Reservation wages and the wage flexibility puzzle

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Abstract

Wages are only mildly cyclical, implying that shocks to labour demand have a large short-run impact on unemployment, at odds with the quantitative predictions of the canonical search model. We emphasize the role of reservation wages in wage cyclicality and argue that reference-dependence in reservation wages can reconcile model predictions and empirical evidence on the cyclicality of both wages and reservation wages. We provide evidence that reservation wages significantly respond to backward-looking reference points, as proxied by rents earned in previous jobs. We also argue that other proposed solutions to the unemployment volatility and wage flexibility puzzle that hinge on alterations to the wage setting mechanism only work for parameter values outside the range typically estimated.

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

The currently dominant model of equilibrium unemployment – the search and matching framework developed by Diamond, Mortensen and Pissarides (see, Pissarides, 2000, for an overview) – offers very valuable insights into labour market dynamics. However, the canonical version of the DMP model struggles to quantitatively match the relatively large unemployment fluctuations and mild cyclicality of wages. This point was highlighted by Shimer (2005), who noted that the canonical model is unable to deliver the observed unemployment volatility in response to productivity shocks of plausible magnitudes. A rich strand of work has addressed the ensuing "Shimer" or "unemployment volatility puzzle" by emphasizing the role of wage rigidity in accounting for the volatility of unemployment and job vacancies. As noted by Hall and Milgrom (2008, p1657), in a large class of models with job search frictions "wage stickiness is the sole determinant of unemployment volatility". Thus unemployment volatility and wage stickiness are two sides of the same coin, and the Shimer puzzle can be rephrased as "why are wages sticky?", which we refer to as the "wage flexibility puzzle".[1]

Empirical evidence indeed suggests that real wages are only mildly procyclical. Extensive work by Blanchflower and Oswald (1994) suggests that the elasticity of wages with respect to the unemployment rate is -0.1, and most existing estimates are not very far from this benchmark (see Card, 1995, for a review of related work, and Nijkamp and Poot, 2005, for a meta-analysis). The modest procyclicality of wages implies that shocks to labour demand have a much larger short-run impact on unemployment rather than wages.

This paper offers an alternative perspective on the Shimer and wage flexibility puzzles and proposes a novel solution – namely we explicitly consider the role of reservation wages and modify the canonical model by introducing backward-looking reference-dependence in their determination. Reference-dependent preferences have often featured in economic behaviour in general and labour supply modelling in particular (Farber, 2008, and Della Vigna 2009), with the aim of explaining observed deviations from the standard neoclassical model of individual decision making. In several contexts, reference points are determined by both past personal experiences and peer influences (Akerlof and Yellen, 1990; Blanchard and Katz, 1999).

In the canonical model, reservation wages are forward-looking, determined by current and future labour market conditions. Introducing reference dependence in job search, shaped

[1] Appendix A provides a more formal analysis of the link between unemployment volatility and wage stickiness for the model we use in this paper.

for instance by one's previous employment history, generates less cyclical reservation wages than the canonical model if reference points are less cyclical than current labour market conditions. If a worker who lost her job at the start of a recession forms future wage aspirations based on her pre-recession earnings, she would set her reservation wage above the level implied by neoclassical – purely forward-looking – preferences. As a consequence, reservation wages may not fall in a recession as much as the canonical model predicts.[2] Related to this point, Falk et al. (2006) show that past minimum wages that are no longer in effect shape reservation wages, making them less cyclical than in the standard search model, and Della Vigna et al. (2017) show that a search model with reference points represented by recent income does a better job than conventional models at explaining the pattern of unemployment exits around the time of benefit exhaustion.

A number of papers in the related literature have addressed the unemployment volatility puzzle by proposing alterations to wage determination in the canonical model, and our framework encompasses most of them. In particular, our model allows for weakly cyclical hiring costs (Pissarides, 2009), infrequent wage negotiations in ongoing job matches (Pissarides, 2009; Rudanko, 2009; Haefke, Sonntag and van Rens, 2013; Kudlyak, 2014), and backward-looking elements in wage negotiations in new matches (Gertler, Sala and Trigari, 2008, and Gertler and Trigari, 2009, introduce both innovations to wage negotiations)[3]. Using these model elements, we derive a relationship between wages and unemployment (the "wage curve") that under plausible assumptions is not shifted by labour demand shocks. Demand shocks, independent of their source or magnitude, are associated with movements along the wage curve, and its slope determines the relative volatility of wages and unemployment over the business cycle. Our approach has a natural analogy in a perfectly competitive labour market model, in which the labour supply curve is not shifted by labour demand shocks. We argue that the wage curve is a useful modelling tool for assessing the relative merit of different theories in explaining the wage flexibility puzzle.

We show that, absent reference dependence, infrequent negotiations, and backward-looking elements in wage setting, the canonical model can only replicate the modest observed cyclicality of wages if replacement ratios are extremely high (see also Hagedorn and Manovskii, 2008). If we allow for infrequent renegotiation of wages, implying higher wage cyclicality on new, rather than continuing, matches, and introduce a backward-looking

[2] See Genesove and Mayer (2001) for a similar application to the housing market.
[3] See also Shimer (2010) and Rogerson and Shimer (2011) for overviews.

component in newly-negotiated wages, the model can only address the wage flexibility puzzle if unemployment persistence is implausibly low or the duration of wage contracts is implausibly long.

In addition, none of these ingredients within the canonical model are able to match the observed cyclicality of reservation wages, which this paper estimates using British and German data and finds to be very similar to the cyclicality in wages. The intuition is that, even if wages are completely acyclical (which might happen for a variety of reasons, see e.g. Shimer, 2004; Hall, 2005; Hall and Milgrom, 2008; Michaillat, 2012), the reservation wage still exhibits a considerable amount of cyclicality because workers would be prepared to accept lower wages in a recession, when job opportunities are scarce, independent of the cyclicality of offered wage. Conversely, we show that introducing reference dependence in the determination of reservation wages can explain the low observed cyclicality in both wages and reservation wages for plausible values of the replacement ratio, the persistence in unemployment, and the length of labour contracts.

By shifting the focus of the wage flexibility puzzle onto reservation wages, this paper also makes a contribution to the empirical analysis of reservation wages. In recent years, rich longitudinal data on job search behaviour in the US, analysed by Krueger and Mueller (2011, 2012, 2016) and Mueller, (2015), have greatly added to knowledge on reservation wage determination, but they cover too short a time span to investigate their cyclicality. Le Barbanchon, Rathelot and Roulet (2016) use French administrative data on reservation wages to estimate their sensitivity to potential benefit duration. Our paper adds to the empirics of reservation wages by exploring their cyclical properties. We provide estimates of the cyclicality of wages and reservation wages for the UK and West Germany using micro data from the British Household Panel Survey (BHPS) and the German Socio Economic Panel (SOEP), respectively. These are the only two known sources of (publicly available) information on reservation wages, which cover at least one full business cycle. Our baseline estimates for the elasticity of wages and reservation wages to aggregate unemployment are about -0.17 and -0.15, respectively, for the UK, but markedly lower and only borderline significant for West Germany. All estimated elasticities are considerably lower than those predicted by the theoretical model without reference dependence.

The paper is organized as follows. Section 2 lays out a job search model with infrequent wage negotiations and a backward-looking component in wage setting, allowing for reference-dependent reservation wages. Section 3 derives theoretical predictions for the cyclicality of newly-negotiated wages, wages in new jobs, average wages and reservation wages, illustrating cyclicality predictions of various models for plausible parameters values. Section 4 estimates wage and reservation wage curves for the U.K. and West Germany. Section 5 identifies reference dependence in reservation wages and proposes a quantitative solution to the wage flexibility puzzle. Section 6 concludes.

2. The model

This section lays out a search and matching model to derive implications for the cyclicality of wages. Our set-up encompasses elements of wage rigidity proposed by previous work on the Shimer puzzle, namely acyclical hiring costs (Pissarides, 2009), infrequent wage negotiations in ongoing matches, and backward-looking elements in wage setting for new hires (Gertler, Sala and Trigari, 2008; Gertler and Trigari, 2009; Pissarides, 2009; Rudanko, 2009; Haefke, Sonntag and van Rens, 2013; Kudlyak, 2014). In addition, we emphasize the role of reservation wages in wage cyclicality, and allow for reference dependence in their determination. In the interest of simplicity we assume away heterogeneity in workers or jobs. A special case of this model is the classical DMP framework with continuous and forward-looking wage negotiation and without reference-dependence in reservation wages.

A. *Employers*

Each firm has one job, which can be either filled and producing or vacant and searching. Denote by $J(t;w)$ the value of a filled job that currently pays a wage w. Wages are occasionally renegotiated, and renegotiation opportunities are assumed to arrive at an exogenous rate ϕ,[4] leading to a staggered wage setting process à la Calvo (1983). The parameter ϕ captures the extent to which wages on new and continuing jobs may differ. If the wage in an existing match is renegotiated, neither party has the option to continue the match at the previous wage, which has thus no influence on the outcome of the wage bargain, and any renegotiation results in a new wage $w_r(t)$. Using this, the value of a filled job that pays a wage w at time t is given by:

[4] We assume renegotiation opportunities arrive exogenously, 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 induce an extra source of cyclicality as it implies more frequent renegotiation in recessions.

$$rJ(t;w) = p(t) - w - s\left[J(t;w) - V(t)\right] + \phi\left[J(t;w_r(t)) - J(t;w)\right] + E_t \frac{\partial J(t;w)}{\partial t}, \qquad (1)$$

where $V(t)$ is the value of a vacant job at time t, $p(t)$ denotes the productivity of a job-worker pair, and is the ultimate source of shocks, and s is the constant rate at which jobs are destroyed[5]. The second term in square brackets represents the change in job value resulting from renegotiation.

The value of a vacant job at time t, $V(t)$, is given by:

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

Following Pissarides (2009) and Silva and Toledo (2009), we allow the cost of a vacancy to include both a per-period cost, $c(t)$, and a fixed cost, $C(t)$, paid upon hiring. The related literature sometimes indexes vacancy costs to productivity shocks or wages (e.g. Pissarides, 2000), and we return to this issue later. For the moment we simply allow both components of vacancy costs to be time-varying, and assume that they are exogenous to the individual firm. Finally, $q(t)$ is the rate at which vacancies are filled. This rate varies over time via the impact of shocks on labour market tightness.

The first expectation term in (2) captures uncertainty about wages in future matches. When a firm and a worker match, we assume that they negotiate a wage with probability α, while with probability $1-\alpha$ a pre-existing ("old") wage is paid, randomly drawn from the existing cross-section of wages[6]. The extent of job creation at old wages (represented by $1-\alpha$) is the source of the backward-looking component in wage setting. As the value function (1) is linear in wages, the first expectation term in (2) can be replaced by averages:

$$rV(t) = -c(t) + q(t)\left[\alpha J(t;w_r(t)) + (1-\alpha)J(t;w_a(t)) - V(t) - C(t)\right] + E_t \frac{\partial V(t)}{\partial t}, \qquad (3)$$

where $w_r(t)$ denotes a newly-negotiated wage and $w_a(t)$ denotes the average wage in the existing distribution. Free entry of vacancies ensures $V(t) = 0$, so (3) can be rearranged to give:

$$\alpha J(t;w_r(t)) + (1-\alpha)J(t;w_a(t)) = C(t) + \frac{c(t)}{q(t)}, \qquad (4)$$

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[5] We will consider later a simple extension with countercyclical job separations.

[6] We assume throughout that old wages generate some surplus to both parties. This is the case whenever there is sufficient surplus-sharing in steady-state and deviations from steady-state are small enough.

i.e. the expected value of a newly-filled job equals the expected cost of filling a vacancy. Expression (1) implies $\partial J(t;w)/\partial w = 1/(r+\phi+s)$, so (4) can be rewritten as:

$$J(t;w_r(t)) = C(t) + \frac{c(t)}{q(t)} - \frac{(1-\alpha)(w_a(t)-w_r(t))}{r+\phi+s}. \tag{5}$$

B. *Workers*

Workers can be either unemployed and searching or employed and producing. The value of being employed at a wage w at time t is denoted by $W(t;w)$ and given by:

$$rW(t;w) = w + \phi\left[W(t;w_r(t)) - W(t;w)\right] - s\left[W(t;w) - U(t)\right] + E_t\frac{\partial W(t;w)}{\partial t},. \tag{6}$$

where $U(t)$ is the value of being unemployed at time t. As (r,ϕ,s) are constant over time, expression (6) shows that $W(t;w)$ can be written as the sum of two terms, $W(t;w) = W_1(t) + W_2(w)$, where the first term is a function of time and the second is a function of the wage. This implies that the difference between the value of working in a job paying $\tilde{w}$ and the value of working in a job paying w can be written as:

$$W(t;\tilde{w}) = W(t;w) + \frac{\tilde{w}-w}{r+\phi+s}. \tag{7}$$

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

$$rU(t) = z + \lambda(t)\left[\alpha W(t;w_r(t)) + (1-\alpha)W(t;w_a(t)) - U(t)\right] + E_t\frac{\partial U(t)}{\partial t}, \tag{8}$$

where z is the flow utility when unemployed, assumed to be fixed in the short-run[7], and $\lambda(t)$ is the rate at which the unemployed find jobs, which varies over time with labour market tightness. In (8) we have again exploited the linearity of value functions in wages to replace wage expectations with their average.

C. *Wage determination.*

[7] Chodorow-Reich and Karabarbounis (2016) argue that z is pro-cyclical. Allowing for procyclical z would make wages more pro-cyclical in this model, making it even harder for other elements of the model to solve the wage flexibility puzzle.

We introduce a reservation wage $\rho(t)$, below which workers are not willing to work, and they evaluate each job opportunity based on the surplus they enjoy relative to the value of a job paying the reservation wage.

We assume Nash bargaining, thus the wage negotiated at time t, $w_r(t)$, is set to maximize the Nash maximand:

$$\left[W(t;w)-W(t;\rho(t))\right]^{\beta}\left[J(t;w)-V(t)\right]^{1-\beta}, \tag{9}$$

where β denotes workers' relative bargaining power. This implies

$$(1-\beta)\frac{\partial J(t;w)}{\partial w}\left[W(t;w_r(t))-W(t;\rho(t))\right]+\beta\frac{\partial W(t;w)}{\partial w}\left[J(t;w_r(t))-V(t)\right]=0. \tag{10}$$

Value functions (1) and (6) imply $\partial W(t;w)/\partial w=-\partial J(t;w)/\partial w$, so that (10) can be rewritten, using (4), as:

$$W(t;w_r(t))=W(t;\rho(t))+\tilde{\beta}\left[\mu(t)-\frac{(1-\alpha)(w_a(t)-w_r(t))}{r+\phi+s}\right], \tag{11}$$

where $\tilde{\beta}\equiv\beta/(1-\beta)$, and $\mu(t)\equiv c(t)/q(t)+C(t)$ represents the amortized hiring cost. According to (11), both $\tilde{\beta}$ and $\mu(t)$ influence the mark-up of wages over the reservation wage. The extra term in $(w_a(t)-w_r(t))$ derives from ex-ante uncertainty about the wage to be paid in a new job, whether it will be drawn from the existing cross-section of wages or newly-negotiated. A higher average wage reduces the value of creating a new job, and, hence, must be offset by lower negotiated wages in equilibrium. Combining (11) with (7) evaluated at $w_r(t)$ implies that newly-negotiated wages are given by:

$$w_r(t)=\rho(t)+\tilde{\beta}(r+\phi+s)\mu(t)-\tilde{\beta}(1-\alpha)\left[w_a(t)-w_r(t)\right], \tag{12}$$

i.e. the currently negotiated wage is given by the reservation wage plus a term that reflects the size of hiring costs, the bargaining power of workers and the uncertainty about wages to be paid in new jobs.

D. *The reservation wage*

The wage equation in (12) is conditional on the reservation wage, which is itself endogenous. We consider alternative models for the determination of the reservation wage.

First, we consider purely forward-looking behaviour, as implicit in the canonical model. In this case the reservation wage is the wage that makes a worker indifferent between a job at that wage and being unemployed. We will call this the optimal reservation wage and denote it by $\rho^o(t)$ which is the solution to $W(t;\rho^o(t)) = U(t)$. Evaluating (8) and (6) at $\rho^o(t)$, yields, after some rearrangement:

$$\begin{aligned} 0 = \rho^o(t) - z + (\phi - \lambda(t))\left[W(t;w_r(t)) - W(t;\rho^o(t))\right] \\ - \lambda(t)(1-\alpha)\left[W(t;w_a(t)) - W(t;w_r(t))\right] + E_t\left[\frac{\partial W(t;\rho^o(t))}{\partial t} - \frac{\partial U(t)}{\partial t}\right] \end{aligned} \quad (13)$$

$W(t;\rho^o(t)) = U(t)$ further implies:

$$\frac{\partial U(t)}{\partial t} = \frac{dW(t;\rho^o(t))}{dt} = \frac{\partial W(t;\rho^o(t))}{\partial t} + \frac{\partial W(t;\rho^o(t))}{\partial w}\frac{\partial \rho^o(t)}{\partial t}. \quad (14)$$

Using (7) and (14), expression (13) can be rearranged to give:

$$\begin{aligned} &(r + \lambda(t) + s)(\rho^o(t) - z) \\ &= E_t \frac{d\rho^o(t)}{dt} + \left[(\lambda(t) - \phi)(w(t) - z) + (1-\alpha)\lambda(t)(w_a(t) - w_r(t))\right]. \end{aligned} \quad (15)$$

Thus the optimal reservation wage is a function of average and newly-negotiated wages, labour market conditions, and the expected change in the optimal reservation wage. Note that the validity of this expression does not hinge on Nash rent-sharing. In fact (15) is valid conditional on wages, however they are determined.

