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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 and matching model. This paper provides an alternative perspective on the wage flexibility puzzle, explaining why the canonical model can only match the observed cyclicality of wages if the replacement ratio is implausibly high. We show that this failure remains even if wages are only occasionally renegotiated, unless the persistence in unemployment is implausibly low. We then provide some evidence that part of the problem comes from the implicit model for the determination of reservation wages. Estimates for the UK and West Germany provide evidence that reservation wages are much less cyclical than predicted even conditional on the observed level of wage cyclicality. We present evidence that elements of perceived "fairness" or "reference points" in reservation wages may address this model failure.

Keywords: Reservation wages; wage cyclicality; reference points.
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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 one controls for the characteristics of workers,[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 too very 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 this wage curve to show that the model can only predict the modest observed pro-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, 2008, Shimer 2010, 2011, 2013, Rogerson and Shimer, 2011, Michaillat, 2012). We find that these elements only address the wage flexibility puzzle if the persistence of unemployment is implausibly low.

Secondly, we derive predictions on 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 of the expected wage offer, and – conditional on this – an extra cyclicality component directly driven by unemployment fluctuations. That is, in

[1] Failure to control for characteristics 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.

recessions the reservation wage falls because the probability of receiving any job offer is lower, thus raising the value of having a job relative to the value of being unemployed.

We then provide estimates of the cyclicality of wages and reservation wages for the UK and West Germany using micro data from the BHPS and the GSOEP, respectively. These are the only two known sources of information on (self-reported) reservation wages, which cover at least one full business cycle. Our 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 slightly lower elasticities for West Germany. Our estimates highlight two flaws in the quantitative predictions of the canonical model. First, wages – 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 parts. The first part stems from wage bargaining and relates the bargained wage to the reservation wage and the mark-up of wages over outside options. The second part 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 increase the predicted cyclicality of wages, worsening the wage flexibility puzzle. Thus we do not further pursue changes to the model of wage determination and explore instead changes to the model of determination of reservation wages, so as to reduce their cyclicality.

We show that allowing for search on-the-job or hyperbolic discounting has implications for the level of reservation wages, but neither addition may improve on their predicted cyclicality without making other model predictions worse. A promising route to address both wage and reservation wage cyclicality consists instead in allowing for backward reference points in reservation wages. This is in line with the view that the wages that workers consider acceptable are relatively rigid insofar as they are influenced by perceptions of fairness, which are typically nailed down to backward-looking reference points (e.g. Akerlof and Yellen, 1990, Falk, Fehr and Zehnder, 2006, DellaVigna et al, 2014). We provide evidence that reservation wages are influenced by ‘reference points’, as proxied by rents enjoyed in previous jobs. While rents should not affect reservation wages if jobseekers are forward looking, they would indeed shape job search behaviour if they represent a reference points for wage aspirations. We finally show that a certain degree of backward looking behaviour in the determination of reservation wages markedly reduces the predicted cyclicality of both wages and reservation wages for plausible parameter values.

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 neew 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 cyclicality of both wages and reservation ages are lower than their theoretical predictions. Section 5 proposes possible alternatives to the canonical model that would reduce the predicted cyclicality of reservation wages, and provides empirical evidence on reference points and backward-looking components in job search. Section 6 finally concludes.

2. The model

This section presents the implications of the canonical search and matching model 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 other, Pissarides, 2009) and for a backward-looking component to wages (see, for example, Gertler and Trigari, 2009). Both elements only have consequences for wage cyclicality when the economy is not always in steady-state, so we allow the economic environment to change over time. In the interests of simplicity we assume there is no 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 to wages. As we show below wages in this special case are predicted to be more strongly cyclical than the general case, as both infrequent renegotiations and a backward looking component in wages act to curb the predicted procyclicality in wages. In other words, both the extra elements 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, drawn at random from the existing cross-section of wages. We assume throughout that all old wages generate some surplus to both parties, which 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 (e.g. a training cost), $C(t)$. In the literature these costs are sometimes indexed to productivity shocks or wages, and we return to this issue later. For the moment we simply allow both components of the vacancy cost to be time-varying, and we 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.

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

The expectation term in (1) captures uncertainty about wages in future matches, namely whether it will be a newly-renegotiated wage, which we denote by $w_r(t)$ or an old wage, sampled from the distribution of existing jobs. As the value functions are linear in the wage, expectations in (1) can be replaced by averages:

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

where $w_a(t)$ denotes the average wage across existing jobs.

Consider next the value of a filled job that currently pays a wage w. We assume that wages are occasionally renegotiated, and renegotiation opportunities arrive at a 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 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 from wage renegotiation.

Free entry of vacancies ensures $V(t) = 0$ at each point in time, 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 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:

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

[3] We assume renegotiation opportunities arrive exogenously at rate ϕ, 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.

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 pays a wage w, and $\lambda(t)$ is the rate at which the unemployed 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 the distribution of wages in old jobs 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 $S(t;w) \equiv W(t;w) - U(t)$:

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

with solution:

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

C. *Wage determination*

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

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

which 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, using (4), be written as:

[4] Chodorow-Reich and Karabarbounis (2013) argue that z is pro-cyclical. Introducing this would obviously make wages even more pro-cyclical, making it even harder for other elements of the model to explain the wage flexibility puzzle.

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

where $\tilde{\beta}\equiv\beta/(1-\beta)$ and $\mu\left(t\right)\equiv c\left(t\right)/q\left(t\right)+C\left(t\right)$ denotes the excess job value over outside options (according to (4)) and is thus related to the mark-up of wages over outside options. The term in $\left(w_a\left(t\right)-w_r\left(t\right)\right)$ captures the idea that vacancies are created before knowing whether the wage will be a newly-renegotiated wage or a draw from the existing cross-section of wages.[5] A higher average wage reduces the value of creating a new job, and must be offset by lower negotiated wages in equilibrium. Combining (13) with (10) evaluated at $w_r\left(t\right)$ implies that current wages are affected by expected future wages (both average and newly-negotiated) and labour market tightness. And, expected future average wages are also influenced by what has happened in the past.

D. *The Reservation Wage*

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

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

Using (10), the reservation wage must satisfy:

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

i.e. it is a function of future expected wages and labour market conditions. In the special case in which there is no renegotiation or discounting ($r=\phi=0$), the reservation wage in steady state is given by:

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

where $u=s/\left(s+\lambda\right)$ 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:

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

E. *The Dynamics of Wages*

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

[5] The presence of this term comes from the modelling device we use to capture the fact that some jobs are at ‘new’ and some at ‘old’ wages. It does not obviously correspond to an economic effect one might expect to see in reality. However, for plausible parameter values, it will turn out to make little difference.

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

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. From (18) it follows 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 equation (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 through $\lambda(t)$, and further structure on their nature is not needed.

3. The Predicted Cyclicality of Wages

This section derives model predictions for the elasticity of wages and reservation wages with respect to the current unemployment rate. Model predictions are based on the assumption that variation in unemployment is driven by changes in job finding (λ), while job separation (s) is 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:

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

Substituting (19) into (14) and re-arranging leads to steady-state wages:

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

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 (Hagedoorn and Manovskii, 2008, do both). In this 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.[6] These assumptions imply that μ is a constant.

The empirical literature on the wage curve typically relates wages to the unemployment rate. Given steady-state unemployment, $u=s/\left(s+\lambda\right)$, (20) can be rewritten as:

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

This wage curve can be thought of as akin to a labour supply curve in a competitive model, in the sense that demand shocks do not feature in the wage curve but drive movements along the curve. The relative variation of wages and unemployment is given by (21), independent of the source or size of the shocks, allowing us to be agnostic about their source and to evaluate the model without having to measure demand shocks.[7]

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

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

where $\eta\equiv z/w$ is the replacement ratio. Because s is substantially larger than ru for conventional values of the interest rate,[8] the term in square brackets is close to 1, and (22) implies that the elasticity of wages with respect to the unemployment rate should be close to one minus the replacement ratio. Using the Blanchflower and Oswald (1994) benchmark estimate for the elasticity of 0.1, the model requires a replacement ratio of 0.9, a value too high to be plausible and implying a huge sensitivity of unemployment to changes in the generosity of unemployment insurance (Costain and Reiter, 2008). Unless one is going to make assumptions that make the replacement ratio extremely high,[9] 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

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[6] Of course, one has to assume that the vacancy cost is in the medium-run linked to productivity and/or wages as otherwise continued growth would make the vacancy filling costs less and less important. And in steady-state comparisons there is no distinction between short- and long-run linkages. But for the other models considered in this paper this is not a problem.

[7] The most common current approach seeks to explain the reduced-form response of endogenous variables like 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 labor will always deliver proportionality between average labor productivity and the wage, though causation may run from the latter to the former.

[8] Though 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 – in the UK this 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 then fail to explain why reservation wages are strongly correlated with expected wages.

[9] There may various ways to deliver a high replacement ratio, e.g. assuming that z is close to p, or that worker's bargaining power is very small. These different approaches may help or hinder the model in fitting the data in other directions.

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 U.K. and West Germany was 0.42 and 0.63, respectively. These estimates do not assign a value to the extra leisure of the unemployed and there is considerable dispute about the size and even sign of this component. Some attach a positive value to leisure while the empirical literature on the determinants of individual well-being has long 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 and Haisken-DeNew, 2009). 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 noting that one of the data sets we use in our empirical analysis contains information on reservation wages and expected wages on getting a job, from which a direct estimate of the ratio of the reservation wage to the expected wage can be obtained $\left(\rho / w\right)$. Using (19), this is related to the replacement ratio according to:

$$1-\frac{\rho}{w}=\left(1-\eta\right)\frac{r+\phi+s}{r+\lambda+s} \tag{23}$$

In the data ρ / w averages 0.8. As the duration of a wage contract $(1/\phi)$ is typically longer than the duration of a spell of unemployment $(1/\lambda)$, (23) then implies an upper bound for the replacement ratio of 0.8. And for realistic values of λ and ϕ, the replacement ratio would be considerably lower.

