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 larger short-run impact on unemployment rather than wages, at odds with the quantitative predictions of the canonical search model – even if wages are only occasionally renegotiated. We argue that one source of the wage flexibility puzzles is plausibly the model for the determination of reservation wages, and consider an alternative reservation wage model based on reference dependence in job search. This extension generates less cyclical reservation wages than the canonical model, as long as reference points are less cyclical than forward-looking components of reservation wages such as the arrival rate of job offers. 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 markedly reduces the predicted cyclicality of both wages and reservation wages and can reconcile theoretical predictions of the canonical model with the observed cyclicality of wages and reservation wages.

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1. Introduction

Empirical evidence suggests that real wages are only mildly pro-cyclical. For example, Blanchflower and Oswald (1994) conclude that, once the composition of the unemployment pool is controlled for,[1] the elasticity of wages with respect to the unemployment rate is -0.1. Although this estimate should not be thought of as a universal constant (see, for example, the review by Card, 1995), most existing estimates are not too far from this benchmark, and the meta-analysis of Nijkamp and Poot (2005) reports a mean estimated elasticity of -0.07. This modest pro-cyclicality in wages implies that shocks to labour demand have a larger short-run impact on unemployment rather than wages.

In recent years most business cycle analysis of labour markets has adopted the currently dominant model of equilibrium unemployment – the search and matching framework developed by Diamond, Mortensen and Pissarides (see, Pissarides, 2000, for an overview). This framework offers undoubtedly valuable insight in interpreting labour market dynamics, but the quantitative predictions of the specific models used have difficulty in matching relatively mild wage cyclicality and large unemployment fluctuations (see Shimer, 2005, and Rogerson and Shimer, 2011, for an overview).

In this paper, we first present an alternative perspective on the wage flexibility puzzle. We use a conventional search and matching framework to derive a relationship between wages and unemployment that, under plausible assumptions, is not shifted by demand shocks. Demand shocks – independent of their source or magnitude – are associated with movements along this curve, and the elasticity of the 'wage curve' derived determines the relative volatility of wages and unemployment over the business cycle. This 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 use the obtained wage curve to show that the model can only replicate the modest observed cyclicality in wages if replacement ratios are extremely high (see also Hagedorn and Manovskii, 2008). This problem is most severe in the version of the canonical model with continual wage re-negotiation. However, we also consider the cases in which wages are only infrequently re-negotiated, implying higher wage cyclicality on new, rather than continuing, matches (Hall, 2005, Pissarides, 2009, and Haefke, Sonntag and Rens, 2008), and in which there is some backward-looking component in wages (Hall, 2005, Hall and Milgrom, 2008, Gertler and Trigari, 2009; Gertler, Sala and Trigari,

[1] Failure to control for the characteristics of the unemployed typically makes wages appear even less cyclical because unemployment in recessions tends to fall most heavily on less-skilled workers, making the skill composition of employment mildly counter-cyclical.

2008, Shimer 2010, 2013, Rogerson and Shimer, 2011, Michaillat, 2012). We find that these elements only address the wage flexibility puzzle if unemployment persistence is implausibly low.

Secondly, we derive predictions for the cyclicality in workers' reservation wages. We show that the canonical model predicts that reservation wages should be more cyclical than wages in new or continuing jobs. The intuition is that the determination of the reservation wage encompasses both the cyclicality in the expected wage offer and, conditional on this, an extra cyclicality component directly driven by unemployment fluctuations. That is, in a recession the reservation wage falls because workers face both a lower expected wage offer and a lower probability of receiving an offer.

In our empirical analysis 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 information on (self-reported) reservation wages, which cover at least one full business cycle. In recent years, rich longitudinal data on job search behaviour in the US, collected and analysed by Krueger and Mueller (2011, 2012, 2016), have greatly added to knowledge on reservation wage determination, but these data cover too short a time span to investigate their cyclicality. This paper contributes to the empirics of reservation wages by exploring their cyclical properties.

Our baseline estimates for the elasticity of wages and reservation wages to aggregate unemployment are about -0.17 and -0.16, respectively, for the UK, and we obtain markedly lower elasticities for West Germany, which are only borderline significant. These estimates highlight two flaws in the quantitative predictions of the canonical model. First, wages, whether in new or continuing jobs, are not as cyclical as the theory predicts for plausible parameter values – and this is the essence of the wage flexibility puzzle. Second, reservation wages are not more cyclical than wages.

We explore the origin of these puzzles by decomposing wage determination into two steps. The first step stems from wage bargaining and relates the bargained wage to the reservation wage and the mark-up of wages over outside options. The second step is derived from the behaviour of the unemployed, and relates the reservation wage to current and expected future unemployment. To raise the wage elasticity relative to the reservation wage elasticity, one could introduce a procyclical wage mark-up. However, this would worsen the wage flexibility puzzle. Thus we do not further pursue changes to the wage determination model and explore instead changes to the model of determination of reservation wages, so as to reduce their cyclicality.

We consider an extension of the canonical search model with search-on-the job, as well as behavioural search models based on present-biased preferences and reference-dependent preferences, respectively. We show that allowing for search on-the-job or hyperbolic discounting in an otherwise canonical search model would not improve model predictions on cyclicality without worsening predictions in other important dimensions. A more promising route consists instead in introducing reference-dependent behaviour in the determination of reservation wages. As long as reference points are less cyclical than forward-looking components of reservation wages such as the arrival rate of job offers, the presence of reference dependence in job search generates less cyclical reservation wages that the canonical search model.

Reference-dependent preferences have attracted increasing attention in economic behaviour in general and labour supply modelling in particular (see – among others – Della Vigna, 2009, Falk, Fehr and Zehnder, 2006, and Farber, 2008), with the aim of explaining observed deviations from the standard neoclassical model of individual decision making. The central idea is one of loss aversion relative to some reference status (Tversky and Kahneman, 1991), whereby utility is more sensitive to losses rather than gains around one's reference point. Reference points may be determined by both past personal experiences and peer influences (Akerlof, 1980; Akerlof and Yellen, 1990; Blanchard and Katz, 1999), and are plausibly less cyclical than forward-looking labour market variables.

We bring these ideas to the job-search context, allowing reservation wages to respond to an individual's past work experience, as proxied by rents enjoyed in previously held jobs. Absent wealth effects (which we show to be negligible in our working sample of unemployed jobseekers) past rents would not affect reservation wages if jobseekers are forward looking, but would in fact influence job search behaviour if they represent a significant reference point for wage aspirations. By exploiting the long panel dimension of the UK BHPS, we provide evidence that reservation wages significantly respond to rents earned in previous jobs, and this effect is robust to controls for individual unobservables. 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 for plausible parameter values. While backward-looking elements of wage setting hardly have an impact on the predicted cyclicality of wages, we show that plausible backward-looking components in reservation wages can reconcile theoretical predictions of the search and matching framework with the observed cyclicality of both wages and reservation wages.

The paper is organized as follows. Section 2 lays out a search and matching model with infrequent wage negotiations and a backward looking component in wages, and Section 3 derives theoretical predictions for the cyclicality of newly-negotiated wages, wages in new jobs, average wages and reservation wages. Section 4 presents estimates of wage and reservation wage curves for the U.K. and West Germany, highlighting that the estimated cyclicalities of both wages and reservation wages are lower than their theoretical predictions. Section 5 proposes alternatives models for the determination of reservation wages and provides evidence on reference dependence and backward-looking behaviour in job search. Section 6 concludes.

2. The model

This section lays out a canonical search and matching model to derive implications for the cyclicality of wages. Our set-up encompasses elements previously highlighted by work on wage cyclicality, and namely it allows for higher wage cyclicality in new than continuing jobs (see, among others, Pissarides, 2009) and for a backward-looking component to wages (see, for example, Gertler and Trigari, 2009). As both elements only have consequences for wage cyclicality out of steady-state, we allow the economic environment to change over time. 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 wage renegotiation and without any backward-looking component in wages. As shown below, wages in this special case are predicted to be more strongly cyclical than in the general case, as both infrequent renegotiations and a backward looking component in wages act to curb their procyclicality. Both additions introduced here give the search and matching model a better chance to match wage and unemployment fluctuations at the business cycle frequency.

A. *Employers*

Each firm has one job, which can be either filled and producing or vacant and searching. If a worker and firm are matched, 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. We assume throughout that all old wages generate some surplus to both parties. This is the case if there is sufficient surplus-sharing in steady-state and the deviations from steady-state are small enough. The extent of job creation at old wages (represented by α) is the source of the backward-looking component in wage determination.

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

$$rV(t) = -c(t) + q(t) E_t \left[J(t; w(t)) - V(t) - C(t) \right] + E_t \frac{\partial V(t)}{\partial t}, \tag{1}$$

where $J(t;w)$ is the value of a filled job at time t, paying a wage w. 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.[2] Finally, $q(t)$ is the rate at which vacancies are filled at time t. This rate varies over time via the impact of shocks on labour market tightness.