It is useful to have an expression for the reservation wage in a steady-state – denote this $\rho*$. From (15) it follows:

$$\rho* = z + \frac{\lambda* - \phi}{r + \lambda* + s}(w* - z). \quad (16)$$

In a special case without renegotiation or discounting ($r = \phi = 0$), the reservation wage in steady state is given by:

$$\rho* = \frac{sz + \lambda* w*}{\lambda* + s} = u* z + (1 - u*)w*, \quad (17)$$

where $u^* = s / (s + \lambda^*)$ denotes the steady-state unemployment rate. This result states that the reservation wage is a weighted average of incomes in and out of work, with the weight on the wage given by the probability of being in employment.

We contrast this reservation wage model with one that deviates from purely forward-looking behaviour by encompassing backward-looking reference points, which we assume to be (partly) determined by recent earnings, as in Falk et al (2006) and Della Vigna et al (2017). Specifically, we assume that the deviation of the current reservation wage from its steady-state level ρ^* (given by (16)) has two components. The first component is a function of the deviation of the optimal, forward looking reservation wage, $\rho^o(t)$, from its steady-state level, ρ^*. The second component is a function of the deviation of a reference wage, denoted by $w_l(t)$, from its steady-state level, w^*:

$$\rho(t) - \rho^* = \alpha_\rho \left[\rho^o(t) - \rho^* \right] + (1 - \alpha_\rho)\alpha_l \left[w_l(t) - w^* \right], \tag{18}$$

where α_ρ captures the weight of forward-looking behaviour in reservation wages, $w_l(t)$ is the last observed wage before job loss, and α_l captures the role of last observed wages in reference points. Lower α_ρ implies stronger reference dependence in reservation wages, and lower α_l implies lower cyclicality in reference points. The special case $\alpha_\rho = 1$ takes us back to the forward-looking model.

E. *The dynamics of wages*

As wages are renegotiated at rate ϕ, the law of motion for average wages can be written as:

$$\frac{dw_a}{dt} = \frac{\lambda(t)u(t)}{1 - u(t)} \alpha (w_r - w_a) + \phi (w_r - w_a) = \left[\alpha \frac{\lambda(t)u(t)}{1 - u(t)} + \phi \right] (w_r - w_a), \tag{19}$$

where $u(t)$ is the unemployment rate at time t. The first term in (19) reflects wage changes from the inflow of new jobs (equal to the separation rate s in steady-state) multiplied by the share of negotiations in new jobs (α), and the second term reflects wage changes from renegotiations in existing jobs. Expression (19) implies that the average wage rises whenever newly-renegotiated wages are higher than average wages.

Turning to the dynamics of the average reference wage, if both those leaving and those entering unemployment are drawn at random (as we assume), then the last observed wage follows the law of motion:

$$\frac{dw_l}{dt} = \frac{s\left[1-u(t)\right]}{u(t)}(w_a - w_l)\,. \tag{20}$$

The reference wage rises (falls) whenever average wages are above (below) previous wages, and it does so at a rate given by the share of the unemployed have just lost their jobs. In steady-state this rate is equal to the job-finding rate λ.

The endogenous variables in the model are the newly-renegotiated wage, $w_r(t)$, the average wage, $w_a(t)$, the reference wage, $w_l(t)$, and the actual and optimal reservation wages, $\rho(t)$ and $\rho^o(t)$, respectively. Their equilibrium values depend on current and future expected labour market conditions, $\lambda(t)$, which we treat as exogenous. Shocks only affect wages and reservation wages via $\lambda(t)$, which is a sufficient statistic for labour market conditions, and further structure on their source and form is not needed.

3. The Predicted Cyclicality of Wages

We derive model predictions for the cyclicality of wages and reservation wages, as measured by their respective elasticity with respect to the current unemployment rate. We start with the special case of a comparison of steady states, before considering the general case in which labour market conditions vary over time.

A. *A comparison of steady states*

In steady-state labour market conditions are constant and all wages, whether pre-existing or newly-negotiated, are equal, and reservation wages are equal to their optimal level. Infrequent wage renegotiation, backward-looking wage determination or reference dependence in reservation wages play no role in comparisons of steady-states as these parameters only affect the model dynamics. Nevertheless, steady state results are a useful benchmark for the more general results presented later.

Combining (12) and (16) leads to the steady-state wage equation:

$$w^* = z + \tilde{\beta}(r + \lambda^* + s)\mu,. \tag{21}$$

illustrating how wages would compare in two steady states that only differ in the job finding rate λ^* and, hence, their unemployment rate. There are two reasons why wages may be procyclical. First, λ^* is higher when unemployment is lower. Second, hiring costs μ may be pro-cyclical for two reasons. First, using (11), if the cost of filling vacancies have a positive flow component ($c > 0$), hiring costs rise when unemployment is low, as vacancy durations rise (q falls). Secondly, vacancy costs themselves (c and C) may vary, and the literature often indexes them to productivity (Pissarides, 2000) or to the level of wages (Hagedorn and Manovskii, 2008, do both). In either case hiring costs are pro-cyclical, in turn accentuating the pro-cyclicality of wages. As one of the aims of this paper is to show why it is hard for the canonical model to generate the modest observed cyclicality of wages, we assume in most of what follows that hiring costs are acyclical, which implies that the value of jobs to firms is also roughly acyclical. Most studies on the costs of filling jobs find the fixed cost component to be more important than the variable cost, so we assume $c = 0$ and that C does not vary with short-term fluctuations in productivity and/or wages.[8] These assumptions imply constant μ.

Given steady-state unemployment, $u^* = s/(s+\lambda^*)$, condition (21) yields a wage curve relating wages to unemployment:

$$w^* = z + \tilde{\beta}\mu\left(r + \frac{s}{u^*}\right). \tag{22}$$

This wage curve is conceptually akin to a labour supply curve in a competitive model, in the sense that demand shocks do not shift the curve, but drive movements along it. The slope of (22) determines the relative response of wages and unemployment to shocks, independent of their source or size, allowing us to be agnostic about the nature of demand shocks, and to evaluate model predictions without measuring them.[9] Appendix A shows how the nature of this relationship can be used to infer the sensitivity of wages and unemployment to productivity, which is the ultimate source of cyclical variations in this model.

[8] Of course, one has to assume that in the long run the vacancy cost is linked to productivity and/or wages as otherwise long-run growth would make the vacancy filling costs less and less important.

[9] The alternative, most common, approach focuses on the reduced-form response of wages and unemployment to the (measured) average product of labour, which is assumed to be an exogenous shock. But, as pointed out by Rogerson and Shimer (2011), a drawback of this approach is that a Cobb-Douglas production function with decreasing returns to labour would always deliver proportionality between average labour productivity and wages, though causation may run from the latter to the former.

In what follows we focus on the elasticity of wages with respect to unemployment as the key cyclicality parameter.[10] Differentiating (22) gives such elasticity across steady-states:

$$\frac{\partial \ln w^*}{\partial \ln u^*} = -\frac{\beta\mu}{1-\beta}\frac{s}{w^*u^*} = -\frac{w^*-z}{w^*}\frac{s}{ru^*+s} = -(1-\eta)\frac{s}{ru^*+s}, \tag{23}$$

where $\eta \equiv z / w^*$ is the replacement ratio. As s is substantially larger than ru for conventional values of the interest rate, the $s/(ru^*+s)$ ratio is close to 1, implying that the unemployment elasticity of wages should be close to one minus the replacement ratio. Using the Blanchflower and Oswald (1994) benchmark of -0.1, expression (24) requires a replacement ratio of 0.9, a very close value to the 0.95 calibration used by Hagedorn and Manovskii (2008).

This value seems implausibly high. The OECD Social Policy Database[11] computes the proportion 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. These estimates do not assign a value to the increase in home time for the unemployed, and there is no definitive evidence on the size of this component. Krueger and Mueller (2012) report that home production and leisure activities increase during unemployment, but at the same time the unemployed enjoy these activities less than the employed.

We propose an approach to calibrate the replacement ratio that avoids the need to make an assumption about the value of home time. Rearranging (16), one can obtain the steady-state relationship between the replacement ratio and ρ^*/w^*, the ratio of reservation wages to wages:

$$1-\frac{\rho^*}{w^*} = (1-\eta)\frac{r+\phi+s}{r+\lambda+s}. \tag{25}$$

In the BHPS, unemployed workers are asked both for their reservation wages and expected wages on re-employment and the answers to these questions can be used to estimate ρ^*/w^*, whose median value during our sample period (1991-2009) is 0.80. As the duration of a wage

[10] Most of the related literature focuses instead on the ratio between the standard deviation of (log) wages and the standard deviation of (log) unemployment. If variation in unemployment is the only factor underlying wage variation (so that a regression of one on the other would have an R^2 of 1), the unemployment elasticity of wages and the ratio of their standard deviations would coincide. However, they would differ whenever there exist other factors causing wage variation, as is typically the case. In this case it is thus preferable to use the elasticity rather than the relative standard deviation as a measure of wage cyclicality (see Mortensen and Nagypal, 2007, p333, for a clear explanation of this point).

[11] http://www.oecd.org/els/soc/NRR_Over5years_EN.xlsx

contract $(1/\phi)$ is typically longer than the duration of a spell of unemployment $(1/\lambda)$, expression (25) implies an upper bound for the replacement ratio of 0.80. And for realistic values of λ and ϕ it will be markedly lower. To get a sense of magnitudes, if wages are renegotiated on average once a year ($\phi = 0.083$ on monthly data) and the job finding rate is set to its average level observed during our sample period for the UK ($\lambda = 0.139$ monthly), the replacement ratio equals 0.69. This value is somewhat above the benefit replacement ratio estimated from the OECD data,[12] but well below the level required to match the estimated elasticity of the wage curve.

In this comparison of steady-states we have assumed, as in much of the related literature, that variation in unemployment rates is associated with variation in job-finding rates, at constant job separation rates. However, countercyclical separations would amplify the impact of shocks on unemployment, as in a recession unemployment increases both because it is harder to find a job and it is easier to be made redundant (see, among others, Fujita and Ramey, 2009, and Elsby, Hobijn and Şahin, 2013). This point is also made in the context of the unemployment volatility puzzle by Robin (2011). If we differentiate (22) for the general case with countercyclical separations we obtain:

$$\begin{aligned}\frac{d\ln w}{d\ln u} &= -\frac{\tilde{\beta}\mu}{w}\frac{s}{u} + \frac{\tilde{\beta}\mu}{w}\frac{ds}{du} = -(1-\eta)\left(\frac{s}{ru+s} - \frac{1}{r+\lambda+s}\frac{ds}{du}\right) \\ &= -(1-\eta)\left(\frac{s}{ru+s} - \frac{su}{r+su}\frac{d\ln s}{d\ln u}\right),\end{aligned} \tag{26}$$

implying that a lower replacement ratio is necessary to match a given elasticity of wages to unemployment, as $d\ln s / d\ln u > 0$. However, the effect is quantitatively very small. Using the estimate of Elsby, Hobijn and Şahin (2013), $d\ln s / d\ln u$ is about 0.17 in the UK and 0.47 in Germany. The required replacement ratio to match a 0.1 elasticity of wages to unemployment would be very close to 0.89 in both countries.

We next turn to the cyclicality of the reservation wage. Using (12) and the assumptions of acyclical hiring costs and steady state ($w_r = w_a$) we obtain:

$$\frac{\partial \ln \rho}{\partial \ln u} = \frac{w^*}{\rho^*}\frac{\partial \ln w}{\partial \ln u} < \frac{\partial \ln w}{\partial \ln u}, \tag{27}$$

[12] This is consistent with a positive value of leisure utility, net of search costs, during unemployment.

i.e. reservation wages are more strongly cyclical than wages, and the ratio between the respective elasticities is given by $\rho^*/w^* = 0.80$. Thus reservation wages are expected to be about 25% more cyclical than wages. The existing literature does not provide estimates for the cyclicality of reservation wages, but later in the paper we provide such estimates for the UK and West Germany.

B. *The General Case*

In the general case workers need to form expectations about the dynamics of labour market conditions, as the reservation wage is forward-looking according to (15). We make the simplest assumption that the expected path of $\lambda(t)$ follows the continuous time version of an AR(1) process:

$$E_t\left(\frac{d\lambda(t)}{dt}\right) = -\xi\left(\lambda(t) - \lambda^*\right), \tag{28}$$

where ξ represents its rate of convergence to steady state, with lower ξ implying higher persistence.

The model is non-linear in $\lambda(t)$, hence we linearize it around its steady-state solution and then derive wage responses to deviations of $\lambda(t)$ from steady-state. These can be in turn related to changes in (the log of) the current unemployment rate. We can prove the following Proposition about the cyclicality in wages and reservation wages:

Proposition 1:

(a) The cyclicality of *newly-negotiated wages*, conditional on the cyclicality of reservation wages, is:

$$\frac{\partial \ln w_r(t)}{\partial \ln u(t)} = \Gamma_r\left[\left(\frac{\rho^*}{w^*}\right)\frac{\partial \ln \rho(t)}{\partial \ln u(t)} + \left(1 - \frac{\rho^*}{w^*}\right)\frac{\partial \ln \mu(t)}{\partial \ln u(t)}\right], \tag{29}$$

where:

$$\Gamma_r \equiv \frac{\alpha s + \phi + \xi}{(\alpha s + \phi + \xi) - \tilde{\beta}(1-\alpha)\xi}. \tag{30}$$

(b) The cyclicality of *reservation wages*, conditional on the cyclicality of newly-negotiated wages, is:

$$\frac{\partial \ln \rho(t)}{\partial \ln u(t)} = -\frac{\alpha_\rho(\lambda^* + s + \xi)}{r + \lambda^* + s + \xi}\left(\frac{w^*}{\rho^*} - 1\right) + \frac{w^*}{\rho^*}\Gamma_\rho \frac{\partial \ln w_r(t)}{\partial \ln u(t)}, \tag{31}$$

where:

$$\Gamma_\rho = \frac{\alpha_\rho\left[(\alpha s + \phi)(\lambda^* - \phi) + \xi(\alpha\lambda^* - \phi)\right]}{(r + \lambda^* + s + \xi)(\alpha s + \phi + \xi)} + \frac{(1 - \alpha_\rho)\alpha_l \lambda^*(\alpha s + \phi)}{(\lambda^* + \xi)(\alpha s + \phi + \xi)}. \tag{32}$$

(c) The cyclicality of *average wages* is:

$$\frac{\partial \ln w_a(t)}{\partial \ln u(t)} = \frac{\alpha s + \phi}{\alpha s + \phi + \xi} \frac{\partial \ln w_r(t)}{\partial \ln u(t)}. \tag{33}$$

(d) The cyclicality of *wages in new jobs* is:

$$\frac{\partial \ln w_n(t)}{\partial \ln u(t)} = \frac{\alpha s + \phi + \alpha\xi}{\alpha s + \phi + \xi} \frac{\partial \ln w_r(t)}{\partial \ln u(t)} = \frac{\alpha s + \phi + \alpha\xi}{\alpha s + \phi} \frac{\partial \ln w_a(t)}{\partial \ln u(t)}. \tag{34}$$

(e) The cyclicality of *reference wages* is:

$$\frac{\partial \ln w_l(t)}{\partial \ln u(t)} = \frac{\alpha s + \phi}{\alpha s + \phi + \xi} \frac{\lambda}{\lambda + \xi} \frac{\partial \ln w_r(t)}{\partial \ln u(t)}. \tag{35}$$

Proof: See Appendix B.

These expressions provide insight on how key elements of the model – infrequent wage renegotiations, unemployment persistence, a backward-looking component in wage setting and reference dependence in reservation wages – affect the cyclicality of wages (average, in new jobs and newly-negotiated), reservation wages and reference wages. One of the advantages of our approach based on the wage curve is that one can provide closed-form expressions for all elasticities of interest.

Equations (33)-(35) express the cyclicality of average wages, wages in new jobs and reference wages as a function of the cyclicality of newly-negotiated wages, showing that newly-negotiated wages are more strongly cyclical than all three of them. The prediction that wages in new jobs are more cyclical than average wages is in line with the evidence presented by Devereux and Hart (2006). This result can help model predictions become closer to the data, as it is the cyclicality of wages on new hires that matters for hiring decisions and the cyclical behaviour of unemployment and vacancies (Hall, 2005, Pissarides, 2009, Haefke, Sonntag and Rens, 2013). Quantitatively, the predicted difference in wage cyclicality between new and continuing jobs widens with the forward-looking component in wages (rising α) and with the length of labour contracts (falling ϕ), and shrinks with unemployment persistence (falling ξ). But, if unemployment is highly persistent, wages in new and continuing jobs tend to display similar degrees of cyclicality, independent of α and ϕ: although wages negotiated at different points in time reflect labour market conditions at different points in time, these are strongly serially correlated, and a regression of wages negotiated in the past on current unemployment alone would detect a significant relationship, with an elasticity not very different from that detected for new jobs. In the limiting case $\xi \to 0$, newly-negotiated wages, average wages, wages in new jobs and reference wages are all equally cyclical. This will turn out to be very important because our benchmark values of ξ are 0.003 and 0.004 for the UK and Germany, respectively.