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

$$\frac{\partial \ln \rho}{\partial \ln u}=\frac{w}{\rho}\frac{\partial \ln w}{\partial \ln u}<\frac{\partial \ln w}{\partial \ln u}, \tag{24}$$

i.e. reservation wages should be more strongly cyclical than wages, and this is one of the predictions that we investigate below. Intuition for this result can be gauged from the special case $r=\phi=0$. In this case, represented by (16), the reservation has a cyclical component driven by the cyclicality of wages, and an extra cyclical component that derives directly from the unemployment rate.[10]

We next turn to the analysis of wage and reservation wage cyclicality out of steady state. The first case we consider is one with continuous re-negotiation ($\phi=\infty$).

B. Continuous wage re-negotiation

When wages are continuously renegotiated ($\phi=\infty$), equation (18) implies that newly-negotiated wages and average wages are the same, and expression (10) can be written as:

[10] One can induce more cyclicality in wages than reservation wages by assuming a procyclical mark-ups is pro-cyclical, but this obviously worsens model predictions for wage cyclicality.

$$S\left(t;w_r\left(t\right)\right)=E_t\int_t^{\infty}e^{-\int_t^{\tau}\left(r+\lambda(x)+s\right)dx}\left(w_r\left(\tau\right)-z\right)d\tau \tag{25}$$

Differentiating (25) gives:

$$\frac{dS\left(t;w_r\left(t\right)\right)}{dt}=-\left(w_r\left(\tau\right)-z\right)+\left(r+\lambda\left(t\right)+s\right)S\left(t;w_r\left(t\right)\right) \tag{26}$$

With continuous wage re-negotiation, equation (13) implies that $S\left(t;w_r\left(t\right)\right)=\tilde{\beta}\mu$, a constant. Substituting this in (26) 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. With $\phi=\infty$, expression (15) implies that the reservation wage is equal to $-\infty$ i.e. workers will accept a job at any wage. The intuition is that with continual wage re-negotiation, as workers expect any accepted wage to be immediately re-negotiated to a higher level. This is an extreme assumption, as workers reasonably expect that their accepted wage would persist for a non-zero period of time. In particular this is the case with occasional wage negotiation and we next turn to this case.

C. Occasional wage re-negotiation

We now need to introduce assumptions about the expected dynamics of labour market conditions, as the reservation wage is forward-looking according to (17). We make the simplest assumption and that the expected path of $\lambda\left(t\right)$ follows the continuous time version of an AR(1) process:

$$E_t\left(\frac{d\lambda\left(t\right)}{dt}\right)=-\xi\left(\lambda\left(t\right)-\lambda^*\right), \tag{27}$$

where λ^* is the steady-state value of λ and ξ represents the rate of convergence to it, whereby lower ξ implies higher persistence.

The model is non-linear in $\lambda\left(t\right)$ so we linearize around the steady-state and then derive wage responses to deviations of $\lambda\left(t\right)$ from the steady-state, which 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[11] and $\phi<\infty$:

a. The cyclicality of newly-renegotiated wages is:

$$\frac{\partial \ln w_r\left(t\right)}{\partial \ln u\left(t\right)}=-\frac{\left(1-\eta^*\right)\left(r+\phi+s\right)\left(\lambda+s+\xi\right)\left(\alpha s+\phi+\xi\right)}{\left(r+\lambda+s\right)\left\{\left(\alpha s+\phi+\xi\right)\left(r+\phi+s+\xi\right)-\left(1-\alpha\right)\xi\left[\tilde{\beta}\left(r+\lambda+s+\xi\right)-\lambda\right]\right\}} \tag{28}$$

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

b. The cyclicality of reservation wages is:

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

c. The cyclicality of the average wage is:

$$\frac{\partial \ln w_a(t)}{\partial \ln u(t)} = \frac{\alpha s+\phi}{\alpha s+\phi+\xi}\frac{\partial \ln w_r(t)}{\partial \ln u(t)} \tag{30}$$

d. The cyclicality of wages in new jobs is:

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

Proof: See Appendix B.

Results (28)-(31) can be used to shed light 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 (e.g. see Devereux and Hart, 2001). Expression (31) delivers this result, and implies that the predicted difference in 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.[12] In the limiting case $\xi \to 0$, renegotiated wages, average wages and wages in new jobs are equally cyclical, and (28)-(31) imply:

$$\frac{\partial \ln w_n(t)}{\partial \ln u(t)} = \frac{\partial \ln w_a(t)}{\partial \ln u(t)} = \frac{\partial \ln w_r(t)}{\partial \ln u(t)} = -\frac{(1-\eta^*)(\lambda^*+s)}{(r+\lambda^*+s)} \approx -(1-\eta^*) \tag{32}$$

where the second 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 (28) can be written as:

12 The model predicts that lagged unemployment would have explanatory power in wage curve estimates (Beaudry and diNardo, 1991; Hagedorn and Manovskii, 2013) but we do not pursue this here.

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

for $r=0$. As the expected duration of a wage contract is typically longer than the expected duration of an unemployment spell ($\phi > \lambda$), (33) predicts that newly-renegotiated wages are more cyclical than in steady state (see (22)). In this case 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.

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 the persistence in unemployment $\xi = 0.003$.[13] We consider a monthly interest rate of $r = 0.003$, and an expected contract length of 12 months, thus $\phi = 0.0833$. Finally we assume that the bargaining power parameter of workers is $\beta = 0.05$ (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 the UK data on reservation wages as a fraction of expected wages (which is about 0.8) and the compute the replacement ratio using condition (23) – at benchmark parameter values this yields a replacement ratio of 0.69. We obtain predictions for wage and reservation wage cyclicality for alternative values of α and plot them in Figure 1. In panel A, the predicted unemployment elasticities are quite high and not very sensitive to the amount of backward-looking behaviour in wage determination, as a consequence of high unemployment persistence. The predicted cyclicality in reservation wages is considerably higher than all measures of wage cyclicality.

If we impose lower unemployment persistence, all predicted elasticities become more sensitive to α. Panel B in Figure 1 illustrates this case based on a hypothetical (and unrealistic) value of $\xi = 0.1$. Lower unemployment persistence also reduces the gap between the predicted cyclicality in wages and reservation wages.

For our benchmark parameter values, the predicted elasticities of wages with respect to the unemployment rate are all well above the 0.1 benchmark estimate argued for by Blanchflower and Oswald (1994). The next section presents some empirical estimates for the UK and Germany as well as some estimates of the cyclicality in reservation wages.

[13] Data for s and u are obtained from the Quarterly Labour Force Survey. 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 the US and unemployment persistence higher, so these are numbers different from those often used in the literature for the analysis of US data.

4. Empirical (reservation) wage curves

A. *Estimates of the wage curve*

In our empirical analysis we use two data sets - British data from the British Household Panel Study (BHPS) and West German data from the German Socioeconomic Panel (GSOEP). 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 both contain information on reservation wages over a long period of time.

We start by providing 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 – as an "empirical law in economics" – 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). Bell, Nickell and Quintini (2002) provide wage curve estimates for the UK, and obtain a short-run elasticity of wages to unemployment around 0.03, and long-run elasticities varying between 0.05 and 0.13. Further work for the UK has found that the sensitivity of wages to unemployment 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 job stayers (Devereux and Hart, 2006). For West Germany, Blanchflower and Oswald (1994) provide estimates for the elasticity of wages to unemployment between -0.1 and -0.2 using ISSP data, and Wagner (1994) finds elasticities between 0 and -0.09 using GSOEP data, and slightly higher estimates up to -0.13 in IAB surveys. More recent work by Baltagi, Blien and Wolf (2009) estimates dynamic specifications on IAB data and finds elasticities significantly 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 that are closest 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. This is a feasible empirical strategy because state level unemployment rates do not show high persistence (Blanchard and Katz, 1992, Hines, Hoynes and Krueger, 2001). But in both the UK and West Germany, regional unemployment differentials are very persistent, making it hard to identify any cyclicality in wages if both time and region fixed effects are included. As a result, our baseline specifications use national unemployment as the business cycle indicator. This obviously means that we cannot also include unrestricted year effects in the regression so we model underlying productivity growth by a linear or quadratic trend. We later present estimates based on regional unemployment – these results typically show even smaller cyclicality in wages, though the 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 GSOEP. Results for the UK are presented in Table 1.[14] 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 yearly 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 about -0.16. Column 3 controls for region-specific trends, and the unemployment elasticity is only marginally affected, and column 4 includes the lagged dependent variable, which automatically restricts the sample to individuals continuously employed, and the unemployment elasticity falls slightly to -0.12.[15] Columns 5 also controls for lagged unemployment, but its effect on wages is not statistically significant.

Columns 6-8 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. Indeed column 6 shows 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. Column 7 shows that this result is robust to the introduction of individual fixed-effects. But when job fixed effects are included in column 8, the difference in cyclicality between old and continuing wages is much lower and borderline significant. As the effect of the interaction term in column 8 is identified by aggregate unemployment fluctuations within a job spell, and unemployment is highly persistent, we likely lack power to identify the effect of interest within job spells, as job spells are on average only observed over 2.6 waves. The alternative explanation is that the quality of newly-created jobs is procyclical, and when such cyclicality is captured by match fixed-effects the excess cyclicality in newly-negotiated wages is much reduced (see also Gertler and Trigari, 2009).

If wages are infrequently renegotiated, one would expect that the unemployment rate at the start of a job continues to have a significant impact on the wage while in that job, over and above the impact of current unemployment. This is tested in column 9, which shows that both starting unemployment and current unemployment have a significant impact on wages. If job fixed effects are included in this specification, the initial unemployment effect falls to -0.020 and is statistically significant at the 1% level. Column 10 controls for the lagged dependent variable, which renders the coefficient on starting unemployment both small and

[14] While Table 1 only reports the coefficients on various business cycle indicators, the full results for our main specification are reported in Table A2. All coefficients have the expected sign in both reservation wage and wage equations.

