table shows the contemporaneous correlation of the unemployment gap with the measures shown in Figure C5. *Data sources:* Bureau of labour Statistics; Congressional Budget Office; [Crump et al. \(2019\)](#); [Sahm \(2019\)](#); authors' calculations.

Appendix Figure C6: Actual vs. counter-factual flow-based unemployment rates



Notes: Each panel plots the difference between actual and counter-factual flow-based unemployment rates where the counter-factual is computed assuming each transition probability is constant at its long-run average, against deviations of the actual transition probability from its long-run average. All deviations are expressed in percentage points. The red lines in each panel plot the predicted difference between actual and counter-factual flow-based unemployment based on a linear adjustment. *Data sources:* U.S. Bureau of Labour Statistics; authors' calculations.

Appendix Figure C7: Alternative calculations for the unemployment gap



Notes: The figure plots the deviation of the counterfactual unemployment gap from the original unemployment gap in black (6-months moving average). The transition probability indicated in each panels' title is kept constant at its historical mean. The red line shows the respective (demeaned) transition probability over time. The graphs are cut at the top and at the bottom. *Data sources:* U.S. Bureau of labour Statistics; authors' calculations.

D Regression robustness - unemployment rate

D.1 Regression tables

The following tables show additional results for the estimation of the effect of the unemployment measures on the change in the unemployment rate.

Appendix Table D2: Unemployment rate dynamics controlling for alternative labour market indicators

	12-months ahead change in unemployment rate			
	(1)	(2)	(3)	(4)
Stock-unempl. rate (u)	-0.281*** (0.079)	-0.357*** (0.119)	-0.119 (0.292)	-0.244*** (0.081)
Unemployment gap (z)	3.460*** (0.651)	2.934*** (0.521)	2.806*** (0.658)	3.002*** (0.591)
Change in stock-unempl.	-0.255** (0.111)			
Vacancy/unemployment		-0.194 (0.314)		
Natural u gap			-0.001 (0.002)	
Labour part. rate				0.319 (0.198)
Adj. R ²	0.334	0.299	0.301	0.330
Num. obs.	409	409	409	409
RMSE	0.780	0.800	0.799	0.782

Notes: Since vacancy data (i.e., the number of job openings) from the BLS is only available starting in December 2000, we extend the series back to 1990 using historical estimates constructed by [Barnichon \(2010\)](#). The *Natural u gap* is the natural unemployment gap defined as the difference between the observed unemployment rate as a share of the labour force and the Congressional Budget Office's *Noncyclical Rate of Unemployment*. The *Labour part. rate* is the labour participation rate of the working age population. The unemployment gap is expressed in standard deviations. Asteriks indicate significance at the 1%, 5%, and 10% level (** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$). Standard errors are Newey-West corrected (18 months). The constant term is omitted from the table.

Appendix Table D3: Unemployment rate dynamics controlling for business cycle indicators

	12-months ahead change in unemployment rate				
	(1)	(2)	(3)	(4)	(5)
Stock-unempl. rate (u)	-0.181 (0.195)	-0.301*** (0.087)	-0.301*** (0.086)	-0.312*** (0.091)	-0.327*** (0.090)
Unemployment gap (z)	3.021*** (0.577)	3.130*** (0.544)	3.117*** (0.462)	2.670*** (0.746)	2.638*** (0.427)
Output gap	0.085 (0.104)				
Oil price (growth rate)		0.004 (0.003)			
Industrial production (growth rate)			0.006 (0.026)		
Supply chain pressure				-0.088 (0.085)	
Recession indicator					0.417 (0.422)
Adj. R ²	0.304	0.306	0.298	0.295	0.314
Num. obs.	409	409	409	314	404
RMSE	0.798	0.797	0.801	0.897	0.794

Notes: *Output gap* is based on series provided by the Congressional Budget Office. *Oil price inflation* is calculated using the West Texas Intermediate (WTI) Crude Oil Price. *Supply chain pressure* is the *Global supply chain pressure index* published by the Federal Reserve Bank of New York (Benigno et al., 2022). The *Recession indicator* is a dummy for NBER-defined recession periods. Oil price inflation, supply chain pressure, as well as the unemployment gap are expressed in standard deviations. Asterisks indicate significance at the 1%, 5%, and 10% level (** $p < 0.01$; * $p < 0.05$; $p < 0.1$). Standard errors are Newey-West corrected (18 months). The constant term is omitted from the table.

Appendix Table D4: Does the unemployment gap depend on price and output expectations?

	Unemployment gap				
	(1)	(2)	(3)	(4)	(5)
Infl. expectation (1y)	0.031 (0.036)				-0.017 (0.043)
Consensus GDP forecast		-0.026 (0.034)			-0.027 (0.030)
Forward Rate 1 Year			0.012 (0.009)		0.026* (0.014)
Term spread (10-2y)				0.010 (0.016)	0.041* (0.025)
Adj. R ²	0.035	0.047	0.046	0.003	0.152
Num. obs.	421	421	421	421	421
RMSE	0.121	0.120	0.120	0.123	0.114

Notes: This table reports estimation results when the 6-month backward looking moving average of the monthly unemployment gap is regressed on 1-year ahead inflation expectations, 1-year ahead consensus GDP forecasts, the 1-year forward rate and the difference between the 10-year and the 2-year treasury yields, denoted as *Term spread (10-2y)*. Asterisks indicate significance at the 1%, 5%, and 10% level (** $p < 0.01$; * $p < 0.05$; $p < 0.1$). Standard errors are Newey-West corrected (18 months). The constant term is omitted from the table.

E Regression robustness - inflation

E.1 Summary statistics

Appendix Table E5

	Mean	S.D.	Skew.	Kurt.	10 th perc.	25 th perc.	50 th perc.	75 th perc.	90 th perc.
Core CPI inflation	2.56	1.1	1.56	5.56	1.61	1.9	2.26	2.85	4.01
CPI core services infl.	3.22	1.12	1	5.1	2.18	2.61	3.06	3.67	4.6
CPI core goods infl.	0.87	2.13	2.47	11.39	-0.9	-0.28	0.42	1.46	2.77
Headline CPI inflation	2.62	1.56	1.11	6.4	1.12	1.7	2.57	3.18	4.14
Headline PCE inflation	2.17	1.29	1.12	6.25	0.85	1.45	2.11	2.62	3.47
Core PCE inflation	2.11	0.95	1.77	6.26	1.25	1.53	1.86	2.28	3.37
Empl. cost infl. (wages)	2.76	0.96	0.75	3.02	1.62	2.04	2.62	3.2	4.32
Empl. cost infl. (total)	3.11	0.86	0.17	2.3	1.95	2.48	3.07	3.73	4.27
ULC inflation	1.57	1.66	-0.48	4.63	-0.22	0.7	1.68	2.5	3.35

Notes: This table shows the summary statistics of the various inflation measures. The numbers are in percentages year-on-year inflation. *S.D.* stands for standard deviation. *Data sources:* U.S. Bureau of labour Statistics; authors' calculations.

Appendix Table E6

	Mean	S.D.	Skew.	Kurt.	10 th perc.	25 th perc.	50 th perc.	75 th perc.	90 th perc.
Infl. expectation (1y)	2.4	0.79	0.28	2.84	1.44	1.77	2.42	2.93	3.39
Oil price inflation	4.97	25.32	0.49	5.24	-22.98	-11.18	3.37	18.73	35.44
Productivity	1	1.12	1.12	6.96	-0.28	0.38	0.91	1.51	2.29
Labour part. rate	-0.09	0.57	-2.84	24.93	-0.6	-0.3	0	0.16	0.45
Industrial production	0.78	2.73	-1.82	13.99	-1.66	0	1.15	2.11	3.15
Supply chain pressure	0.01	0.94	2.26	8.24	-0.73	-0.53	-0.25	0.09	1.05
Vacancy/unemployment	0.68	0.38	1.2	4.32	0.3	0.4	0.6	0.87	1.19
Natural u gap	74.87	158.38	1.25	3.83	-78.48	-43.08	27.5	136.89	337.31
Output gap	-0.61	1.79	-0.52	2.44	-3.11	-1.75	-0.33	0.9	1.54

Notes: This table shows the summary statistics of the main control variables. *Inflation expectation (1y)* are the 1-year expectations of inflation calculated by the [Federal Reserve Bank of Cleveland](#). *Oil price inflation* is calculated using the West Texas Intermediate (WTI) Crude Oil Price. *Productivity* is using the *Nonfarm Business labour productivity output per hour* index. The *Labour part. rate* is the labour participation rate of the working age population (6-month growth rate). *Industrial production* is the 6-month growth rate in the IP index. And finally, *Supply chain pressure* is the *Global supply chain pressure index* published by the Federal Reserve Bank of New York ([Benigno et al., 2022](#)). Since vacancy data (i.e., the number of job openings) from the BLS is only available starting in December 2000, we extend the series back to 1990 using historical estimates constructed by [Barnichon \(2010\)](#). The *Natural u gap* and the *Output gap* are both based on series provided by the Congressional Budget Office. The variables shown are either 6-month growth rates or 6-month moving averages. *S.D.* stands for standard deviation. *Data sources:* U.S. Bureau of labour Statistics; Federal Reserve Bank of New York; Federal Reserve Bank of Cleveland; authors' calculations.