Consider next the predicted cyclicality of newly-negotiated wages and reservation wages. Equation (29) expresses the cyclicality of newly-negotiated wages as a function of the cyclicality of reservation wages and hiring costs. This result follows from the solution to the Nash sharing problem for wage setting (12) and is independent of the specific model of reservation wages used. Similarly, (31) expresses the cyclicality of reservation wages as a function of the cyclicality of newly-negotiated wages and an extra term that, over and above wage cyclicality, predicts reservation wages to fall in a recession: when unemployment rises and the chances of re-employment fall (falling λ), workers are willing to accept lower wage offers. This results follows from the reservation wage model (18) and its validity is independent of the specific model of wage determination used.

This characterization of the wage and reservation wage elasticity is useful to shed light into potential solutions to the wage flexibility puzzle. Consider a case in which wages are only very weakly cyclical (as might happen if outside options have only a limited influence during wage bargaining, for the reasons argued by Hall and Milgrom, 2008). Even if wages are completely acyclical, expression (31) states that reservation wages would still be cyclical, as reemployment chances fall in recessions. In particular, if reservation wages are equal to optimal reservation wages ($\alpha_\rho = 1$) and the interest rate is low relative to the job-finding rate (as indeed it is), the predicted elasticity of reservation wages with respect to unemployment is about $-(w^*/\rho^* - 1)$. In the BHPS data this is estimated to be about -0.25, so reservation wages would be indeed quite cyclical. However, a value of α_ρ below 1, capturing reference dependence in reservation wages, would reduce the predicted cyclicality of reservation wages.

Similarly, (29) predicts that, if unemployment is very persistent ($\xi \to 0$), newly-negotiated wages are less cyclical than reservation wages, unless hiring costs are pro-cyclical. But pro-cyclical hiring costs obviously tend to raise the overall cyclicality of wages, making it harder for the canonical model to address the wage flexibility puzzle. If both reservation wages and hiring costs are not very cyclical, (29) predicts that newly-negotiated wages cannot be very cyclical either.

It is useful to derive a closed-form expression for the cyclicality of average wages in terms of all model parameters. Combining (29), (31) and (33), we derive the following Proposition:

Proposition 2: The cyclicality of *average wages* can be written as:

$$\frac{\partial \ln w_a(t)}{\partial \ln u(t)} = -(1-\eta^*)\frac{\alpha s+\phi}{\alpha s+\phi+\xi}\frac{\Gamma_r}{1-\Gamma_r\Gamma_\rho}\frac{r+\phi+s}{r+\lambda+s}\left[\frac{\alpha_\rho(\lambda+s+\xi)}{r+\lambda+s+\xi}-\frac{\partial \ln \mu(t)}{\partial \ln u(t)}\right]. \tag{36}$$

Proof: Solving (29), (31) and (33), and then using (25) to eliminate ρ^*/w^* leads to (36).

Expression (36) highlights the role of key model parameters in wage cyclicality. However, due to its complexity, (36) is hard to visualise in its most general form, and we will develop our understanding of (36) in steps.

We first consider three special cases without reference dependence in reservation wages ($\alpha_\rho = 1$): the first with continuous wage renegotiation ($\phi = \infty$); the second without backward-looking behaviour in wage setting ($\alpha = 1$); and the third with both infrequent negotiations and backward-looking behaviour in wage setting ($\phi < \infty$ and $\alpha < 1$). We show that a model with continuous wage renegotiation cannot solve the wage flexibility puzzle, for any degree of backward-looking behaviour in wage setting, unless the replacement ratio is implausibly high. The model without backward-looking behaviour in wage determination is also unable to solve the puzzle unless unemployment has low persistence. However, we show that there are combinations of ϕ and α that do predict plausible values of wage cyclicality. But this solution to the puzzle comes with two major drawbacks. First, for plausible values of unemployment persistence a very low value of ϕ is necessary to deliver low wage cyclicality, implying wage contracts longer than 4 years on average. Second, all these versions of the canonical model still predict high cyclicality in reservation wages. This leads us to the introduction of reference dependent reservation wages in the canonical model ($\alpha_\rho < 1$), and we show that the modified model is capable of solving the wage flexibility puzzle for plausible values of all other parameters.

To give a sense of magnitudes involved, we will evaluate expression (36) and the role of its components at benchmark parameter values, unless otherwise stated. The parameter calibration used is described below.

C. *Benchmark parameters*

For the UK, we use the Quarterly Labour Force Survey (LFS) to obtain estimates of the average unemployment rate and monthly separation rate over the same sample period used in Section 4 (1991-2009). This gives $u = 0.067$ and $s = 0.010$. Together, they imply $\lambda = s(1-u)/u = 0.139$. For West Germany, we obtain $u = 0.078$ and $s = 0.012$ on the Socio Economic Panel (SOEP) for 1984-2010, yielding $\lambda = 0.142$.

The persistence parameter ξ is obtained by estimating an AR(1) model on the monthly, seasonally adjusted, time series for the unemployment rate. This series is available for the UK from the Office for National Statistics for 1971 onwards, and we use data for 1971-2014. We estimate $\xi = 0.003$ on the raw series, and $\xi = 0.007$ on HP filtered series. Virtually identical results are obtained by fitting the AR(1) model to the log – as opposed to the level – of the unemployment rate, or when using quarterly series. For West Germany, a harmonised, seasonally adjusted, series for the unemployment rate is available from the Bundesbank, from 1991 onwards, and we use data for 1991-2014. We estimate $\xi = 0.004$ on the raw monthly series, whether in levels or logs, and obtain slightly higher estimates of 0.018-0.019 on the filtered series. Estimates on the quarterly series are very similar to those obtained on the monthly series. [13] We use as benchmark values the estimated obtained on the raw series (0.003 for the UK, 0.004 for West Germany) but will show predictions for higher values of ξ.

We assume an expected contract length of 12 months in both countries, corresponding to $\phi = 0.083$. This seems to be the mode in most medium and large firms according to the review of wage setting practices in the US by Taylor (1999, Section 2.2.1). Gottschalk (2005)

[13] We use conventional smoothing parameters (129600 on monthly data; 1600 on quarterly data) in the HP filter but note that the resulting estimated trend component of unemployment for West Germany retains some degree of cyclicality. The trend becomes less cyclical with higher smoothing parameters, and the estimated persistence on the resulting filtered series is also then higher.

Labor market flows relative to employment and unemployment stocks are lower in the UK and Germany than in the US, and unemployment persistence is higher, thus our estimates for ξ somewhat differ from those often used in the literature for the analysis of US data.

estimates that in the US the hazard of a change in wages peaks 12 months after the previous change and Fabiani et al. (2010) find that 60% of firms in a number of European countries change base wages once a year. While we pick $\phi = 0.083$ as our benchmark value, we will show predictions for a range of values of ϕ.

We set the bargaining power of workers at $\beta = 0.05$ (see estimates reported by Manning, 2011, Table 4), and note incidentally from expression (11) that β has limited importance whenever α is high, or newly-negotiated wages are close enough to average wages. We consider a monthly interest rate $r = 0.003$.

For pinning down the value of the replacement ratio, we use condition (25) to combine BHPS data on reservation wages and expected wages ($\rho / w \simeq 0.80$) and benchmark values for other parameters, which yields $\eta = 0.69$ in the UK. For West 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 by the same amount as in the UK, i.e. 9 percentage points. This is equivalent to assuming that the extra utility of leisure enjoyed during unemployment is the same in both countries, giving $\eta = 0.75$ in West Germany. Our benchmark parameter values are summarized in Table 1.

D. *Continuous Wage Negotiation*

We start our analysis of (36) within the canonical model ($\alpha_\rho = 1$), imposing continuous renegotiation of wages, $\phi = \infty$.[14] We also assume that hiring costs are acyclical, as this makes it easier for the model to deliver low wage cyclicality.

Proposition 3: If $\partial\mu(t) / \partial u(t) = 0$ and $\alpha_\rho = 1$, then $\phi = \infty$ implies:

$$\frac{\partial \ln w_a(t)}{\partial \ln u(t)} = -(1-\eta^*)\frac{\lambda^* + s + \xi}{r + \lambda^* + s} = -(1-\eta^*)\frac{\xi u^* + s}{ru^* + s}. \tag{37}$$

Proof: See Appendix B

This expression coincides with the steady-state result (23), except for the ξu^* term in the numerator, which is quantitatively small as unemployment is highly persistent. At UK

[14] Note inidentally that a model with continuous wage re-negotiation delivers counter-factual predictions about the level of reservation wages, as (15) and (16) imply $\rho^0, \rho^* \to \infty$ for $\phi = \infty$. In other words, workers are willing to accept a job at any wage because they expect any accepted wage to be immediately revised, thanks to continuous renegotiation.

benchmark parameter values, the predicted elasticity of wages to unemployment in and out of steady state is 0.30 and 0.31, respectively. Using values for Germany, we obtain 0.24 and 0.25, respectively. From (37) it follows that – as in steady-state – a model with continuous wage negotiation can only deliver relatively low wage cyclicality if the replacement rate is higher than our calibrated value.

E. ***No backward-looking component in wage determination (*** $\alpha = 1$ ***)***

We now assume that wages are newly-negotiated every time a new match is formed ($\alpha = 1$), while keeping the assumptions of no reference-dependence and acyclical hiring costs.

Proposition 4: If $\partial\mu(t)/\partial u(t) = 0$ and $\alpha_\rho = 1$, then $\alpha = 1$ implies:

$$\frac{\partial \ln w_a(t)}{\partial \ln u(t)} = -(1-\eta^*)\frac{\xi u^* + s}{r u^* + s}\frac{s+\phi}{s+\phi+\xi}\frac{r+\phi+s}{r+\phi+s+\xi}. \tag{38}$$

Proof: See Appendix B

This special case differs from the previous one in (37) by the final two terms in (38), which are both below 1, thus a model with infrequent wage negotiations and $\alpha = 1$ delivers less cyclical wages than one with continuous negotiations. But again this difference is quantitatively small for small enough ξ, and the two models would yield equally cyclical wages for $\xi = 0$. At benchmark parameter values, the predicted wage elasticity in (38) is -0.29 for the UK and -0.23 for Germany. The intuition is that while infrequent negotiations imply that a large share of ongoing wage contracts were negotiated in the past and thus reflect past labour market conditions, current unemployment is strongly correlated with past unemployment because of its high persistence.

F. ***Infrequent Wage Negotiation and Backward-Looking Wages***

While the canonical model may not solve the wage flexibility puzzle with either continuous wage renegotiation or fully forward-looking wage determination (unless unemployment has implausibly low persistence), there exist combinations of α and ϕ that do predict mild wage cyclicality even in the presence of high unemployment persistence. In the extreme case in which $\alpha, \phi \to 0$, (36) implies that the average wage elasticity also goes to zero. By continuity, there must exist values of α and ϕ that deliver a sufficiently low value of the wage elasticity.

Below we discuss the plausibility of such values. Panel A in Figure 1 presents the combinations of ϕ and α that predict elasticities of average wages in the UK of -0.05, -0.1, -0.15 and -0.2 in turn, in correspondence of benchmark values of other parameter. As ϕ and α decrease, predicted wage cyclicality also falls, but the steep slope of the "isoquant" curves imply that ϕ plays a much more important role than α in determining wage cyclicality. But the values of ϕ required to match observed wage cyclicality are much lower than realistic estimates. For example, even if all new job matches are paid old wages ($\alpha = 0$), a value of $\phi = 0.011$ is needed to predict a wage elasticity of -0.1, and $\phi = 0.019$ to predict a wage elasticity of -0.15, which is close to our estimates on BHPS data in the next Section. As $1/\phi$ is the expected duration of a wage contract in months, $\phi = 0.019$ implies that wage contracts are only negotiated every 4 years on average. If some share of newly-hired workers do negotiate their wages ($\alpha > 0$) the implied value of ϕ would be even lower. For example, if $\alpha = 0.5$, wages should be renegotiated nearly every 24 (respectively, 9) years to predict a wage elasticity of -0.10 (respectively, -0.15). These are implausibly long contract durations when compared to available evidence – e.g. Taylor (1999), Gottschalk (2005) and Fabiani et al. (2010) imply that most wage contracts are renegotiated once a year.

In Panel B we show that, if unemployment is less persistent, there exist lower and realistic values of ϕ that would bring wage cyclicality down to a level close to existing estimates. For example, if $\xi = 0.1$, the range of ϕ values consistent with a -0.1 wage elasticity contains 0.083, in line with yearly wage negotiations.

Figure 1 also shows the corresponding reservation wage predictions. Panel A shows that the canonical model with $\xi = 0.003$ would only be able to match a reservation wage elasticity of -0.15 (which we estimate in the next Section) with values of ϕ below 0.02. More importantly, even if we let ξ rise to 0.1, a very low value of ϕ is still needed to reconcile model predictions with the observed cyclicality of reservation wages (Panel B).

Predictions for West Germany are reported in Figure 2. In Panel A the values of ϕ needed to deliver a given wage or reservation wage elasticity for $\xi = 0.004$ are slightly higher than in the UK (and in Panel B a higher, counterfactual, value $\xi = 0.1$ further raises the required values of ϕ). However, as we show in the next Section, the estimated wage and reservation wage elasticities are markedly lower in West Germany than in the UK, in most cases between

0 and -0.05. Reconciling these elasticities with model predictions in Panel A and B would still require implausibly low values of ϕ.

In summary, this analysis has shown that the canonical model can only match the observed cyclicality of wages in both the UK and West Germany under either an implausibly long duration of wage contracts, or an implausibly low value of unemployment persistence. For given values of ϕ and ξ, the canonical model fares much worse at predicting reservation wage cyclicality than wage cyclicality. In other words, a clear drawback to solving the wage flexibility puzzle via low ϕ and high ξ is that the canonical model still predicts considerable "excess" cyclicality in reservation wages, as implied by equation (31).

G. *Reference-Dependence in Reservation Wages*

We next show that a model with reference-dependent reservation wages may fare better in delivering weakly cyclical wages *and* reservation wages, even in the presence of high unemployment persistence. Some insight is gained by considering equation (36) for the limiting case $\xi \to 0$, having imposed acyclical hiring costs.

Proposition 5: If $\partial \ln \mu(t) / \partial \ln u(t) = 0$, then $\xi \to 0$ implies:

$$\frac{\partial \ln w_a(t)}{\partial \ln u(t)} \to -\alpha_\rho (1-\eta^*) \frac{\lambda + s}{r+\lambda+s} \frac{r+\phi+s}{(r+s)\left[1-(1-\alpha_\rho)\alpha_l\right]+(1-\alpha_\rho)(1-\alpha_l)\lambda+\alpha_\rho\phi} \quad (39)$$

Proof: See Appendix B.

Note first that the extent of backward-looking behaviour in wage setting plays no role in expression (39) because, as unemployment is fully persistent, current and lagged wages are perfectly correlated; thus and making wages backward-looking has no effect on cyclicalities. Second, (39) shows that the parameters measuring reference-dependence (α_ρ) and backward-looking behaviour in the determination of reservation wages (α_l) do play a role in wage cyclicality. In particular, as $\alpha_\rho \to 0$ predicted wage cyclicality goes to zero and, conditional on α_ρ, cyclicality rises with α_l, measuring the role of the last observed wage in reference dependence. Turning to reservation wage cyclicality, expression (31) implies that lower α_ρ reduces the cyclicality of reservation wages both directly – via reference dependence – and indirectly, via lower wage cyclicality.

Below we show graphically the relative importance of reference dependence in reservation wages and backward looking behaviour in wage setting in addressing the wage cyclicality puzzle. Panel A in Figure 3 plots the elasticity of average wages in the UK, as a function of $1-\alpha$ and $1-\alpha_\rho$ in turn, in correspondence of benchmark values of other parameters. The top dotted line plots the relationship between the elasticity of average wages and $1-\alpha$, having imposed $\alpha_\rho = 1$. This is the curve denoted "Model 1", delivering a relatively high wage cyclicality, which is not very responsive to the actual level of backward looking behaviour in wage setting. This is a different way of restating the point made in Panel A of Figure 1, namely that the canonical model cannot replicate the observed wage cyclicality for plausible values of ϕ and ξ, whereby α does not have any strong impact.

