

# **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 and informative perspective on the wage flexibility puzzle, which explains why the canonical model can only match the observed cyclicalities 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 Germany provide evidence that reservation wages are much less cyclical than predicted even conditional on the observed level of wage cyclicalities. We present some evidence that elements of perceived “fairness” or “reference points” in reservation wages may address this model failure.

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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,<sup>1</sup> the elasticity of wages with respect to the unemployment rate is -0.1. Although this estimate should not be thought of as a universal constant (see, for example, the review by Card, 1995), most existing estimates are not 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 explains why 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 used 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 model offers undoubtedly valuable insight in interpreting labour markets, but the quantitative predictions of the specific models used have difficulty in matching some features of the data (see Rogerson and Shimer, 2011, for an overview). In particular, it has proved hard to conceive a theory that can explain why wages are relatively unresponsive to labour market conditions, although it should be admitted that this problem has taxed the ingenuity of generations of labour and macro economists. This paper offers new insight on this wage flexibility puzzle.

In this paper, we first present an alternative – but informative – perspective on the wage flexibility puzzle. We use a conventional search and matching framework to derive a relationship between wages and unemployment (or other measures of labour market tightness) that, under plausible assumptions, is not shifted by demand shocks. Demand shocks – independent of their source or magnitude – must then be associated with movements along this curve, and the elasticity of the ‘wage curve’ that we estimate determines the relative volatility of wages and unemployment over the business cycle. Our approach has a natural analogy in a perfectly competitive labour market model, in which the labour supply curve would not be shifted by labour demand shocks. Similarly, it is widely believed that the labour supply elasticity is not sufficient to explain the modest pro-cyclicality in real wages.

Secondly, we use this ‘wage curve’ to show that the model can only predict the modest observed pro-cyclicality in wages if replacement ratios are very high, arguably implausibly high. This problem is most severe in the version of the canonical model with continual wage re-negotiation. However, we also consider the case in which wages are only infrequently re-negotiated, implying higher wage cyclicality on new, rather than continuing, matches (Hall, 2005, Pissarides, 2009, Haefke, Sonntag and Rens, 2008). This extension ameliorates the quantitative predictions of the model, but a sizeable gap with respect to empirical estimates remains, unless one assumes implausibly low persistence in the unemployment rate.

The conclusion that the canonical model requires a high replacement ratio to match the data is not new. For example, Hagedorn and Manovskii (2008) argue for this case and their approach is criticised on these grounds by, among others, Mortensen and Nagypal (2007) and

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<sup>1</sup> 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.

Costain and Reiter (2008). Obtaining similar conclusions as Hagedorn and Manovskii (2008) should not be surprising, as we use a similar model and attempt to explain the same data. But our approach does make clear how the assumption of a high replacement ratio is close to necessary and sufficient to explain the wage flexibility puzzle in the canonical model.

The most common response to this problem is to alter the model of wage determination, typically by introducing some degree of wage rigidity: for example a backward-looking component in wages (see, for example, Hall, 2005, Gertler and Trigari, 2009; Gertler, Sala and Trigari, 2008, and Shimer 2010), or a different disagreement point in wage bargaining (Hall and Milgrom, 2008). Wage rigidity improves the performance of the search and matching models considerably – see, for example, Shimer (2011, 2013) or Michaillat (2012). But, this paper argues that it may not be the only source of the wage flexibility puzzle which derives partly from the behaviour of reservation wages which are less flexible than the theory predicts.

We show that one can decompose the wage curve we derive from the canonical model into two parts. The first is derived 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 labour market conditions. In a recession, the value of having a job rises relative to the value of being unemployed, and as a result reservation wages should fall. We show that the canonical model predicts that reservation wages should be at least as cyclical as wages in new jobs.