E.2 Regression tables

The following tables show additional regression results for the inflation regressions.

E.2.1 Additional controls

Appendix Table E7: Core consumer price index inflation

	Core CPI inflation - 12-months ahead				
	(1)	(2)	(3)	(4)	(5)
Stock-unempl. rate (u)	0.030 (0.047)	0.029 (0.044)	0.029 (0.048)	0.048 (0.046)	0.046 (0.044)
Unemployment gap (z)	-3.546*** (0.511)	-3.541*** (0.458)	-3.530*** (0.475)	-4.130*** (0.333)	-4.148*** (0.335)
Lagged core infl.	0.613*** (0.086)	0.629*** (0.081)	0.611*** (0.082)	0.599*** (0.094)	0.588*** (0.079)
Infl. expectation (1y)	0.026 (0.136)	0.019 (0.130)	0.026 (0.135)	0.113 (0.145)	0.130 (0.124)
Labour productivity (growth rate)		0.045 (0.038)			0.008 (0.053)
Oil price (growth rate)			0.001 (0.003)		0.003 (0.003)
Industrial production (growth rate)				-0.062*** (0.014)	-0.074*** (0.017)
Adj. R ²	0.691	0.693	0.691	0.712	0.717
Num. obs.	409	409	409	409	409
RMSE	0.566	0.565	0.567	0.546	0.542

Notes: *Inflation expectation (1y)* are the 1-year expectations of inflation calculated by the [Federal Reserve Bank of Cleveland](#). *Labour productivity* is using the *Nonfarm Business labour productivity output per hour* index. *Oil price* is calculated using the West Texas Intermediate (WTI) Crude Oil Price. All variables enter the regression as either 6-month growth rates, changes or backward looking moving averages. Asterisks indicate significance at the 1%, 5%, and 10% level (***) $p < 0.01$; (**) $p < 0.05$; (*) $p < 0.1$). Standard errors are Newey-West corrected (18 months). The constant term is omitted from the table.

Appendix Table E8: Unit labour cost inflation

	Unit labor cost inflation - 12-months ahead				
	(1)	(2)	(3)	(4)	(5)
Stock-unempl. rate (<i>u</i>)	-0.391*** (0.134)	-0.390*** (0.135)	-0.388*** (0.125)	-0.419*** (0.116)	-0.412*** (0.116)
Unemployment gap (<i>z</i>)	-7.906*** (1.378)	-7.888*** (1.365)	-7.440*** (1.485)	-6.284*** (0.462)	-5.960*** (0.592)
Lagged ULC infl.	-0.100 (0.074)	-0.098 (0.076)	-0.076 (0.070)	-0.061 (0.075)	-0.027 (0.080)
Infl. expectation (1y)	0.245 (0.180)	0.245 (0.177)	0.183 (0.174)	-0.017 (0.288)	-0.036 (0.263)
Labour productivity (growth rate)		0.010 (0.145)			0.094 (0.084)
Oil price (growth rate)			0.017*** (0.005)		0.013** (0.006)
Industrial production (growth rate)				0.217*** (0.074)	0.191** (0.074)
Adj. R ²	0.321	0.316	0.381	0.397	0.428
Num. obs.	136	136	136	136	136
RMSE	1.423	1.428	1.359	1.341	1.306

Notes: *Inflation expectation (1y)* are the 1-year expectations of inflation calculated by the [Federal Reserve Bank of Cleveland](#). *Labour productivity* is using the *Nonfarm Business labour productivity output per hour* index. *Oil price* is calculated using the West Texas Intermediate (WTI) Crude Oil Price. All variables enter the regression as either 6-month growth rates, changes or backward looking moving averages. Asterisks indicate significance at the 1%, 5%, and 10% level (** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$). Standard errors are Newey-West corrected (18 months). The constant term is omitted from the table.

E.2.2 Different periods

Appendix Table E9: Core CPI inflation across different periods

	Core CPI inflation - 12-months ahead				
	Whole (91-25)	Great Mod. (91-07)	Great Rec. (07-19)	Post GFC (10-25)	Pre COV. (91-19)
Stock-unempl. rate (u)	0.046 (0.044)	0.119** (0.056)	-0.104** (0.049)	0.024 (0.088)	0.056 (0.042)
Unemployment gap (z)	-4.148*** (0.335)	-4.603*** (1.391)	-1.594** (0.770)	-4.670*** (0.702)	-2.608*** (0.817)
Lagged core infl.	0.588*** (0.079)	0.272*** (0.095)	-0.049 (0.056)	0.577*** (0.102)	0.257*** (0.092)
Infl. expectation (1y)	0.130 (0.124)	0.648*** (0.153)	-0.023 (0.101)	0.074 (0.318)	0.480*** (0.086)
Labour productivity (growth rate)	0.008 (0.053)	0.132*** (0.043)	-0.130** (0.063)	-0.122 (0.113)	0.001 (0.044)
Oil price (growth rate)	0.003 (0.003)	0.005*** (0.001)	-0.000 (0.002)	0.008 (0.006)	-0.000 (0.002)
Industrial production (growth rate)	-0.074*** (0.017)	-0.096*** (0.028)	-0.017 (0.032)	-0.109* (0.056)	-0.056* (0.033)
Adj. R ²	0.717	0.776	0.582	0.720	0.720
Num. obs.	409	207	141	175	354
RMSE	0.542	0.296	0.251	0.697	0.339

Notes: Inflation expectation (1y) are the 1-year expectations of inflation calculated by the [Federal Reserve Bank of Cleveland](#). Labour productivity is using the Nonfarm Business labour productivity output per hour index. Oil price is calculated using the West Texas Intermediate (WTI) Crude Oil Price. All variables enter the regression as either 6-month growth rates, changes or backward looking moving averages. Asterisks indicate significance at the 1%, 5%, and 10% level (*** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$). Standard errors are Newey-West corrected (18 months). The constant term is omitted from the table.

Appendix Table E10: Unit labour cost inflation across different periods

	Unit labor cost inflation - 12-months ahead				
	Whole (91-25)	Great Mod. (91-07)	Great Rec. (07-19)	Post GFC (10-25)	Pre COV. (91-19)
Stock-unempl. rate (u)	-0.412*** (0.116)	-0.267 (0.248)	-0.522*** (0.087)	-0.308*** (0.098)	-0.328*** (0.109)
Unemployment gap (z)	-5.960*** (0.592)	-3.737 (4.099)	-8.519*** (2.221)	-4.126*** (0.985)	-6.179*** (1.531)
Lagged ULC infl.	-0.027 (0.080)	0.027 (0.053)	-0.264*** (0.069)	-0.049 (0.084)	-0.098 (0.082)
Infl. expectation (1y)	-0.036 (0.263)	0.484** (0.228)	-0.631** (0.235)	0.315 (0.205)	0.057 (0.290)
Labour productivity (growth rate)	0.094 (0.084)	0.233* (0.125)	0.253 (0.257)	0.270* (0.140)	0.118 (0.140)
Oil price (growth rate)	0.013** (0.006)	0.018** (0.008)	-0.003 (0.003)	0.017 (0.011)	0.010* (0.006)
Industrial production (growth rate)	0.191** (0.074)	0.229 (0.155)	0.275*** (0.075)	0.142 (0.086)	0.217** (0.098)
Adj. R ²	0.428	0.233	0.649	0.353	0.387
Num. obs.	136	69	47	58	118
RMSE	1.306	1.205	1.131	1.238	1.271

Notes: Inflation expectation (1y) are the 1-year expectations of inflation calculated by the [Federal Reserve Bank of Cleveland](#). Labour productivity is using the Nonfarm Business labour productivity output per hour index. Oil price is calculated using the West Texas Intermediate (WTI) Crude Oil Price. All variables enter the regression as either 6-month growth rates, changes or backward looking moving averages. Asterisks indicate significance at the 1%, 5%, and 10% level (*** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$). Standard errors are Newey-West corrected (18 months). The constant term is omitted from the table.

E.2.3 Alternative measures for economic/labour market slack

Tables E11 and E12 show the results using alternative measures for the economic slack variable. While *V/U* stands for the vacancy-to-unemployment ratio, the *Natural u gap* and the *Output gap* are both based on series provided by the Congressional Budget Office.