We next consider the role of reference points in reservation wages, by plotting the relationship between $1-\alpha_\rho$ and the cyclicality in average wages, having ruled out backward looking behaviour in wage setting ($\alpha = 1$). We consider two cases, denoted as "Model 2" and "Model 3", respectively. In Model 2, the reference wage is completely acyclical ($\alpha_l = 0$), and in Model 3 the reference wage is as cyclical as average wages ($\alpha_l = 1$). The main result is that both reservation wage models generate less cyclical wages than a model that introduces the same level of backward-looking behaviour in wage setting. The reduction in cyclicality is clearly greater when the reference point in reservation wages is assumed to be completely acyclical ($\alpha_l = 0$). Panel B in Figure 2 gives a very similar picture for the predicted cyclicality of reservation wages: while the elasticity of reservation wages to unemployment hardly responds to backward-looking behaviour in wage setting, it declines much faster with reference dependence in reservation wages. Panels A and B in Figure 4 give the corresponding predictions for Germany, and allow us to draw exactly the same conclusions about the relative roles of α and α_ρ.

This section has shown that, when reservation wages have a reference-dependent component, our model can produce markedly less-cyclical wages and reservation wages for plausible benchmark parameter values. Once we allow for reference dependence in reservation wages there is no need to alter the wage setting process to make wages more rigid than in the canonical model. While the empirical literature has established that wages are only mildly cyclical, there is no corresponding evidence for reservation wages. We turn to the empirical analysis of wages and reservation wages in the next section.

4. Empirical wage and reservation wage curves.

A. *Estimates of the wage curve*

This Section provides estimates of wage and reservation wage cyclicality for the UK and West Germany, based on data from the BHPS and the SOEP, respectively. Both are longitudinal studies: the BHPS runs from 1991 to 2009, and the SOEP runs from 1984 onwards. The main advantage of these data sets is that they contain information on reservation wages over a long period of time.

We first provide wage curve estimates, and focus on the elasticity of (log) hourly wages to unemployment.[15] Our empirical specification for the wage equation is in line with the wage bargaining model of Section 2, and controls for the usual demographics that influence wages, as well as a measure of the unemployment rate. Wage curves estimated for the US typically use state-level unemployment as the measure of the cycle, and include both year and state fixed effects, identifying the unemployment elasticity of wages from within-region deviations in unemployment from aggregate trends (Blanchard and Katz, 1992, Hines, Hoynes and Krueger, 2001). However, this strategy is not empirically feasible for the UK and West Germany, where regional unemployment differentials are highly persistent, making it hard to identify any cyclicality in wages over and above unrestricted time and region effects. As a result, our baseline specifications use national unemployment as a business cycle indicator, and we model underlying productivity growth by linear or quadratic trends. We also present estimates based on regional unemployment, which typically deliver lower wage cyclicality, though the estimates are imprecise.

Our sample period is 1991-2009 for the UK and 1984-2010 for West Germany. The sample includes employees aged 16-65, with non-missing wage information, Descriptive statistics for our wage samples are reported in Table A1 in the Appendix for both the BHPS

[15] Blanchflower and Oswald (1994) provide estimates of the wage curve for several OECD countries, and suggest a remarkably stable elasticity of wages to unemployment of -0.1. Their work has been extended to cover more recent US evidence by Devereux (2001), Hines, Hoynes and Krueger (2001) and Blanchflower and Oswald (2005). For the UK, Bell, Nickell and Quintini (2002) obtain a short-run elasticity of wages to unemployment in the UK around -0.03, and long-run elasticities varying between -0.05 and -0.13. Further work has found that the sensitivity of wages to unemployment in the UK has increased over recent decades (Faggio and Nickell, 2005, and Gregg, Machin and Salgado, 2014), and that job movers' wages are more procyclical than stayers' (Devereux and Hart, 2006). For Germany, Blanchflower and Oswald (1994) provide estimates between -0.01 and -0.02 using data from the International Social Survey Programme, and Wagner (1994) finds elasticities between 0 and -0.09 on the SOEP, and slightly higher estimates up to -0.13 on data from the Institute for Employment Research (IAB). Baltagi, Blien and Wolf (2009) estimate dynamic specifications on IAB data and find elasticities consistently lower than -0.1. Ammermueller et al. (2010) use data from the German micro census and suggest a -0.03 upper bound for the elasticity in empirical specifications close to ours.

and the SOEP. Regression results for the UK are presented in Table 2.[16] The dependent variable is the log gross hourly wage, deflated by the aggregate consumer price index. All specifications control for individual characteristics (gender, age, education, job tenure and household composition) and region fixed-effects, and standard errors are clustered at the year level. Column 1 includes the (log of the) aggregate unemployment rate and a linear trend, and delivers an insignificant impact of unemployment on wages. The unemployment effect becomes significant in column 2, which includes a quadratic trend. This better absorbs non linearities in aggregate productivity growth, while cyclical wage fluctuations are now captured by the unemployment rate, with an elasticity of -0.165. Column 3 introduces individual fixed-effects, and the unemployment elasticity stays virtually unchanged.

Columns 4 and 5 distinguish between wages on new and continuing jobs, by including an interaction term between the unemployment rate and an indicator for the current job having started within the past year. In column 4 the coefficient on the interaction term implies that newly-negotiated wages are 50% more cyclical than wages on continuing jobs, in line with the hypothesis that wages are only infrequently renegotiated. Note, however, that even wages on continuing jobs significantly respond to the state of the business cycle, consistent with some degree of on-the-job renegotiation. But when job fixed effects are included in column 5, the difference in cyclicality between old and continuing wages is much lower and borderline significant. As the excess cyclicality in column 5 is identified by unemployment fluctuations within a job spell, and unemployment is highly persistent, we likely lack power to identify the effect of interest 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 when such cyclicality is captured by job fixed-effects the excess cyclicality in newly-negotiated wages is much reduced (see Gertler and Trigari, 2009, and Gertler, Huckfeldt and Trigari, 2016 for a similar result for the US). A similar degrees of cyclicality in new and continuing jobs is consistent with very high unemployment persistence.

If wages are infrequently renegotiated, the unemployment rate at the start of a job is expected to have a long-lasting impact on the wage while on the same job, over and above the impact of current unemployment. This is tested in column 6, which shows that both starting and current unemployment have a significant impact on wages. Columns 7 and 8 control for lagged unemployment, with or without its current value, and column 9 controls for the lagged

[16] Full regression results for the specification of column 2 in Table 1 are reported in Table A2 of the Appendix.

dependent variable. In virtually all specifications the wage elasticity to unemployment is negative and significant, and does not rise above -0.17.

When controlling for regional rather than aggregate unemployment, specifications that also include a quadratic trend deliver a negative and significant unemployment elasticity, but its magnitude in all specifications stays above -0.1, as illustrated in Table A3 in the Appendix. Similarly as for aggregate wage curves, we do find evidence of excess cyclicality of wages on new jobs (column 5), but this falls when job fixed-effects are introduced (column 6).

The corresponding results for West Germany are presented in Table 3. The dependent variable is the log monthly wage, deflated by the consumer price index, and all regressions control for the log of monthly hours worked. The use of monthly, as opposed to hourly, wages is motivated by comparability with the reservation wage regressions presented in the next subsection, as information on reservation wages is only available at the monthly level. The unemployment elasticity of wages in all jobs is markedly lower than in UK estimates, in line with previous estimates for West Germany, and is only significant for new matches (column 4) or when lagged unemployment is used (columns 7 and 8). A clear similarity between West Germany and the UK is that the unemployment elasticity of wages is higher for new hires than for continuing jobs, but such difference becomes not significant when controlling for job fixed-effects (column 5). Estimates based on regional unemployment (Table A4 in the Appendix) are qualitatively similar to those reported in Table 3, but with smaller elasticities throughout.

To summarise evidence on the wage equation, our analysis delivers elasticities of wages with respect to unemployment between -0.1 and -0.17 for the UK, and markedly lower values (often non statistically significant) for West Germany.

B. *Estimates of the reservation wage curve*

The role of reservation wages in business cycle fluctuations underexplored, and there exists no empirical work on its cyclicality. An obvious reason for this gap in the literature is the scarcity of reservation wage data. For the US, a few studies analyse reservation wage data occasionally collected (Feldstein and Poterba, 1984; Holzer, 1986a,b; Petterson, 1998; Ryscavage, 1988). In recent years the Survey of Unemployed Workers in New Jersey has substantially advanced the empirical study of reservation wages (Krueger and Muller, 2011, 2012, 2016; Hall and Mueller, 2015) but these only cover a span of 24 weeks. Early work on reservation wages for the UK has used cross-section survey data (Lancaster and Chesher, 1983, Jones, 1988). Le Barbanchon, Rathelot and Roulet (2016) investigate the empirical determinants of reservation wages in France, and find that reservation wages do not significantly respond to benefit duration. In the US, no data source has collected reservation wage information on a regular basis for a long period of time, but this is available in both the BHPS and the SOEP.

In the BHPS respondents in each wave 1991-2009 are asked about the lowest weekly take-home pay that they would consider accepting for a job, and about the hours they would expect to work for this amount. Using answers to these questions we construct a measure of the hourly net reservation wage, and deflate it using the aggregate consumer price index. A similar question is asked of SOEP respondents in all waves since 1987, except 1990, 1991 and 1995. The reservation wage information is elicited in monthly terms[17] 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, or a job of any duration.

The working sample includes all individuals with information on reservation wages. In the BHPS the question on reservation wages is asked of all individuals who are out of work in the survey week and are actively seeking work or, if not actively seeking, would like to have a regular job. In the SOEP the same question is asked of all individuals who are currently out of work but contemplate going back to work in the future. Descriptive statistics for the reservation wage samples are reported in Table A1.

Theory implies that reservation wages should respond to three sets of variables. First, as the reservation wage depends on expected wage offers, reservation wage equations should control for factors featuring in wage curves, namely gender, human capital components, regional and aggregate effects, as well as a measure of workers' outside options, proxied by the unemployment rate. As the duration of unemployment affects workers' employability, this should also be controlled for in reservation wage equations. Second, the reservation wage responds to the probability of receiving a wage offer, and therefore to the unemployment rate. Cyclical factors, as captured by the unemployment rate, thus affect the reservation wage via both the probability of receiving an offer and the expected wage offer. Third, the reservation wage depends on the level of utility enjoyed while out of work, which we proxy using available measures of unemployment benefits and family composition.

The estimates for the UK reservation wage equation are reported in Table 4. The dependent variable is the log of the real hourly reservation wage. All specifications control for

[17] The actual question in German is "Wie hoch müsste der Nettoverdienst mindestens sein, damit Sie eine angebotene Stelle annehmen würden? (im Monat)".

the same set of individual characteristics as wage equations, having replaced job tenure with the elapsed duration of a jobless spell, and for the amount of benefit income received. In column 1 the state of the business cycle is captured by the (log) national unemployment rate and a linear trend is included. The unemployment coefficient is equal to -0.095 and is significant at the 5% level. Such elasticity rises to -0.175 when a quadratic trend is included in column 2, and slightly declines to -0.146 when individual fixed-effects are introduced in column 3. Columns 4 and 5 control for lagged unemployment, and the associated elasticity is somewhat smaller than the elasticities in specification that only control for current unemployment.

The results from regional reservation wage equations are reported in Table A5 and show that only when one controls for a quadratic trend is the unemployment elasticity significant. Overall, the elasticity of reservation wages to regional unemployment is markedly lower than the elasticity with respect to aggregate unemployment.

We estimate similar reservation wage specifications for West Germany,[18] and the results are reported in Table 5. While the elasticity of reservation wages with respect to current unemployment is wrongly signed, the elasticity of reservation wages with respect to lagged unemployment has the expected sign and is significant. This result is also replicated on estimates based on regional unemployment (see Table A6)

From estimates of this Subsection we conclude that there is fairly limited cyclicality in reservation wages. Specifications that control for individual fixed-effects deliver a reservation wage elasticity of -0.146 in the UK, and about zero in West Germany (or -0.082 when using lagged unemployment). Such elasticities are very close to the corresponding wage elasticities (respectively: -0.169, about zero, and -0.065). These estimates are not consistent with the predictions of the canonical model for two reasons. First, the canonical model predicts a reservation wage elasticity close to -0.3 both in the UK and West Germany, and this figure is far outside the range of estimates obtained. Second, the canonical model predicts reservation wages to be more cyclical than wages, while we have empirically established that they display very similar degrees of cyclicality.

[18] In Germany the duration of unemployment compensation is a nonlinear function of age and previous social security contributions, which are potentially correlated to individual characteristics that also determine wages. We thus exploit nonlinearites in entitlement rules to obtain the number of months to benefit expiry, which is used as an instrument for unemployment benefits in Table 5 (in which age and months of social security contributions feature linearly in all regressions). No instruments are required for the UK reservation wage equations as the duration of benefits in the UK is determined by job search behaviour rather than previous employment history.

C. *The quality of reservation wage data*

One concern in the empirical analysis of reservation wages is that the reservation wage data used may be of low quality, hence the lack of a strong response to cyclical fluctuations. However, it should be noted 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 quality of reservation wage data by investigating whether the correlation between reservation wages and job search outcomes has the sign predicted by search theory. Ceteris paribus, a higher reservation wage should cause a higher remaining duration in unemployment and higher entry wages upon job finding.

Table 6 illustrates the effect of reservation wages on each outcome for the UK. Column 1 simply regresses an indicator of whether a worker has found a job in the past year on the reservation wage recorded at the beginning of that year and a set of year and region dummies. The impact of the reservation wage is virtually zero. 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 the usual individual covariates and the national unemployment rate, and indeed shows that, conditional on such factors, workers with higher reservation wages tend to experience significantly longer unemployment spells. Column 3 shows that this results 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. Such elasticity falls by about a quarter in column 5, which controls for individual characteristics, and is further halved in column 6, which controls for individual fixed-effects, but remains statistically significant.

Similar results for West Germany are presented in Table 7, and they are in line with the UK results, with the qualification that the negative impact of reservation wages on job-finding rates is stronger for West Germany than for the UK. 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.

5. Reference dependence in reservation wages

We next aim to identify the presence of reference dependence in reservation wages. If past wages shape reference points, which in turn influence reservation wages, we should observe a significant correlation between past wages and reservation wages. While such correlation is consistent with the existence of reference points, it is clearly also consistent with alternative mechanisms. One possible confounding factor is any direct link between unemployment benefits and past wages, as unemployment income is a key component of reservation wages in the canonical model. This is the case for West Germany, where benefit entitlement is a function of age and previous social security contributions, which are in turn directly linked to past wages, implying a positive correlation between past and reservation wages, over and above the role of reference points. By contrast, in the UK, unemployment compensation only varies (quite coarsely) with family composition, and is not directly linked to previous wages, making the UK an ideal case study for reference points in reservation wages. We thus restrict the analysis that follows to the UK.

The second confounding factor is represented by 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 do not find to be important), whereas a worker who uses past wages as a reference point might do so.

Let's consider a simple empirical model for the reservation wage:

$$\ln \rho_{it} = \beta_1 X_{it} + \beta_2 w_i * + \beta_3 R_{it-d} + \varepsilon_{it}, \tag{40}$$

where X_{it} denotes observable characteristics, $w_i *$ denotes worker ability, and R_{it-d} denotes the level of rents in the last job observed (d periods ago). The coefficient of interest is β_3, indicating whether rents lost with past jobs influence current reservation wages.

Assume the following model for the last observed wage:

$$\ln w_{it-d} = \gamma_1 X_{it-d} + w_i * + R_{it-d} + u_{it-d}. \tag{41}$$

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

$$\ln \rho_{it} = \delta_1 X_{it} + \delta_2 \ln w_{it-d} + \varepsilon_{it}, \tag{42}$$

the OLS estimate for δ_2 would capture the effect of both unobserved heterogeneity and rents on the reservation wage, and is possibly attenuated by the presence of measurement error in past wages. Identification of the effect of interest would require an instrument that represents a significant component of past rents, while being orthogonal to worker ability.

As a proxy for the size of rents in a given job we use industry affiliation, in line with a long-established literature concluding that part of inter-industry wage differentials represent rents (see the classic papers, Krueger and Summers, 1988, and Gibbons and Katz, 1992; and Benito, 2000, and Carruth, Collie and Dickerson, 2004, for British evidence). Specifically, we use as an instrument for previous wages the predicted, inter-industry wage differential obtained on an administrative dataset, the Annual Survey of Hours and Earnings (ASHE), whose sample size allows us to control for industry affiliation at the 4-digit level. 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. The inclusion of individual fixed effects allows us to capture the component of inter-industry wage differentials that is uncorrelated to individual unobservables, and is thus key to justify our exclusion restriction. We then 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 in the presence of wealth effects in job search behaviour (see for example Shimer and Werning, 2007, for a model of job search with asset accumulation). Rents received in previous jobs would have an impact on asset accumulation, in turn affecting worker utility during unemployment and reservation wages. 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 £100 per year. But in order to control for wealth effects, if any, we include indicators for household assets and housing tenure in the estimated reservation wage equations.

Past wages can be obtained for currently unemployed respondents who had previous employment spells over the BHPS sample period. For those who are observed in employment at any of the previous interview dates, we use contemporaneous information on their last observed job. For those who are not observed in employment at any interview date, but had between-interview employment spells, we use the most recent retrospective information on previous jobs. Retrospective employment information is typically more limited than contemporaneous information, and in particular it does not cover working hours. The analysis that follows is thus entirely based on monthly wages and reservation wages.