We provide estimates of the cyclicalities of wages and reservation wages for the UK and 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 reservation wages with respect to aggregate unemployment range between -0.12 and -0.18 for the UK – and results for Germany are similar. These contrast with our estimates for the elasticity of wages with respect to aggregate unemployment range between -0.05 and -0.16 for the UK – and again results for Germany are in the same ballpark. We do find clear evidence that wages in newly-formed matches are markedly more cyclical than wages in continuing matches, with an elasticity between -0.20 and -0.28. This is consistent with infrequent wage negotiation on a given job, and with previous estimates reported by Pissarides (2009). However, we show that this higher elasticity in new jobs can only be reconciled with the theory if unemployment is much less persistent than in the data.

Why are reservation wages less cyclical than the canonical model suggests? We show that allowing for on-the-job search or hyperbolic discounting does little to resolve the problem. We cannot provide specific evidence for this failure, but it has long been argued that the wages that are acceptable to workers have considerable rigidity to them and are plausibly influenced by what is perceived as ‘fair’ (e.g. Akerlof and Yellen, 1990, Falk Fehr and Zehnder, 2006). This hypothesis is consistent with our findings and we present some evidence that they may be important.

The paper is organized as follows. Section 2 derives a “wage curve” from the canonical search and matching model, and highlights quantitative implications for elasticity of wages with respect to the unemployment rate. Section 3 presents estimates of wage curves for the UK and Germany showing that the wage elasticity can only be reconciled with the theory if replacement ratios are implausibly high. Section 4 then illustrates the determination of the

reservation wage, derives model predictions for the cyclicalities of reservation wages and shows that this is much larger than what is observed. Thus the data is inconsistent with implications of the canonical model for reservation wages determination. Section 5 discusses possible alternatives to the canonical model that would deliver less cyclical reservation wages – we argue that reference points are perhaps the most promising approach and present some empirical evidence for their importance. Section 6 concludes.

## 2. The cyclicalities of wages in the canonical model

This section presents the implications of the canonical search and matching model for the cyclicalities of wages. An important recent line of research has argued that the distinction between the cyclicalities of wages in new and continuing jobs is critical (for example, Pissarides, 2009), and this distinction only has consequences when the economy is not always in a steady-state. We therefore consider a model in which the economic environment is changing over time. In the interests of simplicity we assume there is no heterogeneity in workers or jobs.

We model the distinction between new and continuing jobs by assuming that wages in all new jobs are re-negotiated using the standard surplus sharing rule, but re-negotiation opportunities only arrive in existing matches at a rate  $\phi$ ,<sup>2</sup> leading to a staggered wage setting process à la Calvo (1983). This approach is similar in spirit to Gertler and Trigari (2006), although they assume that some new matches are made at ‘old’ wages, whereas we assume that wages are negotiated in all new matches.

If the wage in an existing match is re-negotiated, we assume that the previous wage has no influence on the outcome of the wage bargain, i.e. neither the firm nor the worker have the option to continue the match at the old wage. This means that the value of a job is determined solely by the current time,  $t$ , and the time,  $\tau$ , at which the wage was last negotiated.

### A. Employers

Each firm has one job, which can be either filled and producing or vacant and searching. The value function for a vacant job at time  $t$ ,  $V(t)$ , is given by:

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

where  $J(t; w)$  is the value of a filled job at time  $t$  that pays a wage  $w$ , and  $w(t)$  is the wage negotiated at time  $t$ . 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 to wages, and we return to this issue later. For the moment we simply allow both components of the vacancy cost to be potentially time-varying, and the important assumption is that they are

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<sup>2</sup> We assume renegotiation opportunities arrive exogenously at rate  $\phi$ , 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 cyclicalities as it implies more frequent renegotiation in recessions.

exogenous to the individual firm.<sup>3</sup> Finally,  $q(t)$  is the rate at which vacancies are filled at time  $t$ . The notation chosen allows it to vary over time (typically with shocks, and possibly only via the impact of shocks on labour market tightness), and further detail about the source of the time variation is not needed.

