# Reservation Wages and the Wage Flexibility Puzzle<sup>\*</sup>

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### Abstract

Using micro data for the UK and Germany, we provide novel evidence on the cyclical properties of reservation wages and estimate that wages and reservation wages are characterised by moderate and very similar degrees of cyclicality. Several job search models that quantitatively match the cyclicality of wages tend to overpredict the cyclicality in reservation wages. We show that this puzzle can be addressed when reservation wages display backward-looking reference dependence. Model calibrations that allow for reference dependence match the empirically observed cyclicality of wages and reservation wages for plausible value of all other model parameters.

Keywords: job search; reservation wages; wage cyclicality; reference dependence.

JEL classification: E24; J63; J64.

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## 1 Introduction

Reservation wages play a central role in models of job search, channeling the impact of job finding prospects and welfare policies on unemployment duration and re-employment wages. This paper provides novel evidence on their cyclical behaviour and studies its implications for our understanding of wage and unemployment volatility. Based on micro data for the UK and Germany spanning over two decades, we estimate that wages and reservation wages are characterised by moderate and very similar degrees of cyclicality. We obtain an estimate for the elasticity of wages with respect to unemployment of -0.17 for the UK, and a much lower (in absolute value) and imprecise estimate for Germany. For reservation wages, we obtain an elasticity of about -0.15 for the UK, and again a smaller and only bordeline significant elasticity for Germany.

These results have implications for the quantitative predictions of search and matching models. Since Shimer (2005) and Hall (2005) pointed out that the canonical search model struggled to replicate the weak cyclicality of wages (the wage flexibility puzzle), a number of papers have proposed modifications that introduce some wage rigidity. These include high replacement ratios (Hagedorn and Manovskii, 2008), weakly cyclical hiring costs (Pissarides, 2009), and infrequent or backward-looking wage negotiations (Pissarides, 2009; Rudanko, 2009; Haefke et al., 2013; Kudlyak, 2014; Gertler et al., 2008; Gertler and Trigari, 2009). While these models offer solutions to the wage flexibility puzzle, we show that they predict reservation wages to be more strongly cyclical than wages. The intuition is that reservation wages embody the procyclical behaviour of both expected wage offers and job finding rates: even if wages were acyclical, reservation wages would be pro-cyclical because they positively respond to job-finding rates, which are strongly cyclical. However, our evidence shows that wages and reservation wages display similarly low elasticities with respect to unemployment. Hence, while elements of wage rigidity can address the wage flexibility puzzle, a "reservation wage flexibility puzzle" arises.

We propose that the reservation wage flexibility puzzle can be addressed if reservation wages are shaped by reference-dependent preferences with backward-looking anchoring. Reference-dependence has often featured in labour supply modelling (see Blanchard and Katz 1999, Farber 2008, Della Vigna 2009 and, closely related to our setting, Falk et al. 2006 and Della Vigna et al. 2017, 2022). In several contexts reference dependence is shaped by past experiences, implying less cyclical reservation wages than a fully forward-

looking model whenever reference points are less cyclical than labour market conditions. The underlying mechanism is that reference dependence anchors reservation wages to backward-looking variables such as past earnings, which are typically less cyclical than current and future labour market conditions. Low reservation wage cyclicality then translates into to low wage cyclicality, as wages track reservation wages up to a roughly acyclical mark-up. In addition, reference-dependence during job search is also consistent with limited impacts of potential benefit duration on reservation wages (Schmieder et al., 2016; Le Barbanchon et al., 2019; Jäger et al., 2020).

We embed reference dependence in a framework that nests most existing models of wage rigidity and show that the enriched model can quantitatively match the observed cyclicality in both wages and reservation wages for plausible values of parameters. Because reference dependence helps explain moderate cyclicality in actual wages and not simply reservation wages, additional sources of wage rigidity become less relevant to match empirical cyclicality estimates once reference dependence is included. In principle, reference dependence is sufficient to account for the observed sluggish movement of wages and reservation wages.

The rest of the paper is organised as follows. Section 2 shows estimates of wage and reservation wage elasticities to unemployment for the UK and Germany. Section 3 lays out a job search model with reference-dependent reservation wages. Section 4 derives cyclicality predictions in the special case without reference dependence. Section 5 shows cyclicality results under reference dependence. Section 6 concludes.

## 2 Empirical wage and reservation wage curves

We estimate wage and reservation wage cyclicality, to which model predictions of later sections will be benchmarked, using micro data for the UK and West Germany (referred to as Germany for simplicity), from the BHPS and the SOEP, respectively. Both are longitudinal studies, providing information on wages and reservation wages for the period 1991-2009 for the UK and 1984-2010 for Germany.

### 2.1 Estimates of the wage curve

Wage cyclicality is estimated as an elasticity with respect to the unemployment rate, in the wage-curve approach of Blanchflower and Oswald (1994). The dependent variable is the log pre-tax wage of an individual. All specifications control for individual characteristics (gender, age, education, job tenure, household composition) and individual and region fixed-effects. Our baseline specifications use national unemployment as a business cycle indicator and include a quadratic trend to capture the effects of productivity growth (the Appendix reports estimates based on regional unemployment for completeness). Descriptive statistics are reported in Table A1.<sup>1</sup>

Estimates are presented in Table  $1.^2$  In column 1 the unemployment elasticity of wages for the UK is -0.169 and highly significant. This is the benchmark estimate that we will compare to the predicted cyclicality of wages in our job search model. Columns 2 and 3 distinguish between new and continuing jobs, including an interaction term between the unemployment rate and an indicator for having started the current job within the past year. Estimates in column 2 imply that wages in new jobs are 50% more cyclical than on continuing jobs, in line with infrequent wage negotiations. However, even wages on continuing jobs significantly respond to the state of the business cycle, consistent with some degree of on-the-job renegotiation. When job fixed-effects are included in column 3, the cyclicality differential is much smaller and only borderline significant. Possibly, we have limited power to identify an elasticity within job spells, which are on average only observed over 2.6 waves. The alternative explanation is that the (permanent) quality of newly-created jobs is procyclical, and once this is captured by job fixed-effects the excess cyclicality in new jobs is much reduced (see Gertler and Trigari 2009 and Gertler et al. 2020 for a similar result for the US; see also Bellou and Kaymak 2021 and Figueiredo 2022 for evidence and discussions on the role of job quality in estimates of wage cyclicality). The specification of column 4 delivers a slightly smaller elasticity with respect to lagged unemployment than the benchmark specification of column 1. In all specifications the wage elasticity to unemployment is negative and significant, and the point estimates do not fall below -0.169.

For Germany (columns 5-8), the estimated wage cyclicality is markedly lower than in UK, in line with earlier evidence, and is only significant for new matches (column 6) or

<sup>&</sup>lt;sup>1</sup>While it is convenient to report wage elasticities that are directly comparable to their reservation wage counterparts, a plethora of wage-curve estimates is also available from previous work, see Blanchflower and Oswald (1994, 2005) and Card (1995) for international evidence; Bell et al. (2002), Faggio and Nickell (2005), Devereux and Hart (2006) and Gregg et al. (2014) for the UK; Wagner (1994), Baltagi et al. (2009) and Ammermüller et al. (2010) for Germany.

<sup>&</sup>lt;sup>2</sup>Full estimation results corresponding to specification 2 of Table 1 are reported in A2.

when lagged unemployment is used (column 8). Similarly as in the UK, the estimated cyclicality is higher for new hires than for continuing jobs, but such difference becomes statistically insignificant when controlling for job fixed-effects (column 7). Specifications that control for regional rather than aggregate unemployment are shown in Panel A of Table A3. For both countries, and across various specifications, the estimated wage cyclicality is lower than when using aggregate unemployment as a business cycle indicator.

### 2.2 Estimates of the reservation wage curve

To the best of our knowledge there are no previous estimates on the cyclicality of reservation wages. No US data sets cover a long enough period (see for example rich survey data built and used by Krueger and Müller 2016; Hall and Müller 2018; Mui and Schoefer 2020). In some research (Nekoei and Weber 2017; Jäger et al. 2020) the behaviour of reservation wages is often inferred from the relationship between changes in benefit entitlement, unemployment duration, and re-employment wages.

The BHPS asks unemployed respondents about the lowest weekly take-home pay that they consider accepting for a job, and the hours they expect to work for this amount. From this information we build a measure of the hourly net reservation wage. In the SOEP, information on reservation wages is elicited in monthly terms since 1987 and is not supplemented by information on expected hours; thus specifications for Germany use monthly reservation wages as the dependent variable, and control for whether an individual is looking for a full-time or part-time job.

While there may be concerns about the quality of reservation wage data, Appendix B shows that their correlation with job search outcomes has the sign predicted by search theory: ceteris paribus, higher reservation wages lead to longer job search spells and higher re-employment wages. Though likely noisy, reservation wage data thus embody meaningful information about job search.

Our reservation wage equations control for the same variables as the wage curves to capture the role of the wage offer distribution, plus welfare benefits as a proxy for utility while out of work. The estimates are reported in Table 2. Column 1 for the UK shows an elasticity of reservation wages to unemployment of -0.146. Columns 2, controlling for lagged unemployment instead, delivers an elasticity of -0.112. Columns 3 and 4 estimate similar specifications for Germany. The estimated elasticity with respect to current unemployment is positive but very imprecise, while the elasticity to lagged unemployment is negative, significant, and somewhat smaller than the corresponding value for the UK. As for wage cyclicality, estimates based on regional unemployment tend to deliver lower reservation wage cyclicality, as shown in Panel B of Table A3 for both countries.

The main take-way point is that wages and reservation wages display limited and very similar degrees of cyclicality. In the UK, the estimated elasticity is -0.169 for wages and -0.146 for reservation wages. In Germany, both elasticities are close to zero when using current unemployment, and fall to -0.065 and -0.082, respectively, when using lagged unemployment.

## 3 The model

We lay out a job search model to derive implications for the cyclicality of wages and reservation wages, to be compared to estimates from the previous section. Our setup ecompasses elements of wage rigidity proposed by earlier work on unemployment fluctuations, namely acyclical hiring costs (Pissarides, 2009), infrequent wage negotiations in ongoing matches, and backward-looking elements in wage setting for new hires (Gertler et al., 2008; Gertler and Trigari, 2009; Rudanko, 2009; Haefke et al., 2013; Kudlyak, 2014). We additionally allow for backward-looking reference dependence in the determination of reservation wages.

For simplicity, we assume homogeneous workers and jobs, implying homogeneous wages and reservation wages in steady-state. Outside steady-state, there is heterogeneity across wages set at different times, due to infrequent negotiations, and heterogeneity across wages set at the same time, due to heterogeneous reservation wages, shaped by reference-dependence.

### 3.1 Employers

Each firm has one job.  $J(w; w^l, t)$  denotes the value at time t of a filled job paying wage w to a worker, whose wage in the previous job was  $w^l$ . The presence of backward-looking reference dependence makes the previous wage a state variable in the value of the current job, as it shapes the reservation wage and future negotiations.

Wages are occasionally renegotiated and renegotiation opportunities are assumed to

arrive at an exogenous rate  $\phi$ ,<sup>3</sup> leading to a staggered wage setting process à la Calvo (1983). Upon renegotiation, neither party has the option to continue the match at the current wage, which thus plays no role in wage bargaining. The renegotiated wage, denoted by  $w^r(w^l, t)$ , depends on the past wage as well as on other factors absorbed in time dependence.

Based on these assumptions, a job's value function is

$$rJ(w; w^{l}, t) = p(t) - w - s \left[ J(w; w^{l}, t) - V(t) \right] + \phi \left[ J(w^{r}(w^{l}, t); w^{l}, t) - J(w; w^{l}, t) \right] + E_{t} \frac{\partial J(w; w^{l}, t)}{\partial t},$$
(1)

where V(t) is the value of a vacant job at time t, p(t) denotes the productivity of a match, and s is the separation rate, assumed to be exogenous. The first term on the second line represents the change in job value resulting from renegotiation, which embodies the assumption that the lagged wage is not re-set upon renegotiation and stays equal to the wage in the previous job. Conditional on the current wage, the lagged wage only affects the firm's value function through its role in future renegotiations.

The value of a vacant job at time t is

$$rV(t) = -c(t) + q(t)E_t[J(w; w^l, t) - V(t) - C(t)] + E_t \frac{\partial V(t)}{\partial t}.$$
(2)

Following Pissarides (2009) and Silva and Toledo (2009), hiring involves a flow cost, c(t)and a fixed cost, C(t); q(t) is the rate at which vacancies are filled, varying over time via the impact of shocks on labour market tightness, and we can be agnostic about their nature. Free entry of vacancies implies V(t) = 0.

The term  $E_t[J(w; w^l, t)]$  captures uncertainty about wages in future matches. When a firm and a worker match, they negotiate a wage with probability  $\alpha$ , while with probability  $1 - \alpha$  a pre-existing ("old") wage is paid, randomly drawn from the existing cross-section. The extent of job creation at old wages (represented by  $1 - \alpha$ ) is a backward-looking element in wage setting. Values of  $\alpha$  and  $\phi$  determine the relative cyclicality of wages in new versus continuing matches. In Section 2.1 we found suggestive evidence that wages in new matches are more procyclical than in continuing matches. This is predicted whenever

<sup>&</sup>lt;sup>3</sup>Renegotiation opportunities are not triggered by a threatened separation caused by a demand shock. This amounts to assuming that demand shocks never cause the surplus in continuing matches to become negative. Allowing for this possibility would introduce an extra source of cyclicality as it implies more frequent renegotiation in recessions.

the opportunity to renegotiate the wage in an ongoing job happens infrequently (low  $\phi$ ), relative to the chance to negotiate a new wage upon hiring (high  $\alpha$ ).