The first expectation term in (1) captures uncertainty about the wage in future matches, whether it will be newly-negotiated or drawn instead from the existing wage distribution. As the value functions are linear in wages, the expectations term can be replaced by averages:

$$rV(t) = -c(t) + q(t)\left[\alpha J(t; w_r(t)) + (1-\alpha) J(t; w_a(t)) - V(t) - C(t) \right] + E_t \frac{\partial V(t)}{\partial t}, \tag{2}$$

where $w_r(t)$ denotes a newly-negotiated wage and $w_a(t)$ denotes the average wage in the existing distribution.

Consider next the value of a filled job that currently pays a wage w. Wages are occasionally renegotiated, and renegotiation opportunities arrive at an exogenous rate ϕ,[3] 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

[2] This could be relaxed, but would require more notation for little extra insight.
[3] 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.

match is renegotiated, we assume that 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 wage $w_r(t)$. Using this, the value of a filled job that pays a wage w at time t is given by:

$$rJ(t;w) = p(t) - w - s\left[J(t;w) - V(t)\right] + \phi\left[J(t;w_r(t)) - J(t;w)\right] + E_t\frac{\partial J(t;w)}{\partial t}, \quad (3)$$

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

Free entry of vacancies ensures $V(t)=0$, so that (2) can be re-arranged to give:

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

i.e. the expected value of a newly-filled job equals the expected cost of filling a vacancy. Expression (3) implies $\partial J(t;w)/\partial w = 1/(r+\phi+s)$, so (4) can be rewritten as:

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

B. *Workers*

Workers can be either unemployed and searching or employed and producing. The value of being unemployed at time t is given by:

$$rU(t) = z + \lambda(t)\left[\alpha W(t;w_r(t)) + (1-\alpha)W(t;w_a(t)) - U(t)\right] + E_t\frac{\partial U(t)}{\partial t}, \quad (6)$$

where z is the flow utility when unemployed, assumed to be fixed in the short-run,[4] $W(t;w)$ is the value at t of a job that paying wage w, and $\lambda(t)$ is the rate at which the unemployed

[4] Chodorow-Reich and Karabarbounis (2013) 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 explain the wage flexibility puzzle.

find jobs, which varies over time with labour market tightness. In (6) we have again exploited the linearity of value functions in wages to replace wage expectations with their average.

The value of being employed at a wage w is given by:

$$rW(t;w) = w + \phi\left[W(t;w_r(t)) - W(t;w)\right] - s\left[W(t;w) - U(t)\right] + E_t \frac{\partial W(t;w)}{\partial t}, \qquad (7)$$

implying 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:

$$W(\tau;\tilde{w}) = W(\tau;w) + \frac{\tilde{w} - w}{r + \phi + s}. \qquad (8)$$

Combining workers' value functions (6) and (7) yields the following differential equation for the match surplus $S(t;w) \equiv W(t;w) - U(t)$:

$$\begin{aligned} rS(t;w) = w - z - (s+\phi)S(t;w) + (\phi - \alpha\lambda(t))S(t;w_r) \\ -(1-\alpha)\lambda(t)S(t;w_a) + E_t \frac{\partial S(t;w)}{\partial t}, \end{aligned} \qquad (9)$$

with solution:

$$\begin{aligned} S(t;w) &= \frac{w-z}{r+\phi+s} \\ &+ \frac{1}{r+\phi+s} E_t \int_t^\infty e^{-\int_t^\tau (r+\lambda(x)+s)dx} \left[(\phi - \alpha\lambda(\tau))(w_r(\tau) - z) - (1-\alpha)\lambda(\tau)(w_a(\tau) - z)\right] d\tau. \end{aligned} \qquad (10)$$

C. *Wage determination.*

The Nash rent-sharing condition implies that a wage negotiated at time t, $w_r(t)$, is set to maximize:

$$\left[W(t;w) - U(t)\right]^\beta \left[J(t;w) - V(t)\right]^{1-\beta}, \qquad (11)$$

where β denotes workers' relative bargaining power. This implies

$$(1-\beta)\frac{\partial J(t;w)}{\partial w}\left[W(t;w_r(t)) - U(t)\right] + \beta \frac{\partial W(t;w)}{\partial w}\left[J(t;w_r(t)) - V(t)\right] = 0. \qquad (12)$$

Value functions (3) and (7) imply $\partial W(t;w)/\partial w = -\partial J(t;w)/\partial w$, so that (12) can be rewritten, using (4), as:

$$S\left(t;w_r(t)\right) = \tilde{\beta}\left[\mu(t) - \frac{(1-\alpha)\left(w_a(t) - w_r(t)\right)}{r+\phi+s}\right], \tag{13}$$

where $\tilde{\beta} \equiv \beta/(1-\beta)$ and $\mu(t) \equiv c(t)/q(t) + C(t)$. According to expression (4), $\mu(t)$ denotes the excess job value over outside options, and is thus related to the mark-up of wages over outside options. The term in $\left(w_a(t) - w_r(t)\right)$ 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 (13) with (10) evaluated at $w_r(t)$ implies that current wages are affected by expected future wages – both average and newly-negotiated – and future labour market conditions. Similarly, expected future average wages are influenced by past labour market history.

D. *The reservation wage*

Let $\rho(t)$ denote the reservation wage at time t, which satisfies $S\left(t;\rho(t)\right) = 0$. Using (8) we can rewrite (13) as:

$$w_r(t) = \rho(t) + \tilde{\beta}(r+\phi+s)\mu(t) - \tilde{\beta}(1-\alpha)\left[w_a(t) - w_r(t)\right]. \tag{14}$$

Using (10), the reservation wage must satisfy:

$$\rho(t) = z + E_t \int_t^\infty e^{-\int_t^\tau (r+\lambda(x)+s)dx}\left[\left(\alpha\lambda(\tau)-\phi\right)\left(w_r(\tau)-z\right) + (1-\alpha)\lambda(\tau)\left(w_a(\tau)-z\right)\right]d\tau, \tag{15}$$

and is thus a function of future expected wages and labour market conditions.

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

$$\rho = \frac{sz + \lambda w}{(\lambda+s)} = uz + (1-u)w, \tag{16}$$

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.

For future use, it is helpful to differentiate (15) with respect to time, which leads to:

$$\left(r+\lambda(t)+s\right)\left(\rho(t)-z\right)=E_t\frac{d\rho(t)}{dt}+\left[\left(\alpha\lambda(t)-\phi\right)\left(w_r(t)-z\right)+(1-\alpha)\lambda(t)\left(w_a(t)-z\right)\right]. \quad (17)$$

E. *The dynamics of wages*

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

$$\frac{dw_a}{dt}=\frac{\lambda(t)u(t)}{1-u(t)}\alpha\left(w_r-w_a\right)+\phi\left(w_r-w_a\right)=\left[\frac{\alpha\lambda(t)u(t)}{1-u(t)}+\phi\right]\left(w_r-w_a\right), \quad (18)$$

where $u(t)$ is the unemployment rate at time t. The first term in (18) reflects wage changes from the inflow of new jobs (equal to 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 (18) implies that the average wage rises whenever newly-renegotiated wages are higher than average wages.

The endogenous variables in the model are the newly-renegotiated wage, $w_r(t)$, the average wage, $w_a(t)$, and the reservation wage, $\rho(t)$. Their equilibrium values are obtained from equations (14), (17) and (18), as a function of labour market conditions, $\lambda(t)$, which we treat as exogenous. Shocks only affect wages and reservation wages via $\lambda(t)$, and further structure on their nature 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. Predictions are based on the assumption that variation in unemployment is driven by changes in job finding (λ), while job separations (s) are held constant. We start with a comparison of steady-states, before considering the more 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. Using (15), the steady-state reservation wage must satisfy:

$$\rho = z + \frac{\lambda - \phi}{r + \lambda + s}(w - z). \tag{19}$$

Substituting (19) into (14) and re-arranging leads to the steady-state wage equation:

$$w = z + \tilde{\beta}(r + \lambda + s)\mu. \tag{20}$$

Expression (20) illustrates 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. Secondly, the mark-up μ may be pro-cyclical. Using (13), this happens, first, if there is a flow element to the cost of filling vacancies ($c > 0$), which rises 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 the mark-up is pro-cyclical, in turn accentuating the pro-cyclicality in wages. As one of the aims of this paper is to show why it is hard for this type of model to generate the modest observed level of wage cyclicality, we assume in what follows that the mark-up is 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.[5] These assumptions imply constant μ.

Given steady-state unemployment, $u = s/(s + \lambda)$, condition (20) yields a wage curve relating wages to unemployment:

$$w = z + \tilde{\beta}\mu\left(r + \frac{s}{u}\right). \tag{21}$$

[5] 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.

This wage curve is conceptually akin to a labour supply curve in a competitive model, in the sense that demand shocks do not feature in the curve, but drive movements along it. The slope of (21) 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.[6]

Differentiating (21) gives the elasticity of wages with respect to the unemployment rate across steady-states:

$$\frac{\partial \ln w}{\partial \ln u} = -\frac{\beta\mu}{1-\beta}\frac{s}{wu} = -\frac{w-z}{w}\frac{s}{ru+s} = -(1-\eta)\frac{s}{ru+s}, \tag{22}$$

where $\eta \equiv z/w$ is the replacement ratio. Because s is substantially larger than ru for conventional values of the interest rate,[7] 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 estimate for such elasticity of -0.1, expression (23) requires a replacement ratio of 0.9, a value too high to be plausible, and implying an excessive sensitivity of unemployment to changes in the generosity of unemployment insurance (Costain and Reiter, 2008). Unless the replacement ratio is assumed to be extremely high,[8] the canonical model would fail to fit the data well.