The value of a filled job that pays a wage  $w$  at time  $t$  is given by:

$$rJ(t; w) = p(t) - w - s[J(t; w) - V(t)] + \phi[J(t; w(t)) - J(t; w)] + E_t \frac{\partial J(t; w)}{\partial t}, \quad (2)$$

where  $p(t)$  denotes the productivity of a job-worker pair, and is the ultimate source of shocks,  $s$  is the exogenous rate at which jobs are destroyed, and  $\phi$  is the rate at which wages are re-negotiated. The second term in square brackets represents the capital gain (or loss) from wage re-negotiation in continuing jobs. Free entry of vacancies ensures  $V(t) = 0$  at each point in time, so that (1) can be re-arranged to give:

$$J(t; w(t)) - V(t) = J(t; w(t)) = C(t) + \frac{c(t)}{q(t)}, \quad (3)$$

i.e. the value of a newly-filled job at the current negotiated wage equals the expected cost of filling a vacancy.

### B. Workers

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

$$rU(t) = z + \lambda(t)[W(t; w(t)) - U(t)] + E_t \frac{\partial U(t)}{\partial t}, \quad (4)$$

where  $z$  is the flow of utility when unemployed (assumed to be fixed in the short-run<sup>4</sup>),  $W(t; w)$  is the value at time  $t$  of a job that pays a wage  $w$ , and  $\lambda(t)$  is the rate at which the unemployed find jobs, which is allowed to vary over time (possibly only because labour market tightness varies over time).

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

$$rW(t; w) = w + \phi[W(t; w(t)) - W(t; w)] - s[W(t; w) - U(t)] + E_t \frac{\partial W(t; w)}{\partial t}, \quad (5)$$

where the notation embodies the assumption that a re-negotiated wage will be at the level  $w(t)$ .

### C. Wage determination

We use the conventional rent-sharing condition that a wage negotiated at time  $t$ ,  $w(t)$ , is set to maximize:

<sup>3</sup> Even this could be relaxed, but this would require more notation for little extra insight.

<sup>4</sup> 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.

$$[W(t; w) - U(t)]^\beta [J(t; w) - V(t)]^{1-\beta}, \quad (6)$$

which can be written as:

$$(1-\beta) \frac{\partial J(t; w)}{\partial w} [W(t; w(t)) - U(t)] + \beta \frac{\partial W(t; w)}{\partial w} [J(t; w(t)) - V(t)] = 0. \quad (7)$$

Value functions (2) and (5) imply  $\partial W(t; w) / \partial w = -\partial J(t; w) / \partial w$ , so that (7) can, using (3), be written way as:

$$[W(t; w(t)) - U(t)] = \frac{\beta}{1-\beta} \left[ \frac{c(t)}{q(t)} + C(t) \right] \equiv \mu(t). \quad (8)$$

This wage setting condition states that the value of being employed is a mark-up – denoted by  $\mu(t)$  – over the value of being unemployed. This type of ‘mark-up’ wage curve can be derived from alternative models of wage determination (e.g. the efficiency wage model of Shapiro and Stiglitz, 1985, or the model of Elsby and Michaels, 2013, in which labour demand is downward sloping due to concavity of the production function), and the results that follow might be thought to have more general applicability than the specific model presented here.<sup>5</sup> Note also that past conditions do not feature in (8), but expected future conditions do. Thus we refer to the wage-setting relationship in (8) as a forward-looking, mark-up wage equation.