[15] This is the short-run elasticity of wages with respect to unemployment. Because the coefficient on the lagged dependent variable is large the implied long-run elasticity is considerably larger. But later specifications show that the coefficient on the lagged dependent variable has an upward bias because of omitted fixed effects.

insignificantly different from zero. This because the lagged wage is a sufficient statistic for the long-lasting impact of unemployment in a model with infrequent renegotiation. Column 11 uses the first difference in log wages as the dependent variable and the unemployment elasticity is somewhat reduced. Finally, column 12 introduces individual fixed-effect and the associated cyclicality of wages is very similar to that obtained in the baseline specification of column 2.

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 does not go beyond 5%, as illustrated in Table A3. Similarly as for aggregate wage curves, we do find evidence of excess cyclicality of wages on new jobs (columns 7 and 8), but this falls when job fixed-effects are introduced (column 9). In summary, our wage curve estimates obtained on the BHPS are very similar to those obtained by other studies on various datasets.

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 section, as information on reservation wages is only available at the monthly level. The unemployment elasticity of wages on all jobs is similar to that obtained for the UK, and ranges between virtually zero when controlling for fixed effects and -0.19 in OLS estimates. A clear similarity between the two countries is that the unemployment elasticity of wages is higher for new hires than for continuing jobs.

Overall, these estimates suggest that it is hard to align theoretical predictions represented in Figure 1 with the empirical evidence, which is the essence of the wage flexibility puzzle. We next turn to estimates of the cyclicality in reservation wages.

B. *Estimates of the reservation wage curve*

Existing work on reservation wage cyclicality is scant, as well as on its implication for the canonical search and matching model. An obvious reason for this gap in the literature is the scarcity of data on reservation wages. In the US, there is no data source that has systematically collected reservation wage data on a regular basis for a long period of time,[16] but this is instead available in both the BHPS and the GSOEP.

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 wages, and deflate it using the aggregate consumer price index. A similar question is asked of GSOEP respondents in all waves since 1987, except 1990, 1991

[16] For the US there is only a handful of studies analysing reservation wage data that has occasionally been collected (Feldstein and Poterba, 1984, Holzer, 1986a,b; Petterson, 1998, Ryscavage, 1988). In recent years the panel data collected by Krueger and Muller (2013) has greatly added to the knowledge on reservation wages, but these cover too short a period to investigate their cyclicality. Early work on reservation wages for the UK has used cross-section survey data (Lancaster and Chesher, 1983, Jones, 1988).

and 1995. The reservation wage information is elicited in monthly terms[17] and is not supplemented by information on expected hours, thus our analysis on West Germany refers to monthly reservation wages, and our wage regressions for West Germany 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 GSOEP the same question is asked of all individuals who are currently out of work but contemplate to go back to work in the future. Descriptive statistics for the reservation wage samples are also 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 typically included in earnings functions, namely gender, human capital components, regional and aggregate effects, as well as a measure of the bargaining power of workers, proxied by the unemployment rate (or, equivalently, labour market tightness). As the duration of unemployment affects a worker's set of skills, whether actual or perceived, 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. Finally, the reservation wage depends on the level of utility enjoyed while out of work, and as a proxy for this we use available measures of unemployment benefits and family composition.

The estimates for the reservation wage equations on the BHPS 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, as well as 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 elasticity of reservation wages to the unemployment rate is close to -0.10 and it 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 if one controls for region specific trends in column 3. Column 4 controls for current as well as lagged unemployment, and shows that the main source of cyclicality in the reservation wage is lagged rather than current unemployment. If one only controls for lagged unemployment, the associated coefficient is -0.148 and it is significant at the 5% level (results not reported). Finally, column 5 controls for worker unobserved heterogeneity by including individual fixed-effects, and the elasticity with respect to (lagged) unemployment is somewhat reduced with respect to OLS estimates.

Similarly as for wage equations, alternative business cycle indicators have no impact on reservation wages, except while the (log) labour market tightness, which turns out to have an impact on reservation wages that is very similar to the impact of the (log) aggregate unemployment rate. The results from regional reservation wage equations are reported in

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

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, [18] and the results are reported in Table 4. While the elasticity of reservation wages with respect to current unemployment is not significant (and actually wrongly signed if only a linear trend is included), the elasticity of reservation wages with respect to lagged unemployment is around -0.2 and very similar to the corresponding estimates for the UK.

These results can be broadly summarized by noting that, at best, there is fairly limited cyclicality in reservation wages and that the cyclicality in reservation wages is similar to the cyclicality in all wages, and if anything lower than the cyclicality of wages in new jobs, which is inconsistent with the theoretical predictions summarised in results (28)-(31). In addition, the prediction that reservation wages should be more strongly cyclical than wages is not validated in our estimates.

In particular, the ratio of cyclicalities should be given by the ratio of expected wage to reservation wages. The BHPS elicits information on expected post-unemployment wages. By asking jobseekers how many hours in a week they would be able to work, and what weekly net pay they would expect to receive for those hours, from which we obtain a measure of expected hourly wages. Given a mean ratio of (net) expected wages to reservation wages in our sample of about 1.2,[19] equation (24) predicts that the reservation wage elasticity should be about 20% higher than the elasticity of expected wages.

One potential problem with comparing the cyclicality of wages in new jobs with the cyclicality in reservation wages is that these equations are estimated on different samples of individuals, and differences in elasticities may be in part an outcome of sample selection. For the UK, we can investigate this further by estimating the cyclicality of expected wages on the same reservation wage sample using in Tables 3. The elasticity of the expected wage with respect to unemployment, obtained in a specification identical to that of column 2 of Table 3, is -0.179 (s.e. 0.053). This value is remarkably close to the elasticity of the reservation wage, while the theory predicts that the latter should be higher. Thus differences in sample do not seem to be able to explain our results.

C. *The quality of reservation wage data*

One clear concern 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)

[18] Due to benefit entitlement rules, we need to use an instrument for unemployment benefits in Germany. The duration of unemployment benefits in Germany is a nonlinear function of age and previous social security contributions. These are potentially correlated to individual characteristics that also determine wages. Thus we control for age and months of social security contributions linearly in the regressions, and we exploit nonlinearites in entitlement rules to obtain the number of months to benefit expiry, which we use as an instrument for unemployment benefits. No such instruments are required for the UK as the duration of benefits in the UK is determined by job search behaviour rather than previous employment history.

[19] This is also very similar to the mean ratio of (net) post-unemployment wages to reservation wages.

has the expected sign and is precisely estimated, as shown in Table A2. Below 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, those with higher reservation wages are expected to have a higher expected duration in unemployment, but higher entry wages once they find work.

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, both in terms of the point estimate and its significance. This estimate is likely to be upward biased due to omitted variables, as more able workers have both higher reservation wages and are more likely to find a job. Columns 2 and 3 control for a number of covariates, including the unemployment rate (national or local, respectively), and indeed show that, conditional on such factors, workers with higher reservation wages tend to experience significantly longer unemployment spells.

Columns 4-6 show the impact of reservation wages on wages for those who find jobs. In column 4, which does not control for characteristics, the elasticity of re-employment wages to reservation wages is likely to be upward biased by unobserved individual factors that are associated to both higher reservation wages and re-employment wages. Indeed such elasticity falls by about a quarter in column 5, which controls for individual characteristics, but it remains highly significant. Note that when we control for the aggregate unemployment rate in column 5, its impact on wages is of similar magnitude to the impact estimated in column 7 of Table 1 on the subsample of new job hires, although the sample in Table 1 is much larger because it includes new matches from any origin, while the sample in Table 5 only includes new job matches that originated in non-employment.

Similar results for West Germany are presented in Table 6, and they are clearly in line with the results for the UK, 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

We have highlighted two flaws with the canonical 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 modified to better fit the evidence. Conceptually, the model presented in Section2 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 $\mu(t)$. However, this would increase the predicted cyclicality of wages, worsening the wage flexibility puzzle. Thus we do not further pursue changes to the model of wage determination. Instead we explore changes to the model of determination of reservation wages, so as to curb their cyclicality.

To this purpose we derive the following result for the cyclicality in the reservation wage, conditional on the cyclicality in newly-re-negotiated wages.

Proposition 2: If the mark-up is acyclical and $\phi < \infty$:[20]
The reservation wage equation (17) implies the following relationship between the cyclicality of reservation wages and the cyclicality of newly-renegotiated wages:

$$\left(r+\lambda^{*}+s+\xi\right)\frac{\partial \ln \rho(t)}{\partial \ln u(t)}=\left[\lambda^{*}-\phi-\frac{(1-\alpha)\lambda^{*}\xi}{\alpha s+\phi+\xi}\right]\frac{w^{*}}{\rho^{*}}\frac{\partial \ln w_r(t)}{\partial \ln u(t)}-\left(\lambda^{*}+s+\xi\right)\left(\frac{w^{*}}{\rho^{*}}-1\right) \quad (34)$$

<u>Proof:</u> See Appendix B.

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 suggests $w^{*}/\rho^{*}-1\approx 0.2$, Proposition 2 predicts as much or more cyclicality in reservation wages than we observe in the data, even if wages in newly-renegotiated jobs are acyclical. The intuition is that, independent of wage cyclicality, reservation wages 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 points in job search behaviour.

A. *The reservation wage with on-the-job search*

We have assumed that only unemployed workers search for jobs, while a fraction close to half of new jobs are taken by workers currently employed (Manning, 2003). We next consider how the reservation wage is altered when both the unemployed and the employed search for jobs. The analysis below is conditional on the expected level of 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 are constant.