While a replacement ratio of 0.9 is arguably implausible, it is not straightforward to obtain estimates of flow utility during unemployment, encompassing unemployment compensation and the utility of leisure while unemployed, net of job search costs. The OECD Benefits and Wages Statistics (http://www.oecd.org/els/benefitsandwagesstatistics.htm) show 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 West Germany was 0.42 and 0.63, respectively. These estimates do not assign a value to the increase in leisure time for the unemployed, and there is considerable dispute about the size and even sign of this component. For example,

[6] 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 the wage, though causation may run from the latter to the former.

[7] It may be argued that the unemployed have limited access to credit so that the relevant interest rate for them is the one offered by payday lenders, which in the UK is currently a monthly rate of 36%. This rate of interest could explain why wages are not very responsive to unemployment but, as we discuss later in the paper, would fail to explain why reservation wages are strongly correlated with expected wages.

[8] For example, by assuming that z is close to p, or that worker's bargaining power is very small.

empirical work on the determinants of individual well-being has identified a strong detrimental impact of unemployment on subjective well-being, even conditional on household income (see, among others, Winkelmann and Winkelmann, 1998; Clark, 2003; Kassenboehmer Haisken-DeNew, 2009; Krueger and Mueller, 2012). This evidence points at large non-pecuniary effects of unemployment, and implies that benefit-to-income ratios would provide a rather generous upper bound for true replacement ratios.

We cut through these debates by using information on reservation wages and expected wages upon reemployment, contained in the BHPS, from which we obtain a direct estimate of ρ / w. Using (19), ρ / w is related to the replacement ratio according to:

$$1-\frac{\rho}{w}=(1-\eta)\frac{r+\phi+s}{r+\lambda+s}. \tag{24}$$

In the BHPS, reservation wages are on average 20% lower than expected reemployment wages, i.e. $\rho / w = 0.8$. As the duration of a wage contract $(1/\phi)$ is typically longer than the duration of a spell of unemployment $(1/\lambda)$, (24) implies an upper bound for the replacement ratio of 0.8. And for realistic values of λ and ϕ, the replacement ratio is considerably lower.

We next turn to the cyclicality of the reservation wage. From (14):

$$\frac{\partial \ln \rho}{\partial \ln u}=\frac{w}{\rho}\frac{\partial \ln w}{\partial \ln u}<\frac{\partial \ln w}{\partial \ln u}, \tag{25}$$

i.e. reservation wages are more strongly cyclical than wages, and the ratio between the respective elasticities is given by $\rho / w = 0.8$. Thus reservation wages are expected to be about 20% more cyclical than wages. Intuition for the excess cyclicality of reservation wages can be gauged from the special case $r=\phi=0$, represented by equation (16). In this case the reservation wage has a cyclical component driven by the cyclicality of wages, and an extra cyclical component that derives directly from the unemployment rate.

B. *Continuous wage re-negotiation*

We relax the assumption of steady state, and consider first a special case with continuous wage renegotiation (i.e. $\phi=\infty$). In this case, equation (18) implies that newly-negotiated wages and average wages are equal, and expression (10) can be written as:

$$S\left(t;w_r\left(t\right)\right)=E_t\int_t^{\infty}e^{-\int_t^{\tau}\left(r+\lambda(x)+s\right)dx}\left(w_r\left(\tau\right)-z\right)d\tau. \qquad (26)$$

Differentiating (26) gives:

$$\frac{dS\left(t;w_r\left(t\right)\right)}{dt}=-\left(w_r\left(\tau\right)-z\right)+\left(r+\lambda\left(t\right)+s\right)S\left(t;w_r\left(t\right)\right). \qquad (27)$$

With continuous renegotiation, equation (13) implies a constant surplus, $S\left(t;w_r\left(t\right)\right)=\tilde{\beta}\mu$. Substituting this in (27) and re-arranging yields the same wage equation as in the steady state, (21), thus this version of the model clearly has the same difficulty as the steady-state model in fitting the empirical evidence on the cyclicality of wages.

However, predictions about the level of reservation wages are different. When $\phi\to\infty$, expression (15) implies $\rho\to-\infty$, i.e. workers would accept a job at any wage because, with continuous renegotiation, they expect any accepted wage to be immediately revised.

C. *Occasional wage re-negotiation*

We next relax the assumption of continuous renegotiation. Workers (reasonably) expect that their accepted wages would persist for a non-zero length of time ($\phi<\infty$), and thus need to form expectations about the dynamics of labour market conditions, as the reservation wage is forward-looking according to (17). We make the simplest assumption that the expected path of $\lambda\left(t\right)$ follows the continuous time version of an AR(1) process:

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

where * denotes steady-state values and ξ represents the rate of convergence to steady state, whereby lower ξ implies higher persistence.

The model is non-linear in $\lambda\left(t\right)$, and we linearize it around its steady-state solution, and then derive wage responses to deviations of $\lambda\left(t\right)$ 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: If the mark-up is acyclical and $\phi < \infty$:

(a) The cyclicality of *newly-negotiated wages* is

$$\frac{\partial \ln w_r(t)}{\partial \ln u(t)} = -\frac{(1-\eta^*)(r+\phi+s)(\lambda+s+\xi)(\alpha s+\phi+\xi)}{(r+\lambda+s)\left\{(\alpha s+\phi+\xi)(r+\phi+s+\xi)-(1-\alpha)\xi\left[\tilde{\beta}(r+\lambda+s+\xi)-\lambda\right]\right\}} \quad (29)$$

(b) The cyclicality of *reservation wages* is:

$$\frac{\partial \ln \rho(t)}{\partial \ln u(t)} = \frac{r+\lambda+s}{\lambda-\phi+(r+\phi+s)\eta}\left[1-\frac{\tilde{\beta}(1-\alpha)\xi}{\alpha s+\phi+\xi}\right]\frac{\partial \ln w_r(t)}{\partial \ln u(t)} \quad (30)$$

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

$$\frac{\partial \ln w_a(t)}{\partial \ln u(t)} = \frac{\alpha s+\phi}{\alpha s+\phi+\xi}\frac{\partial \ln w_r(t)}{\partial \ln u(t)} \quad (31)$$

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

$$\frac{\partial \ln w_n(t)}{\partial \ln u(t)} = \frac{\alpha s+\phi+\alpha\xi}{\alpha s+\phi+\xi}\frac{\partial \ln w_r(t)}{\partial \ln u(t)} = \frac{\alpha s+\phi+\alpha\xi}{\alpha s+\phi}\frac{\partial \ln w_a(t)}{\partial \ln u(t)} \quad (32)$$

Proof: See Appendix B, where we allow for the general case of (pro)cyclical $\mu(t)$.

Results (29)-(32) provide insight on how and to what extent infrequent wage renegotiations and a backward looking component in wages may help reconcile theoretical predictions with the modest cyclicality in observed wages.

It has been argued that it is the cyclicality of wages on new hires that matters for the cyclical behaviour of unemployment and vacancies, (Hall, 2005, Pissarides, 2009, Haefke, Sonntag and Rens, 2008), and that wages on new hires are more cyclical than wages on existing jobs (see e.g. Devereux and Hart, 2001). Expression (32) delivers this result, and implies that 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). In particular, when unemployment is highly persistent, wages in new and continuing jobs tend to display similar degrees of cyclicality, independent of any backward-looking component in wages or the length of labour contracts. In this case, 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 $\xi \to 0$, renegotiated wages, average wages and wages in new jobs are equally cyclical, and (29)-(32) imply:

$$\frac{\partial \ln w_n(t)}{\partial \ln u(t)} = \frac{\partial \ln w_a(t)}{\partial \ln u(t)} = \frac{\partial \ln w_r(t)}{\partial \ln u(t)} = -\frac{\left(1-\eta^*\right)\left(\lambda^*+s\right)}{\left(r+\lambda^*+s\right)} \approx -\left(1-\eta^*\right), \tag{33}$$

where the approximation follows from $r \to 0$. This expression replicates result (22).

We next consider the special case in which there is no backward-looking element to wage determination ($\alpha = 1$). In this case (29) can be written as:

$$\begin{aligned}\frac{\partial \ln w_n(t)}{\partial \ln u(t)} = \frac{\partial \ln w_r(t)}{\partial \ln u(t)} &= -\frac{\left(1-\eta^*\right)(r+\phi+s)(\lambda+s+\xi)}{(r+\phi+s+\xi)(r+\lambda+s)} \\ &\approx -\left(1-\eta^*\right)\left[1+\frac{\xi(\phi-\lambda)}{(\phi+s+\xi)(\lambda+s)}\right],\end{aligned} \tag{34}$$

for $r = 0$. As the expected duration of a wage contract is typically longer than the expected duration of an unemployment spell ($\phi > \lambda$), (34) predicts that newly-renegotiated wages are more cyclical than in steady state (see (22)). Wages in new jobs are more cyclical than wages in existing jobs, but a high degree of unemployment persistence implies that, quantitatively, this difference is small (see (32)).