Appendix Table E11

	Core CPI inflation 12m ahead: alternatives								
	U gap	Change u rate	U gap and Change	V/U	U gap and V/U	Natural u gap	U gap and Nat ugap	Output gap	U gap and Output gap
Stock-unempl. rate (<i>u</i>)	0.046 (0.044)	0.052 (0.087)		0.310 (0.205)		-1.396** (0.665)	-0.341 (0.306)	0.213 (0.148)	0.193* (0.105)
Unemployment gap (<i>z</i>)	-4.148*** (0.335)		-4.167*** (0.378)		-4.160*** (0.365)		-3.816*** (0.343)		-4.141*** (0.327)
Change in stock-unempl.		0.072 (0.297)	-0.021 (0.141)						
Vacancy/unemployment				0.954* (0.508)	-0.003 (0.141)				
Natural u gap						0.011** (0.005)	0.003 (0.002)		
Output gap								0.116 (0.080)	0.110 (0.069)
Lagged core infl.	0.588*** (0.079)	0.689*** (0.119)	0.576*** (0.074)	0.523*** (0.136)	0.580*** (0.090)	0.457*** (0.115)	0.535*** (0.084)	0.706*** (0.121)	0.611*** (0.078)
Infl. expectation (1y)	0.130 (0.124)	-0.160 (0.214)	0.125 (0.113)	0.015 (0.216)	0.118 (0.129)	0.617** (0.296)	-0.310* (0.174)	-0.227 (0.230)	0.046 (0.145)
Labour productivity (growth rate)	0.008 (0.053)	0.045 (0.087)	0.015 (0.056)	0.032 (0.081)	0.010 (0.050)	0.051 (0.067)	0.010 (0.052)	0.065 (0.098)	0.014 (0.053)
Oil price (growth rate)	0.003 (0.003)	0.002 (0.004)	0.003 (0.003)	0.003 (0.004)	0.003 (0.003)	0.002 (0.004)	0.003 (0.003)	0.002 (0.004)	0.003 (0.003)
Industrial production (growth rate)	-0.074*** (0.017)	0.029 (0.048)	-0.076** (0.036)	0.008 (0.032)	-0.072*** (0.017)	0.003 (0.027)	-0.070*** (0.016)	0.006 (0.040)	-0.081*** (0.019)
Adj. R ²	0.717	0.518	0.715	0.543	0.715	0.592	0.720	0.524	0.722
Num. obs.	409	409	409	409	409	409	409	409	409
RMSE	0.542	0.708	0.544	0.688	0.544	0.651	0.539	0.703	0.537

Notes: *V/U* stands for the vacancy-to-unemployment ratio. Since vacancy data (i.e., the number of job openings) from the BLS is only available starting in December 2000, we extend the series back to 1990 using historical estimates constructed by Barnichon (2010). The *Natural u gap* and the *Output gap* are both based on series provided by the Congressional Budget Office. *Inflation expectation (1y)* are the 1-year expectations of inflation calculated by the Federal Reserve Bank of Cleveland. *Labour productivity* is using the *Nonfarm Business labour productivity output per hour index*. *Oil price* is calculated using the West Texas Intermediate (WTI) Crude Oil Price. All variables enter the regression as either 6-month growth rates, changes or backward looking moving averages. Asterisks indicate significance at the 1%, 5%, and 10% level (***p* < 0.01; **p* < 0.05; **p* < 0.1). Standard errors are Newey-West corrected (18 months). The constant term is omitted from the table.

Appendix Table E12

	Unit labor cost inflation 12m ahead: alternatives								
	U gap	Change u rate	U gap and Change	V/U	U gap and V/U	Natural u gap	U gap and Nat ugap	Output gap	U gap and Output gap
Stock-unempl. rate (<i>u</i>)	-0.412*** (0.116)	-0.319** (0.155)		0.240 (0.257)		-3.108*** (0.424)	-2.247*** (0.349)	-0.395 (0.328)	-0.406 (0.276)
Unemployment gap (<i>z</i>)	-5.960*** (0.592)		-5.582*** (0.953)		-5.228*** (0.838)		-4.127*** (0.981)		-5.961*** (0.610)
Change in stock-unempl.		-0.168 (0.264)	-0.509** (0.241)						
Vacancy/unemployment				2.100** (0.488)	1.466*** (0.287)				
Natural u gap						0.021*** (0.003)	0.014*** (0.003)		
Output gap								-0.042 (0.217)	0.005 (0.212)
Lagged ULC infl.	-0.027 (0.080)	0.089 (0.105)	0.030 (0.090)	0.043 (0.082)	-0.043 (0.080)	0.003 (0.075)	-0.047 (0.078)	0.085 (0.100)	-0.027 (0.079)
Infl. expectation (1y)	-0.036 (0.263)	-0.326 (0.290)	0.134 (0.211)	-0.289 (0.298)	-0.033 (0.276)	0.755** (0.306)	0.609* (0.323)	-0.327 (0.338)	-0.038 (0.338)
Labour productivity (growth rate)	0.094 (0.084)	0.324 (0.220)	0.218* (0.124)	0.272 (0.182)	0.109 (0.091)	0.279* (0.145)	0.149* (0.088)	0.285 (0.201)	0.094 (0.085)
Oil price (growth rate)	0.013** (0.006)	0.013* (0.007)	0.014** (0.006)	0.012* (0.006)	0.012** (0.005)	0.010* (0.006)	0.011** (0.005)	0.014* (0.007)	0.013** (0.005)
Industrial production (growth rate)	0.191** (0.074)	0.286** (0.138)	0.093 (0.106)	0.316*** (0.092)	0.207*** (0.070)	0.307*** (0.080)	0.223*** (0.065)	0.320*** (0.100)	0.190*** (0.068)
Adj. R ²	0.428	0.279	0.381	0.356	0.464	0.423	0.475	0.278	0.424
Num. obs.	136	136	136	136	136	136	136	136	136
RMSE	1.306	1.467	1.359	1.386	1.264	1.312	1.251	1.467	1.311

Notes: *V/U* stands for the vacancy-to-unemployment ratio. Since vacancy data (i.e., the number of job openings) from the BLS is only available starting in December 2000, we extend the series back to 1990 using historical estimates constructed by Barnichon (2010). The *Natural u gap* and the *Output gap* are both based on series provided by the Congressional Budget Office. *Inflation expectation (1y)* are the 1-year expectations of inflation calculated by the Federal Reserve Bank of Cleveland. *Labour productivity* is using the *Nonfarm Business labour productivity output per hour index*. *Oil price* is calculated using the West Texas Intermediate (WTI) Crude Oil Price. All variables enter the regression as either 6-month growth rates, changes or backward looking moving averages. Asterisks indicate significance at the 1%, 5%, and 10% level (***p* < 0.01; **p* < 0.05; **p* < 0.1). Standard errors are Newey-West corrected (18 months). The constant term is omitted from the table.

E.2.4 Alternative measures for price and wage inflation

Appendix Table E13

	Regression results other price inflation measures - 12m ahead				
	Headline CPI	Core PCE	Headline PCE	Core good CPI	Core service CPI
Stock-unempl. rate (u)	0.028 (0.103)	0.067 (0.041)	0.065 (0.083)	0.481*** (0.142)	-0.089 (0.064)
Unemployment gap (z)	-4.944*** (0.776)	-2.990*** (0.460)	-3.412*** (0.715)	-8.183*** (1.366)	-3.105*** (0.589)
Lagged inflation	0.121 (0.222)	0.650*** (0.085)	0.326 (0.200)	0.355*** (0.081)	0.492*** (0.080)
Infl. expectation (1y)	0.232 (0.317)	-0.006 (0.113)	-0.028 (0.225)	0.460* (0.252)	0.219* (0.127)
Labour productivity (growth rate)	0.082 (0.106)	0.057 (0.040)	0.123 (0.087)	0.104 (0.106)	-0.077 (0.081)
Oil price (growth rate)	0.004 (0.006)	0.002 (0.003)	-0.002 (0.004)	0.010 (0.006)	0.003 (0.003)
Industrial production (growth rate)	-0.040 (0.047)	-0.086*** (0.020)	-0.047 (0.042)	-0.254*** (0.060)	-0.024 (0.030)
Adj. R ²	0.203	0.669	0.252	0.534	0.638
Num. obs.	409	409	409	409	409
RMSE	1.326	0.523	1.068	1.385	0.621

Notes: *Inflation expectation (1y)* are the 1-year expectations of inflation calculated by the [Federal Reserve Bank of Cleveland](#). *Labour productivity* is using the *Nonfarm Business labour productivity output per hour* index. *Oil price* is calculated using the West Texas Intermediate (WTI) Crude Oil Price. All variables enter the regression as either 6-month growth rates, changes or backward looking moving averages. Asteriks indicate significance at the 1%, 5%, and 10% level (*** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$). Standard errors are Newey-West corrected (18 months). The constant term is omitted from the table.