Our results are reported in Table 8. Column 1 reports OLS estimates of the reservation wage equation, controlling for the last observed wage in the BHPS panel. The sample is smaller than the original sample of Table 4, as for about 45% of the reservation wage sample we do not observe any previous job in the BHPS panel. The coefficient on the wage in the last job is, unsurprisingly, positive and highly significant. The specification in column 2 introduces individual fixed-effects, and the coefficient on the lagged wage is markedly reduced, as part of the observed association between current reservation wages and past wages is driven by unobserved worker quality. Column 3 allows for some gradual decay of the influence of past wages on reservation wages, controlling for the interaction between the past wage and the number of years since it was observed. The coefficient on the interaction term implies that the influence of previous wage realisations on current reservation wages should vanish about 4 years after job loss, although this effect is only significant at the 10% level.

Column 4 instruments the previous wage with its rent component, as proxied by the 4-digit industry level differential, and shows that this has a positive and significant impact on the reservation wage, consistent with a model in which previous rents affect workers' reference points during job search. The IV coefficient on the past wage is higher than the OLS coefficient, due to the presence of transitory components, (classical) measurement error, and unobserved compensating differentials in the last observed wage (see also Manning, 2003, chapter 6). The specification in Column 5 introduces individual fixed-effects, and the coefficient of interest is now identified by the sub-sample of individuals with multiple unemployment spells originating from different 4-digit industries. Unlike in the OLS model, the coefficient on the lagged wage remains very close to the one obtained without fixed-effects in column 4. Once lagged wages are instrumented by inter-industry wage differentials, their impact on current wage aspirations is no longer confounded by unobserved ability. Indirectly, this signals that unobserved ability is not driving the (very disaggregate) industry allocation of individuals, confirming the validity of the instrument. Column 6 allows for changes in reference points over time, but the decay effect is no longer significant. In summary, the finding that rents in previous jobs affect reservation wages is not consistent with the determination of reservation wages in the canonical model, but is instead consistent with a model in which reference wages influence reservation wages, and these reference wages are, in part, influenced by past wages.

D. ***Quantitative predictions of reference dependence***

Using estimates from the previous subsections, we consider whether there exists a combination of backward-looking behaviour in wage setting and reservation wages, summarized by a triple of parameter values (α ,α_ρ,α_l), that yields quantitative predictions close to our empirical findings. The data moments we use to nail down the values of these three parameters are: (i) the coefficient on lagged wages in the determination of reservation wages (0.15, from column 6 in Table 8); (ii) the elasticity of wages with respect to unemployment (-0.17, from column 3 of Table 2); (iii) the elasticity of reservation wages with respect to unemployment (-0.15, from column 3 of Table 4). Specifically, we impose $(1-\alpha_\rho)\alpha_l = 0.15$, as $(1-\alpha_\rho)\alpha_l$ is the coefficient on lagged wages in the reservation wage equation (18), and then select combinations of (α,α_ρ) that produce, in correspondence of baseline parameters used in Section 3, an elasticity of wages and reservation wages with respect to unemployment within 0.02 of -0.17 and -0.15, respectively.[19] Figure 3 plots values of (α,α_ρ) that satisfy these criteria. Two clear points emerge. First, only values of α_ρ in the range 0.40-0.55 meet the above criteria and, second, once α_ρ lies in this range, almost any value of α meets the criteria.

This reinforces our earlier point that the degree of backward-looking behaviour in wage-setting has virtually no bite on the predicted cyclicality of wages, while we note here that this is instead quite sensitive to the extent of reference dependence in reservation wages. A model in which between 45% and 60% of the variation in reservation wages is driven by backward-looking reference points is able to match well the observed cyclicality of average wages and reservation wages and address wage (and reservation wage) flexibility puzzles[20].

6. Conclusions

We propose a search model with infrequent wage negotiations and reference dependence in reservation wages to derive a relationship between log wages and log unemployment – the wage curve – which is unaffected by demand shocks. The slope of this curve is an estimate of

[19] The last part of Appendix B derives the equations for the cyclicality of actual and reservation wages when the model for reservation wages is given by (18).
[20] One might wonder whether other models of reservation wages might be able to explain the data. Appendix C considers two further alternatives to the canonical model - on-the-job search (see also Menzio and Shi, 2011) and hyperbolic discounting. As neither option addresses the wage flexibility puzzle we do not pursue them further in the main text.

the relative variability of wages and unemployment in response to demand shocks. Absent reference dependence, we show that the model can only explain the modest pro-cyclicality of wages if replacement ratios are implausibly high, unemployment persistence implausibly low or labour contracts implausibly long. A further model prediction is that reservation wages should be more strongly cyclical than wages, because they embody cyclicality from both expected wage offers and the probability of receiving an offer. We next show next that the introduction of reference dependence in reservation wages – based on backward-looking reference points – can deliver mildly cyclical wages and reservation wages for plausible value of other model parameters.

We turn to individual data for the UK and West Germany and find that within each country wages and reservation wages display very similar degrees of cyclicality, substantially lower than the one predicted by the canonical model without reference dependence. We provide evidence that reservation wages significantly respond to backward-looking reference points, as proxied by rents earned in previous jobs.

In a model calibration we show that backward-looking reference dependence in reservation wages markedly reduces the predicted cyclicality of both wages and reservation wages and can reconcile theoretical predictions of search models with the observed cyclicality of wages and reservation wages.

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Table 1: Benchmark Parameters for the UK and West Germany

Symbol	Interpretation	UK	Germany	Source
s	Separation rate	0.010	0.012	Quarterly LFS (UK), SOEP (Germany)
u	Unemployment rate	0.067	0.078	Official unemployment rate
λ	Job-finding rate	0.139	0.145	Separation rate and unemployment rate: $\lambda = s(1-u)/u$
ξ	Persistence in unemployment	0.003	0.004	AR(1) estimates on monthly series for the unemployment rate
ϕ	Frequency of wage renegotiations	0.083	0.083	Annual frequency (Taylor 1999, Gottshalk 2015, Fabiani 2010)
r	Interest rate	0.003	0.003	Conventional value
η	Replacement rate	0.690	0.754	For UK: Equation (25), using $\rho^*/w^* = 0.80$ (from BHPS). For Germany: benefit replacement ratio + extra utility of leisure during unemployment as implied by UK estimates.
β	Bargaining power of workers	0.050	0.050	Manning (2011, Table 4)

Notes. s, λ, ξ, ϕ and r are expressed in monthly terms.

Table 2
Estimates of a Wage Equation for the UK, 1991-2009.

	Dependent variable: log hourly wage								
	1	2	3	4	5	6	7	8	9
Log wage, lagged									0.102**
									(0.046)
Log unemployment rate	-0.022	-0.165***	-0.169***	-0.147***	-0.109***	-0.137***	-0.022		-0.150***
	(0.032)	(0.044)	(0.044)	(0.042)	(0.029)	(0.039)	(0.070)		(0.009)
Log unemployment rate * new job				-0.075***	-0.019				
				(0.013)	(0.011)				
Log unemployment rate, at start of job						-0.069***			
						(0.013)			
Log unemployment rate, lagged							-0.113**	-0.126**	
							(0.050)	(0.032)	
Trend	linear	quadratic	quadratic	quadratic	quadratic	quadratic	quadratic	quadratic	quadratic
Individual fixed effects			√	√		√	√	√	√
Job fixed effects					√				
Observations	96,270	96,270	92,380	92,380	77,854	91,712	92,380	92,380	53,054
R-squared	0.397	0.397	0.810	0.810	0.889	0.810	0.778	0.778	

Notes. See notes to Table A1 for the sample used. Estimation method: OLS in columns 1-8; Arellano Bond (1991) estimator for dynamic panel data models in column 9. The unemployment concept is national. All regressions include 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 household, and eleven region dummies. Regressions in columns 4 and 5 also include a dummy for new job. Standard errors are clustered at the year level in columns 1 and 2, and using 2-way cluster-robust variance (Cameron and Miller, 2013) in columns 3-9. Source: BHPS.

Table 3
Estimates of a Wage Equation for the West Germany, 1984-2010

	Dependent variable: Log monthly wage								
	1	2	3	4	5	6	7	8	9
Log wage, lagged									0.390***
									(0.027)
Log unemployment rate	0.082	0.002	-0.028	-0.015	-0.005	-0.023	0.070**		-0.015
	(0.048)	(0.025)	(0.019)	(0.018)	(0.015)	(0.019)	(0.025)		(0.030)
Log unemployment rate * new job				-0.096***	0.034				
				(0.026)	(0.022)				
Log unemployment rate, at start of job						-0.011			
						(0.008)			
Log unemployment rate, lagged							-0.120***	-0.065***	
							(0.024)	(0.018)	
Trend	linear	quadratic	quadratic	quadratic	quadratic	quadratic	quadratic	quadratic	quadratic
Individual fixed effects			√	√		√	√	√	√
Job fixed effects					√				
Observations	166,614	166,614	161,075	160,865	149,617	161,075	161,075	161,075	101,526
R-squared	0.649	0.651	0.415	0.415	0.199	0.415	0.415	0.415	

Notes. See notes to Table A1 for the sample used. Estimation method: OLS in columns 1-8; Arellano Bond (1991) estimator for dynamic panel data models in column 9. All regressions include log hours worked, a gender dummy, age and its square, three education dummies, a cubic trend in job tenure, a dummy for married, number of children in household, and eleven region dummies. Regressions in columns 4 and 5 also include a dummy for new job. Standard errors are clustered at the year level in columns 1 and 2, and using 2-way cluster-robust variance (Cameron and Miller, 2013) in columns 3-9. Source: SOEP.

Table 4
Estimates of a Reservation Wage Equation for the UK, 1991-2009.

	Dependent variable: log hourly reservation wage				
	1	2	3	4	5
Log unemployment rate	-0.095**	-0.175***	-0.146***	0.010	
	(0.046)	(0.058)	(0.042)	(0.146)	
Log unemployment rate, lagged				-0.119	-0.112***
				(0.096)	(0.026)
Trend	linear	quadratic	quadratic	quadratic	quadratic
Individual fixed-effects			√	√	√
Observations	14,874	14,874	10,774	10,774	10,774
R-squared	0.248	0.249	0.614	0.614	0.614

Notes. See notes to Table A1 for the sample used. Estimation method: OLS. The unemployment concept is national. All regressions also include 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, a dummy for receipt of housing benefits, and eleven region dummies. Standard errors are clustered at the year level in columns 1 and 2, and using 2-way cluster-robust variance (Cameron and Miller, 2013) in columns 3-5. Source: BHPS.

Table 5
Estimates of a Reservation Wage Equation for West Germany, 1987-2009.

	Dependent variable: log monthly reservation wage				
	1	2	3	4	5
Log unemployment rate	0.173**	0.001	0.038	0.175**	
	(0.070)	(0.065)	(0.054)	(0.070)	
Log unemployment rate, lagged				-0.196***	-0.082*
				(0.064)	(0.045)
Trend	linear	quadratic	quadratic	quadratic	quadratic
Individual fixed-effects			√	√	√
Observations	11,221	11,221	7,911	7,911	7,911
R-squared	0.414	0.418	0.123	0.125	0.123

Notes. See notes to Table A1 for the sample used. Estimation method: IV. All regressions also include 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, a dummy for receipt of housing benefits, controls for whether an individual looks for full-time, part-time or any job (the omitted category being "unsure about preferences"), months of social insurance contributions and eleven region dummies. Unemployment benefits are instrumented by months to benefit expiry. These are obtained by exploiting benefit entitlement rules, based on (nonlinear) functions of age and previous social security contributions. Standard errors are clustered at the year level in columns 1 and 2, and using 2-way cluster-robust variance (Cameron and Miller, 2013) in columns 3-5. Source: SOEP.

Table 6
Reservation Wages, Post-Unemployment Wages and Job Finding Probabilities in the UK, 1991-2009

	Whether found job			Log post-unemployment 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	√			√		
Trend	No	quadratic	quadratic	no	quadratic	quadratic
Further controls		√	√		√	√
Individual fixed-effects			√			√
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

Notes. See notes to Table A1 for the sample used. The wage measure is hourly. Estimation method: OLS. 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, 2013) in columns 3 and 6. Source: BHPS.

Table 7
Reservation Wages, Post-Unemployment Wages and Job Finding Probabilities in West Germany, 1988-2010

	Whether found job			Log post-unemployment 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	√			√		
Trend	no	quadratic	quadratic	no	quadratic	quadratic
Further controls		√	√		√	√
Individual fixed-effects			√			√
Observations	11,534	11,534	8,156	2,984	2,984	755
R-squared	0.007	0.071	0.033	0.244	0.348	0.127

Notes. See notes to Table A1 for the sample used. The wage measure is monthly. Estimation method: OLS. 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, the number of children in the household, whether an individual looks for a full-time, part-time or any job (the omitted category is "unsure about preferences"). 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, 2013) in columns 3 and 6. Source: SOEP.

Table 8
Reservation wages and rents in previous jobs: UK, 1991-2009.

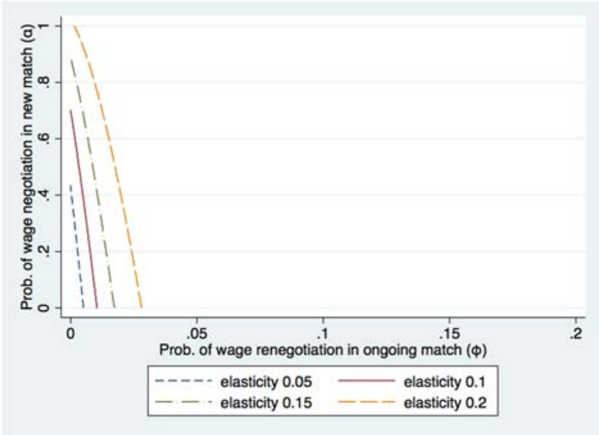
	Dependent variable: log monthly reservation wage					
	1	2	3	4	5	6
Estimation method	OLS	OLS	OLS	IV	IV	IV
Last observed log wage	0.083***	0.033***	0.042***	0.133***	0.149**	0.153***
	(0.005)	(0.010)	(0.011)	(0.018)	(0.063)	(0.067)
Last observed log wage * years since observed			-0.011*			-0.002
			(0.006)			(0.009)
Log unemployment rate	-0.183***	-0.173***	-0.174***	-0.159*	-0.177**	-0.166*
	(0.081)	(0.075)	(0.075)	(0.084)	(0.067)	(0.078)
Trend	quadratic	quadratic	quadratic	quadratic	quadratic	quadratic
Individual FE		√	√		√	√
Observations	8,091	5,737	5,737	7,732	5,520	5,520
R-squared	0.284	0.098	0.099			
First stage, F-test(a)				908.9	53.7	53.7
First stage, F-test(b)						64.2

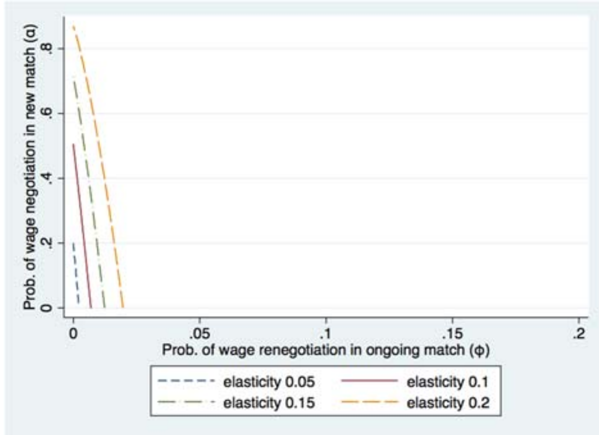
Notes. See notes to Table A1 for the sample used. All regressions also include a gender dummy, age and its square, three education dummies, a cubic trend in the number of years since the last job was observed, a dummy for married, the number of children in the household, the log of unemployment benefits, three dummies for capital income (0, <100£, 100£+ per year, where the excluded category is "don't know"), three dummies for housing tenure (owned with mortgage, local authority rented, other rented, where the excluded category is outright owned) and eleven region dummies. *Instruments used*: predicted industry wage (4-digit) for previous job (columns 4 and 5); predicted industry wage (4-digit) for previous job and its interaction with years since previous job (column 6). (a) denotes Sanderson and Windmeijer (2015) first-stage F-statistic for the first equation (last observed log wage) and (b) denotes the corresponding statistic for the second equation (last observed log wage*years since observed). Standard errors are clustered at the year level in columns 1-2 and 4-5, and using 2-way cluster-robust variance (Cameron and Miller, 2013) in columns 3 and 6. Source: BHPS.

Figure 1: The role of backward looking behaviour in wage setting ($1-\alpha$) and frequency of wage renegotiations (ϕ) in wage and reservation wage cyclicality. UK parameter values.