We finally consider the general case in which there is some backward-looking component to wages ($\alpha < 1$) and a modest amount of unemployment persistence ($\xi > 0$). In general the cyclicality of wages in new hires rises with both α and ξ. Intuitively, as α rises, a smaller fraction of new hires are tied to old wages, and at the same time old wages have a weaker influence on newly-renegotiated wages, according to (13).

To ease intuition for the general case, we obtain predictions from Proposition 1 for plausible parameter values. We use benchmark values for the UK, with an unemployment rate of 7%, a separation rate $s = 0.0125$ and a persistence parameter $\xi = 0.003$.[9] We consider a monthly interest rate of $r = 0.003$, and an expected contract length of 12 months,

[9] Data for s and u are obtained from the Quarterly Labour Force Survey for the same sample period used in Section 4. Together, they imply $\lambda = s(1-u)/u \approx 0.17$. ξ is estimated on a AR(1) model for the quarterly series of unemployment. Flows are lower in the UK than in the US and unemployment persistence is higher, so these are numbers different from those often used in the literature for the analysis of US data.

thus $\phi = 0.0833$. Finally we set the bargaining power of workers at $\beta = 0.05$ (see estimates reported by Manning, 2011, Table 4), and note incidentally from expression (13) that β has limited importance whenever α is high, or newly-negotiated wages are close to average wages. For the value of the replacement ratio we use BHPS data on reservation wages and expected wages ($\rho / w \cong 0.8$) and compute the replacement ratio using condition (24), which yields $\eta = 0.69$ at benchmark parameter values.

As we do not have direct information on the share of new matches that pay a newly-negotiated wage, we obtain predictions for wage and reservation wage cyclicality for alternative values of α. These are plotted in panel A of Figure 1. The predicted elasticities of newly-negotiated wages, wages in new jobs and average wages are relatively high, between -0.27 and -0.3, and thus much higher than the -0.1 benchmark estimate advocated by Blanchflower and Oswald (1994) and broadly replicated in later studies. Moreover wage elasticities are not very sensitive to the amount of backward-looking behaviour in wage determination, $1-\alpha$, as a consequence of high unemployment persistence. To quantitatively illustrate the role played by unemployment persistence, Panel B imposes a higher (and unrealistic) value of $\xi = 0.1$. All predicted elasticities become more sensitive to α, and average wages become markedly more cyclical than newly-negotiated wages.

The predicted cyclicality in reservation wages is considerably higher than all three measures of wage cyclicality. For example, the elasticity of reservation wages with respect to unemployment is about 20% higher than the elasticity of newly-negotiated wages, 25% higher than the elasticity of average wages, and between 20-25% higher than the elasticity of wages in new job, depending on α. These predictions are quantitatively very close to the corresponding steady-state result represented by condition (25). This is again a consequence of high unemployment persistence.

4. Empirical wage and reservation wage curves

A. *Estimates of the wage curve*

This Section contrasts predicted elasticities derived above with empirical estimates of wage and reservation wage cyclicality for the UK and Germany. We use British data from the BHPS and West German data from the SOEP. These are both longitudinal studies, running from 1991 to 2009 and from 1984 to 2010, respectively. The advantage of these data sets is that they contain information on reservation wages over a long period of time.

We first provide estimates of wage curves in line with the literature which gained momentum with Blanchflower and Oswald (1994). The typical approach in this literature regresses the (log of) hourly wages on the usual set of individual covariates and the (log) unemployment rate or some alternative indicator of the business cycle. Blanchflower and Oswald (1994) provide estimates of this specification for several OECD countries, and suggest a remarkably stable elasticity of real wages to the unemployment rate 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 wages of job movers are more procyclical than wages of 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.

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 the state-level unemployment rate as the measure of the cycle, and include both year and state fixed effects, identifying the elasticity of wage to unemployment 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 a linear or quadratic trend. We also present estimates based on regional unemployment, which typically deliver even lower wage cyclicality, though the corresponding estimates are not precise.

Our working sample includes all employees aged 16-65, with non-missing wage information. Descriptive statistics for our wage samples are reported in Table A1 for both the BHPS and the SOEP. Regression results for the UK are presented in Table 1.[10] The dependent variable is the log hourly gross 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, for a similar result for the US).

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

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

and current unemployment have a significant impact on wages. Column 7 controls for both current and lagged unemployment, and shows that lagged unemployment has a stronger bite on wages than current unemployment. Column 8 controls for the lagged dependent variable, which automatically restricts the sample to individuals continuously employed, and the unemployment elasticity remains very close to the baseline specification of column 3.

Other aggregate indicators like the output gap or the output growth rate have no impact on wages, while the (log) labour market tightness has an impact on wages that is very similar to the impact of the (log) aggregate unemployment rate (results not reported). When controlling for regional unemployment, specifications that also include a quadratic trend deliver a negative and significant unemployment elasticity, but its magnitude in all specifications stays below -0.1 in absolute value, as illustrated in Table A3. 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 2. 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 Germany, and is only significant for new matches (column 4) or when lagged unemployment is used (column 7). A clear similarity between 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 in Germany when controlling for job fixed-effects (column 5). Estimates based on regional unemployment (Table A4) are qualitatively similar to those reported in Table 2, 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. Overall, the estimates obtained suggest that it is hard to align theoretical predictions represented in Figure 1, suggesting wage elasticities between -0.27 and -0.3, with the empirical evidence on wage elasticity, and this is the essence of the wage flexibility puzzle.

B. ***Estimates of the reservation wage curve***

Existing work on reservation wage cyclicality is scant, and its role in business cycle fluctuations underexplored. An obvious reason for this gap in the literature is the scarcity of reservation wage data. In the US, no data source has collected reservation wage information on a regular basis for a long period of time,[11] 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[12] 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 earnings functions, 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

[11] For the US, a handful of 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 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).

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

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 3. The dependent variable is the log of the real hourly reservation wage. All specifications control for 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 very slightly declines when individual filed-effects are introduced in column 3. Column 4 controls for lagged unemployment, and shows that the main source of cyclicality in the reservation wage is lagged rather than current unemployment.

Similarly as for wage equations, alternative business cycle indicators have no impact on reservation wages, except the (log) labour market tightness, which has an impact on reservation wages that is very similar to the impact of the (log) aggregate unemployment rate (results not reported). 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, and again lagged unemployment has a stronger impact on reservation wages than current unemployment. 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,[13] and the results are reported in Table 4. 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 reservation wage equations we conclude that there is fairly limited cyclicality in reservation wages. The highest elasticity estimate obtained across our specifications is -0.175 (column 2 in Table 3), which is very similar to the corresponding average wage elasticity of -0.169 (column 2 in Table 1), and in-between estimates of wage

[13] 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 4 (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.

elasticity in new matches (-0.221 and -0.126, obtained with ad without job fixed-effects, respectively). These results are not consistent with theoretical predictions summarised in Proposition 1, and shown graphically in Figure 1, implying that reservation wages should be about 20-25% more cyclical than both average wages and wages in new jobs.

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 poorly informative, 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 5 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 re-employment 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 significant

Similar results for West Germany are presented in Table 6, and they are clearly 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 the estimate of their cyclicality is seriously under-estimated.

5. Alternative reservation wage models

The estimates of the previous Section have highlighted two flaws in the canonical search model. The first is the wage flexibility puzzle, whereby wages – in new or continuing jobs – are not as cyclical as the theory predicts for plausible parameter values. Second, reservation wages are not more cyclical than wages. We next consider how the model may be extended to better fit the evidence.

The model presented in Section 2 has two ingredients. The first is wage determination, conditional on reservation wages, as represented by equation (14). The second is the determination of reservation wages, conditional on wages, as represented by equation (15). To fix the second model flaw and raise the wage elasticity relative to the reservation wage elasticity, one could introduce a procyclical mark-up $\mu(t)$ in wage determination. However, this would increase the predicted cyclicality of wages and exacerbate the wage flexibility puzzle. Thus we do not further pursue changes to the model of wage determination. Instead we explore variations to the model of determination of reservation wages, so as to curb their predicted cyclicality.

To this purpose we derive the following result for the cyclicality of reservation wages, conditional on the cyclicality in newly-renegotiated wages:

Proposition 2: If the mark-up is acyclical and $\phi < \infty$,[14] the reservation wage equation (17) implies the following relationship between the cyclicality of reservation wages and the cyclicality of newly-renegotiated wages:

$$\left(r+\lambda^{*}+s+\xi\right)\frac{\partial \ln \rho(t)}{\partial \ln u(t)}=\left[\lambda^{*}-\phi-\frac{(1-\alpha)\lambda^{*}\xi}{\alpha s+\phi+\xi}\right]\frac{w^{*}}{\rho^{*}}\frac{\partial \ln w_{r}(t)}{\partial \ln u(t)}-\left(\lambda^{*}+s+\xi\right)\left(\frac{w^{*}}{\rho^{*}}-1\right)$$

(35)

Proof: See Appendix B.

[14] The proof in the Appendix B allows for the general case.