Appendix Table E14

	Regression results for wage inflation measures - 12m ahead	
	Employment cost (total)	Employment cost (wage)
Stock-unempl. rate (u)	-0.111* (0.059)	-0.105 (0.065)
Unemployment gap (z)	-1.298*** (0.405)	-2.234*** (0.573)
Lagged inflation	0.578*** (0.111)	0.725*** (0.159)
Infl. expectation (1y)	0.067 (0.127)	-0.196 (0.233)
Labour productivity (growth rate)	0.073 (0.058)	-0.015 (0.047)
Oil price (growth rate)	0.004* (0.002)	0.005** (0.002)
Industrial production (growth rate)	0.018 (0.022)	0.011 (0.026)
Adj. R ²	0.668	0.802
Num. obs.	136	92
RMSE	0.471	0.415

Notes: *Inflation expectation (1y)* are the 1-year expectations of inflation calculated by the [Federal Reserve Bank of Cleveland](#). *Labour productivity* is using the *Nonfarm Business labour productivity output per hour* index. *Oil price* is calculated using the West Texas Intermediate (WTI) Crude Oil Price. All variables enter the regression as either 6-month growth rates, changes or backward looking moving averages. Asteriks indicate significance at the 1%, 5%, and 10% level (***) $p < 0.01$; ** $p < 0.05$; * $p < 0.1$). Standard errors are Newey-West corrected (18 months). The constant term is omitted from the table.

E.3 Individual probabilities

Appendix Table E15: Core consumer price index inflation

	Core CPI inflation - 12-months ahead							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Stock-unempl. rate (u)	-0.178*** (0.054)	0.544*** (0.168)	0.083 (0.103)	-0.422*** (0.092)	0.607*** (0.234)	0.680* (0.346)	-0.172 (0.613)	-0.232 (0.572)
Unemployment gap (z)								-2.992*** (0.798)
Lagged core infl.	0.606*** (0.083)	0.736*** (0.096)	0.691*** (0.121)	0.694*** (0.088)	0.756*** (0.105)	0.516*** (0.126)	0.480*** (0.089)	0.471*** (0.085)
Infl. expectation (1y)	-0.062 (0.135)	-0.490** (0.211)	-0.159 (0.209)	-0.318** (0.152)	-0.321 (0.206)	0.114 (0.183)	0.015 (0.164)	0.145 (0.171)
Labour productivity (growth rate)	-0.142* (0.078)	-0.086 (0.077)	0.055 (0.099)	-0.147* (0.083)	-0.027 (0.074)	0.005 (0.069)	-0.136* (0.072)	-0.047 (0.067)
Oil price (growth rate)	0.001 (0.003)	0.001 (0.003)	0.002 (0.004)	0.002 (0.003)	0.002 (0.003)	0.002 (0.004)	0.002 (0.002)	0.003 (0.002)
Industrial production (growth rate)	0.087*** (0.013)	0.002 (0.040)	0.015 (0.037)	0.085*** (0.019)	0.005 (0.033)	0.036 (0.024)	0.048** (0.021)	-0.053 (0.034)
Employment persistence $\mathbb{P}(E E)$	-1.496*** (0.163)						-3.385** (1.480)	-2.502* (1.394)
Job finding $\mathbb{P}(E U)$		0.171*** (0.050)					0.279* (0.162)	0.276** (0.137)
Inactive-to-empl. $\mathbb{P}(E I)$			0.112 (0.252)				-0.883* (0.526)	-0.713 (0.465)
Job separation $\mathbb{P}(U E)$				1.993*** (0.298)			-3.104* (1.811)	-2.967* (1.665)
Unemployment persistence $\mathbb{P}(U U)$					-0.121*** (0.046)		0.164 (0.142)	0.191 (0.125)
Inactive-to-unemp. $\mathbb{P}(U I)$						-1.460** (0.689)	0.702 (0.999)	0.847 (0.915)
Adj. R ²	0.689	0.608	0.517	0.655	0.583	0.564	0.719	0.750
Num. obs.	409	409	409	409	409	409	409	409
RMSE	0.568	0.638	0.708	0.599	0.658	0.673	0.540	0.509

Notes: Inflation expectation (1y) are the 1-year expectations of inflation calculated by the Federal Reserve Bank of Cleveland. Labour productivity is using the Nonfarm Business labour productivity output per hour index. Oil price is calculated using the West Texas Intermediate (WTI) Crude Oil Price. All variables enter the regression as either 6-month growth rates, changes or backward looking moving averages. Asterisks indicate significance at the 1%, 5%, and 10% level (***) $p < 0.01$; ** $p < 0.05$; * $p < 0.1$. Standard errors are Newey-West corrected (18 months). The constant term is omitted from the table.

Appendix Table E16: Unit labour cost inflation

	Unit labor cost inflation - 12-months ahead							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Stock-unempl. rate (u)	-0.662*** (0.146)	-0.256 (0.289)	-0.654*** (0.147)	-0.809*** (0.212)	-0.173 (0.274)	0.861** (0.415)	-0.053 (0.824)	-0.165 (0.945)
Unemployment gap (z)								-5.438*** (1.317)
Lagged ULC infl.	0.003 (0.079)	0.079 (0.093)	0.077 (0.096)	0.034 (0.081)	0.074 (0.095)	0.040 (0.078)	-0.023 (0.078)	-0.040 (0.085)
Infl. expectation (1y)	-0.290 (0.251)	-0.404 (0.399)	-0.200 (0.244)	-0.475* (0.286)	-0.384 (0.331)	-0.116 (0.149)	0.324 (0.297)	0.478 (0.302)
Labour productivity (growth rate)	-0.035 (0.141)	0.248* (0.140)	0.367 (0.224)	0.034 (0.139)	0.239 (0.151)	0.203 (0.169)	0.118 (0.167)	0.232 (0.165)
Oil price (growth rate)	0.012** (0.006)	0.013* (0.007)	0.015* (0.008)	0.013** (0.006)	0.014* (0.007)	0.011* (0.006)	0.012** (0.006)	0.013** (0.006)
Industrial production (growth rate)	0.406*** (0.088)	0.315*** (0.104)	0.308*** (0.106)	0.380*** (0.105)	0.312*** (0.103)	0.369*** (0.079)	0.394*** (0.072)	0.211** (0.097)
Employment persistence $\mathbb{P}(E E)$	-1.820*** (0.382)						-3.623* (2.057)	-1.624 (1.699)
Job finding $\mathbb{P}(E U)$		0.031 (0.107)					-0.161 (0.282)	-0.148 (0.237)
Inactive-to-empl. $\mathbb{P}(E I)$			-1.506* (0.766)				-1.317 (0.924)	-1.005 (0.901)
Job separation $\mathbb{P}(U E)$				1.809*** (0.576)			-2.813 (2.600)	-2.075 (2.195)
Unemployment persistence $\mathbb{P}(U U)$					-0.039 (0.068)		-0.134 (0.215)	-0.076 (0.195)
Inactive-to-unemp. $\mathbb{P}(U I)$						-2.767*** (0.802)	-0.767 (1.404)	-0.622 (1.414)
Adj. R ²	0.364	0.279	0.316	0.317	0.280	0.363	0.427	0.467
Num. obs.	136	136	136	136	136	136	136	136
RMSE	1.377	1.467	1.428	1.427	1.465	1.378	1.308	1.261

Notes: Inflation expectation (1y) are the 1-year expectations of inflation calculated by the Federal Reserve Bank of Cleveland. Labour productivity is using the Nonfarm Business labour productivity output per hour index. Oil price is calculated using the West Texas Intermediate (WTI) Crude Oil Price. All variables enter the regression as either 6-month growth rates, changes or backward looking moving averages. Asterisks indicate significance at the 1%, 5%, and 10% level (*** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$). Standard errors are Newey-West corrected (18 months). The constant term is omitted from the table.