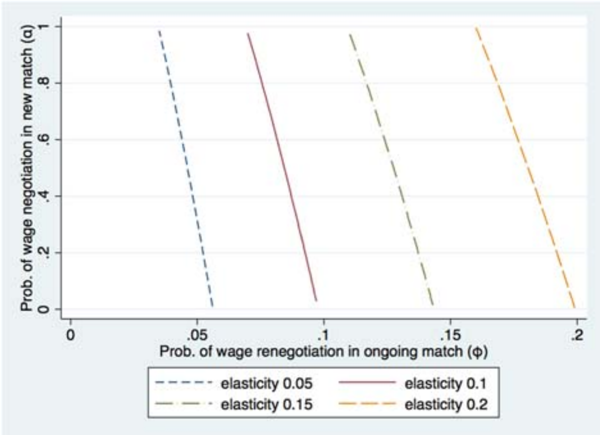
Wage Elasticity | **Reservation Wage Elasticity**

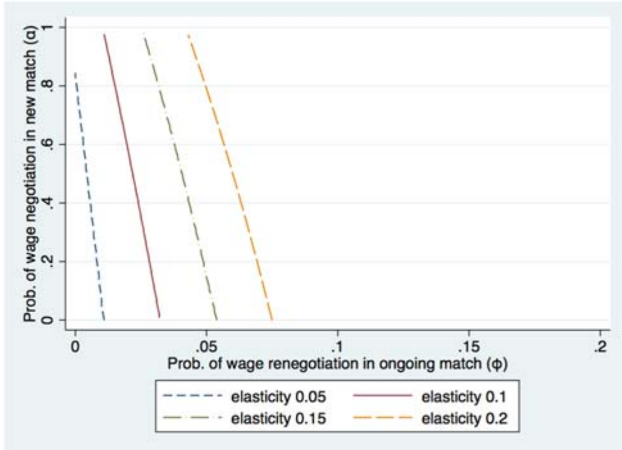
Panel A: ξ = 0.004 (estimated value)





Panel B: ξ = 0.1 (counterfactual persistence)



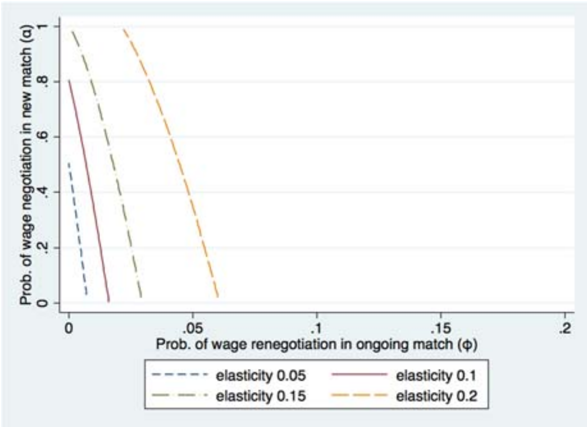


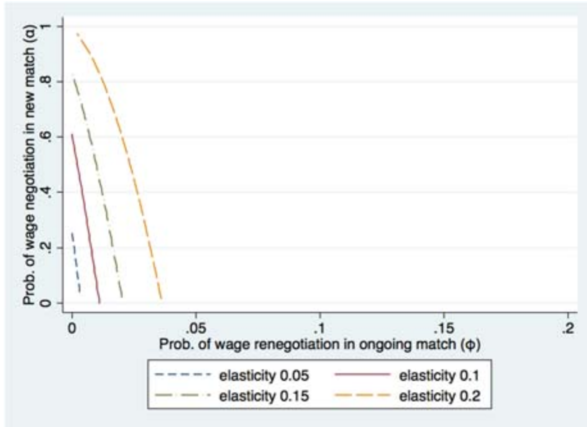
Notes. The curves represent combinations of ϕ and α that deliver indicated values of the elasticity of average wages and reservation wages to unemployment, in correspondence of alternative values of unemployment persistence.

Figure 2: The role of backward looking behaviour in wage setting ($1-\alpha$) and frequency of wage renegotiations (ϕ) in wage and reservation wage cyclicality. West Germany parameter values.

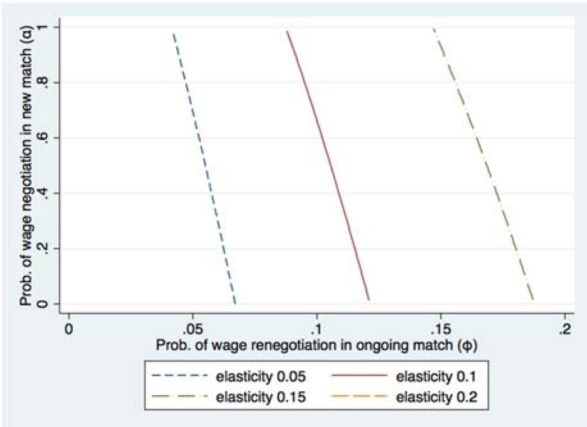
Wage Elasticity | **Reservation Wage Elasticity**

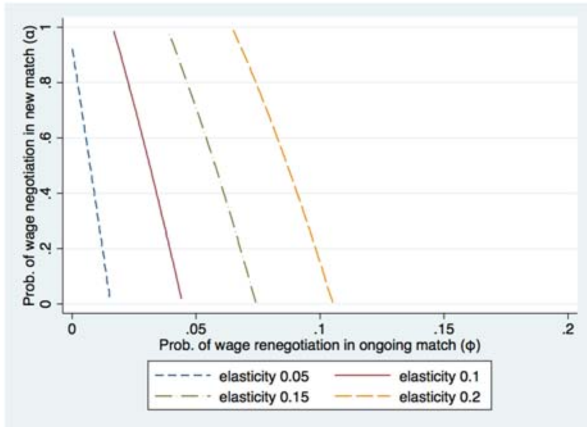
Panel A: ξ = 0.004 (estimated value)





Panel B: ξ = 0.1 (counterfactual persistence)



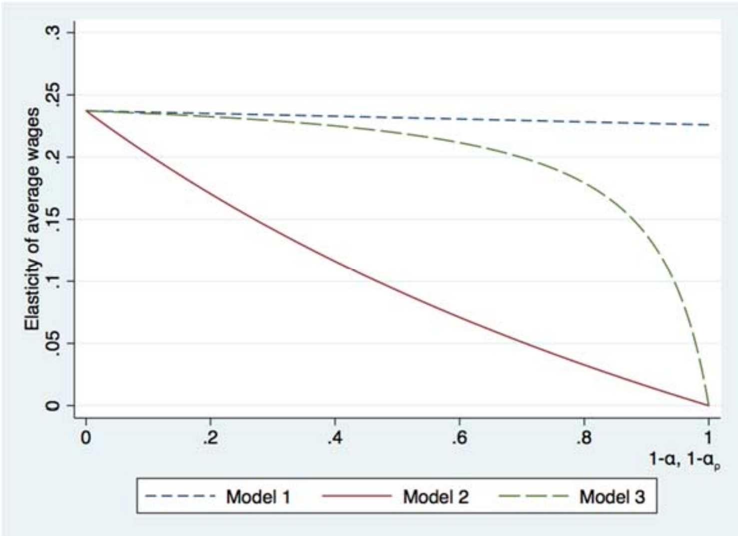


Notes. The curves represent combinations of ϕ and α that deliver indicated values of the elasticity of average wages and reservation wages to unemployment, in correspondence of alternative values of unemployment persistence.

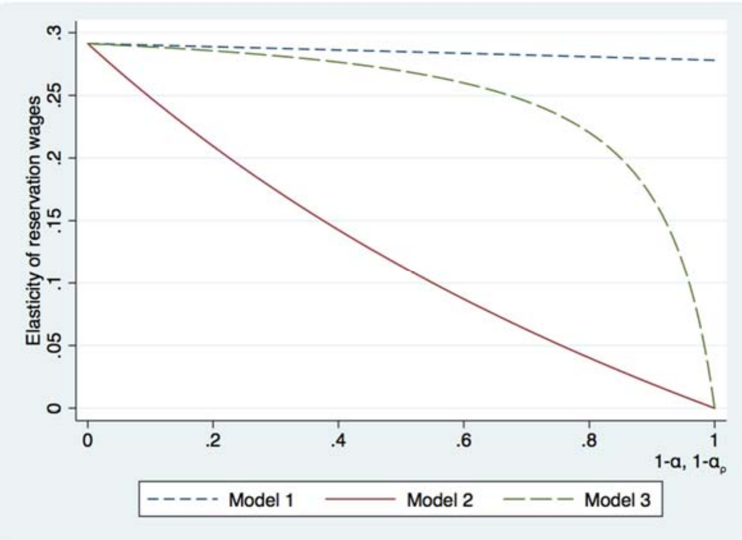
Figure 3

The role of reference dependence in reservation wages ($1-\alpha_\rho$) on wage and reservation wage cyclicality. UK parameter values.

Panel A



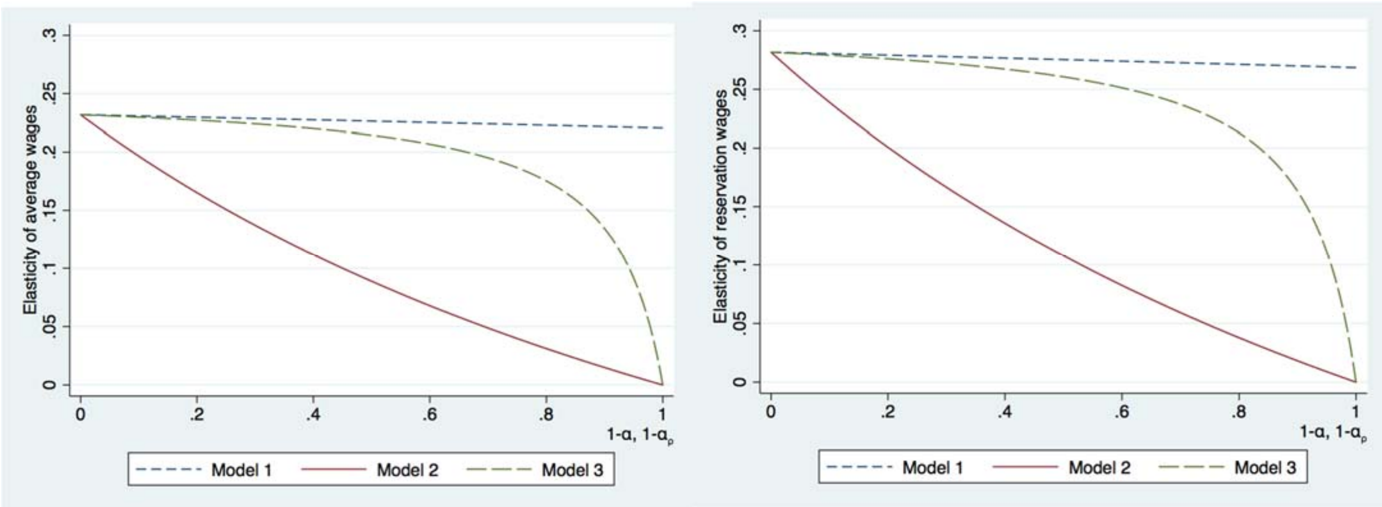
Panel B



Notes: The curves represent predicted elasticities of wages and reservation wages with respect to $1-\alpha$ and $1-\alpha_\rho$. **Model 1** is a special case without reference dependence in reservation wages ($\alpha_\rho = 1$), and the running variable on the horizontal axis is $1-\alpha$, measuring backward looking behaviour in wage setting. **Model 2** is a special case without backward looking behaviour in wage setting ($\alpha = 1$), and the running variable on the horizontal axis is $1-\alpha_\rho$, measuring reference dependence in reservation wages, under the assumption that the reference wage is completely acyclical ($\alpha_l = 0$). **Model 3** is a special case without backward looking behaviour in wage setting ($\alpha = 1$), and the running variable on the horizontal axis is again $1-\alpha_\rho$, under the assumption that the reference wage is as cyclical as the average wage ($\alpha_l = 1$). All other parameter are set at benchmark values, described in Section 3C and Table 1.

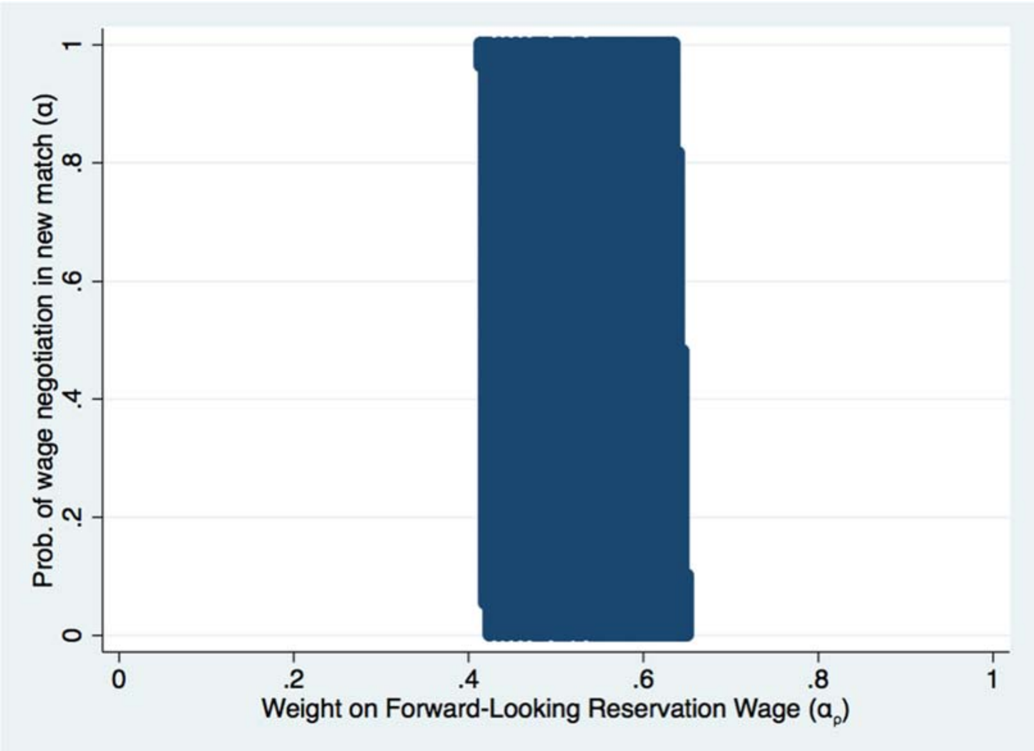
Figure 4
The role of reference dependence in reservation wages ($1-\alpha_\rho$) on wage and reservation wage cyclicality.
West Germany parameter values.

Panel A **Panel B**



Notes: The curves represent predicted elasticities of wages and reservation wages with respect to $1-\alpha$ and $1-\alpha_\rho$. **Model 1** is a special case without reference dependence in reservation wages ($\alpha_\rho = 1$), and the running variable on the horizontal axis is $1-\alpha$, measuring backward looking behaviour in wage setting. **Model 2** is a special case without backward looking behaviour in wage setting ($\alpha = 1$), and the running variable on the horizontal axis is $1-\alpha_\rho$, measuring reference dependence in reservation wages, under the assumption that the reference wage is completely acyclical ($\alpha_l = 0$). **Model 3** is a special case without backward looking behaviour in wage setting ($\alpha = 1$), and the running variable on the horizontal axis is again $1-\alpha_\rho$, under the assumption that the reference wage is as cyclical as the average wage ($\alpha_l = 1$). All other parameter are set at benchmark values, described in Section 3C and Table 1.

Figure 5
Parameter Values that Explain Observed Cyclicality



Notes. The shaded region shows the combinations of α, the probability of negotiating a wage on a new match, and α_ρ, the weight on the forward-looking reservation wage, that predict a wage elasticity and a reservation wage elasticity within 0.02 of -0.17 and -0.15, respectively, for a predicted sensitivity of the reservation wage to the lagged wage $(1-\alpha_\rho)\alpha_l$, equal to 0.15 (taken from column 5 of Table 8). All other parameter are set at baseline values.

Appendix A: Relationship between our approach and the existing literature

Our approach is built on the derivation of a wage curve, i.e. a relationship between wages and unemployment that is not affected by shocks to labour demand (like productivity shocks). Labour demand shocks are associated with movements along the wage curve, but they do not alter its position. We believe this approach has the advantage of being relatively agnostic about the source and nature of demand shocks but it does make it harder to compare with some of the existing literature. Below we outline the relationship between our approach and the more common approach based on the response of unemployment to productivity shocks.

The Impact of Changes in Productivity on Unemployment

For simplicity we limit our discussion to the steady-state, in which the wage curve is given by (22). In steady state, the labour-demand (or vacancy-creation) curve is given by:

$$(p-w)=(r+s)\mu(u), \tag{43}$$

which allows hiring costs to depend on unemployment. Differentiating (43) with respect to productivity, and taking into account the dependence of wages on unemployment through the wage curve gives:

$$1-\frac{w}{p}\frac{\partial \ln w}{\partial \ln u}\frac{\partial \ln u}{\partial \ln p}=\frac{(r+s)\mu}{p}\frac{\partial \ln \mu}{\partial \ln u}\frac{\partial \ln u}{\partial \ln p}=\left(1-\frac{w}{p}\right)\frac{\partial \ln \mu}{\partial \ln u}\frac{\partial \ln u}{\partial \ln p}. \tag{44}$$

Re-arranging (44) leads to:

$$\frac{\partial \ln u}{\partial \ln p}=\frac{1}{\frac{w}{p}\frac{\partial \ln w}{\partial \ln u}+\left(1-\frac{w}{p}\right)\frac{\partial \ln \mu}{\partial \ln u}}. \tag{45}$$

If hiring costs are acyclical, the elasticity of unemployment with respect to productivity is simply the inverse of the elasticity of wages with respect to unemployment, rescaled by the ratio of wages to productivity, which is related to the size of hiring costs relative to productivity. If hiring costs are cyclical, unemployment becomes less sensitive to productivity, and wages become more strongly procyclical.