### 3.2 Workers

To introduce reference dependence, we represent the utility flow of working in a job paying w, when one's previous wage is  $w^l$ , as

$$u(w|w^l) = w + \alpha_\rho \left[ w - (\alpha_l w^l + (1 - \alpha_l) w^*) \right], \qquad (3)$$

where  $\alpha_{\rho} \geq 0$  measures the importance of reference dependence (with  $\alpha_{\rho} = 0$  corresponding to the canonical model) and the reference point is assumed to be the average of the lagged wage  $w^l$  (with weight  $\alpha_l$ ) and the time-invariant, steady-state wage  $w^*$  (with weight  $1 - \alpha_l$ ). Conditional on w, the worker experiences an utility gain (loss) whenever w is above (below) the reference wage.

This modelling of backward-looking reference dependence is standard in the literature (Kahneman and Tversky, 1979; Loomes and Sugden, 1986; Koszegi and Rabin, 2006). The role of reference points in labour supply has been emphasized by Farber (2008) and Della Vigna (2009), among others. Closely related to our approach, the experiment of Falk et al. (2006) shows that minimum wages have lasting effects on subjects' reservation wages, even after their removal; and Della Vigna et al. (2017, 2022) and Marinescu and Skandalis (2020) show evidence on the role of past earnings as reference points during job search.

Given the utility function in (3), the value of employment is given by:

$$rW(w; w^{l}, t) = u(w|w^{l}) + \phi[W(w^{r}(w^{l}, t); w^{l}, t) - W(w; w^{l}, t)] - s[W(w; w^{l}, t) - U(w^{l}, t)] + E_{t} \frac{\partial W(w; w^{l}, t)}{\partial t},$$
(4)

where  $U(w^l, t)$  is the value of unemployment at time t when one's previous wage is  $w^l$ . The second term in (4) captures changes in the value of employment related to wage renegotiation opportunities and the third term captures changes related to job loss.<sup>4</sup>

The value of being unemployed at time t is given by:

$$rU(w^l, t) = z + \lambda(t)E_t[W(w; w^l, t) - U(w^l, t)] + E_t \frac{\partial U(w^l, t)}{\partial t},$$
(5)

<sup>&</sup>lt;sup>4</sup>Similarly as in equation (1), equation (4) assumes that, when thinking about the capital loss from job separation, individuals keep using their previous wage as the reference point.

where z is the flow utility when unemployed and  $\lambda(t)$  is the rate at which the unemployed find jobs, which varies over time with labour market tightness. The reservation wage  $\rho(w^l, t)$  is defined as the wage that makes the worker indifferent between working at that wage and unemployment:

$$W(\rho(w^{l}, t); w^{l}, t) = U(w^{l}, t).$$
(6)

### 3.3 Wage and reservation wage determination

Under Nash bargaining, the wage negotiated at time  $t, w^r(w^l, t)$ , is such that:

$$w^{r}(w^{l},t) = argmax_{w}[W(w;w^{l},t) - W(\rho(w^{l},t);w^{l},t)]^{\beta}[J(w;w^{l},t) - V(t)]^{1-\beta}, \quad (7)$$

where  $\beta$  denotes workers' relative bargaining power. Using (1)-(4), Appendix C.1 proves the following result:

**Proposition 1.** Newly-negotiated wages are given by:

$$w^{r}(w^{l},t) = (1-\beta)\rho(w^{l},t) + \beta \left\{ (r+s+\phi)\mu(t) + [\alpha w^{ru}(t) + (1-\alpha)w^{a}(t)] + \chi(t)(r+s+\phi)[w^{lu}(t) - w^{l}] \right\},$$
(8)

where  $\mu(t) \equiv C(t) + c(t)/q(t)$ ,  $w^{ru}(t)$  is the average newly-negotiated wage for workers recruited from unemployment,  $w^{a}(t)$  is the average wage in the economy,  $w^{lu}(t)$  is the average lagged wage for the unemployed and  $\chi(t) \equiv \frac{\partial J(w;w^{l},t)}{\partial w^{l}}$ .

The structure of (8) is intuitive. Negotiated wages are a weighted average of two terms, with weights given by the firm's and worker's bargaining power, respectively. The first term is the reservation wage. The second term has three components, which collectively capture the cost of replacing the current worker with a new recruit. The first component,  $(r+\phi+s)\mu(t)$ , is related to hiring costs, which the firm saves by hiring the current worker instead of searching for a new one. The second component,  $\alpha w^{ru}(t) + (1-\alpha)w^a(t)$ , is the expected wage the firm would pay if hiring another worker. The third component,  $\chi(t)(r+s+\phi)[w^{lu}(t)-w^l]$ , is related to the difference in the lagged wage between the average and the current unemployed worker, capturing differences in the respective costs of future renegotiations. This component is multiplied by the renegotiation rate  $\phi$  and by the sensitivity of the value of a job to lagged wages,  $\chi(t)$ . Appendix C.3 shows that  $\chi(t)$ only varies with time, and can be treated as exogenous from the perspective of individual wage negotiation.

Despite the relatively unrestricted nature of the model assumptions, (8) gives a fairly simple expression for the wage curve. (8) is expressed in terms of currently-dated variables, with the past and the future entering negotiations only to the extent that they affect the reservation wage and average wages. Moreover, as the negotiated wage for an individual worker is a function of a set of average wages (a property that follows from the linearity of value functions (1)-(4)), we do not need to keep track of higher moments of the wage distribution.

Using (8), wage cyclicality reflects cyclicality in reservation wages and hiring costs  $\mu(t) \equiv C(t) + c(t)/q(t)$ . In what follows we impose constant  $\mu$ . This assumption reduces wage cyclicality and is in line with findings that the fixed cost component C is more important than the flow cost, c. The dependence of wages on the reservation wage in (8) is a key property of this model, as it implies that any element that makes reservation wages less cyclical also makes wages less cyclical.

Reservation wages are defined by the following Proposition, proved in Appendix C.2:

### **Proposition 2.** The reservation wage satisfies the following differential equation

$$[r + \lambda(t) + s]\rho(w^{l}, t) = (r + \phi + s)z + \lambda(t)[\alpha w^{r}(w^{l}, t) + (1 - \alpha)w^{a}(t)] + (r + \phi + s)\frac{\alpha_{\rho}}{1 + \alpha_{\rho}}[\alpha_{l}w^{l} + (1 - \alpha_{l})w^{*}] - \phi w^{r}(w^{l}, t) + E_{t}\frac{\partial\rho(w^{l}, t)}{\partial t}.$$
 (9)

The first two terms in (9) are standard, representing unemployment income and the expected return to job search, respectively. The third term captures the role of reference dependence and the fourth term captures the impact of wage renegotiations, whose frequency makes employment relatively more attractive than unemployment.

## 4 The Cyclicality of Wages and Reservation Wages

To measure cyclicality, we derive closed-form expressions for the linear projection of relevant (log) wage variables on (log) unemployment. Our analytical results for the elasticities of interest transparently highlight the role of various model elements in driving wage cyclicality. In addition, this approach is agnostic about the source of shocks in the model, as the derived relationships between wages and unemployment hold independently of whether shocks to labour demand stem from productivity, macroeconomic policy, or other sources. This approach differs from the standard approach in this literature, which typically simulates the impact of productivity shocks in calibrated models. In Appendix C.8 we show that our closed-form solutions produce results that closely resemble those produced by more standard simulated models with productivity shocks.

### 4.1 Building Blocks

For any variable x, we define the parameter  $\theta_x$  as the linear projection of x(t) on u(t):

$$E_t \left[ (x(t) - x^*) \mid (u(t) - u^*) \right] = \theta_x (u(t) - u^*), \tag{10}$$

where  $x^*$  and  $u^*$  indicate steady-state values. Given  $\theta_x$ , the elasticity of x(t) with respect to u(t) can be evaluated in steady state as  $\varepsilon_x = u^* \theta_x / x^*$ . This corresponds to the coefficient on  $\log u(t)$  in a linear projection of  $\log x(t)$  on  $\log u(t)$ .

We also define the speed of convergence of x(t) to steady state,  $\xi_x$ , such that:

$$E_t \left[ \frac{dx(t)}{dt} \mid (u(t) - u^*) \right] = -\xi_x E_t \left[ (x(t) - x^*) \mid (u(t) - u^*) \right] = -\xi_x \theta_x (u(t) - u^*).$$
(11)

 $\xi_x$  is inversely related to the degree of persistence in x(t); it is positive for backward-looking variables and negative for forward-looking ones.

### 4.2 Model dynamics without reference-dependence

We first describe dynamics in a fully forward-looking economy ( $\alpha_{\rho} = 0$ ), providing a natural benchmark for the case with reference dependence. This additionally establishes that our model formulation is consistent with previous results on wage cyclicality. In this economy, lagged wages are irrelevant. Newly-negotiated wages and average wages may differ due to backward-looking wage determination ( $\alpha < 1$ ) and occasional renegotiation ( $\phi < \infty$ ).

Introducing  $\eta = z/w^*$  as the steady-state replacement ratio and  $\tilde{\beta} = \beta/(1-\beta)$  as workers' relative bargaining power, Appendix C.5 proves the following proposition:

#### **Proposition 3.** With no reference dependence and a constant $\mu$

(a) the elasticity of newly-negotiated wages with respect to unemployment is given by:

$$\varepsilon_{w^r} = -(1-\eta)\frac{s-u^*\xi_u}{ru^*+s} \frac{r+\phi+s}{(r+\phi+s+\xi_\rho)(1+\widetilde{\beta}\Gamma)+\Gamma\left[\lambda^*(1+\widetilde{\beta})-\widetilde{\beta}\phi\right]},\qquad(12)$$

where:

$$\Gamma = \frac{(1-\alpha)\xi_w}{\alpha s + \phi + \xi_w};\tag{13}$$

(b) the elasticity of average wages is given by:

$$\varepsilon_w = \frac{\alpha s + \phi}{\alpha s + \phi + \xi_w} \varepsilon_{w^r}; \tag{14}$$

(c) the elasticity of reservation wages is given by:

$$\varepsilon_{\rho} = (1 + \widetilde{\beta}\Gamma) \frac{w^*}{\rho^*} \varepsilon_{w^r}.$$
(15)

Results (12), (14) and (15) provide closed-form elasticities for the wage concepts of interest, that we evaluate at benchmark parameter values described below.

### 4.2.1 Benchmark parameters

We adopt a monthly calibration. For the UK, we use the Quarterly Labour Force Survey (LFS) to obtain the average unemployment rate and monthly separation rate during 1991-2009. This gives u = 0.067 and s = 0.010, implying  $\lambda = s(1 - u)/u = 0.139$ . For Germany, we obtain u = 0.078 and s = 0.012 on the SOEP for 1984-2010, implying  $\lambda = 0.142$ . We set the bargaining power of workers at 0.05 (see estimates reported by Manning 2003, Table 4) and the monthly interest rate at 0.003.

We assume an expected contract length of 12 months, corresponding to  $\phi = 0.083$ , based on evidence reported by Taylor (1999), Gottschalk (2005) and Fabiani et al. (2010), and will show robustness analysis around this value. For the convergence parameters  $\xi_u$ ,  $\xi_w$  and  $\xi_\rho$  we use the simulated model described in Appendix D.7, in which we assume a productivity process with persistence 0.983 (as in Gertler and Trigari 2009). This yields  $\xi_u = 0.0036$ ,  $\xi_w = 0.0074$  and  $\xi_\rho = -0.0253$ . For unemployment, the persistence estimated on the simulated data is very close to the estimates we obtain by fitting AR(1) models on the monthly series for the unemployment rate in the UK and Germany.<sup>5</sup> As long, high-frequency, time series are not available for wages and reservation wages, we

<sup>&</sup>lt;sup>5</sup>We estimate  $\xi_u = 0.003$  for the UK on the monthly, seasonally adjusted, time series for the unemployment rate, available from the Office for National Statistics from 1971 onwards. For Germany, a harmonised, seasonally adjusted, series for the unemployment rate is available from the Bundesbank, from 1991 onwards, on which we obtain  $\xi_u = 0.004$ . We also use HP filtered series (with a conventional smoothing parameters of 129600 on monthly data), giving  $\xi_u = 0.004$  for the UK and  $\xi_u = 0.018$ for Germany, but the resulting trend component of unemployment for Germany retains some degree of cyclicality. For both countries, estimates on log unemployment and/or quarterly series give very similar results to those obtained on the level of monthly unemployment.

cannot estimate these directly, and use the values from the simulated data.

For the replacement ratio, Appendix C.7 calibrates  $\eta$  based on the steady-state relationship between wages and reservation wages and data on welfare benefits from the OECD Social Policy Database. This procedure gives  $\eta = 0.69$  for the UK and  $\eta = 0.75$ for Germany. All parameters and their sources are summarized in Table 3.