E.4 Alternative inflation expectation measures

Appendix Table E17: Core consumer price index inflation

	Core CPI inflation - 12-months ahead			
	(1)	(2)	(3)	(4)
Stock-unempl. rate (u)	0.046 (0.044)	0.016 (0.050)	0.036 (0.049)	-0.062 (0.119)
Unemployment gap (z)	-4.148*** (0.335)	-4.119*** (0.380)	-3.932*** (0.461)	-5.547*** (0.637)
Lagged core infl.	0.588*** (0.079)	0.567*** (0.079)	0.638*** (0.070)	0.348* (0.187)
Labour productivity (growth rate)	0.008 (0.053)	0.003 (0.054)	0.019 (0.073)	-0.194 (0.122)
Oil price (growth rate)	0.003 (0.003)	0.004 (0.003)	0.003 (0.003)	0.009 (0.006)
Industrial production (growth rate)	-0.074*** (0.017)	-0.071*** (0.018)	-0.061** (0.028)	-0.124** (0.053)
Infl. expectation (1y), Cleveland	0.130 (0.124)			
Infl. expectation (1y), SPF		0.219 (0.136)		
Infl. expectation (1y), Michigan			-0.004 (0.151)	
Infl. expectation (1y), Atlanta				0.760 (0.566)
Adj. R ²	0.717	0.717	0.712	0.742
Num. obs.	409	408	409	149
RMSE	0.542	0.539	0.547	0.700

Notes: Inflation expectation (1y) are the 1-year expectations of inflation from different sources: *Cleveland* from the [Federal Reserve Bank of Cleveland](#), *SPF* from the [Survey of professional forecasters](#), *Michigan* from the [Michigan survey of consumers](#) *Atlanta* from the [Atlanta Fed Business inflation expectations](#). *Labour productivity* is using the *Nonfarm Business labour productivity output per hour* index. *Oil price* is calculated using the West Texas Intermediate (WTI) Crude Oil Price. All variables enter the regression as either 6-month growth rates, changes or backward looking moving averages. Asterisks indicate significance at the 1%, 5%, and 10% level (** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$). Standard errors are Newey-West corrected (18 months). The constant term is omitted from the table.

Appendix Table E18: Unit labour cost inflation

	Unit labor cost inflation - 12-months ahead			
	(1)	(2)	(3)	(4)
Stock-unempl. rate (u)	-0.412*** (0.116)	-0.409*** (0.096)	-0.406*** (0.086)	-0.399*** (0.122)
Unemployment gap (z)	-5.960*** (0.592)	-6.109*** (0.612)	-5.832*** (0.736)	-4.239*** (0.979)
Lagged ULC infl.	-0.027 (0.080)	-0.034 (0.078)	-0.046 (0.075)	-0.001 (0.067)
Labour productivity (growth rate)	0.094 (0.084)	0.089 (0.086)	0.183* (0.109)	0.310** (0.146)
Oil price (growth rate)	0.013** (0.006)	0.013** (0.006)	0.011** (0.005)	0.019* (0.011)
Industrial production (growth rate)	0.191** (0.074)	0.183*** (0.065)	0.210*** (0.065)	0.114* (0.068)
Infl. expectation (1y), Cleveland	-0.036 (0.263)			
Infl. expectation (1y), SPF		0.076 (0.287)		
Infl. expectation (1y), Michigan			0.409 (0.288)	
Infl. expectation (1y), Atlanta				0.540** (0.245)
Adj. R ²	0.428	0.428	0.443	0.445
Num. obs.	136	136	136	50
RMSE	1.306	1.306	1.289	1.126

Notes: Inflation expectation (1y) are the 1-year expectations of inflation from different sources: *Cleveland* from the [Federal Reserve Bank of Cleveland](#), *SPF* from the [Survey of professional forecasters](#), *Michigan* from the [Michigan survey of consumers](#) *Atlanta* from the [Atlanta Fed Business inflation expectations](#). *Labour productivity* is using the *Nonfarm Business labour productivity output per hour* index. *Oil price* is calculated using the West Texas Intermediate (WTI) Crude Oil Price. All variables enter the regression as either 6-month growth rates, changes or backward looking moving averages. Asterisks indicate significance at the 1%, 5%, and 10% level (** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$). Standard errors are Newey-West corrected (18 months). The constant term is omitted from the table.

E.5 Alternative measures from the literature

Crump et al. (2024) natural rate Crump et al. (2024) introduce a new measure of the natural rate of unemployment, building on earlier work by Crump et al. (2019). They define the natural rate as the unemployment level at which inflation remains stable after controlling for supply shocks. The measure is estimated using labour market flows in a two-state economy that abstracts from inactivity and focuses exclusively on the labour force.

Heise–Pearce–Weber (HPW) index Heise et al. (2024) construct a composite indicator of labour

market tightness defined as a weighted average of two components: the vacancy-to-effective-searcher ratio and an adjusted quits rate. The weights (0.08 and 0.14, respectively) are chosen to reflect the relative importance of each component for wage growth dynamics (replicated the data as good as possible based on their paper).

Vacancy-to-effective-searcher ratio (HPW): Defined as job openings divided by an “effective searcher” measure that aggregates unemployed workers and nonparticipants, weighted by their job-search intensity (e.g., long-term unemployed receive lower weights, marginally attached workers partial weights). This ratio captures labour demand relative to effective labour supply.

Adjusted quits rate (HPW): Measured as quits per 100 employees, with missing observations imputed using predicted values when necessary. Higher quits signal stronger worker confidence and tighter labour markets, as voluntary separations increase when outside options improve.

FERU (Michaillat) Michaillat and Saez (2024) develop the *full-employment rate of unemployment* (FERU), defined as the unemployment rate that achieves social efficiency by minimizing unproductive labour use. FERU is given by $u^* = \sqrt{uv}$, where u denotes the unemployment rate and v the vacancy rate. The measure identifies the unemployment level consistent with a socially optimal allocation of labour under search frictions.

Acceptance rate (Moscarini and Postel-Vinay (2023)) Moscarini and Postel-Vinay (2023) study on-the-job search and employment transitions within a job-ladder framework. They define the acceptance rate as $AC = \frac{EE^{\text{new}}}{UE}$ where EE^{new} denotes new employment from employment and UE unemployment-to-employment transitions.

Sahm rule The Sahm rule is a recession indicator triggered when the three-month moving average of the unemployment rate rises by at least 0.5 percentage points above its 12-month minimum.

While the HPW and FERU indices outperform our unemployment gap in terms of in-sample fit for wage inflation (ULC) at a 12-month horizon, they only outperform our measure for price inflation (core CPI) in the post-GFC period from 2010 to 2025. Both the HPW index and FERU rely on vacancy data, which introduces two main differences. First, the Job Openings and labour Turnover Survey, which provides vacancy data, only begins in 2000. Second, vacancy data exhibits different dynamics. Our unemployment gap, constructed solely from labour force flows, demonstrates more consistent performance across different economic regimes. Critically, for core CPI inflation — arguably the more relevant target for monetary policy — our measure performs comparably or better throughout most of the sample, with the HPW and FERU advantages concentrated in the specific post-GFC environment.

This suggests our flow-based measure captures more fundamental and stable relationships between labour market dynamics and price pressures, whereas vacancy-based measures may be capturing regime-specific correlations that do not generalize across structural breaks.

Appendix Table E19: Core consumer price index inflation

	Core CPI inflation 12m ahead: alternatives						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Stock-unempl. rate (u)	0.046 (0.044)	0.310 (0.205)	0.580** (0.273)	0.829*** (0.198)	-0.176*** (0.068)	0.638*** (0.151)	-0.075 (0.082)
Unemployment gap (z)	-4.148*** (0.335)						
Vacancy/unemployment		0.954* (0.508)					
Crump u gap			-0.005** (0.002)				
Heise-Pearce-Weber index				5.883*** (1.219)			
Full-empl. rate of unemp. (Michaillat)					1.619*** (0.284)		
Acceptance rate (Moscarini)						-59.150*** (11.268)	
Sahm rule							0.299 (0.195)
Lagged core infl.	0.588*** (0.079)	0.523*** (0.136)	0.482*** (0.102)	0.136 (0.111)	0.125 (0.086)	0.638*** (0.111)	0.612*** (0.104)
Infl. expectation (1y)	0.130 (0.124)	0.015 (0.216)	-0.022 (0.157)	-0.400*** (0.135)	0.597*** (0.120)	-0.106 (0.191)	-0.044 (0.147)
Labour productivity (growth rate)	0.008 (0.053)	0.032 (0.081)	-0.066 (0.066)	-0.126* (0.067)	0.035 (0.048)	-0.117 (0.074)	-0.061 (0.066)
Oil price (growth rate)	0.003 (0.003)	0.003 (0.004)	0.001 (0.003)	0.003 (0.002)	0.004 (0.002)	0.001 (0.004)	0.000 (0.003)
Industrial production (growth rate)	-0.074*** (0.017)	0.008 (0.032)	0.031 (0.033)	-0.022 (0.021)	-0.040** (0.017)	0.007 (0.041)	0.021 (0.044)
Adj. R ²	0.717	0.543	0.598	0.758	0.777	0.598	0.564
Num. obs.	409	409	402	362	409	341	409
RMSE	0.542	0.688	0.650	0.499	0.481	0.659	0.673

Notes: *Inflation expatiation (1y)* are the 1-year expectations of inflation calculated by the [Federal Reserve Bank of Cleveland](#). *Labour productivity* is using the *Nonfarm Business labour productivity output per hour* index. *Oil price* is calculated using the West Texas Intermediate (WTI) Crude Oil Price. All variables enter the regression as either 6-month growth rates, changes or backward looking moving averages. Asteriks indicate significance at the 1%, 5%, and 10% level (*** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$). Standard errors are Newey-West corrected (18 months). The constant term is omitted from the table.