Note that, given the assumption of constant returns to scale in this model, TFP shocks are identical to average labour productivity so that the assumption of exogenous TFP shocks also implies that the measured average product of labour is exogenous. But, as pointed out by Rogerson and Shimer (2011), a different assumption about the production function might lead to different conclusions. For example, a Cobb-Douglas production function with decreasing returns to labour would always deliver proportionality between average labour productivity and the wage, though causation may run from the latter to the former. In this case the correlation between wages and productivity is uninformative about anything other than the production function. Our approach allows us to be more agnostic about the form of the production function although one should recognize that different production functions might lead to different wage curves (though see also Elsby and Michaels, 2013, who derive a very similar wage curve)

Elasticity versus *Relative Standard Deviations*

Our main parameter of interest is the elasticity of log wages with respect to log unemployment as estimated from wage and reservation wage curves. Most of the existing literature uses relative standard deviations as the parameter of interest. Suppose the relationship between log wages and log unemployment is written as:

$$\ln w = \beta_0 + \beta \ln u + \varepsilon$$

where for simplicity we assume there are no other regressors and β denotes a regression coefficient (and not the bargaining power of workers as used in the main body of the paper). If the correlation coefficient between $\ln w$ and $\ln u$ is r, the following relationships hold:

$$\beta = \frac{\text{cov}(\ln w, \ln u)}{\text{var}(\ln u)} = r\frac{\text{stdev}(\ln w)}{\text{stdev}(\ln u)}$$

Thus the regression coefficient (our elasticity) and the ratio of standard deviations are identical whenever $r = -1$ or, equivalently, the R^2 from the regression equals 1. Many models in the literature implicitly assume this because they are one-factor models in which TFP alone causes variation in unemployment and wages. If variation in unemployment is driven by TFP shocks then one could also convert this to the relative standard deviation of wages and productivity.

If $r \neq 1$ then the elasticity and relative standard deviations are different but in this case the elasticity is preferable as we are interested in the variation in wages driven by unemployment not the total variation. Mortensen and Nagypal (2007, p333) provide a very clear discussion of these issues.

The Impact of Changes in Unemployment Benefits on Unemployment

The parameter configuration of Hagedorn and Manovskii (2008) has been criticized by Costain and Reiter (2008) for making unemployment excessively sensitive to changes in unemployment benefits. It is therefore our interest to consider the prediction of our model. In the steady-state changes in the value of home time z shift wages one-for-one (see (22)), so that the elasticity of wages with respect to z is given by:

$$\frac{\partial \ln w}{\partial \ln z} = \eta. \tag{46}$$

If hiring costs are acyclical, the elasticity of unemployment to z is given by:

$$\frac{\partial \ln u}{\partial \ln z} = \frac{\partial \ln w}{\partial \ln z} / \frac{\partial \ln w}{\partial \ln u} = \eta / \frac{\partial \ln w}{\partial \ln u}. \tag{47}$$

However, Costain and Reiter (2008) assume that unemployment benefits (b) are the sole determinant of z. This may not always be the case, especially in models with reference-dependence. If one allows a different link between benefits and z we have that:

$$\frac{\partial \ln u}{\partial \ln b} = \frac{\partial \ln u}{\partial \ln z}\frac{\partial \ln z}{\partial \ln b} = \eta \frac{\partial \ln z}{\partial \ln b} / \frac{\partial \ln w}{\partial \ln u}. \tag{48}$$

One can then explain a small aggregate impact of benefits on aggregate unemployment through a small impact of benefits on z and, hence, reservation wages. This is consistent with our empirical evidence: our reservation wage equations we include benefits and find them to have only a small though significant effect on reservation wages.

Appendix B: Proof of Propositions

Proof of Proposition 1

We prove Proposition 1 in steps, summarised in the following results:

Result 1:

$$E_t\left(\lambda(\tau)\middle|\lambda(t)\right) = e^{-\xi|(\tau-t)|}\lambda(t) + \left[1 - e^{-\xi|(\tau-t)|}\right]\lambda^*. \tag{49}$$

This follows from (28) and holds for any τ, higher or lower than t.

Result 2:

Linearizing the model around the steady-state, we can express any model variable $x(t)$ as:

$$x(t) - x^* = \theta_x(\lambda(t) - \lambda^*). \tag{50}$$

Combining (50) and (28) gives:

$$E_t\left(\frac{dx(t)}{dt}\middle|\lambda(t)\right) = \theta_x E_t\left(\frac{d\lambda(t)}{dt}\middle|\lambda(t)\right) = -\xi\theta_x(\lambda(t) - \lambda^*) \tag{51}$$

for forward-looking variables, and:

$$E_t\left(\frac{dx(t)}{dt}\middle|\lambda(t)\right) = \theta_x E_t\left(\frac{d\lambda(t)}{dt}\middle|\lambda(t)\right) = \xi\theta_x(\lambda(t) - \lambda^*) \tag{52}$$

for backward-looking variables. Note that, for backward-looking variables, past realizations of λ would have an explanatory power independent of $\lambda(t)$.

Result 3: The sensitivity of the (log) unemployment rate to $\lambda(t)$ is given by:

$$\frac{d\ln u(t)}{d\lambda(t)} = -\frac{1}{\lambda^* + s + \xi}. \tag{53}$$

Proof: Unemployment follows a differential equation $du(t)/dt = s(1-u(t)) - \lambda(t)u(t)$, which can be linearized around the steady-state to yield:

$$\frac{du(t)}{dt} = -(\lambda^* + s)(u(t) - u^*) - u^*(\lambda(t) - \lambda^*). \tag{54}$$

Using (50) and (52) (as unemployment is backward-looking), (54) can be written as $\theta_u = -u^*/(\lambda^* + s + \xi)$, which implies (53). This result is useful because we are ultimately interested in the elasticity of wages with respect to unemployment. Using (53) we can convert the sensitivity of any model variable to $\lambda(t)$ into an unemployment elasticity.

<u>Result 4</u>: *The cyclicality of average wages*

Linearizing (19) around steady-state gives:

$$\frac{dw_a}{dt} = -(\alpha s + \phi)\left[(w_a - w_a^*) - (w_r - w_r^*)\right] + \frac{\alpha u^*\left(w_r^* - w_a^*\right)}{1 - u^*}(\lambda(t) - \lambda^*), \tag{55}$$

where the second term is zero because re-negotiated wages are equal to average wages in steady state. As the average wage is a backward-looking variable we the can then derive:

$$\theta_{w_a} = \frac{\alpha s + \phi}{\alpha s + \phi + \xi}\theta_{w_r} \tag{56}$$

i.e. average wages are less cyclical than newly-negotiated wages unless there is continual wage re-negotiation ($\phi = \infty$) or unemployment is fully persistent ($\xi = 0$). This gives Proposition 1(c). As wages in new jobs are equal to w_r with probability α and w_a with probability $1-\alpha$ this also proves Propostion 1(d).

<u>Result 5</u>: *The cyclicality of reference wages*

Linearizing (20) around the steady-state gives:

$$\frac{dw_l}{dt} = \lambda^*\left[(w_a - w_a^*) - (w_l - w_l^*)\right], \tag{57}$$

using the fact that reference wages are equal to average wages in steady state. As the reference wage is a backward-looking variable we the can then derive:

$$\theta_{w_l} = \frac{\lambda^*}{\lambda^* + \xi}\theta_{w_a} \tag{58}$$

i.e. reference wages are less cyclical than average wages unless unemployment is fully persistent ($\xi = 0$). Combining (58) and (56) gives Proposition 1(e).

<u>Result 6</u>: The cyclicality of newly-negotiated wages

The linearized version of (12) can be written as:

$$\theta_{w_r} = \theta_\rho + \tilde{\beta}(r+\phi+s)\theta_\mu - \tilde{\beta}(1-\alpha)(\theta_{w_a} - \theta_{w_r}) = \theta_\rho + \frac{w^* - \rho^*}{\mu^*}\theta_\mu - \tilde{\beta}(1-\alpha)(\theta_{w_a} - \theta_{w_r}), \quad (59)$$

which allows for cyclicality in hiring costs. Using (56) we can eliminate θ_{w_a} from (59) and re-arrange to obtain:

$$\left(1 - \frac{\tilde{\beta}(1-\alpha)\xi}{\alpha s + \phi + \xi}\right)\theta_{w_r} = \theta_\rho + \frac{w^* - \rho^*}{\mu^*}\theta_\mu \quad (60)$$

which can be expressed in elasticity form:

$$\left(1 - \frac{\tilde{\beta}(1-\alpha)\xi}{\alpha s + \phi + \xi}\right)\frac{\partial \ln w_r(t)}{\partial \ln u(t)} = \frac{\rho^*}{w^*}\frac{\partial \ln \rho(t)}{\partial \ln u(t)} + \left(1 - \frac{\rho^*}{w^*}\right)\frac{\partial \ln \mu(t)}{\partial \ln u(t)}. \quad (61)$$

This proves Proposition 1(a).

<u>Result 6</u>: The cyclicality of optimal reservation wages

The linearized version of (15) can be written as:

$$\begin{aligned} E_t \frac{d\rho^o(t)}{dt} &= (r + \lambda^* + s)(\rho^o(t) - \rho^*) - (\alpha\lambda^* - \phi)(w_r(t) - w_r^*) \\ &\quad - (1-\alpha)\lambda^*(w_a(t) - w_a^*) + (\rho^* - w^*)(\lambda(t) - \lambda^*). \end{aligned} \quad (62)$$

As the reservation wage is forward-looking, from (62) we can derive:

$$(r + \lambda^* + s + \xi)\theta_{\rho^o} = (\alpha\lambda^* - \phi)\theta_{w_r} + (1-\alpha)\lambda^*\theta_{w_a} + (w^* - \rho^*) \quad (63)$$

Finally, using (56) to eliminate θ_{w_a} from (63) yields:

$$(r + \lambda^* + s + \xi)\theta_{\rho^o} = \left[\lambda^* - \phi - \frac{(1-\alpha)\lambda^*\xi}{\alpha s + \phi + \xi}\right]\theta_{w_r} + (w^* - \rho^*). \quad (64)$$

<u>Result 7</u>: The cyclicality of reservation wages

From (18) we have that:

$$\theta_\rho = \alpha_\rho \theta_{\rho^o} + (1-\alpha_\rho)\alpha_l \theta_{w_l}, \quad (65)$$

Which, using (58) and (56) can be written as:

$$\theta_\rho = \alpha_\rho \theta_{\rho^o} + \frac{(1-\alpha_\rho)\alpha_l(\alpha s + \phi)\lambda}{(\alpha s + \phi + \xi)(\lambda + \xi)}\theta_{w_r}, \quad (66)$$

Substituting (64) into (66) and converting to an elasticity with respect to unemployment proves Proposition 1(b).

Result 8: The cyclicality of newly-negotiated wages.

Solving (60), (64) and (66) leads to:

$$\theta_{w_r} = \frac{(w^*-\rho^*)(\alpha s+\phi+\xi)\left[(r+\lambda+s+\xi)\dfrac{\theta_\mu}{\mu^*}+\alpha_\rho\right]}{(\alpha s+\phi+\xi)(r+\lambda(1-\alpha_\rho)+\phi\alpha_\rho+s+\xi)-(1-\alpha)\xi\left[\tilde{\beta}(r+\lambda+s+\xi)-\alpha_\rho\lambda\right]-(1-\alpha_\rho)\alpha_l(r+\lambda+s+\xi)\dfrac{\lambda}{\lambda+\xi}}. \tag{67}$$

Using (25), this can be expressed in elasticity form:

$$\frac{\partial \ln w_r(t)}{\partial \ln u(t)} = -\frac{(1-\eta^*)\dfrac{r+\phi+s}{r+\lambda+s}(\alpha s+\phi+\xi)\left[(\lambda+s+\xi)\alpha_\rho-(r+\lambda+s+\xi)\dfrac{\partial \ln \mu(t)}{\partial \ln u(t)}\right]}{(\alpha s+\phi+\xi)(r+\lambda(1-\alpha_\rho)+\phi\alpha_\rho+s+\xi)-(1-\alpha)\xi\left[\tilde{\beta}(r+\lambda+s+\xi)-\alpha_\rho\lambda\right]-(1-\alpha_\rho)\alpha_l(r+\lambda+s+\xi)\dfrac{\lambda}{\lambda+\xi}} \tag{68}$$

Setting $\theta_\mu = 0$ yields (29).

Proof of Proposition 3

If $\alpha_\rho = 1$, then as $\phi \to \infty$, (30) shows that $\Gamma_r \to 1$. (32) shows that we also have:

$$\frac{\Gamma_\rho}{r+\phi+s} \to \frac{1}{r+\lambda+s+\xi} \tag{69}$$

Substituting into (36) and setting the hiring cost cyclicality to zero we have that:

$$\frac{\partial \ln w_a(t)}{\partial \ln u(t)} \to -(1-\eta^*)\frac{\lambda^*+s+\xi}{r+\lambda^*+s} = -(1-\eta^*)\frac{\xi u^*+s}{ru^*+s} \tag{70}$$

which gives (37).

Proof of Proposition 4

If $\alpha_\rho = 1$, and $\alpha = 1$, (30) shows that $\Gamma_r \to 1$. (32) shows that we also have:

$$\Gamma_\rho = \frac{\lambda-\phi}{r+\lambda+s+\xi} \tag{71}$$

Substituting into (36) and setting the hiring cost cyclicality to zero we have that:

$$\frac{\partial \ln w_a(t)}{\partial \ln u(t)} = -(1-\eta^*)\frac{\lambda^* + s + \xi}{r + \lambda^* + s}\frac{s+\phi}{s+\phi+\xi}\frac{r+s+\phi}{r+s+\phi+\xi} \tag{72}$$

which gives (38).

Proof of Proposition 4

As $\xi \to 0$ we have that $\Gamma_r \to 1$ and:

$$\Gamma_\rho \to \frac{\alpha_\rho(\lambda - \phi)}{r + \lambda + s} + (1-\alpha_\rho)\alpha_l \tag{73}$$

Substituting into (36), setting the hiring cost cyclicality to zero, and re-arranging leads to (39)
.

Appendix B: Additional Tables and Figures

Table A1: Descriptive statistics

	United Kingdom				West Germany			
	Wage sample		Reservation. wage sample		Wage sample		Reservation wage sample	
Variables:	Mean	St. dev.	Mean	St. dev.	Mean	St. dev.	Mean	St. dev.
Reservation wage			5.226	6.206			1180.366	703.219
Wage	9.866	6.203			2387.666	1898.023		
Female	0.526	0.500	0.546	0.498	0.430	0.495	0.616	0.486
Age	38.106	11.691	34.666	14.024	39.039	11.644	33.289	11.316
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			276.414	318.201			255.835	448.710
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					38.495	12.680		
Number of observations	96,270		14,874		166,614		11,221	

Notes. Samples include employees aged 16-65 with non-missing wage information (wage sample), and unemployed jobseekers aged 18-65 with non-missing reservation wage information (reservation wage sample). Source: BHPS 1991-2009 and SOEP 1984-2010.

Table A2. Detailed results on wage and reservation wage equations for the UK and West Germany

	United Kingdom		West Germany	
	1	2	3	4
Dependent variable:	Log wage	Log res wage	Log wage	Log res wage
Log aggregate 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
	(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	0.018***	-0.002	0.037***	0.013**
(years)	(0.001)	(0.002)	(0.002)	(0.005)
Duration in current status ^{2}	-0.010***	-0.001	-0.012***	-0.014**
(years/10)	(0.001)	(0.002)	(0.001)	(0.006)
Duration in current status ^{3}	0.017***	0.003	0.002***	0.003**
(years/100)	(0.002)	(0.003)	(0.000)	(0.002)
Log(Unemp benefits + 1)		0.004**		0.004
		(0.001)		(0.003)
Receives housing benefits		0.017**		-0.075***
		(0.008)		(0.026)
Social insurance contributions (months)				0.005***
(years)				(0.001)
Looking for full-time work				0.151***
				(0.036)
Looking for part-time work				-0.507***
				(0.033)
Looking for any hours				-0.051*
				(0.031)
Log hours worked			0.912***	
			(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***
	(0.000)	(0.000)	(0.078)	(0.253)
Observations	96,270	14,847	166,614	11,221
R-squared	0.397	0.249	0.605	0.359

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

Table A3: Estimates of a Wage Equation for the UK, 1991-2009.
Further estimates with regional controls.