#### 4.2.2 Quantitative results

The elasticity results in (12), (14) and (15) encompass existing results in related work. Consider the special case with continuous wage negotiation,  $\phi = \infty$ : (12) and (14) imply:

$$\varepsilon_w = \varepsilon_{w^r} - (1 - \eta) \frac{s - u^* \xi_u}{r u^* + s}.$$
(16)

As the job destruction rate s is much larger than the  $ru^*$  product, and unemployment is highly persistent, i.e.  $\xi_u$  is positive but very low, the  $(s - u^*\xi_u)/(ru^* + s)$  ratio is close to 1. For the UK's parameter values from Table 3,  $(s - u^*\xi_u)/(ru^* + s) = 0.96$ , and corresponding values for Germany give an almost identical result. Equation (16) then implies that the elasticity of wages should be almost exactly equal to one minus the replacement ratio, so that a high replacement ratio is required to deliver weakly cyclical wages, consistent with the results in Hagedorn and Manovskii (2008), who propose a model calibration with  $\eta = 0.95$ .

The replacement ratio need not be as high if wage negotiation only happens occasionally and has backward-looking components. In the limiting case in which all new jobs are filled at existing wages ( $\alpha = 0$ ) and these are never re-negotiated ( $\phi = 0$ ), (14) implies that average wages are acyclical. By continuity, there must exist small enough values of  $\alpha$  and  $\phi$  that deliver a sufficiently low wage elasticity, providing a solution to the wage flexibility puzzle.

However, reservation wages retain some cyclicality even in the special case in which wages are completely acyclical, as shown by combining (12) and (15) for  $\alpha = \phi = 0$ :

$$\varepsilon_{\rho} = -\frac{w^*}{\rho^*} (1-\eta) \frac{s-u^* \xi_u}{ru^* + s} \frac{r+s}{r+s+\xi_{\rho}+\lambda^*} < 0.$$
(17)

Evaluated at baseline parameter values,  $\varepsilon_{\rho} = -0.038$ . Even when wages are acyclical, reservation wages are cyclical via the effect of the unemployment rate on the probability of receiving an offer.

Below we illustrate the reservation wage flexibility puzzle for a range of  $\alpha$  and  $\phi$  values, setting all other parameter values as indicated in Table 3.

Panel A in Figure 1 shows predictions for the elasticity of the average wage (using (14)) for alternative values for re-negotiation frequencies  $\phi$  (on the horizontal axis) and negotiation probabilities among new-hires  $\alpha$  (the different curves, correspond to  $\alpha = 1$ , 0.7, and 0.4, respectively). As expected, for given  $\phi$ , higher  $\alpha$  delivers higher wage cyclicality, i.e. a lower curve. The horizontal line represents the target wage elasticity for the UK,  $\varepsilon_w = -0.169$ , and the vertical line represents annual renegotiations,  $\phi = 0.083$ . When wages are fully forward-looking ( $\alpha = 1$ ), only implausibly low values of  $\phi$  around 0.02 (corresponding to renegotiations every 50 months), can match the target elasticity. In order to match the wage elasticity for Germany (-0.028), an even lower  $\phi$  is needed. The canonical model fares better with some degree of backward looking behaviour in wage setting. When  $\alpha = 0.7$ , the model matches the target UK elasticity when negotiations happen every 20 months ( $\phi = 0.05$ ). When  $\alpha = 0.4$  the model matches the target under annual negotiations ( $\phi = 0.083$ ), showing that plausible rigidities in wage setting can fully address the wage flexibility puzzle. This result closely replicates the calibration of Gertler and Trigari (2009).

However, the model parameters that match the cyclicality of wages overpredict the cyclicality of reservation wages. Panel B shows predictions for the cyclicality of reservation wages based on (15). The target value for the UK is  $\varepsilon_{\rho} = -0.146$ , and the model fares much worse at matching this. For example, under fully forward-looking wages, there is no value of  $\phi$  above 0.02 that gets even close to replicating the estimates reservation wage elasticity. When  $\alpha = 0.7$ , the model matches the target for  $\phi = 0.02$ , and when  $\alpha = 0.7$  the model matches the target for  $\phi = 0.04$ , well below the plausible value corresponding to annual renegotiations. While low values of  $\alpha$  can match wage cyclicality, they still overpredict the cyclicality of the reservation wage in correspondence of  $\phi$ .

This is illustrated in Panel C, showing predictions for the ratio of the two elasticities, where the horizontal line represents the target ratio for the UK ( $\varepsilon_w/\varepsilon_{\rho} = 0.169/0.146 =$ 1.16). For example, we noted that, under  $\alpha = 0.4$ , a value of  $\phi = 0.083$  can match the wage elasticity in Panel A. But the same  $\alpha$  and  $\phi$  values would predict a ratio between the wage and reservation wage elasticity of about 0.68, while this ratio is 1.16 in reality. The conclusion is that one cannot find combinations of  $\alpha$  and  $\phi$  parameters that match both the wage and reservation wage elasticities.

## 5 Reference dependence in reservation wages

We finally allow for backward-looking reference dependence in reservation wages. The main difference with respect to the canonical model is that past wages now matter for wage negotiation – both for the unemployed, upon hiring, and for the employed, whenever renegotiation opportunities arise. We therefore need to keep track of past wages and distinguish between past employment and unemployment status. Appendix C.9 follows similar steps to those outlined above and derives analytical expressions for elasticities in terms of model parameters. These analytical results are less insightful than those summarized in Proposition 3 for the fully forward-looking case, because the model has ten endogenous variables<sup>6</sup> (and as many persistence parameters), leading to a system of ten equations in ten unknowns. Similarly as for the canonical model, we obtain a very high correlation (0.993) between analytical and simulated results (see Appendix D.7 and Panel B of Figure D1).

We consider the combinations of backward-looking behaviour in wages  $(1 - \alpha)$ , reference dependence in reservation wages  $(\alpha_{\rho})$ , and backward-looking components in reference points  $(\alpha_l)$  that yield model predictions close to our elasticity estimates for benchmark values of other parameters.

Panel A of Figure 2 shows parameter combinations that deliver an elasticity of wages with respect to unemployment within 0.04 of -0.169 and an elasticity of reservation wages with respect to unemployment within 0.04 of  $-0.146.^7 \alpha_{\rho}$  and  $\alpha_l$  vary along the vertical and horizontal axes, respectively, and each curve is drawn in correspondence of a value for  $\alpha_l$ .

Reference dependence in reservation wages (i.e.  $\alpha_{\rho} > 0$ ) is necessary to match the empirical estimates, as there is no overlap between any of the curves and the horizontal axis ( $\alpha_{\rho} = 0$ ). Hence it is not possible for a model with fully forward-looking reservation wages to match estimated elasticities, independent of the degree of backward-looking behaviour in wage setting (i.e. for any  $0 \le \alpha \le 1$ ). On the contrary, it is possible for

<sup>&</sup>lt;sup>6</sup>The negotiated wage, reservation wage and past wage for those previously employed and for those previously unemployed (six variables); the overall wage in the economy; the arrival rate of job offers; the derivatives of reservation and newly-negotiated wages with respect to lagged wages (two variables).

<sup>&</sup>lt;sup>7</sup>Our choice of error margin corresponds almost exactly to the standard error on each parameter estimate, from Tables 1 and 2, respectively.

a model with fully forward-looking wage setting ( $\alpha = 1$ ) to match estimated elasticities, provided there is sufficient reference dependence in reservation wages; this shows that reference dependence reduces the need for alternative solutions to the wage flexibility puzzle based on backward-looking wage setting. For example, for  $\alpha = 0.4$ , values of  $\alpha_{\rho}$ between 0.4 and 0.65 can match target wage and reservation wage elasticities for a range of  $\alpha_l$  values between 0 and 0.6. For higher values of  $\alpha$ , including the fully forward-looking case  $\alpha = 1$ , there exist combinations of  $\alpha_{\rho}$  and  $\alpha_l$  that match both elasticities.

To gauge which combinations of  $\alpha$ ,  $\alpha_{\rho}$  and  $\alpha_{l}$  values are empirically plausible, it is useful to link them to an additional data moment. It can be shown that  $\alpha_{l}$  is closely related to the elasticity of reservation wages to the lagged wage, which we denote by  $\gamma \equiv \partial \ln(\rho^{*})/\partial \ln(w^{*})$ .<sup>8</sup> Panel B of Figure 2 depicts ( $\alpha, \alpha_{\rho}, \gamma$ ) combinations that match the empirical elasticities, leaving variation in  $\alpha_{l}$  in the background. The lines show that values of  $\gamma$  that can match the data lie between 0 and 0.38.

While data on reservation wages and past wages can in principle provide evidence on  $\gamma$ , the identification of reference dependence involves challenges related to the confounding role of unobservable characteristics, wealth effects, and the mechanical relationship between reservation wages and past wages that arises when unemployment benefits are indexed to past wages. We discuss these challenges in Appendix E and suggest an identification method based on instruments for past wages in reservation wage equations. The resulting elasticity of reservation wages with respect to past wages is about 0.15, which implies  $\gamma = 0.15 \frac{\rho^*}{w^*} = 0.12$ , within the range of plausible values shown in Panel B of Figure 2. The model with reference dependence can therefore match the observed elasticities in wages and reservation wages under standard assumptions about wage rigidity as well as in the presence of fully forward-looking wage setting.

### 6 Conclusions

This paper provides novel evidence on the cyclicality of reservation wages. Based on micro data for the UK and Germany, we find that wages and reservation wages display very similar and modest degrees of cyclicality. Job search models that are able to match the observed degree of wage cyclicality by introducing elements of rigidity in wage setting typically overpredict the cyclicality of reservation wages. We show that reference

<sup>&</sup>lt;sup>8</sup>The relationship between  $\alpha_l$  and  $\gamma$  is pinned down by equations (75) and (76) in Appendix D.4.

dependent preferences can deliver mildly cyclical reservation wages by anchoring them to backward-looking variables such as past earnings, which are typically less cyclical than labour market conditions. Weakly cyclical reservation wages are then reflected into weakly cyclical wages, as wages track reservation wages up to a roughly acyclical markup. We conclude that a model with reference dependence can match empirical elasticities of wages and reservation wages.

## References

- Ammermüller, A., C. Lucifora, F. Origo, and T. Zwick, "Wage Flexibility in Regional Labour Markets: Evidence from Italy and Germany," *Regional Studies*, 2010, 44 (4), 401–421.
- Baltagi, B., U. Blien, and K. Wolf, "New Evidence on the Dynamic Wage Curve for Western Germany: 1980-2004," *Labour Economics*, 2009, 16 (1), 47–51.
- Bell, B., S. Nickell, and G. Quintini, "Wage Equations, Wage Curves and All That," Labour Economics, 2002, 9 (3), 341–360.
- Bellou, A. and B. Kaymak, "The Cyclical Behavior of Job Quality and Real Wage Growth," American Economic Review: Insights, 2021, 3 (1), 83–96.
- Benito, A., "Inter-Industry Wage Differentials in Great Britain," Oxford Bulletin of Economics and Statistics, 2000, 62 (S1), 727–746.
- Blanchard, O. and L. Katz, "Wage Dynamics: Reconciling Theory and Evidence," American Economic Review, 1999, 89 (2), 69–74.
- Blanchflower, D. and A. Oswald, The Wage Curve, MIT Press, 1994.
- $\_$  and  $\_$ , "The Wage Curve Reloaded," *NBER WP 11338*, 2005.
- Calvo, G., "Staggered Prices in a Utility Maximising Framework," Journal of Monetary Economics, 1983, 12 (3), 383–398.
- Cameron, C. and D. Miller, "A Practitioner's Guide to Cluster-Robust Inference," Journal of Human Resources, 2015, 50 (2), 317–372.
- Card, D., "The Wage Curve: A Review," Journal of Economic Literature, 1995, 33 (2), 785–799.
- Carruth, A., W. Collier, and A. Dickerson, "Inter-industry Wage Differences and Individual Heterogeneity," Oxford Bulletin of Economics and Statistics, 2004, 66 (5), 811–847.
- **Della Vigna, S.**, "Psychology and Economics : Evidence from the Field," Journal of Economic Literature, 2009, 47 (2), 315–372.
- \_ , A. Lindner, B. Reizer, and J. Schmieder, "Reference-Dependent Job Search: Evidence from Hungary," Quarterly Journal of Economics, 2017, 132 (4), 1969–2018.
- \_, J. Heining, J. Schmieder, and S. Trenkle, "Evidence on Job Search Models from a Survey of Unemployed Workers in Germany," *Quarterly Journal of Economics*, 2022, 137, 1181–1232.
- Devereux, P. J. and R. A. Hart, "Real Wage Cyclicality of Job Stayers, Within-Company Job Movers, and Between-Company Job Movers," *Industrial and Labor Relations Review*, 2006, 60 (1), 105–119.
- Faberman, J., A. Müller, A. Şahin, and G. Topa, "Job Search Behavior among the Employed and Nonemployed," *Econometrica*, 2021, 90, 1743–1749.