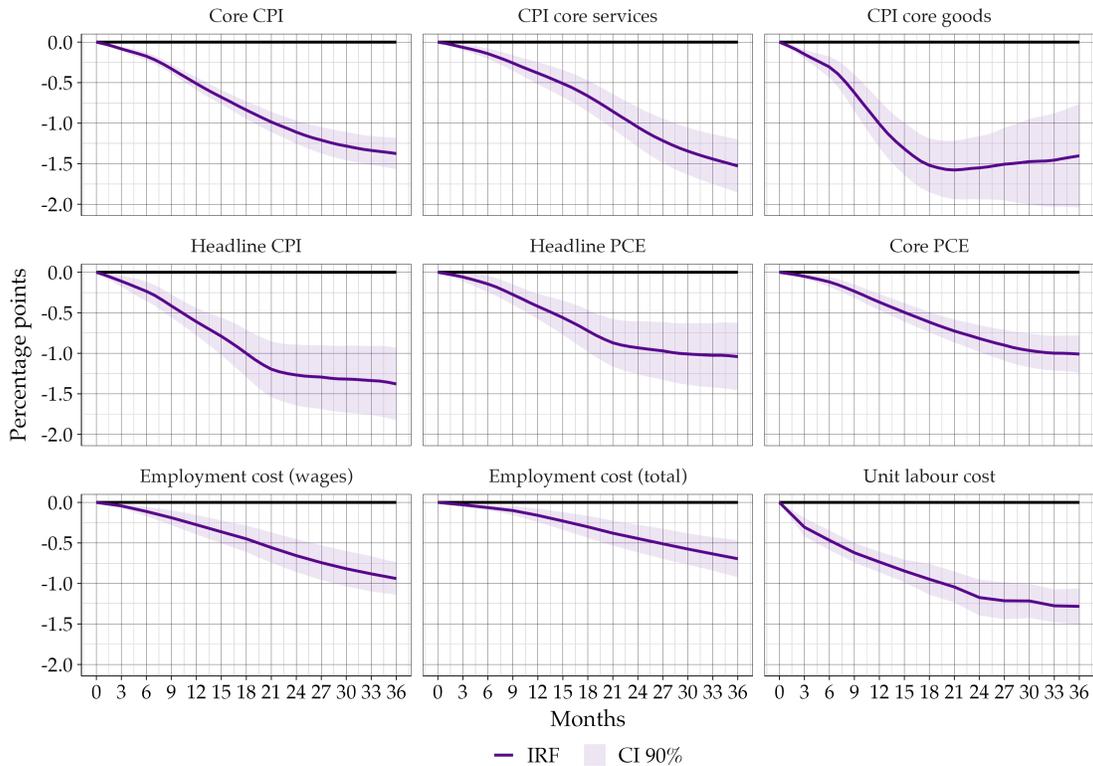
Appendix Table E20: ULC inflation

	Unit labor cost inflation 12m ahead: alternatives						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Stock-unempl. rate (<i>u</i>)	-0.412*** (0.116)	0.240 (0.257)	0.237 (0.310)	0.363** (0.166)	-0.584*** (0.110)	0.071 (0.160)	-0.422*** (0.131)
Unemployment gap (<i>z</i>)	-5.960*** (0.592)						
Vacancy/unemployment		2.100*** (0.488)					
Crump <i>u</i> gap			-0.005** (0.002)				
Heise-Pearce-Weber index				5.888*** (0.795)			
Full-empl. rate of unemp. (Michaillat)					1.807*** (0.264)		
Acceptance rate (Moscarini)						-62.219*** (15.780)	
Sahm rule							0.196 (0.258)
Lagged ULC infl.	-0.027 (0.080)	0.043 (0.082)	0.039 (0.078)	-0.017 (0.067)	-0.023 (0.061)	0.021 (0.108)	0.079 (0.090)
Infl. expectation (1y)	-0.036 (0.263)	-0.289 (0.298)	-0.392 (0.340)	-1.314*** (0.180)	-0.015 (0.240)	-0.832*** (0.237)	-0.331 (0.266)
Labour productivity (growth rate)	0.094 (0.084)	0.272 (0.182)	0.152 (0.138)	0.223 (0.160)	0.303*** (0.104)	0.095 (0.180)	0.205 (0.136)
Oil price (growth rate)	0.013** (0.006)	0.012* (0.006)	0.011* (0.006)	0.007 (0.006)	0.009* (0.005)	0.011 (0.008)	0.012** (0.006)
Industrial production (growth rate)	0.191** (0.074)	0.316*** (0.092)	0.350*** (0.105)	0.381*** (0.082)	0.283*** (0.088)	0.415*** (0.095)	0.330*** (0.093)
Adj. R ²	0.428	0.356	0.320	0.502	0.490	0.386	0.285
Num. obs.	136	136	134	121	136	114	136
RMSE	1.306	1.386	1.433	1.276	1.234	1.458	1.461

Notes: *Inflation expectation (1y)* are the 1-year expectations of inflation calculated by the [Federal Reserve Bank of Cleveland](#). *Labour productivity* is using the *Nonfarm Business labour productivity output per hour* index. *Oil price* is calculated using the West Texas Intermediate (WTI) Crude Oil Price. All variables enter the regression as either 6-month growth rates, changes or backward looking moving averages. Asteriks indicate significance at the 1%, 5%, and 10% level (** $p < 0.01$; * $p < 0.05$; $p < 0.1$). Standard errors are Newey-West corrected (18 months). The constant term is omitted from the table.

E.6 Local projection

Appendix Figure E8: Change in inflation upon a 1 standard deviation increase in the u gap



Notes: This figure shows the dynamic response (local projection) of various inflation measures to a one-standard deviation increase in the unemployment gap. The purple line shows the response to a simple univariate regression, while the red line shows the response for our baseline model (which includes various control variables). The shaded area represents the Newey-West corrected 90% confidence interval. *Data sources:* Authors' calculations.

E.7 Instrumental variable approach

Phillips curve regressions are prone to endogeneity issues, which can bias estimates and undermine inference. [Barnichon and Mesters \(2020\)](#) outline several sources of endogeneity, including unobserved variables and cost-push factors that simultaneously affect both inflation and the economic slack variable. To address these concerns, [Barnichon and Mesters \(2020\)](#) discusses a potential solutions, which is to use an instrumental variable. Following this approach, [Table E21](#) presents an instrumental variable regression where the unemployment gap is instrumented using the orthogonalized monetary policy shock from [Bauer and Swanson \(2023\)](#). Since the gap is a moving average over the previous six months, it is instrumented using the current and five lags of the shock. The first stage regression

then writes as follows:

$$z_{t+h} = \alpha_{i,h} + \beta_h S_t + \gamma_h^i \pi_{t-n}^i + \delta_h^i \pi_{t+1y}^e + \theta_h^i X_t + \epsilon_{i,t+h} \quad (\text{E.1})$$

where z_t is the unemployment gap and S_t is the set of instruments.

Appendix Table E21

	IV: instrumenting the unemployment gap with MPS			
	CPI core (5 lags)	CPI core (11 lags)	ULC (5 lags)	ULC (11 lags)
Stock-unempl. rate (u)	0.047* (0.024)	0.046* (0.023)	-0.439*** (0.140)	-0.385*** (0.126)
Unemployment gap ^{Fitted} (z)	-3.663** (1.516)	-3.339*** (0.791)	-9.317 (7.006)	-3.910* (2.224)
Lagged inflation	0.602*** (0.053)	0.606*** (0.046)	-0.095 (0.153)	0.004 (0.072)
Infl. expectation (1y)	0.095 (0.117)	0.070 (0.079)	0.144 (0.418)	-0.172 (0.248)
Labour productivity (growth rate)	0.014 (0.035)	0.018 (0.029)	-0.021 (0.272)	0.150 (0.123)
Oil price (growth rate)	0.003** (0.001)	0.003* (0.002)	0.013** (0.005)	0.012** (0.005)
Industrial production (growth rate)	-0.063* (0.036)	-0.056** (0.023)	0.121 (0.156)	0.239*** (0.079)
Wu-Hausman	0.108 (0.743)	1.02 (0.313)	0.267 (0.606)	1.038 (0.31)
Kleibergen-Paap	0.659 (0.995)	1.461 (1)	0.591 (0.997)	0.741 (1)
Cragg-Donald test	1.814	3.034	0.554	2.395
First stage F-stat	1.791 (0.1)	2.995 (0.001)	0.532 (0.783)	2.295 (0.012)
Num. obs.	402	397	134	133

Notes: The monetary policy shocks used as instruments are the orthogonalized series by [Bauer and Swanson \(2023\)](#). The indication in the column title of 5 or 11 lags refers to the number of monthly shocks that were used as instruments. *Inflation expectation (1y)* are the 1-year expectations of inflation calculated by the [Federal Reserve Bank of Cleveland](#). *Productivity* is using the *Nonfarm Business labour productivity output per hour* index. *Oil price inflation* is calculated using the West Texas Intermediate (WTI) Crude Oil Price. The *Labour part. rate* is the labour participation rate of the working age population. And finally, *Supply chain pressure* is the *Global supply chain pressure index* published by the Federal Reserve Bank of New York ([Benigno et al., 2022](#)). All variables enter the regression as either 6-month growth rates, changes or backward looking moving averages. Productivity, oil price inflation, as well as the unemployment gap are expressed in standard deviations. Asterisks indicate significance at the 1%, 5%, and 10% level (*** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$). Standard errors are heteroscedasticity robust. The constant term is omitted from the table. The IV tests show the p-value in brackets behind the statistic.