If the interest rate is small and $\partial \ln w_r(t) / \partial \ln u(t) = 0$, the elasticity of reservation wages with respect to unemployment equals $-(w^* / \rho^* - 1)$. As BHPS data suggest $w^* / \rho^* - 1 \approx 0.2$, Proposition 2 predicts as much or more cyclicality in reservation wages than we observe in the data, even if wages in newly-negotiated jobs are acyclical. The intuition is that, independent of wage cyclicality, reservation wages are predicted to fall in a recession as the chances of finding a job fall, making workers more likely to accept low-wage jobs.

We next consider alternative models for the determination of reservation wages – a search model with the possibility of on-the-job search, a model in which workers use hyperbolic discounting, and a model with reference dependence in job search behaviour.

A. *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.

Appendix C shows that, if the interest rate is small relative to transition rates, the reservation wage approximately satisfies:

$$\rho \approx z + (1-u)\left(1 - \frac{\lambda^e}{\lambda^u}\right)(w_a - z), \tag{36}$$

where w_a denotes the average wage. Equation (16) is a special case of (36) for $\lambda^e = 0$.

According to (36), 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 offers a higher flow utility than one enjoys 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 (36), 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 (36), 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, but the cyclicality of λ^e/λ^u is less clear. To provide evidence on the cyclicality of λ^e/λ^u, Appendix D shows that this ratio is positively related to 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.

Using data from the UK Labour Force Survey, we show that the fraction of new jobs filled by previously employed workers, and thus λ^e/λ^u, are countercyclical; and that $\lambda^e/\lambda^u < 1$ (about 0.6 at the mean unemployment rate). 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. The latter effect dominates quantitatively, thus on-the-job search may not solve the puzzle of the modest cyclicality in the reservation wage.

B. *Reservation wages under 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 Appendix E below shows that hyperbolic discounting is not likely to have important consequences for the cyclicality of the reservation wage.

C. *Reference dependence in job search*

In recent years reference-dependent preferences have often featured in economic behavior in general and labor supply modelling in particular (see Della Vigna 2009 for an extensive survey and Farber, 2008, for an application to labor supply), with the aim of explaining observed deviations from the standard neoclassical model of individual decision making. The central idea is one of loss aversion relative to some reference status (Tversky and Kahneman, 1991), implying that changes in some relevant outcome below one's reference point produce greater utility losses than utility gains produced by an equivalent change above it. In several contexts, reference points are determined by both past personal experiences and peer influences (Akerlof, 1980; Akerlof and Yellen, 1990; Blanchard and Katz, 1999).

The presence of reference dependence in job search – shaped for instance by one's previous employment history – would generate less cyclical reservation wages than the canonical model, as long as reference points are less cyclical than forward-looking variables that feature in it (typically the probability of receiving an offer and the expected wage offer distribution). Consider a worker who lost her job at the start of a recession. If she is adverse to losses relative to her previous earnings standards, she may decide to attenuate such losses by setting a reservation wage that exceeds the level that she would set under neoclassical preferences, rationalizing why reservation wages would not fall in a recession as much as the canonical model would predict.[15] Closely related to our setting, Falk et al. (2006) show in a laboratory experiment that past minimum wages that are no longer in effect influence reservation wages, making reservation wages less cyclical than in the standard search model. Recently, Della Vigna et al. (2014) argue that a model of reference-dependent job search, 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.

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

[15] See Genesove and Mayer (2001) for a similar application to the housing market.

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 is simply a function of 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 should not use past rents in forming their current reservation wages (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:

$$\ln \rho_{it} = \beta_1 X_{it} + \beta_2 w_i^* + \beta_3 \mu_{it-d} + \varepsilon_{it}, \tag{37}$$

where X_{it} denotes observable characteristics, w_i^* denotes worker ability, and μ_{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.

Let's assume the following model for the last observed wage:

$$\ln w_{it-d} = \gamma_1 X_{it-d} + w_i^* + \mu_{it-d} + u_{it-d} \tag{38}$$

and let's imagine to simply regress the reservation wage on the last observed wage:

$$\ln \rho_{it} = \delta_1 X_{it} + \delta_2 \ln w_{it-d} + \varepsilon_{it}. \tag{39}$$

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. Specifically, 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 use the estimated industry effects to construct predicted industry-level wages, which we then match to individual records in the BHPS, and use 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, which in turn affects 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 7. Column 1 reports OLS estimates of a reservation wage equation for the UK, controlling for the last observed wage in the BHPS panel. The sample is substantially smaller than the original sample of Table 3, 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 realizations 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 driven 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 finally allows for changes in reference points over time, but the decay effect is no longer significant. In summary, the finding that evidence 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.

We next explore the ability of a model with reference-dependent reservation wages to explain the evidence on the (limited) cyclicality of wages and reservation wages. We retain the model for wage determination introduced in Section 2, and combine it with a different reservation wage model, in which reservation wages are a linear combination of the optimal reservation wage derived in (15), which we will denote by $\rho_0(t)$, and a reference point which itself is a linear combination of the most recent wage, denoted by $w_l(t)$ and an acyclical component, k:

$$\rho(t) = \alpha_\rho \rho_0(t) + (1-\alpha_\rho)\left[\alpha_l w_l(t) + (1-\alpha_l)k\right], \tag{40}$$

where α_ρ captures forward-looking behaviour in reservation wages, 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 way in which these elements influence the predicted cyclicality of wages is best understood through simulation. Section 3 has shown how model predictions for cyclicality are affected by varying persistence in wage setting (and implicitly imposing $\alpha_\rho = 1$), and noted that while the predicted cyclicality falls with $1-\alpha$, quantitatively this effect is small as a consequence of high persistence in labour market conditions. In Figure 2, we plot for reference the relationship between $1-\alpha$ and the cyclicality in average wages for $\alpha_\rho = 1$ and benchmark values of other parameters. This is the curve denoted "Persistence in Wages Only".[16]

We next consider the role of persistence in reservation wages, by plotting the relationship between $1-\alpha_\rho$ and the cyclicality in average wages, using the same benchmark parameter values described in Section 3C, and having ruled out persistence in wage setting ($\alpha = 1$). We consider two cases, $\alpha_l = 1$ and $\alpha_l = 0$, under the assumption that the last observed wage $w_l(t)$ is as cyclical as average wages. The main results is that both models generate less cyclical wages than a model that introduces the same level of persistence in wage setting. The reduction in cyclicality is clearly greater when the reference point in reservation wages is assumed to be completely acyclical ($\alpha_l = 0$).

We consider whether there exists a combination of parameter values ($\alpha, \alpha_\rho, \alpha_l$) that would lead to 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 7); (ii) the elasticity of wages with respect to unemployment (-0.17, from column 3 of Table 1); (iii) the elasticity of reservation wages with respect to unemployment (-0.16, from column 3 of Table 3).

[16] This simply replicates, on a different scale, the curve denoted "Average Wages" of Figure 1.

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 (40), 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 -0.16, respectively.[17]. Figure 3 then plots the values of (α, α_ρ) that satisfy these criteria. Two clear points emerge. First, only values of α_ρ in the range $0.47-0.67$ 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 backward-looking behaviour in reservation wages. A model in which between one third and one half of 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.

6. Conclusions

We use a canonical search model to derive a relationship between wages and unemployment – the wage curve – which is plausibly unaffected by demand shocks. The slope of this curve is an estimate of the relative variability of wages and unemployment in response to demand shocks. We show how the model can only explain the modest pro-cyclicality of wages if replacement ratios are implausibly high. The wage flexibility puzzle persists even in the presence of a backward-looking component in wage determination, and if wages are only infrequently renegotiated – unless unemployment has implausibly low persistence. 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 then investigate and reject model predictions using micro data on wages and reservation wages for the UK and Germany, and namely we find that wages are only moderately cyclical, and that reservation wages and not more strongly cyclical than wages.

[17] 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 (40).

We argue that one source of both puzzles is plausibly the model for the determination of reservation wages, and consider alternative models that would curb their cyclicality. In particular, reference dependence in job search behaviour generates less cyclical reservation wages than the canonical model, as long as reference points are less cyclical than forward-looking components of reservation wages such as the arrival rate of job offers.

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 for plausible parameter values and can reconcile theoretical predictions of search and matching models with the observed cyclicality of wages and reservation wages.

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Table 1
Estimates of a Wage Equation for the UK, 1991-2009.

	Dependent variable: log hourly wage							
	1	2	3	4	5	6	7	8
Log wage, lagged								0.102**
								(0.046)
Log unemployment rate	-0.022	-0.165***	-0.169***	-0.146***	-0.110***	-0.137***	-0.022	-0.150***
	(0.032)	(0.044)	(0.014)	(0.011)	(0.011)	(0.014)	(0.023)	(0.009)
Log unemployment rate * new job				-0.075***	-0.016*			
				(0.008)	(0.009)			
Log unemployment rate, at start of job						-0.069***		
						(0.010)		
Log unemployment rate, lagged							-0.113***	
							(0.017)	
Trend	linear	quadratic	quadratic	quadratic	quadratic	quadratic	quadratic	quadratic
Individual fixed effects			√	√		√	√	√
Job fixed effects					√			
Observations	96,270	96,270	92,381	92,381	77,854	91,713	70,438	53,054
R-squared	0.397	0.397	0.268	0.269	0.117	0.270	0.748	

Notes. See notes to Table A1 for the sample used. Estimation method: OLS in columns 1-7; Arellano Bond (1991) estimator for dynamic panel data models in column 8. 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 3-8. Source: BHPS.