- Fabiani, S., K. Galuscak, C. Kwapil, A. Lamo, and T. Room, "Wage Rigidities and Labor Market Adjustment in Europe," *Journal of the European Economic* Association, 2010, 8 (2-3), 497–505.
- Faggio, G. and S. Nickell, "The Responsiveness of Wages to Labour Market Conditions in the UK," *Labour Economics*, 2005, *12*, 685–696.
- Falk, A., E. Fehr, and C. Zehnder, "Fairness Perceptions and Reservation Wages -The Behavioural Effects of Minimum Wage Laws," *Quarterly Journal of Economics*, 2006, 121 (4), 1347–1381.
- Farber, H., "Reference-Dependent Preferences and Labor Supply: The Case of New York City Taxi Drivers," American Economic Review, 2008, 98 (3), 1069–1082.
- Figueiredo, A., "Wage Cyclicality and Labor Market Sorting," American Economic Review: Insights, 2022, 4, 425–42.
- Gertler, M. and A. Trigari, "Unemployment Fluctuations with Staggered Nash Wage Bargaining," *Journal of Political Economy*, 2009, 117 (1), 38–86.
- -, C. Huckfeldt, and A. Trigari, "Unemployment Fluctuations, Match Quality, and the Wage Cyclicality of New Hires," *Review of Economic Studies*, 2020, 87 (4), 1876– 1914.
- \_, L. Sala, and A. Trigari, "An Estimated Monetary DSGE Model with Unemployment and Staggered Nominal Wage Bargaining," *Journal of Money, Credit and Banking*, 2008, 40 (8), 1713–1764.
- Gibbons, R. and L. Katz, "Does Unmeasured Ability Explain Inter-Industry Wage Differentials?," *Review of Economic Studies*, 1992, 59 (3), 515–535.
- Gottschalk, P., "Downward Nominal-Wage Flexibility: Real or Measurement Error?," *Review of Economics and Statistics*, 2005, 87 (3), 556–568.
- Gregg, P., S. Machin, and M. Fernandez-Salgado, "Real Wages and Unemployment in the Big Squeeze," *Economic Journal*, 2014, 124 (576), 408–432.
- Haefke, C., M. Sonntag, and T. van Rens, "Wage Rigidity and Job Creation," Journal of Monetary Economics, 2013, 60 (8), 887–899.
- Hagedorn, M. and I. Manovskii, "The Cyclical Behavior of Equilibrium Unemployment and Vacancies Revisited," *American Economic Review*, 2008, 98 (4), 1692–1706.
- Hall, R., "Employment Fluctuations with Equilibrium Wage Stickiness," American Economic Review, 2005, 95 (1), 50–65.
- and A. Müller, "Wage Dispersion and Search Behavior: The Importance of Nonwage Job Values," *Journal of Political Economy*, 2018, 126 (4), 1594–1637.
- and P. Milgrom, "The Limited Influence of Unemployment on the Wage Bargain," American Economic Review, 2008, 98 (4), 1653–1674.
- Jäger, S., B. Schoefer, S. Young, and J. Zweimüller, "Wages and the Value of Nonemployment," *Quarterly Journal of Economics*, 2020, 135 (4), 1905–1963.

- Kahneman, D. and A. Tversky, "Prospect Theory: An Analysis of Decision under Risk," *Econometrica*, 1979, 47 (2), 263–292.
- Koszegi, B. and M. Rabin, "A Model of Reference-Dependent Preferences," *Quarterly Journal of Economics*, 2006, 121 (4), 1133–1165.
- Krueger, A. and A. Müller, "A Contribution to the Empirics of Reservation Wages," American Economic Journal: Economic Policy, 2016, 8 (1), 142–179.
- and L. Summers, "Efficiency Wages and the Inter-Industry Wage Structure," Econometrica, 1988, 56 (2), 259–293.
- Kudlyak, M., "The Cyclicality of the User Cost of Labor," Journal of Monetary Economics, 2014, 68, 53–67.
- Le Barbanchon, T., R. Rathelot, and A. Roulet, "Unemployment Insurance and Reservation Wages: Evidence from Administrative Data," *Journal of Public Economics*, 2019, 171, 1–17.
- Loomes, G. and R. Sugden, "Disappointment and Dynamic Consistency in Choice under Uncertainty," *Review of Economic Studies*, 1986, 53 (2), 271–282.
- Manning, A., Monopsony in Motion: Imperfect Competition in Labor Markets, Princeton: Princeton University Press, 2003.
- Marinescu, Ioana and Daphne Skandalis, "Unemployment Insurance and Job Search Behavior," *Quarterly Journal of Economics*, 2020, 136 (2), 887–931.
- Mas, A. and A. Pallais, "Labor Supply and the Value of Non-work Time: Experimental Estimates from the Field," *American Economic Review: Insights*, 2019, 1 (1), 111–126.
- Mui, P. and B. Schoefer, "Reservation Raises: The Aggregate Labor Supply Curve at the Extensive Margin.," *Mimeo.*, 2020.
- Nekoei, A. and A. Weber, "Does Extending Unemployment Benefits Improve Job Quality?," *American Economic Review*, 2017, 107 (2), 527–561.
- **Pissarides, C.**, "The Unemployment Volatility Puzzle: Is Wage Stickiness the Answer?," *Econometrica*, 2009, 77 (5), 1339–1369.
- Rudanko, L., "Labor Market Dynamics under Long-term Wage Contracting," *Journal* of Monetary Economics, 2009, 56, 170–183.
- Sanderson, E. and F. Windmeijer, "A Weak Instrument F-test in Linear IV Models with Multiple Endogenous Variables," *Journal of Econometrics*, 2016, 190 (2), 212–221.
- Schmieder, J., T. von Wachter, and S. Bender, "The Effect of Unemployment Benefits and Nonemployment Durations on Wages," *American Economic Review*, 2016, 106 (3), 739–777.
- Shimer, R., "The Cyclical Behavior of Equilibrium Unemployment and Vacancies," American Economic Review, 2005, 95 (1), 25–49.

- Silva, J. I. and M. Toledo, "Labor Turnover Costs and the Cyclical Behavior of Vacancies and Unemployment," *Macroeconomic Dynamics*, 2009, 13 (S1), 76–96.
- Taylor, J. B., "Staggered Price and Wage Setting in Macroeconomics," in J B Taylor and M Woodford, eds., *Handbook of Macroeconomics*, Elsevier, 1999.

Wagner, J., "German Wage Curves, 1979-1990," Economic Letters, 1994, 44, 307–311.

		UK (199	(1-2009)		Ğ	ermany (	1984-201	(0
		2	က	4	ഹ	9	2	$\infty$
Log unemployment rate	-0.169	-0.147	-0.109		-0.028	-0.015	-0.005	
	(0.044)	(0.042)	(0.029)		(0.019)	(0.018)	(0.015)	
Log unemployment rate		-0.075	-0.019			-0.096	0.034	
* new job		(0.013)	(0.011)			(0.026)	(0.022)	
Log unemployment rate,				-0.126				-0.065
lagged				(0.032)				(0.018)
Individual fixed effects	>	>		>	>	>		>
Job fixed effects			>				>	
Observations	92,380	92,380	77,854	92,380	161,075	160,865	149,617	161,075
R-squared	0.810	0.810	0.889	0.778	0.415	0.415	0.199	0.415

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Table

national. All regressions include a quadratic time trend, a gender dummy, age and its square, three education dummies, a cubic trend in job tenure, a dummy for married, the number of children in the household, and region dummies. Regressions in columns 3 and 7 also include a dummy for the job having started in the previous 12 months. Standard errors use 2-way cluster-robust SSChourly (monthly) wage for the UK (Germany), deflated by the aggregate consumer price index. The unemployment concept is variance (Cameron and Miller, 2015). Source: BHPS and SOEP.

## **Tables and Figures**

	ITK (190	1-2000)	2	Menna	(0106-1981)
	1	2	5	4	2
Log unemployment rate	-0.146		0.	038	
	(0.042)		0)	054)	
Log unemployment rate, lagged		-0.112			-0.082
		(0.026)			(0.045)
Individual fixed effects	>	~	>	>	
Observations	10,774	10,774	7,	911	7,911
R-squared	0.614	0.614	0.	123	0.123

Table 2: Estimates of Reservation Wage Equations for the UK and Germany

by months to benefit expiry. These are obtained by exploiting benefit entitlement rules, based on (nonlinear) functions of age Notes. The sample includes unemployed jobseekers aged 18-65 with non-missing reservation wage information. The dependent variable is the log net hourly (monthly) reservation wage for the UK (Germany), deflated by the aggregate consumer price index. The unemployment concept is national. All regressions also include a quadratic time trend, a gender dummy, age and its square, three education dummies, a cubic trend in unemployment duration, a dummy for married, the number of children in the household, the log of unemployment benefits, and region dummies. For the UK, regressions additionally include a dummy for receipt of housing benefits; for Germany they additionally include dummies for looking for full-time, part-time or any job (omitted category: unsure about preferences), and months of social insurance contributions. For Germany, unemployment benefits are instrumented and previous social security contributions. Standard errors use 2-way cluster-robust variance (Cameron and Miller, 2015). Source: BHPS and SOEP.

Variable	Symbol	UK	Germany	Source
Unemployment rate	u	0.067	0.078	Quarterly LFP (UK) SOEP (Germany)
Separation rate	S	0.010	0.012	Quarterly LFP (UK) SOEP (Germany)
Job-finding rate	λ	0.139	0.142	Separation rate and unemployment rate $(\lambda = s(1-u)/u)$
Frequency of wage negotiations	$\phi$	0.083	0.083	Annual frequency (Taylor, 1999)
Interest rate	r	0.003	0.003	Conventional value
Replacement rate	η	0.690	0.754	For UK: equation (44), using $\rho^*/w^* = 0.8$ (from BHPS) For Germany: benefit replacement ratio + extra utility of leisure during unemployment as implied by UK estimates
Bargaining power of workers	eta	0.05	0.05	Manning (2003)
Productivity persistence parameter		0.983	0.983	Gertler and Trigari (2009)

## Table 3: Benchmark Parameters Values

Notes:  $s, \lambda, \phi$  and  $\xi_u$  are expressed in monthly terms.



### Figure 1: Predictions of the canonical model

Notes. The Figure shows predicted elasticities in the canonical model under alternative combinations of parameters. Panels A, B and C plot the predicted wage elasticity, reservation wage elasticity and the ratio between the two, respectively. The target elasticities are the estimated values for the UK:  $\varepsilon_w = -0.169$  (from specification 1 in Table 1);  $\varepsilon_\rho = -0.146$  (from specification 1 in Table 2);  $\varepsilon_w/\varepsilon_\rho = 1.16$ . All other parameters are set at baseline values reported in Table 3.



Figure 2: Parameter combinations that match the observed cyclicality of wages and reservation wages

Notes. **Panel A**: The lines represent combinations of  $\alpha$  (probability of negotiating a wage on a new match),  $\alpha_{\rho}$  (role of reference points during job search) and  $\alpha_l$  (weight of past earnings in reference points) that predict wage and reservation wage elasticities within 0.04 of -0.169 and -0.146, respectively. **Panel B**: The lines represent combinations of  $\alpha$ ,  $\alpha_{\rho}$  and  $\gamma$  (the sensitivity of the reservation wage with respect to the past wage) that predict wage and reservation wage elasticities within 0.04 of -0.169 and -0.146, respectively. Given ( $\alpha, \alpha_{\rho}, \alpha_l$ ),  $\gamma$  is obtained from equations (75) and (76) in Appendix D.4. All other parameters are set at baseline values reported in Table 3.

Statistics
Summary
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Table

		1	JK			Geri	nany	
	Wage	sample	Res. we	age sample	Wage	sample	Res. wa	ge sample
Variables:	Mean	St. dev.	Mean	St. dev.	Mean	St. dev.	Mean	St. dev.
Reservation wage			5.226	6.206			1180.4	703.2
Wage	9.866	6.203			2387.7	1898.0		
Female	0.526	0.500	0.546	0.498	0.430	0.495	0.616	0.486
Age	38.1	11.7	34.7	14.0	39.0	11.6	33.3	11.3
Higher education	0.117	0.321	0.247	0.431	0.254	0.435	0.143	0.350
Upper secondary education	0.269	0.443	0.353	0.478	0.528	0.499	0.549	0.498
Lower secondary education	0.405	0.491	0.314	0.464	0.178	0.382	0.211	0.408
No qualifications	0.209	0.407	0.085	0.280	0.040	0.040	0.097	0.086
Married	0.717	0.451	0.514	0.500	0.657	0.475	0.559	0.497
No. Kids	0.686	0.965	0.917	1.168	0.730	0.990	1.027	1.120
Duration in current status (years)	4.880	5.969	4.387	5.748	10.464	9.653	2.962	3.902
Benefits			276.4	318.2			255.8	448.7
Looking for full-time work							0.482	0.500
Looking for part-time work							0.382	0.486
Looking for either							0.109	0.312
Unsure about working hours							0.027	0.161
Social insurance contributions (months)							5.242	6.878
Months to benefit expiry							1.109	3.679
Entitled to unemployment benefits							0.196	0.397
Hours worked					38.5	12.7		
Number of observations	96	,270	1	1,874	166	,614	11.	221
Notes. Samples include employees aged 18-65 with reservation wage information (reservation wage sa	n non-missi mple). Sou	ng wage infor rce: BHPS 19	mation (wa 991-2009 an	ge sample); und d SOEP 1984-2	employed jo 2010.	bseekers aged	18-65 with	non-missing

## Online Appendix

		UK	Ge	rmany
Dependent variable	log wage	log res wage	log wage	log res wage
Log national unemployment rate	-0.165	-0.175	0.002	0.001
	(0.044)	(0.058)	(0.025)	(0.065)
Female	-0.263	-0.102	-0.265	-0.188
	(0.009)	(0.011)	(0.015)	(0.018)
Age	0.073	0.033	0.082	0.018
	(0.002)	(0.002)	(0.002)	(0.003)
$Age^{2}$ (/100)	-0.084	-0.034	-0.009	-0.003
	(0.002)	(0.002)	(0.000)	(0.000)
Lower secondary qualification	0.193	0.068	0.023	-0.016
• <u>-</u>	(0.008)	(0.009)	(0.011)	(0.024)
Upper secondary qualification	0.361	0.157	0.230	0.093
	(0.007)	(0.011)	(0.015)	(0.023)
Higher education	0.710	0.352	0.562	0.276
	(0.004)	(0.013)	(0.019)	(0.029)
Married	0.092	0.042	0.032	-0.038
	(0.006)	(0.006)	(0.003)	(0.010)
No. kids in household	-0.019	0.018	-0.020	-0.006
	(0.003)	(0.004)	(0.004)	(0.005)
Duration in current status (years)	0.018	-0.002	0.037	0.013
	(0.001)	(0.002)	(0.002)	(0.005)
Duration in current status <sup>2</sup> $(/10)$	-0.010	-0.001	-0.012	-0.014
(, , )	(0.001)	(0.002)	(0.001)	(0.006)
Duration in current status <sup>3</sup> (/100)	0.017	0.003	0.002	0.003
	(0.002)	(0.003)	(0.000)	(0.002)
Log(Unemp benefits + 1)	(0.002)	0.004	(0.000)	0.004
		(0.001)		(0.003)
Receives housing benefits		0.017		-0.075
0		(0.008)		(0.026)
Social insurance contributions (vears)		(0.000)		0.005
				(0.001)
Looking for full-time work				0.151
0				(0.036)
Looking for part-time work				-0.507
0				(0.033)
Looking for any hours				-0.051
				(0.031)
Log hours worked			0.912	(0.00-)
			(0.042)	
Year	-0.009	0.004	0.022	0.027
	(0.007)	(0.007)	(0.002)	(0.008)
$(Year-1990)^2$	0.001	0.001	-0.696	-1.003
<pre> /</pre>	(0.000)	(0.000)	(0.078)	(0.253)
	00.070	14.047	100 01 4	11 001
Observations B-squared	90,270 0 307	14,847	100,014	11,221 0.350
IL SQUALUU	0.031	0.243	0.000	0.003

# Table A2: Detailed Results on Wage and Reservation Wage Equations for theUK and Germany

Notes. See notes to Table A1 for samples used. <sup>27</sup>The wage measure is hourly for the UK and monthly for Germany. All regressions include region dummies. Standard errors are clustered at the year level. Source: BHPS 1991-2009 and SOEP 1984-2010.