The first-stage F-statistics for the 11-lag model indicate that the instruments are statistically significant, although on a rather low level. The Kleibergen-Paap statistic, which tests for weak instruments, is low with p-values close to one, signaling potential concerns regarding instrument strength. The Wu-Hausman test examines whether the unemployment gap is truly endogenous, and the high p-values suggest we cannot reject exogeneity, implying that OLS estimates may be reliable in these specifications. The Cragg-Donald statistic, which also assesses instrument relevance in the presence of multiple endogenous regressors, is similarly low, reinforcing the caution about weak instruments.

Taken together, these diagnostics indicate that while the instruments are predictive, they are weak, and the unemployment gap appears only mildly endogenous.

F Proofs

F.1 Proof of Proposition 4.

Based on Proposition 2, when $\theta = 0$, the wage rate w_t paid by flexible-wage firms, satisfies:

$$w_t = (1 - \eta)y(s_t) + \eta \left[U(s_t) - \beta \int U(s_{t+1}) dF(s_{t+1}) \right] \\ + (1 - \eta)\beta \frac{\ell_{t+1}}{\ell_t} \int V_{f_{t+1}}(s_{t+1}) dF(s_{t+1}) + \eta\beta p_t^e \left[\int [V_{w_{t+1}}(s_{t+1}) - U_{t+1}(s_{t+1})] dF(s_{t+1}) \right]$$

Then noting that the optimality condition (5.2) must hold at any time t , and using expression (6.3) for the value of unemployment U_t , the expression for the average equilibrium wage rate w_t paid by flexible wage firms satisfies:

$$\frac{w_t - b}{1 - \eta} = y - b + \beta \left[\frac{\ell_{t+1}}{\ell_t} - (e - h_t) \right] V_{t+1} \quad (\text{F.1})$$

Then using this expression, the average value of a match for flexible wage firms simplifies as:

$$V_t = y - w_t + \beta \frac{\ell_{t+1}}{\ell_t} V_{t+1} = \eta(y - b) + \beta \left[\eta \frac{\ell_{t+1}}{\ell_t} + (1 - \eta)(p_t^e - p_t^h) \right] V_{t+1}$$

Turning to sticky-wage firms, based on proposition 3, their average wage rate satisfies:

$$\lambda_t w_t^{(1)} + (1 - \lambda_t)w_{t-1} = (1 - \eta)y(s_t) + \eta(1 - \lambda_t)w_{t-1} + \lambda_t \eta \left[U(s_t) - \int U(s_{t+1}) dF(s_{t+1}) \right] \\ + (1 - \eta)\beta \frac{\ell_{t+1}}{\ell_t} \int V_{f_{t+1}}(s_{t+1}) dF(s_{t+1}) - \lambda_t \eta \beta p_t^e \left[\int [V_{w_{t+1}}(s_{t+1}) - U(s_{t+1})] dF(s_{t+1}) \right] \quad (\text{F.2})$$

Now, given the optimality condition (5.2) must hold at any time, and using expression (6.3) for the value of unemployment $U(s_t)$, the average rate w_t^s paid by sticky-wage firms simplifies as:

$$w_t^s = w_t + (1 - \lambda_t) \left[\beta(1 - \eta)(p_t^e - p_t^h) V_{t+1} + \eta(w_{t-1} - b) \right] \quad (\text{F.3})$$

F.2 Proof of proposition 5.

According to expressions (6.4) and (6.5), an increase in u_t affects the flexible wage rate w_{t+n} as follows:

$$\frac{\partial w_{t+n}}{\partial u_t} = \beta(1 - \eta) \frac{p_h}{\ell} \left[\frac{\partial V_{t+n+1}}{\partial u_t} - \frac{V}{\ell} \frac{\partial \ell_{t+n}}{\partial u_t} \right] \quad (\text{F.4})$$

where V denotes the steady-state value of a match for firms, and ℓ denotes steady-state employment, i.e. $V = \frac{\eta(y-b)}{1-\beta x}$ and $\ell = (p_e - \delta)/(1 - \delta)$. Then given that higher unemployment raises the value of a match V_{t+n} (through the $\{x_{t+i}\}_{i \geq 0}$ factors), and given that higher unemployment depresses subsequent employment, i.e. $\frac{\partial \ell_{t+n}}{\partial u_t} \leq 0$, the average flexible wage w_{t+n} always increases with the unemployment rate u_t . Similarly, according to expression (6.4) and (6.5), an increase in u_t affects the average wage rate w_{t+n}^s as follows:

$$\frac{\partial w_{t+n}^s}{\partial u_t} = \frac{\partial w_{t+n}}{\partial u_t} + p_e \left[\beta(1 - \eta) \delta \frac{\partial V_{t+n+1}}{\partial u_t} + \eta \frac{\partial w_{t-1}}{\partial u_t} \right] + \frac{\partial(1 - \lambda_{t+n})}{\partial u_t} [\beta(1 - \eta) \delta V + \eta(w - b)] \quad (\text{F.5})$$

Then using expressions (6.4), (6.5) and (6.6) for the average flexible wage rate w_t and the value for firms of a match under flexible wages V_t , the change in the average wage w_{t+n}^s due to an increase in stock-based unemployment writes, up to a positive multiplicative constant, as:

$$\frac{\partial w_{t+n}^s}{\partial u_t} \equiv \beta \frac{1 - \beta \delta^2}{1 - \beta x \delta} \left[\frac{\delta}{p_e} + \eta \right] + \eta \delta \frac{(\beta \delta)^2}{1 - \beta x \delta} - 1$$

The wage rate w_{t+n}^s is therefore increasing in the unemployment rate u_t if and only if:

$$\beta \eta p_e \geq \frac{(1 - \beta \delta^2)(p_e - \beta \delta)}{1 - \beta \delta^2 + \delta(1 - \delta + \beta \delta^2)} \quad (\text{F.6})$$

which holds for sufficiently large η (and β).

F.3 Proof of proposition 6.

Let us start with the relationship between the employment retention rate p_t^e and the wage rate w_{t+n} paid flexible-wage firms. Based on expressions (6.4) and (6.5), a change in the former affects the latter according to the following expression:

$$\frac{\partial w_{t+n}}{\partial p_t^e} = \beta(1 - \eta) \frac{p_h}{\ell} \left[\frac{\partial V_{t+n+1}}{\partial p_t^e} - \frac{V}{\ell} \frac{\partial \ell_{t+n}}{\partial p_t^e} \right]$$

In addition, using the recursive definition (6.6) for V_t and the law of motion for ℓ_t , we have:

$$\frac{\partial V_{t+n}}{\partial p_t^e} = \beta x \frac{\partial V_{t+n+1}}{\partial p_t^e} + \beta V \left[\rho_e^n - \frac{\eta p_h}{\ell^2} \frac{\partial \ell_{t+n}}{\partial p_t^e} \right] \text{ where } x = \eta + (1 - \eta)\delta \text{ and } \frac{\partial \ell_{t+n}}{\partial p_t^e} = \ell \frac{\delta^n - \rho_e^n}{\delta - \rho_e}$$

Iterating this relationship forward, the change in the value of a match V_{t+n} due to a change in the employment retention rate p_t^e can be expressed as :

$$\frac{\partial V_{t+n}}{\partial p_t^e} = \beta V \left[\frac{\rho_e^n}{1 - \beta x \rho_e} - \frac{\eta p_h}{\ell(\delta - \rho_e)} \left[\frac{\delta^n}{1 - \beta x \delta} - \frac{\rho_e^n}{1 - \beta x \rho_e} \right] \right]$$