Arrival rates of job offers for the employed and for 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:

$$rW(w)=w-s\left[W(w)-U\right]+\lambda^{e}\int_{w}\left[W(x)-W(w)\right]dF(x), \quad (35)$$

and

$$rU=z+\lambda^{u}\int_{\rho}\left[W(x)-U\right]dF(w), \quad (36)$$

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

[20] The proof in the Appendix A allows for the general case.

$$\rho = z + \left(\lambda^u - \lambda^e\right)\int_\rho \left[W\left(w\right) - U\right] dF\left(w\right)$$
$$= z + \left(\lambda^u - \lambda^e\right)\int_\rho \frac{1 - F\left(w\right)}{r + s + \lambda^e\left[1 - F\left(w\right)\right]} dw, \tag{37}$$

where the second equality follows from integration by parts, given $W'(w) = \left\{r + s + \lambda^e\left[1 - F\left(w\right)\right]\right\}^{-1}$. Appendix C shows that, if the interest rate is small relative to transition rates, the reservation wage approximately satisfies:

$$\rho \approx z + (1-u)\left(1 - \frac{\lambda^e}{\lambda^u}\right)\left(w_a - z\right), \tag{38}$$

where w_a denotes the average wage across workers. Equation (16) is a special case of (38) for $\lambda^e = 0$.

According to (38), 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 address the puzzle, it comes with the less desirable consequences that the reservation wage is independent of factors that influence the distribution of wages. This prediction is strongly rejected in the data, as high-wage workers tend to have relatively higher reservation wages. Detailed results reported in columns 2 and 4 of Table A2 show that gender, age and education affect both wages and reservation wages in the same direction, thus the reservation wage is positively related to the wage that workers expect to earn.[21] Taken to (38), this result implies that off-the-job search is more effective than on-the-job search, a conclusion that is also in line with direct estimates of labour market transition rates.

In general, the reservation wage embodies the cyclicality in wages, plus a further cyclical component coming represented by $(1-u)\left(1-\lambda^e/\lambda^u\right)$. The term $1-u$ is obviously pro-cyclical, but the cyclicality of λ^e/λ^u is less clear. To provide evidence on the cyclicality of λ^e/λ^u we show (in Appendix D) 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. Intuitively, the two measures are related as the more effective on-the-job search, the higher the fraction of new jobs that are filled by someone already employed. Using data from the UK Labour Force Survey, Appendix D shows that the fraction of new jobs filled by previously employed workers is strongly countercyclical, and that $\lambda^e/\lambda^u < 1$ (about 0.6 at the mean unemployment rate) and counter-cyclical. The result $\lambda^e/\lambda^u < 1$ makes reservation wages less cyclical than in the case without on-the-job search, but its cyclicality λ^e/λ^u makes the reservation wage more cyclical. The latter effect

[21] One could perhaps explain this through wealth effects but most of the unemployed have very little in the way of accumulated wealth or access to capital markets.

dominates quantitatively, thus on-the-job search cannot solve the puzzle of the modest cyclicality in the reservation wage.

B. *The reservation wage and 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 (2013) has argued that the unemployed tend to be too optimistic about their job prospects, and Della Vigna and Paserman (2005) and Paserman (2008) argue that hyperbolic discounting has large effects on search intensity but very small effects on the reservation wage. They do not investigate the implication of their model for the cyclicality of reservation wages, but Appendix E argues that hyperbolic discounting is not likely to have important implications for the cyclicality of the reservation wage.

C. *Reference points in job search*

A number of studies have long suggested that reservation wages are determined by perceptions of fairness, and that these are heavily influenced by both past personal experience and reference groups (see, for example, Akerlof, 1980; Akerlof and Yellen, 1990; Blanchard and Katz, 1999). Falk, Fehr and Zehnder (2004) show, in an experimental setting, that past minimum wages that are no longer in effect influence reservation wages, making reservation wages less cyclical than in the optimizing job search models. Recently, DellaVigna 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 how benefit exhaustion affects unemployment exits.

If past wages shape reference points, which in turn influence reservation wages, we should observe a significant correlation between past wages and reservation wages, which will be investigated in this subsection. While such correlation is consistent with the existence of reference points, it is clearly also consistent with alternative mechanisms. One possible confounding factor is any direct link between unemployment benefits and past wages, as unemployment income is a key component of reservation wages in the canonical model. This is the case for West Germany, where benefit entitlement is a function of age and previous social security contributions, which are in turn directly linked to past wages, implying a positive correlation between past and reservation wages, over and above the role of reference points. By contrast, in the UK unemployment compensation 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 very important), whereas a worker who uses past wages as a reference point might do so.

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

$$\log \rho_{it} = \beta_1 X_{it} + \beta_2 w*_i + \beta_3 \mu_{it-d} + \varepsilon_{it}\,, \tag{39}$$

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:

$$\log w_{it-d} = \gamma_1 X_{it-d} + w*_i + \mu_{it-d} + u_{it-d}\,. \tag{40}$$

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

$$\log \rho_{it} = \delta_1 X_{it} + \delta_2 \log w_{it-d} + \varepsilon_{it}\,. \tag{41}$$

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

As a proxy for the size of rents in a given job we use industry affiliation, in line with a long-established literature concluding that part of inter-industry wage differentials represent rents (see the classic papers, Krueger and Summers, 1988, and Gibbons and Katz, 1992; and Benito, 2000, and Carruth, Collie and Dickerson, 2004, for British evidence). Specifically, we use as an instrument for previous wages the predicted, inter-industry wage differential obtained on an administrative dataset, the Annual Survey of Hours and Earnings (ASHE), whose sample size allows us to control for industry affiliation at the 4-digit level. We estimate a log wage regression 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 crucial 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 the determination of reservation wages (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, not surprisingly, positive and highly significant. The specification in column 2 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 10 years after job loss. This is consistent with the argument in DellaVigna et al (2104) that reference points do change over time. Column 3 introduces individual fixed-effects, and the coefficient of interest is identified from individuals with multiple unemployment spells, originated from different industries. The coefficient on the past wage is markedly lower than in column 2, but still positive and significant. The difference between OLS and FE coefficients is, not surprisingly, revealing a sizeable ability component in the past effect estimated in column 2.

Column 4 instruments the previous wage with its rent component, as proxied by the 4-digit industry level differential, and shows that this rent component 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 and (classical) measurement error in the actual wage (see also Manning, 2003, chapter 6). The specification in Column 5 allows for decay of reference points over time, and its speed is very close quantitatively to that obtained using OLS. Column 6 finally introduces individual fixed-effects, and the coefficient on the past wage is only very slightly reduced with respect to column 5, although the decay effect is no longer significant.

In summary, we do find evidence that rents in previous jobs tend to affect reservation wages. Overall, this finding is not consistent with the determination of reservation wages in the canonical model, but is instead consistent with a model in which past wages shape workers' reference points and job search behaviour.

D. *Rigidities in Reservation Wages*

Having empirically established that reference points influence reservation, this section outlines a model that incorporates some backward-looking behaviour in the determination of reservation wages. This would make reservation wages less responsive to the state of the business cycle and, via wage determination, would reduce the cyclicality of wages themselves.

We retain the model for wage determination introduced in Section 2, and combine it with two alternative reservation wage models with a backward-looking element. In the first, reservation wages are a linear combination of the optimal reservation wage derived in (15), which we will denote by $\rho_0(t)$, and a constant, acyclical reference point component, k:

$$\rho(t) = \alpha_\rho \rho_0(t) + (1 - \alpha_\rho)k \tag{42}$$

Lower α_ρ implies a stronger backward-looking persistence in reservation wages. In the second model, the reference point is represented by the average wage, which is itself cyclical, and affects reservation wages up to a constant k:

$$\rho(t) = \alpha_\rho \rho_0(t) + (1 - \alpha_\rho)(w_a(t) - k) \tag{43}$$

Consider first the cyclicality in average wages at benchmark parameter values and $\alpha_\rho = 1$, as a function of the degree of persistence in wage-setting behaviour (α). This is denoted by the line 'Persistence in Wages Only' in Figure 2. As expected, wage cyclicality falls with their persistence, but quantitatively this effect is small. As discussed in Section 3 this is a consequence of the high empirical persistence in unemployment.

Figure 2 also displays the cyclicality in average wages at benchmark parameter values and no backward-looking behaviour in wages (i.e. $\alpha = 1$), as a function of the degree of persistence in reservations wages (α_ρ). The notation 'Model 1' and 'Model 2' refers to the cases shown in equations (42) and (43), respectively. Both models generate less cyclicality in actual wages than a model that introduces the same level of persistence in wage determination. Unsurprisingly, the reduction in cyclicality is greater when the reference point in reservation wages is assumed to be completely acyclical (Model 1). If the reference point is as cyclical as average wages (Model 2), a high reference point dependence is needed to generate the cyclicality that is observed in the data.

Although this model is very stylized, it does suggest that some degree of persistence in reservation wages – possibly driven by reference points – is needed for the model to explain the low observed cyclicality in wages.

6. Conclusions

We used a canonical search and matching model to derive a wage curve, i.e. a relationship between log wages and log unemployment that 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 if one allows for occasional wage re-negotiation and a backward-looking component to wage determination, unless unemployment has implausibly low persistence.

We also show that the canonical model implies that reservation wages are more cyclical than actual wages, but British and German data do not support this prediction.

We then argue that one (though plausibly not the only) source of the puzzle is the model for the determination of reservation wages, as these are less cyclical than one would expect, conditional on the observed cyclicality in wages. We finally show evidence of significant, backward-looking reference point elements in reservation wages, which help rationalize the mild cyclicality in both wages and reservation wages.