	U	K	Gerr	nany
	1	2	3	4
Panel A: Wage equations				
Log regional unemployment rate	-0.053		-0.008	
	(0.017)		(0.015)	
Log regional unemployment rate,		-0.065		-0.044
lagged		(0.013)		(0.014)
Individual fixed effects	$\checkmark$	$\checkmark$	$\checkmark$	$\checkmark$
Observations	92,380	92,380	160,865	$101,\!526$
R-squared	0.809	0.810	0.414	0.415
Panel B: Reservation wage equation	ons			
Log regional unemployment rate	-0.034		0.034	
	(0.030)		(0.023)	
Log regional unemployment rate,		-0.078		-0.031
lagged		(0.024)		(0.023)
Individual fixed effects	$\checkmark$	$\checkmark$	$\checkmark$	$\checkmark$
Observations	10,774	10,774	7,911	7,911
R-squared	0.613	0.614	0.124	0.123

Table A3: Estimates of Wage and Reservation Equations for the UK andGermany: Additional Estimates with Regional Controls

Notes. Panel A: See notes to Table 1 in the main text. Panel B: See notes to Table 2 in the main text. The unemployment concept is regional.

## **B** The quality of reservation wage data

While there may be concerns about the quality of reservation wage data, we note that the impact of most covariates considered on reservation wages (e.g. age, education and gender) has the expected sign and is precisely estimated, as shown in Table A2. We further address concerns about the informative content of reservation wage data by testing whether their correlation with job search outcomes has the sign predicted by search theory. Ceteris paribus, a higher reservation wage should cause a longer remaining duration in unemployment and higher entry wages upon job finding.

Table B1 illustrates the effect of reservation wages on each outcome. Panel A shows estimates for the UK. Column 1 regresses an indicator of re-employment in the past year on the reservation wage recorded at the beginning of the year and a set of year and region dummies. The impact of the reservation wage is virtually zero, but this estimate is likely to be upward biased due to omitted controls for worker ability, as more able workers have both higher reservation wages and are more likely to find employment. Column 2 controls for individual covariates and the national unemployment rate and shows that, conditional on these, workers with higher reservation wages tend to experience significantly longer unemployment spells. Column 3 shows that this result is robust to the introduction of individual fixed-effects.

Columns 4-6 show the impact of reservation wages on wages for those who find jobs. In column 4, which does not control for individual characteristics, the estimated elasticity of reemployment wages with respect to reservation wages is positive and highly significant, but likely to be upward biased by unobserved individual factors that are associated to both higher reservation wages and higher reemployment wages. The elasticity falls by about a quarter in column 5, which controls for individual characteristics, and is further halved in column 6, which includes individual fixed-effects, but remains statistically significant. Results for Germany are presented in Panel B, and they are in line with the UK results. The conclusion from this analysis is that the reservation wage data, though undoubtedly noisy, embody meaningful information about job search behaviour, and there is no particular reason to think that their cyclicality is systematically under-estimated.

		Panel A: UK (1991-2009)					
	W	hether found	d job	Log pos	st-unemploy:	ment wage	
	1	2	3	4	5	6	
Log reservation wage	-0.001	-0.020	-0.020	0.436	0.312	0.157	
	(0.008)	(0.008)	(0.011)	(0.021)	(0.036)	(0.080)	
Year dummies	$\checkmark$			$\checkmark$			
Trend	no	quadratic	quadratic	no	quadratic	quadratic	
Further controls		$\checkmark$	$\checkmark$		$\checkmark$	$\checkmark$	
Individual fixed-effects			$\checkmark$			$\checkmark$	
Observations	$15,\!278$	14,701	$10,\!642$	$2,\!685$	2,594	602	
R-squared	0.018	0.078	0.039	0.217	0.299	0.290	
		Pane	l B: Germa	any (198	<b>34-2010</b> )		
	W	hether found	d job	Log pos	st-unemploy:	ment wage	
	1	2	3	4	5	6	
Log reservation wage	0.033	-0.081	-0.100	0.737	0.391	0.123	
	(0.007)	(0.011)	(0.016)	(0.023)	(0.034)	(0.106)	
Year dummies	$\checkmark$			$\checkmark$			
Trend	no	quadratic	quadratic	no	quadratic	quadratic	
Further controls		$\checkmark$	$\checkmark$		$\checkmark$	$\checkmark$	
Individual fixed-effects			$\checkmark$			$\checkmark$	
Observations	11 524	11 534	8 156	2,984	2.984	755	
	11,004	11,004	0,100	2,001	2,004	100	

 Table B1: Reservation Wages, Post-unemployment Wages and Job Finding

 Probabilities

Notes. All specifications include eleven region dummies. Further controls in columns 2, 3, 5 and 6 are a gender dummy, age and its square, three education dummies, a cubic trend in unemployment duration, a dummy for married and the number of children in the household. Standard errors are clustered at the year level in columns 1, 2, 4 and 5; and using 2-way cluster-robust variance (Cameron and Miller, 2015) in columns 3 and 6. Source: BHPS and SOEP.

### C Derivation of model results

### C.1 Proof of Proposition 1: The wage equation

Maximizing the Nash maximand (7) with respect to  $w^r(w^l, t)$  implies the first-order condition:

$$(1-\beta)\frac{\partial J(w^{r}(w^{l},t);w^{l},t)}{\partial w^{r}}[W(w^{r}(w^{l},t);w^{l},t) - W(\rho(w^{l},t);w^{l},t)] + \beta\frac{\partial W(w^{r}(w^{l},t);w^{l},t)}{\partial w^{r}}J(w^{r}(w^{l},t);w^{l},t) = 0,$$
(18)

where V(t) = 0 has been imposed. The following result will be useful:

**Lemma.**  $J(w; w^l, t)$  and  $W(w; w^l, t)$  are linear in w with a slope that does not depend on  $w^l$  or t.

*Proof.* Equations (1) and (4) imply:

$$\frac{\partial W(w;w^l,t)}{\partial w} = \frac{1+\alpha_{\rho}}{r+\phi+s}, \frac{\partial J(w;w^l,t)}{\partial w} = -\frac{1}{r+\phi+s}.$$
(19)

As  $(r, \phi, s)$  are constant, (19) implies that  $W(w; w^l, t)$  and  $J(w; w^l, t)$  are separable and linear in w. This in turn implies that  $\partial J(w; w^l, t)/\partial t$  and  $\partial W(w; w^l, t)/\partial t$  do not depend on w. We additionally assume and verify below that  $\partial J(w; w^l, t)/\partial w^l$  is independent of w, and hence  $\partial J(w; w^l, t)/\partial w^l = \partial J(w^r; w^l, t)/\partial w^l$ . The derivative of the value functions with respect to  $w^l$  can be written as:

$$\frac{\partial J(w;w^l,t)}{\partial w^l} = \frac{1}{r+s} \frac{\partial \chi(t)}{\partial t} - \frac{\phi \psi^J}{r+s} \pi(t) \equiv \chi(t)$$
(20)

with  $\pi(t) \equiv \frac{\partial w^r(w^l, t)}{\partial w^l}$ . This shows that lagged wages only affect the value functions through their impact on wage negotiation. The derivatives  $\pi(t)$  and  $\chi(t)$  are not known at this stage but, using an "assume and verify" approach, they turn out to be independent of  $w^l$ . (19) and (20) then imply that  $J(w; w^l, t)$  is linear in  $w^l$ . Given (19), one can write

$$W(w^{r}(w^{l},t);w^{l},t) - W(\rho(w^{l},t);w^{l},t) = \frac{(1+\alpha_{\rho})\left[w^{r}(w^{l},t) - \rho(w^{l},t)\right]}{r+\phi+s}.$$
 (21)

As the value function (1) is linear in current wages (from the Lemma),  $E_t[J(w; w^l, t)]$  in the value function (2) is equal to  $\alpha J(w^{ru}(t); w^{lu}(t), t) + (1 - \alpha)J(w^a(t); w^{lu}(t), t)$ , where  $w^{ru}(t)$  is the average newly-negotiated wage for workers hired from unemployment,  $w^a(t)$ is the average wage among all employed workers and  $w^{lu}(t)$  is the average lagged wage for those coming from unemployment. Using this and imposing V(t) = 0, (2) gives:

$$\alpha J(w^{ru}(t); w^{lu}(t), t) + (1 - \alpha) J(w^{a}(t); w^{lu}(t), t) = C(t) + \frac{c(t)}{q(t)} = \mu(t),$$
(22)

i.e. the expected value of a newly-filled job equals the total expected cost of filling a

vacancy,  $\mu(t)$ . Using (21) and (22), (18) can be written as:

$$(1-\beta)\frac{w^{r}(w^{l},t)-\rho(w^{l},t)}{r+\phi+s} = \beta \bigg\{ J(w^{r}(w^{l},t);w^{l},t) - \alpha J(w^{ru}(t);w^{lu}(t),t) - (1-\alpha)J(w^{a}(t);w^{lu}(t),t) + \mu(t) \bigg\}.$$
(23)

Using (19) and (20) to evaluate value functions in (23) gives

$$(1-\beta)[w^{r}(w^{l},t) - \rho(w^{l},t)] = \beta \bigg\{ [\alpha w^{ru}(t) + (1-\alpha)w^{a}(t) - w^{r}(w^{l},t)] \\ - \chi(t)(r+\phi+s)[w^{l} - w^{lu}(t)] + (r+\phi+s)\mu(t) \bigg\},$$

which can be rearranged to give the wage equation (8). This proves the Proposition.  $\Box$ 

A result that will be useful later is the relationship between wages and reservation wages in steady state. From equation (8) this can be written as:

$$w^* = \rho^* + \widetilde{\beta}(r + \phi + s)\mu.$$
(24)

## C.2 Proof of Proposition 2: The reservation wage equation

The value of being unemployed for a worker is given by:

$$rU(w^{l},t) = z + \lambda(t)E_{t}[\alpha W(w^{r}(w^{l},t);w^{l},t) + (1-\alpha)W(w^{a}(t);w^{l},t) - U(w^{l},t)] + E_{t}\frac{\partial U(w^{l},t)}{\partial t}.$$
(25)

Using (21) and (25), (6) can be written as:

$$(1 + \alpha_{\rho})\rho(w^{l}, t) - \alpha_{\rho} \left[\alpha_{l}w^{l} + (1 - \alpha_{l})w^{*}\right] + \frac{\phi(1 + \alpha_{\rho})[w^{r}(w^{l}, t) - \rho(w^{l}, t)]}{r + \phi + s} = z + \frac{\lambda(t)(1 + \alpha_{\rho})[\alpha w^{r}(w^{l}, t) + (1 - \alpha)w^{a}(t) - \rho(w^{l}, t)]}{r + \phi + s} + E_{t}\frac{\partial U(w^{l}, t)}{\partial t} - E_{t}\frac{\partial W(\rho(w^{l}, t); w^{l}, t)}{\partial t}.$$
(26)

Equation (6) implies:

$$\frac{\partial U(w^l, t)}{\partial t} = \frac{\partial W(\rho(w^l, t); w^l, t)}{\partial t} + \frac{\partial W(\rho(w^l, t); w^l, t)}{\partial w} \frac{\partial \rho(w^l, t)}{\partial t},$$
(27)

so that (26) becomes:

$$(1 + \alpha_{\rho})\rho(w^{l}, t) - \alpha_{\rho} \left[\alpha_{l}w^{l} + (1 + \alpha_{\rho})w^{*}\right] + \frac{\phi(1 + \alpha_{\rho})[w^{r}(w^{l}, t) - \rho(w^{l}, t)]}{r + \phi + s} = z + \frac{\lambda(t)(1 + \alpha_{\rho})[\alpha w^{r}(w^{l}, t) + (1 - \alpha)w^{a}(t) - \rho(w^{l}, t)]}{r + \phi + s} + \frac{(1 + \alpha_{\rho})}{r + \phi + s}E_{t}\frac{\partial\rho(w^{l}, t)}{\partial t},$$

which can be rearranged to give the differential equation for the reservation wage in (9).