Then using these expressions, an increase in the employment retention rate p_t^e raises the wage rate paid by flexible-wage firms after n periods if and only if

$$\beta \left[\frac{\rho_e^{n+1}}{1 - \beta x \rho_e} - \frac{\eta(1 - \delta)}{\delta - \rho_e} \left[\frac{\delta^{n+1}}{1 - \beta x \delta} - \frac{\rho_e^{n+1}}{1 - \beta x \rho_e} \right] \right] \geq \frac{\delta^k - \rho_e^n}{\delta - \rho_e}$$

which simplifies as a lower bound on the auto-correlation parameter ρ_e in the form:

$$\frac{\partial w_{t+n}}{\partial p_t^e} \geq 0 \Leftrightarrow \rho_e + \delta \geq \frac{1 - \beta \delta^2}{\beta \delta} \left[\mathcal{S}_n(\rho_e) - 1 + \frac{\delta \beta x}{1 - \delta \beta x} \left[\frac{\delta}{\rho_e} \right]^n \right]$$

Let us now turn to the case of the average wage w_{t+n}^s paid by sticky-wage firms. Following expressions (6.4) and (6.5) in proposition 5, this wage rate writes as:

$$w_{t+n}^s = w_{t+n} + \mathcal{P}_{t+n} \text{ where } \mathcal{P}_t = (1 - \lambda_t) \left[\beta(1 - \eta)(p_t^e - p_t^h)V_{t+1} + \eta(w_{t-1} - b) \right]$$

Then given that the flexible wage rate w_{t+n} is increasing in the employment retention rate p_t^e under condition (6.8), we only have to show that the wage premium \mathcal{P}_{t+n} is also increasing in the employment retention rate p_t^e under the very same condition (6.8).

For this let us first note that the (second) term in brackets in the expression of \mathcal{P}_{t+n}^s is naturally increasing in the employment retention rate p_t^e . In addition, the fraction $1 - \lambda_{t+n}$ of pre-existing workers in the total workforce also increases in the employment retention rate p_t^e since we have:

$$\frac{\partial(1 - \lambda_{t+n})}{\partial p_t^e} = \rho_e^{n-1} + \frac{1 - \delta}{e - \delta} \left[\frac{\partial \ell_{t+n-1}}{\partial p_t^e} - \frac{\partial \ell_{t+n}}{\partial p_t^e} \right] = \frac{(1 - \delta)^2}{e - \delta} \frac{\partial \ell_{t+n-1}}{\partial p_t^e} \geq 0$$

Based on these two properties, condition (6.8) ensures that w_{t+n} and w_{t+n}^s are increasing in the employment retention rate p_t^e .

F4 Proof of proposition 7.

Given expressions (6.4) and (6.5) for the average wage rate paid by flexible wage rate w_t , an increase in the hiring rate at time t raises the wage rate w_{t+n} after k periods if and only if:

$$\rho_h^n + \frac{p_h}{V} \frac{\partial V_{t+n+1}}{\partial p_t^h} \geq \frac{p_h}{\ell} \frac{\partial \ell_{t+n}}{\partial p_t^h}$$

Now given the law of motion of employment $\ell_{t+1} = p_t^e \ell_t + (1 - \ell_t) p_t^h$, a change in the hiring rate at time t raises employment k periods later such that:

$$\frac{\partial \ell_{t+n}}{\partial p_t^h} = (1 - \ell) \frac{\rho_h^n - \delta^n}{\rho_h - \delta}$$

In addition, given the recursive definition (6.6) of the equilibrium value V_t of a match for flexible-wage firms, a change in the hiring rate at time t produces a change in V_{t+n} such that:

$$\frac{\partial V_{t+n}}{V \partial p_t^h} = \beta \frac{\partial x_{t+n}}{\partial p_t^h} + \beta x \frac{\partial V_{t+n+1}}{V \partial p_t^h}$$

Iterating this expression forward, we can simplify the impact of a change in the hiring rate on the subsequent value V of match under flexible wages as:

$$\frac{\partial V_{t+n}}{V \partial p_t^h} = \frac{\beta}{\ell} \left[\frac{\rho_h^n}{1 - \beta x \rho_h} \left[\eta - \ell - \frac{\eta(1 - p_e)}{\rho_h - \delta} \right] + \frac{\eta(1 - p_e)}{\rho_h - \delta} \frac{\delta^n}{1 - \beta x \delta} \right]$$

Plugging this last expression in the original inequality condition then yields that the wage rate w_{t+n} paid by flexible-wage firms increases with the hiring rate p_t^h if and only if

$$\mathcal{S}_n(\rho_h) + \frac{\beta x \delta}{1 - \beta x \delta} \left(\frac{\delta}{\rho_h} \right)^n \leq \frac{1}{1 - \beta \delta^2} \left[1 + \frac{\delta}{1 - p_e} [1 - \beta p_e \rho_h] \right]$$

Using now expressions (6.4) and (6.5), the change in the average wage rate paid by sticky-wage firms w_{t+n}^s periods after a change in the hiring rate p_t^h writes as:

$$\frac{\partial w_{t+n}^s}{\partial p_t^h} = \frac{\partial w_{t+n}}{\partial p_t^h} + e \left[\beta(1 - \eta) \left[\delta \frac{\partial V_{t+n+1}}{\partial p_t^h} - \rho_h^n V \right] + \eta \frac{\partial w_{t+n-1}}{\partial p_t^h} \right] + \frac{p_e}{\ell} \left[\frac{\partial \ell_{t+n-1}}{\partial p_t^h} - \frac{\partial \ell_{t+n}}{\partial p_t^h} \right] [\beta(1 - \eta) \delta V + \eta(w - b)]$$

Then using the properties that $\eta(w - b) = (1 - \beta \delta)(1 - \eta)V$ and

$$\frac{\partial V_{t+n+1}}{V \partial p_t^h} = \frac{1}{p_h} \left[\frac{1}{\beta(1 - \eta) \frac{V}{\ell}} \frac{\partial w_{t+n}}{\partial p_t^h} - \rho_h^n + \frac{p_h}{\ell} \frac{\partial \ell_{t+n}}{\partial p_t^h} \right]$$

the previous expression for the change in the average wage rate w_{t+n}^s simplifies as:

$$\frac{\partial w_{t+n}^s}{\partial p_t^h} = \frac{1}{(1-\eta)V} \left[\left[1 + p_e \frac{\delta}{1-\delta} \right] \frac{\partial w_{t+n}}{\partial p_t^h} + p_e \eta \frac{\partial w_{t+n-1}}{\partial p_t^h} \right] - \frac{p_e}{p_e - \delta} p_e \beta \rho_h^n + \frac{p_e}{\ell} \left[\frac{\partial \ell_{t+n-1}}{\partial p_t^h} - (1-\beta\delta) \frac{\partial \ell_{t+n}}{\partial p_t^h} \right]$$

Finally, let us write the change in the wage rate of flexible-wage firms as:

$$\frac{\partial w_{t+n}}{\partial p_t^h} = \frac{\beta(1-\eta)V\rho_h^n}{\ell(1-\beta x\rho_h)} W_n(\rho_h) \quad \text{with} \quad W_n(\rho_h) = 1 + \delta \frac{1-\beta p_e \rho_h}{1-p_e} - (1-\beta\delta^2) \left[S_n(\rho_h) + \frac{\beta x \delta}{1-\beta x \delta} \left(\frac{\delta}{\rho_h} \right)^n \right]$$

Finally using these relationships and some algebra, one can show an increase in the hiring rate at time t raises the average wage rate of sticky-wage firms after k periods if and only if the auto-correlation parameter ρ_h satisfies:

$$S_n(\rho_h) + \frac{\beta x \delta}{1-\beta x \delta} \left(\frac{\delta}{\rho_h} \right)^n \leq \frac{1}{1-\beta\delta^2} \left[1 + \frac{\delta}{1-p_e} [1-\beta p_e \rho_h] \right] + \Phi(\rho_h) \mathcal{W}_n(\rho_h)$$

where $\Phi(\cdot)$ and $\mathcal{W}_k(\cdot)$ follow the expressions laid out in proposition 7 with

$$\begin{aligned} \varphi &= \beta\delta \frac{1-\beta\delta^2}{1-p_e} \quad \text{and} \quad \varphi_0 = \eta(1-\delta)\varphi \quad \text{and} \quad \varphi_1 = (1-\delta+p_e\delta)\varphi \\ \omega_0 &= 1 - (1-\beta\delta)\delta \quad \text{and} \quad \omega_1 = \eta \frac{p_e - \delta}{1-p_e} \frac{1-\beta\delta^2}{1-\beta x \delta} \delta \quad \text{and} \quad \omega_2 = \frac{p_e}{1-p_e} \beta\delta \end{aligned}$$

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