Table 1: Estimates of a Wage Equation for the UK, 1991-2009.
Business cycle indicator: Aggregate unemployment

	1	2	3	4	5	6	7	8	9	10	11	12
Dependent variable	Log wage	Log wage	Log wage	Log wage	Log wage	Log wage	Log wage	Log wage	Log wage	Log wage	Δ Log wage	Log wage
Log wage, lagged				0.759***	0.759***					0.759***		0.102**
				(0.005)	(0.005)					(0.005)		(0.046)
Log unemp rate	-0.022	-0.165***	-0.155***	-0.123***	-0.106***	-0.141***	-0.146***	-0.110***	-0.144***	-0.123***	-0.092***	-0.150***
	(0.032)	(0.044)	(0.043)	(0.017)	(0.025)	(0.044)	(0.011)	(0.011)	(0.040)	(0.017)	(0.021)	(0.009)
Log unemp rate, lagged					-0.014							
					(0.020)							
Log unemp * new job						-0.069***	-0.075***	-0.016*				
						(0.018)	(0.008)	(0.009)				
Log unemp rate, at start of job									-0.039***	-0.003	0.004	
									(0.008)	(0.004)	(0.004)	
Trend	linear	quadratic	quadratic	quadratic	quadratic	quadratic	quadratic	quadratic	quadratic	quadratic	quadratic	quadratic
Region specific trend			√									
Individual fixed effects							√					√
Job fixed effects								√				
Observations	96,270	96,270	96,270	70,901	70,901	96,270	96,270	96,270	95,584	70,438	70,438	53,054
R-squared	0.397	0.397	0.398	0.748	0.748	0.398			0.398	0.748	0.015	

Notes. The wage measure is hourly. All regressions include 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 6-8 also include a dummy for new job. Estimates in column 12 are obtained using the Arellano Bond (1991) estimator for dynamic panel data models. Standard errors are clustered at the year level in columns 1-11, and using 2-way cluster-robust variance (Cameron and Miller, 2013) in column 12. Source: BHPS.

Table 2: Estimates of a Wage Equation for the West Germany, 1987-2010

	1	2	3	4	5	6	7	8	9	10	11	12
Dependent variable	Log wage	Log wage	Log wage	Log wage	Log wage	Log wage	Log wage	Log wage	Log wage	Log wage	Δ Log wage	Log wage
Log wage, lagged				0.729***	0.729***					0.729***		0.398***
				(0.007)	(0.007)					(0.007)		(0.027)
Log unemployment rate	0.082	0.002	0.002	-0.019	0.011	0.041	-0.015	-0.005	0.018	-0.016	-0.034**	-0.018
	(0.048)	(0.025)	(0.025)	(0.014)	(0.020)	(0.027)	(0.018)	(0.015)	(0.022)	(0.014)	(0.015)	(0.025)
Log unemployment rate, lagged					-0.038*							
					(0.020)							
Log unemployment rate * new job						-0.268***	-0.096***	0.034				
						(0.041)	(0.026)	(0.022)				
Log unemp rate, at start of job									-0.027***	-0.007***	-0.000	
									(0.007)	(0.002)	(0.002)	
Trend	linear	quadratic	quadratic	quadratic	quadratic	quadratic	quadratic	quadratic	quadratic	quadratic	quadratic	quadratic
Region specific trend			√									
Individual fixed effects							√					√
Job fixed effects								√				
Observations	166,614	166,614	166,614	129,323	129,323	166,416	160,865	149,617	166,614	129,323	129,323	101,526
R-squared	0.649	0.651	0.651	0.858	0.858	0.652	0.415	0.199	0.652	0.858	0.045	

Notes. The wage measure is monthly. 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 sixteen region dummies. Estimates in column 12 are obtained using the Arellano Bond (1991) estimator for dynamic panel data models. Standard errors are clustered at the year level in columns 1-11, and using 2-way cluster-robust variance (Cameron and Miller, 2013) in column 12. Source: GSOEP.

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

	1	2	3	4	5
Dependent variable					
Estimation method	OLS	OLS	OLS	OLS	FE
Log unemployment rate	-0.095*	-0.175***	-0.164**	0.115	0.010
	(0.046)	(0.058)	(0.058)	(0.156)	(0.104)
Log unemployment rate, lagged				-0.215*	-0.119
				(0.112)	(0.073)
Trend	linear	quadratic	quadratic	quadratic	quadratic
Region specific trends			√		
Observations	14,874	14,874	14,874	14,874	14,874
R-squared	0.248	0.249	0.249	0.249	

Notes. Dependent variable: log reservation wage. The reservation wage measure is hourly. 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 1-4, and using 2-way cluster-robust variance (Cameron and Miller, 2013) in column 5. Source: BHPS.

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

	1	2	3	4	5
Dependent variable					
Estimation method	IV	IV	IV	IV	IV+FE
Log unemployment rate	0.173**	0.001	0.003	0.184**	0.175**
	(0.070)	(0.065)	(0.064)	(0.074)	(0.070)
Log unemployment rate, lagged				-0.255***	-0.196***
				(0.051)	(0.064)
Trend	linear	quadratic	quadratic	quadratic	quadratic
Region specific trends			√		
Observations	11,221	11,221	11,221	11,221	7,911
R-squared	0.414	0.418	0.418	0.419	0.125

Notes. Dependent variable: log reservation wage. The reservation wage measure is monthly. 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 sixteen 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 1-4, and using 2-way cluster-robust variance (Cameron and Miller, 2013) in column 5. Source: GSOEP.

Table 5
Reservation wages, post-unemployment wages and job finding probabilities in the UK, 1991-2009

	1	2	3	4	5	6
Dependent variable	Whether found a job			Log post-unemployment wage		
Estimation method	OLS	OLS	OLS	OLS	OLS	OLS
Log reservation wage	-0.001	-0.020**	-0.022***	0.436***	0.312***	0.308***
	(0.008)	(0.008)	(0.007)	(0.021)	(0.036)	(0.037)
Log unemployment rate, aggregate		-0.069			-0.216**	
		(0.069)			(0.077)	
Log unemployment rate, regional			-0.036			0.015
			(0.026)			(0.057)
Year dummies	√			√		
Trend	no	quadratic	quadratic	no	quadratic	quadratic
Further controls		√	√		√	√
Observations	15,278	14,701	14,700	2,685	2,594	2,593
R-squared	0.018	0.078	0.085	0.217	0.299	0.303

Notes. The wage measure is hourly. 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, and eleven region dummies. Standard errors are clustered at the year level. Source: BHPS.

Table 6
Reservation wages, post-unemployment wages and job finding probabilities in West Germany, 1987-2010

	1	2	3	4	5	6
Dependent variable		Whether found a job			Log post-unemployment wage	
Estimation method	OLS	OLS	OLS	OLS	OLS	OLS
Log reservation wage	0.033***	-0.081***	-0.081***	0.737***	0.390***	0.389***
	(0.007)	(0.011)	(0.011)	(0.023)	(0.034)	(0.034)
Log unemployment rate, aggregate		-0.067*			-0.243	
		(0.038)			(0.141)	
Log unemployment rate, regional			-0.018			-0.086
			(0.029)			(0.068)
Year dummies	√			√		
Trend	no	quadratic	quadratic	no	quadratic	quadratic
Further controls		√	√		√	√
Observations	11,534	11,534	11,534	2,984	2,984	2,984
R-squared	0.006	0.071	0.071	0.239	0.349	0.348

Notes. The wage measure is monthly. 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") and sixteen region dummies. Standard errors are clustered at the year level. Source: GSOEP.

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

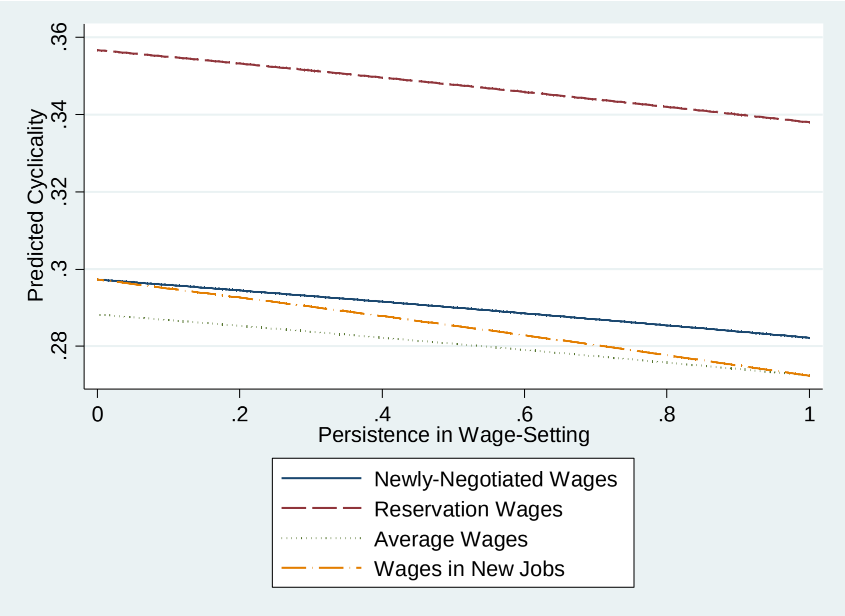
	1	2	3	4	5	6
Estimation method	OLS	OLS	FE	IV	IV	IV+FE
Last observed log wage	0.083***	0.101***	0.042***	0.133***	0.177***	0.153***
	(0.005)	(0.008)	(0.011)	(0.018)	(0.022)	(0.067)
Last observed log wage * years since observed		-0.009***	-0.011*		-0.017***	-0.002
		(0.002)	(0.006)		(0.006)	(0.009)
Log unemployment rate	-0.183***	-0.182***	-0.174***	-0.159*	-0.156*	-0.166*
	(0.081)	(0.081)	(0.075)	(0.084)	(0.084)	(0.078)
Trend	quadratic	quadratic	quadratic	quadratic	quadratic	quadratic
Observations	8,091	8,091	5,737	7,732	7,732	5,520
R-squared	0.284	0.286	0.099			
First stage, F-test(a)				908.9	544.9	48.2
First stage, F-test(b)					292.9	52.8

Notes. Dependent variable: log monthly reservation wage. 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 (column 4); predicted industry wage (4-digit) for previous job and its interaction with years since previous job (columns 5-6). (a) denotes Angrist and Pischke (2009) 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.