Table 2
Estimates of a Wage Equation for the West Germany, 1984-2010

	Dependent variable: Log monthly wage							
	1	2	3	4	5	6	7	8
Log wage, lagged								0.390***
								(0.027)
Log unemployment rate	0.082	0.002	-0.028	-0.015	-0.005	-0.023	0.065**	-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							-0.118***	
							(0.025)	
Trend	linear	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	144,529	101,526
R-squared	0.649	0.651	0.415	0.415	0.199	0.415	0.419	

Notes. See notes to Table A1 for the sample used. Estimation method: OLS in columns 1-7; Arellano Bond (1991) estimator for dynamic panel data models in column 8. 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 3-8. Source: SOEP.

Table 3
Estimates of a Reservation Wage Equation for the UK, 1991-2009.

	Dependent variable: log hourly reservation wage			
	1	2	3	4
Log unemployment rate	-0.095**	-0.175***	-0.164***	0.010
	(0.046)	(0.058)	(0.040)	(0.114)
Log unemployment rate, lagged				-0.119
				(0.079)
Trend	linear	quadratic	quadratic	quadratic
Individual fixed-effects			√	√
Observations	14,874	14,874	10,774	10,774
R-squared	0.248	0.249	0.110	0.110

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 and 4. Source: BHPS.

Table 4
Estimates of a Reservation Wage Equation for West Germany, 1987-2009.

	Dependent variable: log monthly reservation wage			
	1	2	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***
				(0.064)
Trend	linear	quadratic	quadratic	quadratic
Individual fixed-effects			√	√
Observations	11,221	11,221	7,911	7,911
R-squared	0.414	0.418	0.123	0.125

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 column 3 and 4. Source: SOEP.

Table 5
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 6
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.

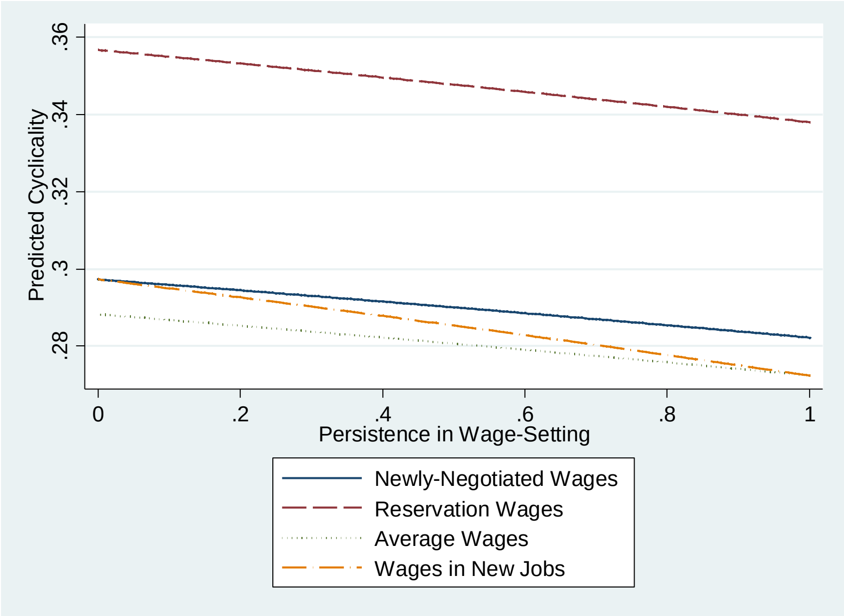
Table 7
Reservation wages and rents in previous jobs: UK, 1991-2009.

	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			-0.011*			-0.002
			(0.006)			(0.009)
Inter-industry wage differential						
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

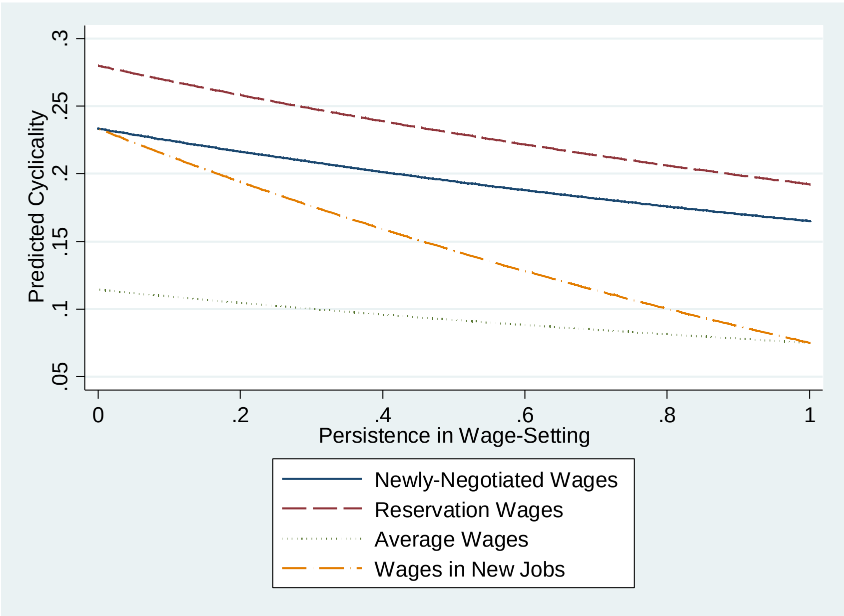
Notes. See notes to Table A1 for the sample used. All regressions also include a gender dummy, age and its square, three education dummies, a cubic trend in the number of years since the last job was observed, a dummy for married, the number of children in the household, the log of unemployment benefits, 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
Persistence in Wage-Setting and Predicted Wage Cyclicality

Panel A: Realistic (High) Value of Unemployment Persistence

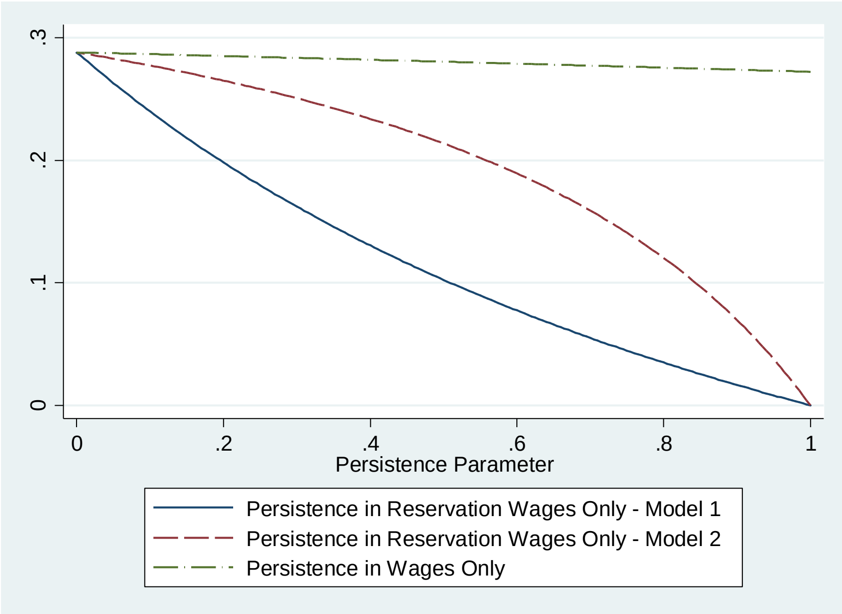


Panel B: Unrealistic (Low) Value of Unemployment Persistence



Notes. Figures plots (the absolute value of) predicted elasticities of wages and reservation wages to unemployment, using results (29)-(32) of Section 3C. Parameter values used are as described in Section 3C. Panel A assumes $\xi = 0.003$, while Panel B assumes $\xi = 0.1$.

Figure 2
Persistence in Reservation Wages and Predicted Wage Cyclicality



Notes: These are predictions from the model of Section 5D. Parameter values used are described in Section 3C and Section 5D.

Figure 3
Parameter Values that Explain Observed Cyclicality

Notes. The shaded region shows the combinations of α, the probability of negotiating a new wage, and α_ρ, the weight on the forward-looking reservation wage that predict both a wage elasticity and a reservation wage elasticity within 0.04 of -0.166 for a predicted sensitivity of the reservation wage to the lagged wage $(1 - \alpha_\rho)\alpha_r$, equal to 0.15 (taken from column 6 of Table 7). All other parameter are set at baseline values.