## C.3 The linearity of the reservation and newly-negotiated wages in lagged wages

By taking derivatives of (8) and (9) with respect to  $w^l$ , we obtain, respectively:

$$\pi(t) = (1 - \beta)\gamma(t) - \beta\chi(t)/\psi^J$$
(28)

$$[r + \lambda(t) + s]\gamma(t) = (r + \phi + s)\frac{\alpha_{\rho}}{1 + \alpha_{\rho}}\alpha_{l} + [\alpha\lambda(t) - \phi]\pi(t) + E_{t}\frac{\partial\pi(t)}{\partial t}, \qquad (29)$$

where  $\gamma(t) \equiv \partial \rho(w^l, t) / \partial w^l$ . One can then combine (28) and (29) together with (20) to solve for  $\pi(t)$ ,  $\chi(t)$  and  $\gamma(t)$ .

### C.4 From individual to aggregate relationships

Taking averages of (9) gives the average reservation wage for the unemployed,  $\rho^u(t)$ , and the employed,  $\rho^e(t)$ , respectively:

$$\rho^u(t) = \rho(w^{lu}(t), t); \qquad \rho^e(t) = \rho(w^{le}(t), t)$$

where  $w^{lu}(t)$  and  $w^{le}(t)$  denote their respective average lagged wages and t denotes the time at which the average is taken. Taking averages of (8) gives the average renegotiated wage for the unemployed and the employed, respectively:

$$\begin{split} w^{ru}(t) = &(1-\beta)\rho^{u}(t) + \beta \left\{ (r+\phi+s)\mu(t) + [\alpha w^{ru}(t) + (1-\alpha)w^{a}(t)] \right\} \\ w^{re}(t) = &(1-\beta)\rho^{e}(t) + \beta \left\{ (r+\phi+s)\mu(t) + [\alpha w^{ru}(t) + (1-\alpha)w^{a}(t)] + \chi(t)(r+s+\phi)[w^{lu}(t) - w^{le}(t)] \right\}. \end{split}$$

### C.5 Proof of Proposition 3.

Without reference dependence, the lagged wage does not affect the negotiated wage, nor any of the value functions;  $\chi(t) = 0$  and the wage equation (8) can be written as:

$$w^{r}(t) = (1 - \beta)\rho(t) + \beta \left\{ (r + \phi + s)\mu + [\alpha w^{r}(t) + (1 - \alpha)w(t)] \right\}.$$
 (30)

Taking the linear projection and defining  $\theta_x$  as in (10), (30) can be written as:

$$\theta_{w^r} = (1 - \beta)\theta_\rho + \beta[\alpha\theta_{w^r} + (1 - \alpha)\theta_w], \tag{31}$$

Average wages follow the differential equation:

$$\frac{dw^{a}(t)}{dt} = \frac{\lambda(t)u(t)}{1 - u(t)}\alpha \left[w^{ru}(t) - w^{a}(t)\right] + \phi \left[w^{re}(t) - w^{a}(t)\right],$$
(32)

i.e.  $w^{a}(t)$  changes through wage renegotiation for the employed (at rate  $\phi$ ) and through new hires, some of whom negotiate a new wage (at rate  $\lambda(t)u(t)\alpha$ ). Without reference dependence,  $w^{ru}(t) = w^{re}(t)$ . Hence, linearising (32) around steady-state leads to:

$$\xi_w \theta_w = (\alpha s + \phi)(\theta_{w^r} - \theta_w), \tag{33}$$

where  $\xi_x$  has been defined in equation (11). This can be re-arranged as:

$$\alpha \theta_{w^r} + (1 - \alpha) \theta_w = (1 - \Gamma) \theta_{w^r}, \tag{34}$$

where  $\Gamma = (1 - \alpha)\xi_w/(\alpha s + \phi + \xi_w)$ .

Unemployment follows the differential equation:

$$\frac{du(t)}{dt} = s \left[1 - u(t)\right] - \lambda(t)u(t).$$
(35)

Linearizing and taking the linear projection gives

$$\theta_{\lambda} = -(s + \lambda^* - \xi_u)/u^*. \tag{36}$$

Substituting (34) into (31) gives:

$$\theta_{w^r} = \theta_\rho - \tilde{\beta} \Gamma \theta_{w^r}. \tag{37}$$

Linearizing and taking the linear projection of (9) leads to the following expression for the sensitivity of the reservation wage:

$$(r + \lambda^* + s + \xi_{\rho})\theta_{\rho} = \lambda^* [\alpha \theta_{w^r} + (1 - \alpha)\theta_w] - \phi \theta_{w^r} + \theta_{\lambda}(w^* - \rho^*).$$
(38)

Substituting (34) and (37) into (38) gives:

$$[(r+\lambda^*+s+\xi_{\rho})(1+\widetilde{\beta}\Gamma)-\lambda^*(1-\Gamma)+\phi]\theta_{w^r}=\theta_{\lambda}(w^*-\rho^*).$$
(39)

Converting (36) to an elasticity gives:

$$\varepsilon_{w^r} = -\frac{w^* - \rho^*}{w^*} \frac{\lambda^* + s - \xi_u}{(r + \lambda^* + s + \xi_\rho)(1 + \widetilde{\beta}\Gamma) - \lambda^*(1 - \Gamma) + \phi}.$$
(40)

The next sub-section illustrates the relationship between the endogenous reservation wage,  $\rho^*$ , and the benefits replacement ratio,  $\eta$ , which can be thought of as a policy choice and is used in (12).

### C.6 The relationship between $\rho$ and $\eta$ in steady state

In steady-state, all wages are equal to  $w^*$  and the value of being employed at a wage w (possibly different from  $w^*$ ) is given by:

$$rW(w) = w - s[W(w) - U] + \phi[W(w^*) - W(w)].$$
(41)

The steady-state value of being unemployed is given by:

$$rU = z + \lambda [W(w^*) - U], \qquad (42)$$

where z is the flow utility from being unemployed. The steady-state reservation wage  $\rho^*$  satisfies  $W(\rho^*) = U$ . Using (41) and (42), this can be written as:

$$\rho^* + \phi[W(w^*) - U] = z + \lambda[W(w^*) - U]$$

Rearranging using the comparison of (41) and (42) leads to:.

$$\rho^* = z + (\lambda - \phi)[W(w^*) - U] = z + \frac{\lambda - \phi}{r + \lambda + s}(w^* - z),$$
(43)

From (43) it follows that

$$1 - \frac{\rho^*}{w^*} = (1 - \eta) \frac{r + \phi + s}{r + \lambda^* + s}.$$
(44)

Substituting (44) into (40) gives the elasticity of the negotiated wage in equation (12). Finally, the elasticity of the reservation wage can be expressed as a function of  $\varepsilon_{w^r}$  using (37), which gives equation (15). The next sub-section describes we calibrate the replacement ratio  $\eta$ .

### C.7 Calibration of the replacement ratio $\eta$

We calibrate  $\eta$  from the steady state relationship between wages and reservation wages in (44). In the BHPS, unemployed workers are asked about their reservation wage and their expected wage upon re-employment, and the answers to these questions can be used to estimate  $\rho^*/w^*$ , whose median value is 0.80. As the duration of a wage contract,  $1/\phi$ , is typically longer than the duration of an unemployment spell,  $1/\lambda$ , equation (44) implies  $\eta < 0.80$ . Using UK data ( $\lambda = 0.139$  monthly) and assuming annual renegotiations ( $\phi = 0.083$  on monthly data) gives  $\eta = 0.69$ , in line with the calibrations of Hall and Milgrom (2008); Mas and Pallais (2019); Faberman et al. (2021). This value is somewhat higher than the benefit replacement ratio of 0.60 estimated from the OECD data,<sup>9</sup> For Germany, there is no available information on expected wages during unemployment, thus we calibrate the replacement ratio assuming that it exceeds the unemployment benefit ratio (0.69) by the same amount as in the UK, i.e. 9 percentage points. This is equivalent to assuming that the extra utility of home time during unemployment is the same in both countries, giving  $\eta = 0.75$  in Germany.

### C.8 Analytical results and simulations

We have used a continuous-time formulation in the model above because it leads to simpler notation. However, we need a discrete-time formulation to compare analytical results to those of a simulated model. This is presented in Appendix D, leading to the discrete time versions of our main elasticity results. In the simulated model, the source of shocks is given by productivity fluctuations, which directly impact the job creation condition (64). We assume an autoregressive productivity process with a monthly

<sup>&</sup>lt;sup>9</sup>The OECD Social Policy Database computes the portion of net in-work income that is maintained when a worker becomes unemployed, by household composition and unemployment duration. In 2001, the overall average of this ratio across worker types in the UK and Germany was 0.60 and 0.66, respectively.

persistence parameter of 0.983 and a standard deviation of 0.007 (Gertler and Trigari, 2009; Gertler et al., 2020). We also normalize steady state productivity to 1. We simulate 10,000 months and discard the first 500. Panel A in Figure D1 plots analytical against simulated elasticities for alternative combinations of  $\alpha \in [0.3, 1]$  and  $\phi \in [0.08, 0.2]$ , keeping all other parameters at benchmark values. For the analytical results, as we do not have estimates for  $\xi_w$  and  $\xi_{\rho}$ , we calibrate all persistence parameters (including  $\xi_u$ ) to those predicted by the simulated model. For the simulated results, elasticities are obtained from regressions of log simulated wages and reservation wages on log simulated unemployment. The two methods produce near identical results, with a coefficient of correlation of 0.999. Our closed-form expression can therefore closely replicate results from simulated models based on productivity shocks.

### C.9 The model with reference dependence

This subsection derives results akin to those presented in Proposition 3 for the model with reference dependence. Taking the linear projection of the reservation wage equation (9) gives:

$$[r+\lambda(t)+s]\theta_{\rho} = (r+\phi+s)\frac{\alpha_{\rho}\alpha_{l}}{1+\alpha_{\rho}}\theta_{w^{l}} + \lambda^{*}[\alpha\theta_{w^{r}} + (1-\alpha)\theta_{w}] + \theta_{\lambda}w^{*} - \phi\theta_{w^{r}}.$$
 (45)

Averaging this expression for the unemployed and employed respectively, we obtain:

$$[r + \lambda(t) + s] \theta_{\rho^e} = (r + \phi + s) \frac{\alpha_{\rho} \alpha_l}{1 + \alpha_{\rho}} \theta_{w^{le}} + \lambda^* [\alpha \theta_{w^{re}} + (1 - \alpha) \theta_w] + \theta_{\lambda} w^* - \phi \theta_{w^{re}}$$
(46)

$$[r + \lambda(t) + s] \theta_{\rho^{u}} = (r + \phi + s) \frac{\alpha_{\rho} \alpha_{l}}{1 + \alpha_{\rho}} \theta_{w^{lu}} + \lambda^{*} [\alpha \theta_{w^{ru}} + (1 - \alpha) \theta_{w}] + \theta_{\lambda} w^{*} - \phi \theta_{w^{ru}}$$

$$(47)$$

Similarly for newly-negotiated wages, taking averages of (8) for those coming from unemployment and employment, respectively, gives

$$\theta_{w^{ru}} = (1 - \beta)\theta_{\rho^u} + \beta \left[\alpha \theta_{w^{ru}} + (1 - \alpha)\theta_w\right]$$
(48)

$$\theta_{w^{re}} = (1-\beta)\theta_{\rho^e} + \beta \bigg\{ \left[ \alpha \theta_{w^{ru}} + (1-\alpha)\theta_w \right] + \chi(t)(r+s+\phi) \left[ \theta_{w^{lu}} - \theta_{w^{le}} \right] \bigg\},$$
(49)

where the solution for  $\chi(t)$  follows from (20), (28) and (29).

The next set of equations are related to wage dynamics. Average wages follow the differential equation (32). Linearizing and taking the linear projection this becomes:

$$\xi_w \theta_w = \alpha s(\theta_{w^{ru}} - \theta_w) + \phi(\theta_{w^{re}} - \theta_w).$$
(50)

The lagged wage for the unemployed follows the differential equation:

$$\frac{dw^{lu}(t)}{dt} = \frac{s(1-u(t))}{u(t)}(w_a(t) - w^{lu}(t)),$$
(51)

as it changes only with the inflow of workers from employment, who have average wage  $w_a(t)$ . Linearizing and taking the linear projection, (51) gives:

$$\xi_{lu}\theta_{w^{lu}} = \lambda^*(\theta_w - \theta_{w^{lu}}). \tag{52}$$

The lagged wage for the employed follows the differential equation:

$$\frac{dw^{le}(t)}{dt} = \frac{\lambda(t)u(t)}{1 - u(t)} (w^{lu}(t) - w^{le}(t)),$$
(53)

as it changes only with the inflow of workers from unemployment, who have a lagged wage  $w^{lu}(t)$ . Linearizing and taking the linear projection, (53) gives:

$$\xi_{le}\theta_{w^{le}} = s(\theta_{w^{lu}} - \theta_{w^{lu}}). \tag{54}$$

Finally, there is the linear projection of the expression for unemployment dynamics (36) obtained above:

$$\theta_{\lambda} = -(s + \lambda^* - \xi_u)/u^* \tag{55}$$

Equations (46)-(50), (52), (54), (55), (20), (28) and (29) form a system of 11 equations that can be solved for the unknowns  $\theta = (\theta_w, \theta_{\rho^e}, \theta_{\rho^u}, \theta_{w^{re}}, \theta_{w^{ru}}, \theta_{w^{le}}, \theta_{w^{lu}}, \theta_{\lambda}, \pi(t), \gamma(t), \chi(t))$ , in terms of the model parameters. The elements of the  $\theta$  vector can be converted into elasticities using  $\varepsilon_x = u^* \theta_x / x^*$ .