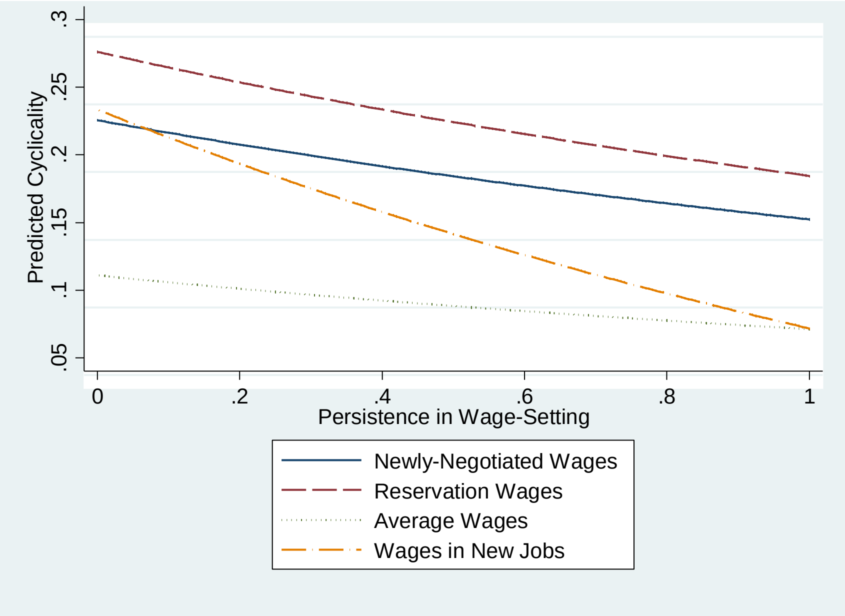
Figure 1

How Persistence in Wage-Setting Affects the Cyclicality in Wages

Panel A: Realistic (High) Value of Unemployment Persistence



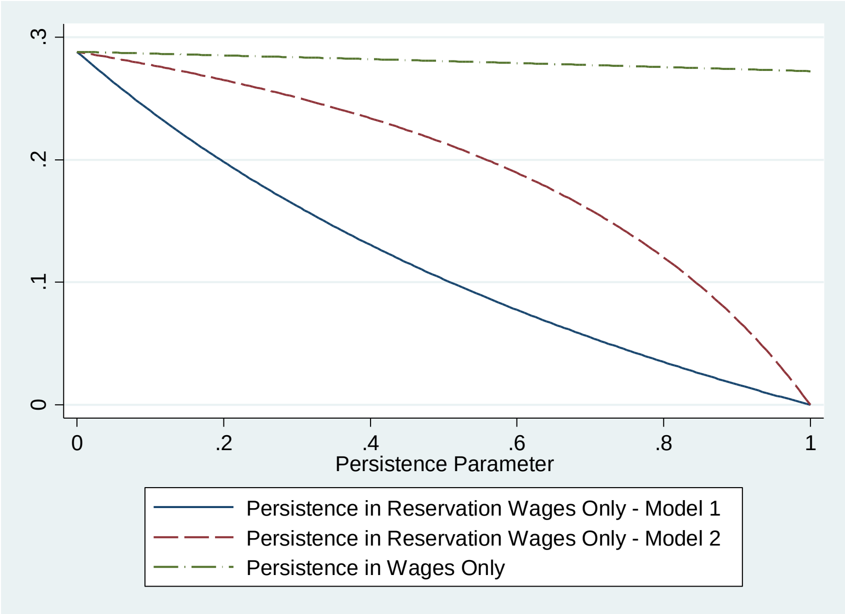
Panel B: Unrealistic (Low) Value of Unemployment Persistence



Notes: The parameter values are as described in Section 3c in the paper. Panel A assumes $\xi = 0.003$, while Panel B assumes $\xi = 0.1$.

Figure 2

The Impact of Persistence in Wages and Reservation Wages on the Predicted Cyclicality in Actual Average Wages



Notes: These are the predictions from the model of Section 5d in which the parameter values are as described in section 3c.

Appendix Tables and Figures

Table A1: Descriptive statistics

	United Kingdom						West Germany					
	Reservation wage sample			Wage sample			Reservation wage sample			Wage sample		
Variables:	No. obs	Mean	St. dev.	No. obs	Mean	St. dev.	No. obs	Mean	St. dev.	No. obs	Mean	St. dev.
Reservation wage	14874	5.226	6.206				11221	1180.36	703.219			
Wage				96270	9.866	6.203	11221			166614	2387.66	1898.02
Female	14874	0.546	0.498	96270	0.526	0.500	11221	0.616	0.486	166614	0.430	0.495
Age	14874	34.666	14.024	96270	38.106	11.691	11221	33.289	11.316	166614	39.039	11.644
Higher education	14874	0.247	0.431	96270	0.117	0.321	11221	0.143	0.350	166614	0.254	0.435
Upper secondary education	14874	0.353	0.478	96270	0.269	0.443	11221	0.549	0.498	166614	0.528	0.499
Lower secondary education	14874	0.314	0.464	96270	0.405	0.491	11221	0.211	0.408	166614	0.178	0.382
No qualifications	14874	0.085	0.280	96270	0.209	0.407	11221	0.097	0.086	166614	0.040	0.040
Married	14874	0.514	0.500	96270	0.717	0.451	11221	0.559	0.497	166614	0.657	0.475
No. Kids	14874	0.917	1.168	96270	0.686	0.965	11221	1.027	1.120	166614	0.730	0.990
Duration in current status (years)	14874	4.387	5.748	96270	4.880	5.969	11221	2.962	3.902	166614	10.464	9.653
Benefits	14874	276.414	318.201				11221	255.835	448.710			
Looking for full-time work							11221	0.482	0.500			
Looking for part-time work							11221	0.382	0.486			
Looking for either							11221	0.109	0.312			
Unsure about working hours							11221	0.027	0.161			
Social insurance contributions (months)							11221	5.242	6.878			
Months to benefit expiry							11221	1.109	3.679			
Entitled to unemployment benefits							11221	0.196	0.397			
Hours worked										166614	38.495	12.680

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

	1	2	3	4
	United Kingdom		West Germany	
Dependent variable:	Log res wage	Log wage	Log res wage	Log wage
Log aggregate unemployment rate	-0.175***	-0.165***	0.001	0.002
	(0.058)	(0.044)	(0.065)	(0.025)
Female	-0.102***	-0.263***	-0.188***	-0.265***
	(0.011)	(0.009)	(0.018)	(0.015)
Age	0.033***	0.073***	0.018***	0.082***
	(0.002)	(0.002)	(0.003)	(0.002)
Age^2 (/100)	-0.034***	-0.084***	-0.003***	-0.009***
	(0.002)	(0.002)	(0.000)	(0.000)
Lower secondary qualification	0.068***	0.193***	-0.016	0.023**
	(0.009)	(0.008)	(0.024)	(0.011)
Upper secondary qualification	0.157***	0.361***	0.093***	0.230***
	(0.011)	(0.007)	(0.023)	(0.015)
Higher education	0.352***	0.710***	0.276***	0.562***
	(0.013)	(0.004)	(0.029)	(0.019)
Married	0.042***	0.092***	-0.038***	0.032***
	(0.006)	(0.006)	(0.010)	(0.003)
No. kids in household	0.018***	-0.019***	-0.006	-0.020***
	(0.004)	(0.003)	(0.005)	(0.004)
Duration in current status	-0.002	0.018***	0.013**	0.037***
(years)	(0.002)	(0.001)	(0.005)	(0.002)
Duration in current status^2	-0.001	-0.010***	-0.014**	-0.012***
(years/10)	(0.002)	(0.001)	(0.006)	(0.001)
Duration in current status^3	0.003	0.017***	0.003**	0.002***
(years/100)	(0.003)	(0.002)	(0.002)	(0.000)
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			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	0.004	-0.009	0.027***	0.022***
	(0.007)	(0.007)	(0.008)	(0.002)
(Year-1990)^2	0.001**	0.001***	-1.003***	-0.696***
	(0.000)	(0.000)	(0.253)	(0.078)
Observations	14,847	96,270	11,221	166,614
R-squared	0.249	0.397	0.359	0.605

Notes. Wage measures are hourly for the U.K. and monthly for West Germany. All regressions include region dummies. Standard errors are clustered at the year level. Source: BHPS and GSOEP.

Table A3: Estimates of a Wage Equation for the UK, 1991-2009.
Business cycle indicator: regional unemployment

	1	2	3	4	5	6	7	8	9	10	11	12	13
Dependent variable	Log wage	Log wage	Log wage	Log wage	Log wage	Log wage	Log wage	Log wage	Log wage	Log wage	Log wage	Δ Log wage	Log wage
Log wage, lagged					0.759***	0.759***					0.759***		0.073
					(0.005)	(0.005)					(0.005)		(0.052)
Log unemp rate	0.010	-0.009	-0.036***	-0.051***	-0.018**	-0.006	-0.022*	-0.042***	-0.042***	-0.027	-0.018	-0.022**	-0.058***
	(0.010)	(0.011)	(0.012)	(0.011)	(0.009)	(0.010)	(0.013)	(0.006)	(0.006)	(0.018)	(0.011)	(0.010)	(0.022)
Log unemp rate, lagged						-0.021**							
						(0.009)							
Log unemp * new job							-0.041***	-0.035***	-0.012***				
							(0.009)	(0.005)	(0.005)				
Log unemp rate, at start of job										-0.051***	-0.008*	0.001	
										(0.010)	(0.004)	(0.005)	
Trend	No	Linear	quadratic	quadratic	quadratic	quadratic	quadratic	quadratic	quadratic	quadratic	quadratic	quadratic	quadratic
Region specific trend				√									
Year dummies	√												
Individual fixed effects								√					√
Job fixed effects									√				
Observations	96,269	96,269	96,269	96,269	70,901	70,901	96,269	96,269	96,269	95,583	70,438	70,438	53,054
R-squared	0.399	0.397	0.397	0.397	0.748	0.748	0.398				0.748	0.015	

Notes. The wage measure is hourly. 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. Estimates in column 12 are obtained using the Arellano Bond (1991) estimator for dynamic panel data models. Standard errors are clustered at the (year) level in columns 1-11, and using 2-way cluster-robust variance (Cameron and Miller, 2013) in column 12. Source: BHPS.