	Dependent variable: Log hourly wage									
	1	2	3	4	5	6	7	8	9	10
Log hourly wage, lagged										0.073
										(0.052)
Log regional unemployment rate	0.010	-0.009	-0.036*	-0.053***	-0.044**	-0.042***	-0.039**	-0.010		-0.058***
	(0.010)	(0.022)	(0.019)	(0.017)	(0.017)	(0.010)	(0.016)	(0.022)		(0.022)
Log regional unemployment rate * new job					-0.032***	-0.011**				
					(0.005)	(0.006)				
Log regional unemployment rate, at start of job							-0.084***			
							(0.015)			
Log regional unemployment rate, lagged								-0.060***	-0.065***	
								(0.017)	(0.013)	
Trend	no	linear	quadratic	quadratic	quadratic	quadratic	quadratic	quadratic	quadratic	quadratic
Year dummies	√									
Individual fixed effects				√	√		√	√	√	√
Job fixed effects						√				
Observations	96,269	96,269	96,269	92,380	92,380	77,854	91,712	92,380	92,380	53,054
R-squared	0.399	0.397	0.397	0.809	0.810	0.889	0.810	0.810	0.810	

Notes. See notes to Table A1 for sample. Estimation method: OLS in columns 1-8; Arellano Bond (1991) estimator for dynamic panel data models in column 10. All regressions include 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 eleven region dummies. Standard errors are clustered at the region*year level in column 1; at the year level in columns 2 and 3; and using 2-way cluster-robust variance (Cameron and Miller, 2013) in columns 4-10. Source: BHPS.

**Table A4: Estimates of a Wage Equation for West Germany, 1984-2010.
Further estimates with regional controls**

	Dependent variable: log monthly wage									
	1	2	3	4	5	6	7	8	9	10
Log monthly wage, lagged										0.390***
										(0.027)
Log regional unemployment rate	-0.033**	0.015	0.006	-0.008	-0.003	0.001	-0.009	0.049***		-0.004
	(0.016)	(0.026)	(0.023)	(0.015)	(0.014)	(0.011)	(0.015)	(0.016)		(0.016)
Log regional unemployment rate * new job					-0.039***	-0.011				
					(0.013)	(0.011)				
Log regional unemployment rate, at start of job							-0.013			
							(0.009)			
Log regional unemployment rate, lagged								-0.079***	-0.044***	
								(0.013)	(0.014)	
Trend	no	linear	quadratic	quadratic	quadratic	quadratic	quadratic	quadratic	quadratic	quadratic
Year dummies	√									
Individual fixed effects				√	√		√	√	√	√
Job fixed effects						√				
Observations	166,614	166,614	166,614	161,075	160,865	149,617	157,241	161,075	161,075	101,526
R-squared	0.652	0.649	0.651	0.414	0.415	0.199	0.422	0.415	0.415	

Notes. All regressions include 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, log hours worked and eleven region dummies. Estimates in column 10 are obtained using the Arellano Bond (1991) estimator for dynamic panel data models Standard errors are clustered at the region*year level in column 1; at the year level in columns 2 and 3; and using 2-way cluster-robust variance (Cameron and Miller, 2013) in columns 4-10. Source: SOEP.

Table A5: Estimates of a Reservation Wage Equation for the UK, 1991-2009. Further estimates with regional controls.

	Dependent variable: Log hourly reservation wage					
	1	2	3	4	5	6
Log regional unemployment rate	0.007	-0.047	-0.054*	-0.034	0.048	
	(0.025)	(0.031)	(0.028)	(0.030)	(0.037)	
Log regional unemployment rate, lagged					-0.106***	-0.078***
					(0.030)	(0.024)
Trend	no	linear	quadratic	quadratic	quadratic	quadratic
Year dummies	√					
Individual fixed-effects				√	√	√
Observations	14,873	14,873	14,873	10,774	10,774	10,774
R-squared	0.252	0.247	0.247	0.613	0.614	0.614

Notes. See notes to Table A1 for the sample used. Estimation method: OLS. All regressions also include 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, a dummy for receipt of housing benefits, and eleven region dummies. Standard errors are clustered at the year*region level in column 1, at the year level in columns 2 and 3, and using 2-way cluster-robust variance (Cameron and Miller, 2013) in columns 4-6. Source: BHPS.

Table A6: Estimates of a Reservation Wage Equation for West Germany. Further estimates with regional controls

	Dependent variable: Log monthly reservation wage					
	1	2	3	4	5	6
Log regional unemployment rate	-0.079*	0.028	0.018	0.034	0.116***	
	(0.043)	(0.044)	(0.028)	(0.023)	(0.029)	
Log regional unemployment rate, lagged					-0.113***	-0.031
					(0.032)	(0.023)
Trend	no	linear	quadratic	quadratic	quadratic	quadratic
Year dummies	√					
Individual fixed-effects				√	√	√
Observations	11,221	11,221	11,221	7,911	7,911	7,911
R-squared	0.421	0.413	0.418	0.124	0.125	0.123

Notes. See notes to Table A1 for the sample used. Estimation method: IV. All regressions also include 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, a dummy for receipt of housing benefits, controls for whether an individual looks for full-time, part-time or any job (the omitted category being "unsure about preferences"), months of social insurance contributions and eleven region dummies. Unemployment benefits are instrumented, see notes to Table 5. Standard errors are clustered at the year) level in columns 1-3, and using 2-way cluster-robust variance (Cameron and Miller, 2013) in columns 4-6. Source: SOEP.

Appendix D: Alternative models for the reservation wage

D.1 *The reservation wage with on-the-job search*

Our baseline model assumes that only the unemployed search for jobs, while a fraction close to half of new jobs are taken by workers currently employed (Manning, 2003). This subsection considers how the reservation wage is altered when both the unemployed and the employed search for jobs. The analysis is conditional on expected wages, without need to specify the process for wage determination.

For simplicity, we assume that the economy is in steady-state, so wages and job offer arrival rates for employed and unemployed jobseekers are constant, and they will be denoted by λ^e and λ^u, respectively. The corresponding value functions are given by:

$$rW(w) = w - s\left[W(w) - U\right] + \lambda^e \int_w \left[W(x) - W(w)\right] dF(x) \tag{74}$$

and

$$rU = z + \lambda^u \int_\rho \left[W(x) - U\right] dF(w), \tag{75}$$

respectively. The reservation wage satisfies $W(\rho) = U$, and can be expressed as:

$$\rho = z + \left(\lambda^u - \lambda^e\right) \int_\rho \left[W(w) - U\right] dF(w) = z + \left(\lambda^u - \lambda^e\right) \int_\rho \frac{1 - F(w)}{r + s + \lambda^e\left[1 - F(w)\right]} dw, \tag{76}$$

where the second equality follows from integration by parts, given $W'(w) = \left\{r + s + \lambda^e\left[1 - F(w)\right]\right\}^{-1}$. The possibility of search on-the-job implies that the distribution of wages across workers, $G(w)$ differs from the distribution of wage offers $F(w)$ and it can be shown (see Burdett and Mortensen, 1998) that the two are related by:

$$1 - G(w) \;=\; \left(s + \lambda^e\right) \frac{1 - F(w)}{s + \lambda^e\left[1 - F(w)\right]}, \tag{77}$$

having imposed $F(\rho) = 0$ as no firm chooses to offer a wage below the reservation wage in equilibrium. Using (67) and the approximation $r \approx 0$, (76) can be written as:

$$\rho \approx z + \frac{\lambda^u - \lambda^e}{s + \lambda^e} \int_\rho \left[1 - G(w)\right] dw = z + \frac{\lambda^u - \lambda^e}{s + \lambda^e}\left(w_a - \rho\right). \tag{78}$$

Re-arranging gives:

$$\rho \approx \frac{\left(s + \lambda^e\right) z + \left(\lambda^u - \lambda^e\right) \overline{w}}{s + \lambda^u}. \tag{79}$$

Unemployment is given by $u = s/(s+\lambda^u)$, and substituting this in (79) gives

$$\rho \approx z + (1-u)\left(1 - \frac{\lambda^e}{\lambda^u}\right)(w_a - z), \tag{80}$$

where w_a denotes the average wage. Equation (17) is a special case of (80) for $\lambda^e = 0$.

According to (80), reservation wages are acyclical whenever the job arrival rates for employed and unemployed workers are equal, $\lambda^e = \lambda^u$, as in this case the reservation wage equals the flow of unemployment income, $\rho = z$ (Burdett and Mortensen, 1998). Intuitively, taking or leaving a job offer has no consequences for future job opportunities when arrival rates are independent of one's employment status, and the optimal search strategy consists in accepting the first offer that provides a higher flow utility than that enjoyed while unemployed. If z is not cyclical, neither is the reservation wage.

While this seems an attractive path to reduce the cyclicality of reservation wages, it has the less desirable consequence that the reservation wage is independent of factors that influence the distribution of wages. This prediction is strongly rejected by the data, as high-wage workers tend to have relatively higher reservation wages. Detailed results reported in Table A2 show that gender, age and education affect wages and reservation wages in the same direction, thus the reservation wage is positively related to the wage that workers expect to earn. Taken to (80), this result implies that off-the-job search is more effective than on-the-job search, a conclusion that is also in line with structural estimates of labour market transition rates.

In general, using (80), the reservation wage embodies the cyclicality in wages, plus a further cyclical component represented by $(1-u)(1-\lambda^e/\lambda^u)$. The term $1-u$ is clearly pro-cyclical. To determine the cyclicality of cyclicality of the term in λ^e/λ^u, we show that this ratio is positively related to the fraction of new jobs filled by previously employed workers, which can be directly measured on data on labour market transitions. The two measures are related as the more effective on-the-job search, the higher the fraction of jobs that are filled by someone already employed.

To see this, denote by f the position of a firm in the wage offer distribution. The fraction of workers employed in firms at or below position f satisfies:

$$\left[s + \lambda^e(1-f)\right]G(f)(1-u) = \lambda^u uf, \tag{81}$$

which simply equates flows into and out of firms paying f or below. Re-arranging and using $u = s/(s+\lambda^u)$ gives:

$$G(f) = \frac{sf}{s+\lambda^e(1-f)}. \tag{82}$$

Total recruits to a firm at position f, $R(f)$, are given by:

$$R(f) = \lambda^u u + \lambda^e(1-u)G(f) = \frac{s\lambda^u}{s+\lambda^u}\ \frac{s+\lambda^e}{s+\lambda^e(1-f)} \tag{83}$$

and total recruits in the economy are given by:

$$R = \int_0^1 R(f)df = \frac{s\lambda^u}{s+\lambda^u}\ \frac{s+\lambda^e}{s+\lambda^e(1-f)} = \frac{s\lambda^u}{s+\lambda^u}\frac{s+\lambda^e}{\lambda^e}\ln\left(\frac{s+\lambda^e}{s}\right). \tag{84}$$

As the total recruits from unemployment are given by λ^u / u, this implies that the fraction of recruits from employment, which we will denote by ζ, is given by:

$$\zeta = 1 - \frac{\lambda^e}{(s+\lambda^e)\ln\left(\frac{s+\lambda^e}{s}\right)} = \frac{\lambda^e / \lambda^u}{\left(\frac{u}{1-u}+\frac{\lambda^e}{\lambda^u}\right)\ln\left(1+\frac{\lambda^e}{\lambda^u}\frac{1-u}{u}\right)}. \tag{85}$$

We obtain evidence on ζ from the UK Quarterly LFS, looking at the previous quarter's employment status of newly-hired workers.[21] During 1993-2012, this fraction is on average 60.1%. Regressing ζ on the unemployment rate show that ζ is pro-cyclical, with a slope coefficient on unemployment of approximately 1 (see results reported in Table C1 below). Using (85), an average unemployment rate in the UK over 1993-2012 of 6.8% and an average ζ of 60.1% implies $\lambda^e / \lambda^u = 0.612$. Based on (80), the result $0 < \lambda^e / \lambda^u < 1$ would make reservation wages less cyclical than in the case with $\lambda^e = 0$, while the cyclicality of λ^e / λ^u would make reservation wages more cyclical.

To resolve this ambiguity, note that (85) implies an inverse relationship between ζ and unemployment even if λ^e / λ^u does not vary with the cycle. But the strength of the relationship between ζ and u shown in Table D1 is weaker than we would expect from (85) if λ^e / λ^u were acyclical. This implies that, as u rises, so does λ^e / λ^u. The estimates in Table D1 imply $\lambda^e / \lambda^u = 0.726$ for $u = 0.01$ and $\lambda^e / \lambda^u = 0.443$ for $u = 0.04$. According to (80), this mechanisms acts to make the reservation wage even more sensitive to the unemployment rate.

[21] We do not adjust this statistic for time aggregation, so it may be possible that a worker in employment this quarter and 3 quarters ago has had an intervening period of non-employment. Given the outflow rates from unemployment in the UK this makes little difference to the computations.

Table D1
The Cyclicality in the Fraction of New Hires from Previously Jobs

	Dependent variable: Fraction of new hires from previous jobs			
Unemployment rate	-1.51**	-1.91**	-1.02	-0.97
	(0.065)	(0.076)	(0.081)	(0.195)
Region effects	No	yes	No	yes
Year effects	No	no	Yes	yes
R squared	0.57	0.69	0.67	0.75
No. observations	416	416	416	416

Notes: Each observation is a region-year cell, and all regressions are weighted by cell size. Cells based on less than 50 observations are omitted. Sample period: 1993-2012. Source: UK LFS.

D2. *The reservation wage with hyperbolic discounting*

The models so far considered have assumed that individuals have rational expectations and time-consistent preferences, but a growing body of evidence casts doubt on both these assumptions. In the area of job search, Spinnewijn (2015) argues that the unemployed tend to be overoptimistic about their job prospects, and Della Vigna and Paserman (2005) and Paserman (2008) show that hyperbolic discounting has large effects on search intensity but very small effects on the reservation wage. They do not investigate the implication of hyperbolic discounting for the cyclicality of reservation wages, but the analysis below shows that hyperbolic discounting is not likely to have important consequences for the cyclicality of the reservation wage.

To stay close to our benchmark framework, we use the continuous time version of hyperbolic discounting developed by Harris and Laibson (2013). Consider the arrival rate of a shock – here denoted by δ – which turns one into a person (the future self) who cares less about the future than one's current self. The weight attached to the future self is denoted by ψ and the expectation is that the future self is an exponential discounter. The value function for being employed (6) is now modified to:

$$rW\left(w\right)=w-s\left[W\left(w\right)-U\right]+\delta\left[\psi\tilde{W}\left(w\right)-W\left(w\right)\right], \tag{86}$$

where $\tilde{W}(w)$ is the value of being employed for the future non-hyperbolic self, given by (6):

$$r\tilde{W}\left(w\right)=w-s\left[\tilde{W}\left(w\right)-\tilde{U}\right]. \tag{87}$$

The value function for the unemployed can similarly be written as:

$$rU=z+\lambda\left(W-U\right)+\delta\left(\psi\tilde{U}-U\right), \tag{88}$$

where $\tilde{U}$ is given by (8). Thus:

$$\tilde{W}-\tilde{U}=\frac{w-z}{r+s+\lambda} \tag{89}$$

and:

$$r\tilde{U}=z+\frac{\lambda(w-z)}{r+s+\lambda}. \tag{90}$$

From (86) and (88) one can then derive:

$$W-U=\frac{(w-z)+\delta\psi\left(\tilde{W}-\tilde{U}\right)}{r+s+\lambda+\delta}. \tag{91}$$

Using (91), (88) and (89) one can, after some re-arrangement, derive:

$$rU=\frac{r+\delta\psi}{r+\delta}z+\frac{\lambda(w-z)\left[r(r+s+\lambda+\delta\psi)+\delta\psi(r+s+\lambda+\delta)\right]}{(r+s+\lambda)(r+s+\lambda+\delta)(r+\delta)}. \tag{92}$$

The reservation wage, ρ, must satisfy $W(\rho)=U$. Using (86), this implies:

$$rU=\rho+\delta\left[\psi\tilde{W}(\rho)-U\right]. \tag{93}$$

Using (87) we obtain:

$$\tilde{W}(\rho)=\frac{\rho+s\tilde{U}}{r+s}. \tag{94}$$

Combining (93) and (94) leads to the following expression for the reservation wage:

$$\rho=\frac{(r+s)(r+\delta)U-\delta\psi s\tilde{U}}{r+s+\lambda+\delta\psi}.$$

Substituting this into (92) and (90) and re-arranging leads to the following expression:

$$\rho= z+\frac{\lambda(w-z)}{r+s+\lambda}\left(\frac{r+s}{r+s+\lambda+\delta}+\frac{\delta\psi}{r+s+\lambda+\delta\psi}\right) \le z+\frac{\lambda(w-z)}{r+s+\lambda}.$$

The inequality shows that hyperbolic discounting (δ) lowers the reservation wage, and it reduces the weight on the wage in the determination of the reservation wage. Both results are intuitive as hyperbolic discounting makes an individual more present-oriented. The reduced weight on the wage makes the reservation wage less sensitive to the unemployment rate, but at the same time makes wages and reservation wages less strongly correlated. In the calibration of Harris and Laibson (2012), $\delta=2/3$ (at the annual level) and $\psi\geq 12$. In this case the reservation wage is very close to z, clearly making it insensitive to unemployment, but at the cost of making it insensitive to the expected wage, while Table A2 shows that wages and reservation wages respond in very similar ways to most covariates considered.