## D The model in discrete time

This section builds the discrete-time equivalent to the model of Section 3, where all building blocks and notation are defined. The discrete-time model will be used to deliver numerical simulations for wage and reservation wage elasticities, obtained by imposing a stochastic process for labour productivity, to be compared to our analytical solutions. We present the general model with reference dependence, where the special case  $\alpha_{\rho} = 0$ denotes the canonical model.

### D.1 Employers

The value at time t of a job that pays a wage  $w_t$  to worker with lagged wage  $w^l$  is

$$J_t(w_t, w^l) = p_t - w_t + \frac{1}{1+r} \left\{ (1-s) \left[ (1-\phi) E_t J_{t+1}(w_t, w^l) + \phi E_t J_{t+1}(w_{t+1}^r(w^l), w^l) \right] + s E_t V_{t+1} \right\}.$$
 (56)

From (56) two results follow, which will be used in later derivations:

$$\frac{\partial J_t(w_t, w^l)}{\partial w_t} = -\frac{1+r}{(1+r) - (1-s)(1-\phi)} \equiv -\psi^J$$
(57)

$$\frac{\partial J_t(w_t, w^l)}{\partial w^l} = \frac{1-s}{1+r} \left[ (1-\phi) \frac{\partial E_t J_{t+1}(w_t, w^l)}{\partial w^l} + \phi \left( \frac{\partial E_t J_{t+1}(w_{t+1}^r(w^l), w^l)}{\partial w_{t+1}^r} \pi_{t+1} + \frac{\partial E_t J_{t+1}(w_{t+1}^r(w^l), w^l)}{\partial w^l} \right) \right], \quad (58)$$

with  $\pi_t \equiv \partial w_t^r(w^l) / \partial w^l$ . Using (57) and  $\chi_t = -\partial J_t(w_t, w^l) / \partial w^l$ , which turns out to vary with time only, (58) can be rewritten as:

$$\chi_t = \frac{(1-s)\phi\psi^J}{1+r}\pi_{t+1} + \chi_{t+1}\frac{1-s}{1+r}.$$
(59)

The value of a vacant job is given by:

$$V_{t} = -c_{t} + \frac{1}{1+r} \left\{ q_{t} E_{t} [\alpha J_{t+1}(w_{t+1}^{ru}, w_{t+1}^{lu}) + (1-\alpha) J_{t+1}(w_{t}^{a}, w_{t+1}^{lu}) - C_{t}] + (1-q_{t}) E_{t} V_{t+1} \right\}.$$
(60)

Imposing free entry and  $\mu_t = \mu$ , (60) can be re-arranged to give:

$$E_t[\alpha J_{t+1}(w_{t+1}^{ru}, w_{t+1}^{lu}) + (1 - \alpha)J_{t+1}(w_t^a, w_{t+1}^{lu})] = \mu$$
(61)

which, using (57), can be rewritten as:

$$E_t J_{t+1}(w_{t+1}^{ru}, w_{t+1}^{lu}) = \mu - (1 - \alpha)\psi^J(w_{t+1}^{ru} - w_t^a).$$
(62)

Evaluating (56) at the expected newly-negotiated wage and the expected lagged wage for the unemployed  $(J_t(w_t^{ru}, w_t^{lu}))$  and rearranging yields:

$$(1+r)\left[\mu - (1-\alpha)\psi^{J}(w_{t}^{ru} - w_{t-1}^{a})\right] = (1+r)(p_{t} - w_{t}^{ru}) + (1-s)\left\{(1-\phi)\left[J_{t+1}(w_{t}^{ru}(w_{t}^{lu}), w_{t}^{lu}) - J_{t+1}(w_{t+1}^{ru}, w_{t+1}^{lu})\right] + \mu - (1-\alpha)\psi^{J}(w_{t+1}^{ru} - w_{t}^{a})\right\}$$
(63)

Using (57) and (59), (63) leads to yield a job creation curve, relating average negotiated wages for the unemployed,  $w_t^{ru}$  to labour productivity  $p_t$ :

$$(1+r)\left[\mu - (1-\alpha)\psi^{J}(w_{t}^{ru} - w_{t-1}^{a})\right] = (1+r)(p_{t} - w_{t}^{ru}) + (1-s)\left\{(1-\phi)\left[\psi^{J}(w_{t+1}^{ru} - w_{t}^{ru}) + \chi_{t+1}(w_{t+1}^{lu} - w_{t}^{lu})\right] + \mu - (1-\alpha)\psi^{J}(w_{t+1}^{ru} - w_{t}^{a})\right\},$$
(64)

### D.2 Workers

The value at time t of being employed at wage  $w_t$  for a worker with lagged wage  $w^l$  is:

$$W_{t}(w_{t}, w^{l}) = w_{t} + \alpha_{\rho} \left[ w_{t} - (\alpha_{l}w^{l} + (1 - \alpha_{l})w^{*}) \right] + \frac{1}{1 + r} \left\{ sE_{t}U_{t+1}(w^{l}) + (1 - s) \left[ \phi E_{t}W_{t+1}(w^{r}_{t+1}(w^{l}), w^{l}) + (1 - \phi)E_{t}W_{t+1}(w_{t}, w^{l}) \right] \right\},$$
(65)

in turn implying:

$$\frac{\partial W_t(w_t, w^l)}{\partial w_t} = \frac{(1 + \alpha_\rho) (1 + r)}{(1 + r) - (1 - s)(1 - \phi)} = \psi^W \tag{66}$$

### D.3 Reservation wage determination

The value function for unemployment is:

$$U_t(w^l) = z + \frac{1}{1+r} \left\{ (1-\lambda_t) E_t U_{t+1}(w^l) + \lambda_t \left[ \alpha E_t W_{t+1}(w^r_{t+1}(w^l), w^l) + (1-\alpha) E_t W_{t+1}(w^a_t, w^l) \right] \right\}$$
(67)

The reservation wage satisfies  $W_t(\rho_t(w^l), w^l) = U_t(w^l)$ . Hence, combining (65) and (67) gives:

$$(1+r) \left\{ \rho_t(w^l) + \alpha_{\rho} \left[ \rho_t(w^l) - \left( \alpha_l w^l + (1-\alpha_l) w^* \right) \right] \right\} + \psi^W (1-s) \left[ \phi E_t(w^r_{t+1}(w^l) - \rho_{t+1}(w^l)) + (1-\phi) E_t(\rho_t(w^l) - \rho_{t+1}(w^l)) \right]$$
(68)  
=  $(1+r)z + \psi^W \lambda_t \left[ \alpha E_t(w^r_{t+1}(w^l) - \rho_{t+1}(w^l)) + (1-\alpha) E_t(w^a_t - \rho_{t+1}(w^l)) \right] ,$ 

imposing  $U_{t+1}(w^l) = W_{t+1}(\rho_{t+1}(w^l), w^l)$ . Differentiating (68) with respect to  $w^l$  gives:

$$(1+r)[\gamma_t(1+\alpha_{\rho}) - \alpha_l \alpha_{\rho}] + \psi^W(1-s)(\phi E_t(\pi_{t+1} - \gamma_{t+1}) + (1-\phi)E_t(\gamma_t - \gamma_{t+1})) = \psi^W E_t \{\lambda_t [\alpha(\pi_{t+1} - \gamma_{t+1}) - (1-\alpha)(\gamma_{t+1})]\}.$$
(69)

where  $\gamma_t = \partial \rho_t(w^l) / \partial w^l$ . (69) provides a difference equation relating the derivative of the reservation wage with respect to the lagged wage  $\gamma_t$  to the derivative of the negotiated wage with respect to the lagged wage  $\pi_t$ .

### D.4 Wage determination

The Nash bargaining solution can be written as:

$$(1-\beta)\frac{\partial J_t(w^r(w^l), w^l)}{\partial w^r} [W_t(w^r(w^l); w^l) - W_t(\rho(w^l), w^l)] + \beta \frac{\partial W_t(w^r(w^l), w^l)}{\partial w^r} J_t(w^r(w^l), w^l) = 0.$$
(70)

Using (66) one can write:

$$W_t(w^r(w^l), w^l) - W_t(\rho(w^l), w^l) = \psi^W[w^r(w^l) - \rho(w^l)].$$
(71)

Using (71) in (70), adding and subtracting  $\beta \psi^W J_t(w_t^{ru}, w_t^{lu})$  on the right hand side and using (62) yields:

$$(1-\beta)\psi^{J}(w_{t}^{r}(w^{l})-\rho_{t}(w^{l})) = \beta \left\{ J_{t}(w_{t}^{r}(w^{l}),w^{l}) - J_{t}(w_{t}^{ru},w_{t}^{lu}) + \mu - (1-\alpha)\psi^{J}(w_{t}^{ru}-w_{t-1}^{a}) \right\}$$
(72)

Finally, substituting (57) and (59) into (72) and rearranging gives:

$$(1-\beta)(w_t^r(w^l) - \rho_t(w^l)) = \beta \left\{ \alpha w_t^{ru} + (1-\alpha)w_{t-1}^a - w_t^r(w^l) - \chi_t/\psi^J(w^l - w_t^{lu}) + \mu/\psi^J \right\}$$
(73)

The derivative of (73) with respect to  $w^l$  gives:

$$(1-\beta)(\pi_t - \gamma_t) = -\beta \left(\pi_t + \frac{\chi_t}{\psi^J}\right).$$
(74)

Together, (69) and (74) solve for  $\pi_t$  and  $\gamma_t$  in terms of model parameters. Neither depends on wage levels confirming the assumption that  $w_t^r$  and  $\rho_t$  are linear in  $w^l$ . Using (59), these derivatives simplify in steady state to:

$$\gamma = \pi \Theta$$
(75)
$$= (O(1 + c_{1})(1 + m) + c_{1}W(1 - c_{2}) + c_{1}W)^{*}(O - c_{2})) - (1 + m)c_{2}c_{2}$$
(76)

$$\pi \left( \Theta(1+\alpha_{\rho})(1+r) + \psi^{W}(1-s)\phi(1-\Theta) + \psi^{W}\lambda^{*}(\Theta-\alpha) \right) = (1+r)\alpha_{l}\alpha_{\rho}$$
(76)

with  $\Theta = \frac{r+s+\beta(1-s)\phi}{(r+s)(1-\beta)}$ .

### D.5 Aggregate relationships

Taking averages of (73) for those previously unemployed and employed, respectively gives:

$$w_t^{ru} = (1 - \beta)\rho_t^u + \beta \left\{ w_t^{ru} + \mu/\psi^J - (1 - \alpha)(w_t^{ru} - w_{t-1}^a) \right\},$$
(77)

$$w_t^{re} = (1 - \beta)\rho_t^e + \beta \left\{ w_t^{ru} + \mu/\psi^J - (1 - \alpha)(w_t^{ru} - w_{t-1}^a) - \chi_t/\psi^J(w_t^{le} - w_t^{lu}) \right\}.$$
 (78)

Similarly, evaluating  $w^l$  for the employed and unemployed in (68), respectively, gives:

$$(1+r) \left\{ \rho_t^u + \alpha_\rho \left[ \rho_t^u - (\alpha_l w^{lu} + (1-\alpha_l) w^*) \right] \right\} + \psi^W (1-s) \left[ \phi E_t (w_{t+1}^{ru} - \rho_{t+1}^u) + (1-\phi) (\rho_t^u - \rho_{t+1}^u) \right] \\ = (1+r)z + \psi^W E_t \left\{ \lambda_t \left[ \alpha (w_{t+1}^{ru} - \rho_{t+1}^u) + (1-\alpha) (w_t^a - \rho_{t+1}^u) \right] \right\},$$
(79)  
$$(1+r) \left\{ \rho_t^e + \alpha_\rho \left[ \rho_t^e - (\alpha_l w^{le} + (1-\alpha_l) w^*) \right] \right\} + \psi^W (1-s) \left[ \phi E_t (w_{t+1}^{re} - \rho_{t+1}^e) + (1-\phi) (\rho_t^e - \rho_{t+1}^e) \right] \\ = (1+r)z + \psi^W E_t \left\{ \lambda_t \left[ \alpha (w_{t+1}^{re} - \rho_{t+1}^e) + (1-\alpha) (w_t^a - \rho_{t+1}^e) \right] \right\}.$$
(80)

Average lagged wage for the unemployed and the employed, are given by the following dynamic equations, respectively:

$$w_t^{lu} = \frac{(1 - \lambda_{t-1})u_{t-1}w_{t-1}^{lu} + s(1 - u_{t-1})w_{t-1}^a}{(1 - \lambda_{t-1})u_{t-1} + s(1 - u_{t-1})}$$
(81)

$$w_t^{le} = \frac{\lambda_{t-1}u_{t-1}w_{t-1}^{lu} + (1-s)(1-u_{t-1})w_{t-1}^{le}}{\lambda_{t-1}u_{t-1} + (1-s)(1-u_{t-1})}.$$
(82)

Finally, the average wage is given by:

$$w_t^a = \frac{(1-s)(1-u_{t-1})\left[\phi w_t^{re} + (1-\phi)w_{t-1}^a\right] + \lambda_{t-1}u_{t-1}\left[\alpha w_t^{ru} + (1-\alpha)w_{t-1}^a\right]}{\lambda_{t-1}u_{t-1} + (1-s)(1-u_{t-1})}.$$
 (83)

### D.6 Elasticities

The wage setting process is captured by ten equations: the two Nash bargaining solutions (77), (78); two reservation wage equations ((68) evaluated at  $w^{le}$  and  $w^{lu}$  respectively); the three laws of motion for average wages (lagged and current) (81), (82), (83) and the derivatives (74) and (69). These can be jointly solved for the nine endogenous variables regarding wages:  $w_t^a$ ,  $w_t^{re}$ ,  $w_t^{ru}$ ,  $w_t^{le}$ ,  $w_t^{lu}$ ,  $\rho_t^e$ ,  $\rho_t^u$ ,  $\pi_t$ ,  $\gamma_t$ , conditional on market tightness  $\lambda_t$ . The model is closed by the job creation curve (64), expressing  $\lambda_t$  as a function of the exogenous productivity process  $p_t$ .