Table A4: Estimates of a Wage Equation for West Germany – further estimates with regional controls

	1	2	3	4	5	6	7	8	9	10	11	12	13
Dependent variable	Log wage	Log wage	Log wage	Log wage	Log wage	Log wage	Log wage	Log wage	Log wage	Log wage	Log wage	Δ Log wage	Log wage
Log wage, lagged					0.729***	0.729***					0.725***		0.398***
					(0.005)	(0.005)					(0.005)		(0.017)
Log unemp rate	-0.033**	0.015	0.006	0.013	-0.011*	0.011	0.016	-0.003	0.001	-0.000	-0.012*	-0.024***	-0.004
	(0.016)	(0.013)	(0.011)	(0.012)	(0.006)	(0.008)	(0.011)	(0.008)	(0.006)	(0.012)	(0.006)	(0.006)	(0.026)
Log unemp rate, lagged						-0.029***							
						(0.008)							
Log unemp * new job							-0.069***	-0.039***	-0.011				
							(0.017)	(0.012)	(0.010)				
Log unemp rate, at start of job										0.034***	0.007***	-0.002	
										(0.003)	(0.002)	(0.002)	
Trend	No	Linear	quadratic	quadratic	quadratic	quadratic	quadratic	quadratic	quadratic	quadratic	quadratic	quadratic	quadratic
Region specific trend				√									
Year dummies	√												
Individual fixed effects								√					√
Job fixed effects									√				
Observations	166,614	166,614	166,614	166,614	129,323	129,323	166,416	160,865	149,617	162,722	126,260	126,260	101,526
R-squared	0.652	0.649	0.651	0.651	0.858	0.858	0.651	0.415	0.199	0.658	0.859	0.047	

Notes. The wage measure is monthly. 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 sixteen region dummies. Estimates in column 12 are obtained using the Arellano Bond (1991) estimator for dynamic panel data models. Standard errors are clustered at the year level in columns 1-11, and using 2-way cluster-robust variance (Cameron and Miller, 2013) in column 12. Source: GSOEP.

Table A5: Estimates of a Reservation Wage Equation for the UK – further estimates with regional controls

	1	2	3	4	5	6
Dependent variable						
Estimation method	OLS	OLS	OLS	OLS	OLS	FE
Log unemployment rate, regional	0.007	-0.047	-0.054*	-0.064**	0.028	0.048
	(0.026)	(0.031)	(0.028)	(0.028)	(0.039)	(0.031)
Log unemployment rate, regional, lagged					-0.100**	-0.106***
					(0.037)	(0.028)
Year dummies	√					
Trend	No	linear	quadratic	quadratic	quadratic	quadratic
Region specific trend				√		
Observations	14,873	14,873	14,873	14,873	14,873	14,873
R-squared	0.252	0.247	0.247	0.248	0.248	

Notes. Dependent variable: log reservation wage. The reservation wage measure is monthly. 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 1-15, and using 2-way cluster-robust variance (Cameron and Miller, 2013) in column 5. Source: BHPS.

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

	1	2	3	4	5	6
Dependent variable						
Estimation method	IV	IV	IV	IV	IV	IV+FE
Log unemployment rate, regional	-0.079*	0.028	0.018	0.023	0.119***	0.116***
	(0.043)	(0.027)	(0.022)	(0.023)	(0.029)	(0.035)
Log unemployment rate, regional, lagged					-0.131***	-0.113***
					(0.024)	(0.034)
Year dummies	√					
Trend	No	linear	quadratic	quadratic	quadratic	quadratic
Region specific trend				√		
Observations	11,221	11,221	11,221	11,221	11,221	7,911
R-squared	0.421	0.413	0.418	0.418	0.419	0.125

Notes. Dependent variable: log reservation wage. The reservation wage measure is monthly. 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 sixteen region dummies. Unemployment benefits are instrumented, see notes to Table 4. Standard errors are clustered at the year) level in columns 1-15, and using 2-way cluster-robust variance (Cameron and Miller, 2013) in column 5. Source: GSOEP.

Appendix B

Proof of Proposition 1

We start by stating some useful results:

Result 1:

$$E_t\left(\lambda(\tau)\middle|\lambda(t)\right)=e^{-\xi|(\tau-t)|}\lambda(t)+\left[1-e^{-\xi|(\tau-t)|}\right]\lambda^*, \tag{44}$$

This follows from (27). Note that expression (44) is valid for any τ, higher or lower than t, a property which will be useful below.

Result 2:

When linearizing the model about the steady-state, we can express any variable $x(t)$ as:

$$x(t)-x^*=\theta_x\left(\lambda(t)-\lambda^*\right) \tag{45}$$

Combining (45) and (27) gives:

$$E_t\left[\frac{dx(t)}{dt}\middle|\lambda(t)\right]=\theta_x E_t\left[\frac{d\lambda(t)}{dt}\middle|\lambda(t)\right]=-\xi\theta_x\left(\lambda(t)-\lambda^*\right) \tag{46}$$

for forward-looking variables, and:

$$E_t\left[\frac{dx(t)}{dt}\middle|\lambda(t)\right]=\theta_x E_t\left[\frac{d\lambda(t)}{dt}\middle|\lambda(t)\right]=\xi\theta_x\left(\lambda(t)-\lambda^*\right) \tag{47}$$

for backward-looking variables.

Note that, for backward-looking variables, past realizations of λ would have an explanatory power independent of $\lambda(t)$, but we are interested here in what an econometrician would find when regressing contemporaneous variables on each other.

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

$$\frac{d\ln u(t)}{d\lambda(t)}=-\frac{1}{\lambda^*+s+\xi} \tag{48}$$

Proof: The unemployment rate follows the differential equation:

$$\frac{du(t)}{dt}=s\left[1-u(t)\right]-\lambda(t)u(t) \tag{49}$$

Which can be linearized about the steady-state to yield:

$$\frac{du(t)}{dt}=-\left[\lambda^*+s\right]\left[u(t)-u^*\right]-u^*\left[\lambda(t)-\lambda^*\right] \tag{50}$$

Using (45) and (47) (because unemployment is a backward-looking variable), (50) can, after some re-arrangement, be written as:

$$\theta_u = -\frac{u^*}{\lambda^* + s + \xi} \tag{51}$$

which implies (48).

Result 3 is useful because we are ultimately interested in the elasticity of relevant wage measures with respect to the log of unemployment, as this is the relationship typically estimated in the empirical literature. Using (48) we can convert the sensitivity of any model variable to $\lambda(t)$ into an unemployment elasticity.

Result 4: The cyclicality of average wages

We now consider the cyclicality of wages, and namely: average wages; wages in new jobs; newly-renegotiated wages; and reservation wages. Linearizing (18) about the steady-state gives:

$$\frac{dw_a}{dt} = -[\alpha s + \phi]\left[(w_a - w_a^*) - (w_r - w_r^*)\right] + \frac{\alpha u^*(w_r^* - w_a^*)}{1-u^*}\left[\lambda(t) - \lambda^*\right] \tag{52}$$

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

$$\theta_{w_a} = \frac{\alpha s + \phi}{\alpha s + \phi + \xi}\theta_{w_r} \tag{53}$$

i.e. average wages are less cyclical than newly-re-negotiated wages unless there is continual wage re-negotiation ($\phi = \infty$) or there is complete persistence in unemployment ($\xi = 0$).

Result 5: The cyclicality of renegotiated wages

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

$$\begin{aligned}\theta_{w_r} &= \theta_\rho + \tilde{\beta}(r + \phi + s)\theta_\mu - \tilde{\beta}(1-\alpha)\left[\theta_{w_a} - \theta_{w_r}\right] \\ &= \theta_\rho + \frac{w^* - \rho^*}{\mu^*}\theta_\mu - \tilde{\beta}(1-\alpha)\left[\theta_{w_a} - \theta_{w_r}\right].\end{aligned} \tag{54}$$

Where we have allowed, in the general case, for some cyclicality in the mark-up. Note that this is only valid if $\phi < \infty$, 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 (54) ill-defined. Using (53) we can eliminate θ_{w_a} from (54) and re-arrange to yield:

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

This can then be converted to elasticities to yield:

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

Result 5: The cyclicality in reservation wages

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

$$\begin{aligned} E_t\frac{d\rho(t)}{dt}&=(r+\lambda^*+s)\left(\rho(t)-\rho^*\right)-(\alpha\lambda^*-\phi)\left(w_r(t)-w_r{}^*\right)\\ &\quad-(1-\alpha)\lambda^*\left(w_a(t)-w_a{}^*\right)+\left[\rho^*-w^*\right]\left(\lambda(t)-\lambda^*\right) \end{aligned} \tag{57}$$

As the reservation wage is a forward-looking variable, from (57) we can derive:

$$(r+\lambda^*+s+\xi)\theta_\rho=(\alpha\lambda^*-\phi)\theta_{w_r}+(1-\alpha)\lambda^*\theta_{w_a}+\left[w^*-\rho^*\right] \tag{58}$$

(53), (54) and (58) together with (55) give a set of linear equations for the elasticity of wages and reservation wages with respect to unemployment as a function of the parameters of the model. And, using (53) to eliminate θ_{w_a} from (58) yields:

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

Proof of Proposition 1a

Solving (55) and (59) leads to:

$$\theta_{w_r}=\frac{(w^*-\rho^*)(\alpha s+\phi+\xi)\left[(r+\lambda+s+\xi)\frac{\theta_\mu}{\mu^*}+1\right]}{(\alpha s+\phi+\xi)(r+\phi+s+\xi)-(1-\alpha)\xi\left[\tilde{\beta}(r+\lambda+s+\xi)-\lambda\right]} . \tag{60}$$

Using (23), this can be converted to elasticity form:

$$\frac{\partial \ln w_r(t)}{\partial \ln u(t)}=-\frac{(1-\eta^*)(r+\phi+s)(\alpha s+\phi+\xi)\left[(\lambda+s+\xi)-(r+\lambda+s+\xi)\frac{\partial \ln \mu(t)}{\partial \ln u(t)}\right]}{(r+\lambda+s)\left\{(\alpha s+\phi+\xi)(r+\phi+s+\xi)-(1-\alpha)\xi\left[\tilde{\beta}(r+\lambda+s+\xi)-\lambda\right]\right\}} \tag{61}$$

Which, setting $\theta_\mu=0$, is (28).