Appendix A: 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

	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

for the UK and West Germany

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
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)	(0.007)	(0.006)	(0.006)	(0.007)	(0.008)	(0.022)
Log regional unemployment rate * new job					-0.032***	-0.011**			
					(0.006)	(0.006)			
Log regional unemployment rate, at start of job							-0.084***		
							(0.010)		
Log regional unemployment rate, lagged								-0.060***	
								(0.007)	
Trend	no	linear	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	53,054
R-squared	0.399	0.397	0.397	0.267	0.267	0.116	0.269	0.267	

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 9. 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 4-9. 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
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	0.046***	-0.004
	(0.016)	(0.026)	(0.023)	(0.015)	(0.014)	(0.011)	(0.015)	(0.015)	(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								-0.074***	
								(0.011)	
Trend	no	linear	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	144,513	101,526
R-squared	0.652	0.649	0.651	0.414	0.415	0.199	0.422	0.419	

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 9 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 4-9. 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
Log regional unemployment rate	0.007	-0.047	-0.054*	-0.034**	0.048
	(0.025)	(0.031)	(0.028)	(0.023)	(0.030)
Log regional unemployment rate, lagged					-0.106***
					(0.027)
Trend	no	linear	Quadrati	quadrati	quadratic
Year dummies	√				
Individual fixed-effects				√	√
Observations	14,873	14,873	14,873	10,774	10,774
R-squared	0.252	0.247	0.247	0.109	0.111

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 and 5. 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
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***
					(0.032)
Trend	no	linear	quadratic	quadratic	quadratic
Year dummies	√				
Individual fixed-effects				√	√
Observations	11,221	11,221	11,221	7,911	7,911
R-squared	0.421	0.413	0.418	0.124	0.125

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 4. 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 and 5. Source: SOEP.

Appendix B: Proof of Propositions 1 and 2

We start by stating some useful results:

Result 1:

$$E_t\left(\lambda(\tau)\middle|\lambda(t)\right)=e^{-\xi|(\tau-t)|}\lambda(t)+\left[1-e^{-\xi|(\tau-t)|}\right]\lambda^*. \tag{41}$$

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:

$$x(t)-x^*=\theta_x\left(\lambda(t)-\lambda^*\right). \tag{42}$$

Combining (42) and (28) gives:

$$E_t\left(\frac{dx(t)}{dt}\middle|\lambda(t)\right)=\theta_x E_t\left(\frac{d\lambda(t)}{dt}\middle|\lambda(t)\right)=-\xi\theta_x\left(\lambda(t)-\lambda^*\right) \tag{43}$$

for forward-looking variables, and:

$$E_t\left(\frac{dx(t)}{dt}\middle|\lambda(t)\right)=\theta_x E_t\left(\frac{d\lambda(t)}{dt}\middle|\lambda(t)\right)=\xi\theta_x\left(\lambda(t)-\lambda^*\right) \tag{44}$$

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:

$$\frac{d\ln u(t)}{d\lambda(t)}=-\frac{1}{\lambda^*+s+\xi}. \tag{45}$$

Proof: The unemployment rate follows the differential equation:

$$\frac{du(t)}{dt}=s\left(1-u(t)\right)-\lambda(t)u(t), \tag{46}$$

which can be linearized around the steady-state to yield:

$$\frac{du(t)}{dt}=-\left(\lambda^*+s\right)\left(u(t)-u^*\right)-u^*\left(\lambda(t)-\lambda^*\right). \tag{47}$$

Using (42) and (44) (as unemployment is a backward-looking variable), (47) can be written as $\theta_u=-u^*/(\lambda^*+s+\xi)$, which implies (45).

Result 3 is useful because we are ultimately interested in the elasticity of relevant wage measures with respect to the log of unemployment. Using (45) 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 (18) around steady-state gives:

$$\frac{dw_a}{dt} = -(\alpha s+\phi)\left[\left(w_a - w_a^*\right)-\left(w_r - w_r^*\right)\right]+\frac{\alpha u^*\left(w_r^* - w_a^*\right)}{1-u^*}\left(\lambda(t)-\lambda^*\right), \qquad (48)$$

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:

$$\theta_{w_a} = \frac{\alpha s+\phi}{\alpha s+\phi+\xi}\theta_{w_r} \qquad (49)$$

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 ($\xi = 0$).

<u>Result 5</u>: The cyclicality of newly-negotiated wages

The linearized version of (14) can be written as:

$$\begin{aligned}\theta_{w_r} &= \theta_\rho + \tilde{\beta}\left(r+\phi+s\right)\theta_\mu - \tilde{\beta}\left(1-\alpha\right)\left(\theta_{w_a} - \theta_{w_r}\right)\\ &= \theta_\rho + \frac{w^* - \rho^*}{\mu^*}\theta_\mu - \tilde{\beta}\left(1-\alpha\right)\left(\theta_{w_a} - \theta_{w_r}\right),\end{aligned} \qquad (50)$$

in which we allow for cyclicality in the mark-up. Note that this is only valid for $\phi < \infty$, as (14) shows that the gap between a newly-negotiated wage and the reservation wage goes to infinity as $\phi \to \infty$, making the derivative in (50) ill-defined. Using (49) we can eliminate θ_{w_a} from (50) and re-arrange to obtain:

$$\left(1-\frac{\tilde{\beta}(1-\alpha)\xi}{\alpha s+\phi+\xi}\right)\theta_{w_r} = \theta_\rho + \frac{w^* - \rho^*}{\mu^*}\theta_\mu, \qquad (51)$$

which can be expressed in elasticity form:

$$\left(1-\frac{\tilde{\beta}(1-\alpha)\xi}{\alpha s+\phi+\xi}\right)\frac{\partial \ln w_r(t)}{\partial \ln u(t)} = \frac{\rho^*}{w^*}\frac{\partial \ln \rho(t)}{\partial \ln u(t)} + \left(1-\frac{\rho^*}{w^*}\right)\frac{\partial \ln \mu(t)}{\partial \ln u(t)}. \qquad (52)$$

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

The linearized version of (17) can be written as:

$$E_t \frac{d\rho(t)}{dt} = \left(r+\lambda^*+s\right)\left(\rho(t)-\rho^*\right)-\left(\alpha\lambda^*-\phi\right)\left(w_r(t)-w_r^*\right)$$
$$-(1-\alpha)\lambda^*\left(w_a(t)-w_a^*\right)+\left(\rho^*-w^*\right)\left(\lambda(t)-\lambda^*\right). \tag{53}$$

As the reservation wage is forward-looking, from (53) we can derive:

$$\left(r+\lambda^*+s+\xi\right)\theta_\rho = \left(\alpha\lambda^*-\phi\right)\theta_{w_r}+(1-\alpha)\lambda^*\theta_{w_a}+\left(w^*-\rho^*\right). \tag{54}$$

Expressions (49), (50) and (54) – together with (51) – give a set of linear equations for the elasticity of wages and reservation wages with respect to unemployment, as a function of model parameters. Finally, using (49) to eliminate θ_{w_a} from (54) yields:

$$\left(r+\lambda^*+s+\xi\right)\theta_\rho = \left[\lambda^*-\phi-\frac{(1-\alpha)\lambda^*\xi}{\alpha s+\phi+\xi}\right]\theta_{w_r}+\left(w^*-\rho^*\right). \tag{55}$$

<u>*Proof of Proposition 1a*</u>

Solving (51) and (55) leads to:

$$\theta_{w_r} = \frac{\left(w^*-\rho^*\right)\left(\alpha s+\phi+\xi\right)\left[\left(r+\lambda+s+\xi\right)\frac{\theta_\mu}{\mu^*}+1\right]}{\left(\alpha s+\phi+\xi\right)\left(r+\phi+s+\xi\right)-(1-\alpha)\xi\left[\tilde{\beta}\left(r+\lambda+s+\xi\right)-\lambda\right]}. \tag{56}$$

Using (24), this can be expressed in elasticity form:

$$\frac{\partial \ln w_r(t)}{\partial \ln u(t)} = -\frac{\left(1-\eta^*\right)\left(r+\phi+s\right)\left(\alpha s+\phi+\xi\right)\left[\left(\lambda+s+\xi\right)-\left(r+\lambda+s+\xi\right)\frac{\partial \ln \mu(t)}{\partial \ln u(t)}\right]}{\left(r+\lambda+s\right)\left\{\left(\alpha s+\phi+\xi\right)\left(r+\phi+s+\xi\right)-(1-\alpha)\xi\left[\tilde{\beta}\left(r+\lambda+s+\xi\right)-\lambda\right]\right\}}. \tag{57}$$

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

<u>*Proof of Proposition 1b*</u>

Solving (51) and (55) leads to:

$$\theta_\rho = \frac{(w^*-\rho^*)\left\{\left[\left(\alpha s+\phi+\xi\right)\left(\lambda-\phi\right)-\lambda(1-\alpha)\xi\right]\frac{\theta_\mu}{\mu^*}+\left[\left(\alpha s+\phi+\xi\right)-\tilde{\beta}(1-\alpha)\xi\right]\right\}}{\left(\alpha s+\phi+\xi\right)\left(r+\phi+s+\xi\right)-(1-\alpha)\xi\left[\tilde{\beta}\left(r+\lambda+s+\xi\right)-\lambda\right]}. \tag{58}$$

Expressing this in elasticity form and setting $\theta_\mu = 0$ yields (30).

<u>*Proof of Propositon 1c*</u>

This follows directly from (49).

Proof of Propositon 1d

This follows directly from (49) and the fact that wages in new jobs are equal to w_r with probability α and w_a with probability $1-\alpha$.

Proof of Proposition 2

This follows directly from (55).