To study how the system responds to shocks, we use the linear projection definition for a hypothetical variable x on the unemployment rate (as in Section 4.1):

$$E(x_t - x^* | u_t - u^*) = \theta_x(u_t - u^*)$$
  

$$E(x_{t+1} - x_t | u_t - u^*) = \xi_x E(x_t - x^* | u_t - u^*) = \xi_x \theta_x(u_t - u^*).$$

Starting with negotiated wages, we take linear projections of (77) and (78) to obtain, respectively:

$$(1 - \alpha\beta)\theta_{w^{ru}} = (1 - \beta)\theta_{\rho^u} + \beta(1 - \alpha)(1 - \xi_a)\theta_w, \tag{84}$$

$$\theta_{w^{re}} = (1-\beta)\theta_{\rho^e} + \beta \left[ (1-\alpha)(1-\xi_w)\theta_w + \alpha\theta_{w^{ru}} - \frac{\chi^*}{\psi^J}(\theta_{w^{le}} - \theta_{w^{lu}}) \right].$$
(85)

Equations (68) and (81)-(83) are nonlinear because they involve the product between various wage concepts and  $\lambda_t$ . We linearise around steady state and then apply the linear projection. Define  $R_x \equiv \frac{\partial f(x)}{\partial x}|_{ss}$  as the derivative of a function f(x) evaluated at the steady state value of  $x, x^*$ . Starting with (79), and using (66) and (24), we obtain:

$$\theta_{\rho^u} R_{\rho^u} = \tilde{\beta} \mu \theta_\lambda + (1 + \xi_{w^{ru}}) R_{w^r} \theta_{w^{ru}} + R_w \theta_w + \theta_{w^l} R_{w^{lu}}, \tag{86}$$

where  $R_w = \psi^W \lambda^* (1 - \alpha), \ R_{w^r} = \psi^W \lambda^* \alpha - (1 - s) \phi \psi, \ R_{w^l} = (1 + r)(\alpha_l \alpha_\rho)$  and  $R_{\rho^u} = \psi^W [(1 + r) + [\lambda^* - (1 - s)](1 + \xi_{\rho^u})]$ . Similarly for (80):

$$\theta_{\rho^e} R_{\rho^e} = \tilde{\beta} \mu \theta_{\lambda} + (1 + \xi_{w^{re}}) R_{w^r} \theta_{w^{re}} + R_w \theta_w + \theta_{w^l} R_{w^{le}}, \tag{87}$$

where  $R_{\rho^e} = \psi^W[(1+r) + [\lambda^* - (1-s)](1+\xi_{\rho^e})]\}$ . Linearising (83) gives:

$$w_{t} = f_{w^{ru}}(w_{t}^{ru} - w^{*}) + f_{w^{re}}(w_{t}^{re} - w^{*}) + f_{u}(u_{t-1} - u^{*}) + f_{\lambda}(\lambda_{t-1} - \lambda^{*}) + f_{w}(w_{t-1}^{a} - w^{*}),$$
(88)

where  $f_x \equiv \frac{\partial w}{\partial x}|_{ss}$ , with  $f_u = f_\lambda = 0$ ,  $f_{w^{ru}} = \alpha s$ ,  $f_{w^{re}} = (1-s)\phi$  and  $f_w = (1-\alpha)s + (1-s)(1-\phi)$ . Taking the linear projection of (88) and (81) gives:

$$\theta_w (1 + \xi_w - f_w) = \theta_{w^{ru}} (1 + \xi_{ru}) f_{w^{ru}} + \theta_{w^{re}} (1 + \xi_{re}) f_{w^{re}}.$$

$$\theta_{w^{lu}} (1 + \xi_{lu}) = \frac{(1 - \lambda^*) u^* \theta_{w^{lu}} + s(1 - u^*) \theta_w}{(1 - \lambda^*) u^* + s(1 - u^*)}.$$
(89)

Imposing the steady state condition  $s(1 - u^*) = \lambda^* u^*$  and re-arranging gives:

$$\theta_{w^{lu}} = \frac{\lambda^* \theta_w}{\xi_{lu} + \lambda^*}.$$
(90)

Finally, repeating the same steps for (82) gives:

$$\theta_{w^{le}} = \frac{s\theta_{w^{lu}}}{\xi_{le} + s}.$$
(91)

The elasticity of lagged wages for the unemployed and the employed follow from (90) and (91), respectively:

$$\varepsilon_{lu}(\xi_{lu} + \lambda^*) = \lambda^* \varepsilon_w \tag{92}$$

$$\varepsilon_{le} = \frac{s}{\xi_{le} + s} \varepsilon_{lu} \tag{93}$$

and the elasticity of the average wage follows from (89):

$$\varepsilon_w(1+\xi_w-f_w) = \varepsilon_{ru}(1+\xi_{ru})f_{w^{ru}} + \varepsilon_{re}(1+\xi_{re})f_{w^{re}}.$$
(94)

The elasticities of renegotiated wages for the unemployed and the employed follow from (73) and (85) respectively:

$$(1 - \alpha\beta)\varepsilon_{ru} = (1 - \beta)\varepsilon_{\rho^{u}}\frac{\rho^{*}}{w^{*}} + \beta(1 - \alpha)(1 - \xi_{a})\varepsilon_{w}$$
(95)

$$\varepsilon_{re} = (1 - \beta)\varepsilon_{\rho^e} \frac{\rho^*}{w^*} + \beta \left[ (1 - \alpha)(1 - \xi_w)\varepsilon_w + \alpha\varepsilon_{ru} - \frac{\chi^*}{\psi^J}(\varepsilon_{le} - \varepsilon_{lu}) \right].$$
(96)

Finally, the elasticities of the reservation wage for the unemployed and the employed follow from (79) and (80), respectively, also using  $\theta_{\lambda} = -(s + \lambda_{ss} - \xi_u)/u_{ss}$ :

$$\varepsilon_{\rho^{e}}R_{\rho^{e}}\frac{\rho^{*}}{w^{*}} = -(1-\eta)\frac{1+r}{ru^{*}+s}(s-\xi_{u}u^{*}) + (1+\xi_{w^{re}})R_{w^{r}}\varepsilon_{w^{re}} + R_{w}\varepsilon_{w} + R_{w^{l}}\varepsilon_{w^{le}}$$
(97)

$$\varepsilon_{\rho^{u}}R_{\rho^{u}}\frac{\rho^{*}}{w^{*}} = -(1-\eta)\frac{1+r}{ru^{*}+s}(s-\xi_{u}u^{*}) + (1+\xi_{w^{ru}})R_{w^{r}}\varepsilon_{w^{ru}} + R_{w}\varepsilon_{w} + R_{w^{l}}\varepsilon_{w^{lu}}$$
(98)

We next solve for the elasticities of the seven wage variables by combining (92)-(98).

### D.7 Analytical results vs. simulations

Similarly as for the canonical model, we compare analytical results and numerical simulations for elasticities, which are plotted in Panel B of Figure D1 for alternative combinations of  $\alpha \in [0.3, 1]$ ,  $\phi \in [0.08, 0.2]$ ,  $\frac{\alpha_{\rho}}{1+\alpha_{\rho}} \in [0, 0.7]$  and  $\alpha_l \in [0.3, 1]$ . The plot shows that analytical results closely track the simulated results, with a correlation of 0.993.



Notes. Panel A plots simulated against analytical elasticity results for the forward-looking model, for 72 parameter combinations of  $\alpha \in [0.3, 1]$ and  $\phi \in [0.06, 0.16]$ . Panel B plots corresponding results for the model with reference dependence, for 4608 parameter combinations of  $\alpha \in [0.3, 1]$ ,  $\phi \in [0.06, 0.16]$ ,  $\frac{\alpha_{\rho}}{1+\alpha_{\rho}} \in [0, 0.7]$ ,  $\alpha_l \in [0.3, 1]$ . The correlation coefficient between simulated and analytical results is 0.999 in Panel A and 0.993 in Panel B.

## E Estimates of reference dependence in reservation wages

The observed relationship between reservation wages and pre-unemployment wages is informative of backward-looking reference dependence, but may be subject to biases. For example, a direct link between unemployment benefits and past wages (as in Germany), will give a role for lagged wages in determining reservation wages. But in the UK benefits only vary (coarsely) with family composition, and are not directly linked to previous wages. We thus restrict the analysis that follows to the UK.

A second possible source of bias comes from unobserved productivity components of past wages, which are reflected in reservation wages in the canonical model via their effect on the wage offer distribution. Our approach consists in isolating the component of past wages that can be reasonably interpreted as rents – as opposed to productivity – and observe its correlation with reservation wages. A rational worker would not use past rents in forming their current reservation wage (absent wealth effects, which we find to be unimportant in our sample), whereas a worker who uses past wages as a reference point might do so. Consider a simple empirical model for the reservation wage:

$$\ln \rho_t = \beta_1 X_t + \beta_2 w^* + \beta_3 R_{t-d} + \varepsilon_t,$$

where  $X_t$  denotes observable characteristics,  $w^*$  denotes worker ability, and  $R_{t-d}$  denotes rents in the last job observed, d periods earlier. The coefficient of interest is  $\beta_3$ . Assume the following model for the last observed wage:

$$\ln w_{t-d} = \gamma_1 X_{t-d} + w^* + R_{t-d} + u_{t-d}.$$

If one regresses the reservation wage on the last observed wage as in:

$$\ln \rho_t = \delta_1 X_t + \delta_2 \ln w_{t-d} + \varepsilon_t, \tag{99}$$

the OLS estimate for  $\delta_2$  would capture the effect of both unobserved heterogeneity and rents on the reservation wage. Identification of the effect of interest requires an instrument that represents a component of past rents, while being orthogonal to worker ability.

We use wage differentials associated with industry affiliation as a proxy for the size of rents, in line with a long-established literature concluding that part of inter-industry wage structure reflects rents (see Krueger and Summers 1988; Gibbons and Katz 1992 for classic references and Benito 2000; Carruth et al. 2004 for UK evidence). Specifically, we instrument previous wages using the predicted, inter-industry wage differential obtained on administrative data from the Annual Survey of Hours and Earnings (ASHE). We estimate a log wage equation for 1982-2009 on ASHE, controlling for 4-digit industry effects, unrestricted age effects, region, and individual fixed effects. These capture the component of inter-industry wage differentials that is uncorrelated to individual unobservables, which is important for our exclusion restriction. We match the estimated industry effects to individual records in the BHPS, and use them as an instrument for last observed wages in reservation wage regressions. Having controlled for unobserved heterogeneity in the construction of our instrument, the exclusion restriction would still be violated if rents in previous jobs would contribute to savings, in turn affecting utility during unemployment. This does not seem to be a major issue in our working sample, in which more than three quarters of unemployed workers have no capital income, and another 11% have capital income below 100GBP per year. But we control for wealth effects, if any, by including indicators for household assets and housing tenure in the estimated reservation wage equations.

Table E1 reports IV estimates of the reservation wage equation (99). The sample is smaller than the original sample of Table 2, as for about 45% of the reservation wage sample no previous jobs are recorded. The coefficient on the wage in the last job is positive and significant, and robust to the inclusion of individual fixed-effects (in which case the coefficient of interest is identified by the sample of individuals with multiple unemployment spells originating from different 4-digit industries). The stability of the coefficient across the two specifications implies that the estimated impact of past wages is not substantially confounded by unobserved ability, as one would expect when past wages are instrumented by their rent components.

Estimation method	1 IV	2 IV
Last observed log wage	0.133 (0.018)	0.149 (0.063)
Individual fixed effects		$\checkmark$
Observations	7,732	5,520
First stage, $F$ -test <sup>(a)</sup>	908.9	908.9

 Table E1: Reservation Wages and Rents in Previous Jobs

Notes. Regressions also control for log unemployment rate, a quadratic time trend, a gender dummy, age and its square, three education dummies, a cubic trend in the number of years since the last job was observed, a dummy for married, the number of children in the household, the log of unemployment benefits, three dummies for levels of capital income, three dummies for housing tenure and eleven region dummies. The instruments used for last observed wage is the predicted industry wage (4-digit) in the previous job. (a) denotes Sanderson and Windmeijer (2016) first-stage F-statistic. Standard errors are clustered at the year level. Source: BHPS, 1991-2009.