Proof of Proposition 1b

Solving (55) and (59) leads to:

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

(62)

Converting to an elasticity and setting $\theta_\mu = 0$, this gives (29).

Proof of Propositon 1c

This follows directly from (53).

Proof of Propositon 1d

This follows directly from (53) and the fact that wages in new jobs are w_r with probability α and w_a with probability $(1-\alpha)$.

Proof of Proposition 2

This follows directly from (59) after converting to an elasticity with respect to unemployment.

Appendix C

The reservation wage with on-the-job search

The possibility of search on-the-job causes the distribution of wages across workers, $G(w)$ to be different from the distribution of wage offers $F(w)$ and it can be shown (Burdett and Mortensen, 1998) that the two are related by:

$$1-G(w) = \frac{1-F(w)}{s+\lambda^e\left[1-F(w)\right]}\frac{s+\lambda^e\left[1-F(\rho)\right]}{1-F(\rho)} \tag{63}$$

Using (63) and the usual approximation $r \approx 0$, (37) can be written as:

$$\rho \approx z+\frac{(\lambda^u-\lambda^e)\left[1-F(\rho)\right]}{s+\lambda^e\left[1-F(\rho)\right]}\int_\rho\left[1-G(w)\right]dw = z+\frac{(\lambda^u-\lambda^e)\left[1-F(\rho)\right]}{s+\lambda^e\left[1-F(\rho)\right]}(\overline{w}-\rho), \tag{64}$$

where $\overline{w}$ denotes the average wage across workers. Re-arranging gives:

$$\rho \approx \frac{\left\{s+\lambda^e\left[1-F(\rho)\right]\right\}z+(\lambda^u-\lambda^e)\left[1-F(\rho)\right]\overline{w}}{s+\lambda^u\left[1-F(\rho)\right]}. \tag{65}$$

The unemployment rate is given by:

$$u = \frac{s}{s+\lambda^u\left[1-F(\rho)\right]} \tag{66}$$

and substituting this in (65) gives (38).

Appendix D

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.[22] During 1993-2012, this fraction is on average 60.1%. We then regress ζ on the unemployment rate and report regression results in Table B1, showing that ζ is pro-cyclical, with a slope coefficient on the unemployment rate of approximately 1.

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 who employed in firms at or below position f satisfies:

$$\left[s+\lambda^e(1-f)\right]G(f)(1-u)=\lambda^u uf, \tag{67}$$

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

$$G(f)=\frac{sf}{s+\lambda^e(1-f)}. \tag{68}$$

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

$$R(f)=\lambda^u u+\lambda^e(1-u)G(f)=\frac{s\lambda^u}{s+\lambda^u}\ \frac{s+\lambda^e}{s+\lambda^e(1-f)} \tag{69}$$

and total recruits in the economy are given by:

$$R=\int_0^1 R(f)\,df=\ \frac{s\lambda^u}{s+\lambda^u}\ \frac{s+\lambda^e}{s+\lambda^e(1-f)}=\frac{s\lambda^u}{s+\lambda^u}\frac{s+\lambda^e}{\lambda^e}\ln\left(\frac{s+\lambda^e}{s}\right). \tag{70}$$

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:

$$1-\zeta=\frac{\lambda^e}{\left(s+\lambda^e\right)\ln\left(\frac{s+\lambda^e}{s}\right)}=\frac{\lambda^e/\lambda^u}{\left(\frac{u}{1-u}+\frac{\lambda^e}{\lambda^u}\right)\ln\left(1+\frac{\lambda^e}{\lambda^u}\frac{1-u}{u}\right)}. \tag{71}$$

Using (71), an average unemployment rate in the UK over 1993-2012 of 6.8% and an average ζ of 60.1% imply $\lambda^e / \lambda^u \approx 0.612$.

As expected, $1-\zeta$ is increasing in the unemployment rate and decreasing in λ^e / λ^u. Thus (71) implies an inverse relationship between ζ and unemployment even if λ^e / λ^u

[22] 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.

does not vary with the cycle. But the strength of the relationship between ζ and unemployment shown in Table B1 is weaker than we would expect from (71) if λ^e / λ^u were acyclical. This implies that, as unemployment rises, so does λ^e / λ^u. The estimates in Table B1 imply $\lambda^e / \lambda^u = 0.726$ for $u = 0.1$ and $\lambda^e / \lambda^u = 0.443$ for $u = 0.04$. According to (38), this mechanisms acts to make the reservation wage even more sensitive to the unemployment rate.

Table B1
Regression Analysis of the Cyclicality in the Proportion of New Hires Who Were Previously Employed

	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-cell year, and all regressions weighted by cell size. Cells based on less than 50 observations are omitted.

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). In order to stay as close as possible to our benchmark framework, we use the continuous time version of hyperbolic discounting developed by Harris and Laibson (2013), rather than the more conventional discrete time version. 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 than one's current self. The weight one attaches to the future self is denoted by ψ. The expectation is that the future self is a straightforward exponential discounter.[23] The value function for being employed (7) is now modified to:

$$rW(w) = w - s\left[W(w) - U\right] + \delta\left[\psi\tilde{W}(w) - W(w)\right] \tag{72}$$

where $\tilde{W}(w)$ is the value of being employed for the future non-hyperbolic self. This value function is the same as (7) i.e. is given by:

[23] The alternative, sophisticated model, in which it is thought that the future self has hyperbolic preferences in isomorphic to the case where the interest rate is much higher than one would expect and is given by $\left[r + \eta(1-\gamma)\right]$. This makes the reservation wage less sensitive to unemployment but just in the standard way of making the weight on the wage very low.

$$r\tilde{W}(w) = w - s\left[\tilde{W}(w) - \tilde{U}\right] \tag{73}$$

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

$$rU = z + \lambda\left[W - U\right] + \delta\left[\psi\tilde{U} - U\right] \tag{74}$$

$$r\tilde{U} = z + \lambda\left[\tilde{W} - \tilde{U}\right] \tag{75}$$

From (73) and (75) one can readily derive that:

$$\tilde{W} - \tilde{U} = \frac{\left[w - z\right]}{r + s + \lambda} \tag{76}$$

and that:

$$r\tilde{U} = z + \frac{\lambda\left[w - z\right]}{r + s + \lambda} \tag{77}$$

From (72) and (74) one can then derive that:

$$W - U = \frac{\left[w - z\right] + \delta\psi\left(\tilde{W} - \tilde{U}\right)}{r + s + \lambda + \delta} \tag{78}$$

Using (78), (74) and (76) one can then, after some re-arrangement, derive:

$$rU = \frac{r + \delta\psi}{r + \delta} z + \frac{\lambda\left[w - z\right]\left[r\left(r + s + \lambda + \delta\psi\right) + \delta\psi\left(r + s + \lambda + \delta\right)\right]}{\left(r + s + \lambda\right)\left(r + s + \lambda + \delta\right)\left(r + \delta\right)} \tag{79}$$

For the reservation wage ρ, $W(\rho) = U$. Using (72) this implies:

$$rU = \rho + \delta\left[\psi\tilde{W}(\rho) - U\right] \tag{80}$$

Using (73) we obtain:

$$\tilde{W}(\rho) = \frac{\rho + s\tilde{U}}{r + s} \tag{81}$$

Combining (80) and (81) leads to the following expression for the reservation wage:

$$\rho = \frac{\left[\left(r + s\right)\left(r + \delta\right)U - \delta\psi s\tilde{U}\right]}{\left(r + s + \lambda + \delta\psi\right)} \tag{82}$$

Substituting this into (79) and (77) and re-arranging leads to the following expression:

$$\rho = z + \frac{\lambda\left[w - z\right]}{\left(r + s + \lambda\right)}\left[\frac{\left(r + s\right)}{\left(r + s + \lambda + \delta\right)} + \frac{\delta\psi}{\left(r + s + \lambda + \delta\psi\right)}\right] \leq z + \frac{\lambda\left[w - z\right]}{\left(r + s + \lambda\right)} \tag{83}$$

The inequality shows that hyperbolic discounting lowers the reservation wage. Also, hyperbolic discounting 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.

The calibration used by Harris and Laibson (2012) is $\alpha = 2/3$ (at the annual level) and that the arrival rate of a change of self. δ, is at least 12. In this case the reservation wage is almost the same as z. This obviously makes the reservation wage insensitive to unemployment, but at the cost of making it insensitive to the expected wage, while we have shown in Table A2 that wages and reservation wages respond in very similar ways to most covariates considered.

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