Appendix C: Predicted Cyclicality with a Backward-Looking Reservation Wage Equation

This section presents the equations for the predicted cyclicality in wages and reservation wages for the model of section 5D with backward-looking reservation wages (40). Equations (31) and (32) for the cyclicality of average wages and wages in new jobs still hold, conditional on the cyclicality of wages in newly-renegotiated jobs. Equation (50) also holds, conditional on the cyclicality in reservation wages. Equation (55) for the cyclicality in the forward-looking part of the reservation wage holds, but this is no longer the same as the cyclicality in the actual reservation wage. We continue to use θ_ρ to denote the sensitivity of the actual reservation wage to deviations of λ from steady-state but now use θ_{ρ_0} for the sensitivity of the forward-looking reservation wage to deviations of λ from steady-state so that (55) can be written as:

$$\left(r+\lambda^*+s+\xi\right)\theta_{\rho_0}=\left[\lambda^*-\phi-\frac{(1-\alpha)\lambda^*\xi}{\alpha s+\phi+\xi}\right]\theta_{w_r}+\left(w^*-\rho^*\right). \tag{59}$$

Using (40), the following condition must hold:

$$\theta_\rho=\alpha_\rho\theta_{\rho_0}+\left(1-\alpha_\rho\right)\alpha_r\theta_{w_l}, \tag{60}$$

where θ_{w_l} is the sensitivity of the lagged wage to deviations of λ from steady-state. For the lagged wage we assume this is the average previous wage among the unemployed. This implies that the evolution of the lagged wage must follow the following dynamics:

$$\frac{dw_l}{dt}=\frac{s\left[1-u\left(t\right)\right]}{u\left(t\right)}\left(w_a-w_l\right). \tag{61}$$

Linearizing (61) around the steady-state gives:

$$\frac{dw_l}{dt}=-\lambda*\left[\left(w_l-w_l^*\right)-\left(w_a-w_a^*\right)\right]-\frac{s\left(w_a^*-w_l^*\right)}{u^{*2}}\left(\lambda\left(t\right)-\lambda^*\right), \tag{62}$$

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

$$\theta_{w_l} = \frac{\lambda}{\lambda+\xi}\theta_{w_a} = \frac{\lambda}{\lambda+\xi}\frac{\alpha s+\phi}{\alpha s+\phi+\xi}\theta_{w_r} \qquad (63)$$

Where the final term comes from (49). Substituting (63) into (60) then gives an expression for θ_ρ as a function of θ_{w_r}.

Appendix D: The reservation wage with on-the-job search

Derivation of expression (36)

Arrival rates for the employed and the unemployed are denoted by λ^e and λ^u, respectively, and both depend on labour market tightness, and the corresponding value functions are given by:

$$rW(w) = w - s\left[W(w) - U\right] + \lambda^e \int_w \left[W(x) - W(w)\right] dF(x), \qquad (64)$$

and

$$rU = z + \lambda^u \int_\rho \left[W(x) - U\right] dF(w), \qquad (65)$$

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

$$\begin{aligned}\rho &= z + \left(\lambda^u - \lambda^e\right)\int_\rho \left[W(w) - U\right] dF(w) \\ &= z + \left(\lambda^u - \lambda^e\right)\int_\rho \frac{1-F(w)}{r+s+\lambda^e\left[1-F(w)\right]} dw,\end{aligned} \qquad (66)$$

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 (Burdett and Mortensen, 1998) that the two are related by:

$$1-G(w) = \frac{1-F(w)}{s+\lambda^e\left[1-F(w)\right]}\;\frac{s+\lambda^e\left[1-F(\rho)\right]}{1-F(\rho)}. \qquad (67)$$

Using (63) and the approximation $r \approx 0$, (66) can be written as:

$$\rho \approx z + \frac{\left(\lambda^u - \lambda^e\right)\left[1-F(\rho)\right]}{s+\lambda^e\left[1-F(\rho)\right]}\int_\rho \left[1-G(w)\right] dw = z + \frac{\left(\lambda^u - \lambda^e\right)\left[1-F(\rho)\right]}{s+\lambda^e\left[1-F(\rho)\right]}\left(w_a - \rho\right). \qquad (68)$$

Re-arranging gives:

$$\rho \approx \frac{\left\{s+\lambda^e\left[1-F(\rho)\right]\right\}z+\left(\lambda^u-\lambda^e\right)\left[1-F(\rho)\right]\bar{w}}{s+\lambda^u\left[1-F(\rho)\right]}. \tag{69}$$

The unemployment rate is given by $u = s/[s+\lambda^u(1-F(\rho)]$, and substituting this in (69) gives (36).

The fraction of jobs filled by the currently employed

We obtain evidence on the fraction of workers who are recruited from previous jobs (which we will denote by ζ) from the UK Quarterly Labour Force Survey, looking at the previous quarter's employment status of newly-hired workers.[18] During 1993-2012, this fraction is on average 60.1%. Regressions of ζ on the unemployment show that ζ is pro-cyclical, with a slope coefficient on unemployment of approximately 1 (results reported in Table D1).

We next consider the relationship between ζ and λ^e/λ^u in a search model with permanent wage dispersion. 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:

$$\left[s+\lambda^e(1-f)\right]G(f)(1-u)=\lambda^u uf, \tag{70}$$

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

$$G(f)=\frac{sf}{s+\lambda^e(1-f)}. \tag{71}$$

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

$$R(f)=\lambda^u u+\lambda^e(1-u)G(f)=\frac{s\lambda^u}{s+\lambda^u}\;\frac{s+\lambda^e}{s+\lambda^e(1-f)} \tag{72}$$

and total recruits in the economy are given by:

$$R=\int_0^1 R(f)\,df = \frac{s\lambda^u}{s+\lambda^u}\;\frac{s+\lambda^e}{s+\lambda^e(1-f)}=\frac{s\lambda^u}{s+\lambda^u}\frac{s+\lambda^e}{\lambda^e}\ln\left(\frac{s+\lambda^e}{s}\right). \tag{73}$$

As the total recruits from unemployment are given by $\lambda^u u$, this implies that the fraction of recruits from non-employment, $1-\zeta$, is given by:

[18] 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.

$$1-\zeta=\frac{\lambda^e}{\left(s+\lambda^e\right)\ln\left(\frac{s+\lambda^e}{s}\right)}=\frac{\lambda^e/\lambda^u}{\left(\frac{u}{1-u}+\frac{\lambda^e}{\lambda^u}\right)\ln\left(1+\frac{\lambda^e}{\lambda^u}\frac{1-u}{u}\right)}. \tag{74}$$

Using (74), an average unemployment rate in the UK over 1993-2012 of 6.8% and an average ζ of 60.1% imply $\lambda^e/\lambda^u=0.612$. As expected, $1-\zeta$ is increasing in the unemployment rate and decreasing in λ^e/λ^u. Thus (74) 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 (74) 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 (36), this mechanisms acts to make the reservation wage even more sensitive to the unemployment rate.

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.

Appendix E: The reservation wage with hyperbolic discounting

We next consider how the presence of hyperbolic discounting may affect reservation wages (see also Della Vigna and Paserman, 2005, Paserman, 2008) and, 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 one cares less about the future than one's current self. The weight attached to the future self is denoted by ψ. The expectation is that the future self is a straightforward exponential discounter. The value function for being employed (7) is now modified to:

$$rW(w) = w - s\left[W(w) - U\right] + \delta\left[\psi\tilde{W}(w) - W(w)\right], \tag{75}$$

where $\tilde{W}(w)$ is the value of being employed for the future non-hyperbolic self, given by (7):

$$r\tilde{W}(w) = w - s\left[\tilde{W}(w) - \tilde{U}\right]. \tag{76}$$

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

$$rU = z + \lambda(W - U) + \delta\left(\psi\tilde{U} - U\right), \tag{77}$$

where $\tilde{U}$ is given by (6). Thus:

$$\tilde{W} - \tilde{U} = \frac{w - z}{r + s + \lambda} \tag{78}$$

and:

$$r\tilde{U} = z + \frac{\lambda(w - z)}{r + s + \lambda}. \tag{79}$$

From (75) and (77) one can then derive:

$$W - U = \frac{(w - z) + \delta\psi\left(\tilde{W} - \tilde{U}\right)}{r + s + \lambda + \delta}. \tag{80}$$

Using (80), (77) and (78) one can, after some re-arrangement, derive:

$$rU = \frac{r + \delta\psi}{r + \delta} z + \frac{\lambda(w - z)\left[r(r + s + \lambda + \delta\psi) + \delta\psi(r + s + \lambda + \delta)\right]}{(r + s + \lambda)(r + s + \lambda + \delta)(r + \delta)}. \tag{81}$$

The reservation wage, ρ, must satisfy $W(\rho) = U$. Using (75), this implies:

$$rU = \rho + \delta\left[\psi\tilde{W}(\rho) - U\right]. \tag{82}$$

Using (76) we obtain:

$$\tilde{W}(\rho) = \frac{\rho + s\tilde{U}}{r + s}. \tag{83}$$

Combining (82) and (83) 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 (81) and (79) 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) $\psi \geq 12$. In this case the reservation wage is very close to z, clearly making the reservation wage 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.