Combining workers’ value functions (4) and (5) yields:

$$\begin{aligned} r[W(t; w) - U(t)] &= w - z - (\phi + s)[W(t; w) - U(t)] \\ &\quad + (\phi - \lambda(t))[W(t; w(t)) - U(t)] + E_t \frac{\partial [W(t; w) - U(t)]}{\partial t} \\ &= w - z - (\phi + s)[W(t; w) - U(t)] + (\phi - \lambda(t))\mu(t) + E_t \frac{\partial [W(t; w) - U(t)]}{\partial t}, \end{aligned} \quad (9)$$

where the second equality follows from (8). The differential equation in (9) has solution:

$$W(t; w) - U(t) = \frac{w - z}{r + \phi + s} + E_t \int_t^\infty e^{-(r+\phi+s)(\tau-t)} (\phi - \lambda(\tau)) \mu(\tau) d\tau. \quad (10)$$

Using (8), the wage setting condition (10) can be re-arranged to derive the following closed-form solutions for wages negotiated at time  $t$ :

$$w(t) = z + (r + \phi + s) \left[ \mu(t) - E_t \int_t^\infty e^{-(r+\phi+s)(\tau-t)} (\phi - \lambda(\tau)) \mu(\tau) d\tau \right]. \quad (11)$$

To understand the workings of the model, it is easiest to start with the simplest case of a static steady-state.

#### D. The static steady state

Assume the economy is in steady-state, i.e. current labour market conditions are expected to persist for ever. In this case (16) reduces to a very simple wage curve:

$$w = z + \mu(r + \lambda + s). \quad (12)$$

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<sup>5</sup> This also means that if the model does fit the data one should be cautious about assuming that the model is correct.

In the comparison of steady-states, there are two reasons why wages may be procyclical. First,  $\lambda$ , the outflow rate from unemployment, is higher when unemployment is lower, making wages pro-cyclical. Secondly, the mark-up,  $\mu$ , may be pro-cyclical. From (8) there are a number of reasons why this might be the case. 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 (i.e.  $q$  falls). This mechanism makes wages pro-cyclical. Secondly, the vacancy costs themselves ( $c$  and  $C$ ) may vary, and the literature sometimes indexes them to productivity (see, for example, Pissarides, 2000) or to the level of wages (Hagedoorn and Manovskii, 2008, do both). The indexing of vacancy costs to either productivity or wages makes the mark-up pro-cyclical, and this accentuates 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 levels of cyclicity in wages, in what follows we assume that the mark-up is acyclical. We would justify this on the grounds that most studies of 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 the fixed costs do not vary with short-term fluctuations in productivity and/or wages.<sup>6</sup> These assumptions imply that  $\mu$  is a constant.

The empirical literature on the wage curve typically relates wages to the unemployment rate. We can use the definition of the steady-state unemployment rate  $u$ ,  $u = s / (s + \lambda)$ , to rewrite (12) as follows:

$$w = z + \mu(r + \lambda + s) = z + \mu\left(r + \frac{s}{u}\right). \quad (13)$$

The wage curve in (13) offers some interpretation advantages over the traditional wage setting condition of the search and matching model. It 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 and simply drive movements along the curve. The relative variation of wages and unemployment is given by (13), independent of the source or size of the shocks to labour demand, allowing us to be agnostic about their source and to evaluate the model without having to measure demand shocks, something which is often problematic.<sup>7</sup>

Differentiating (13) under the assumption of a constant mark-up gives the elasticity of wages with respect to the unemployment rate across steady-states:

$$\frac{\partial \ln w}{\partial \ln u} = -\frac{\mu s}{wu} = -\frac{w-z}{w} \frac{s}{ru+s} = -(1-\eta) \left[ \frac{s}{ru+s} \right], \quad (14)$$

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<sup>6</sup> 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.

<sup>7</sup> For example, 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.

where  $\eta \equiv z/w$  is the replacement ratio. Because  $s$  is substantially larger than  $ru$  for conventional values of the interest rate,<sup>8</sup> the term in square brackets is close to 1, and (14) 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,<sup>9</sup> the canonical model would fail to fit the data well.

While a replacement ratio of 0.9 is a arguably implausible, it is not straightforward to obtain estimates of flow utility during unemployment, encompassing unemployment compensation and the utility of leisure while unemployed, net of job search costs. The OECD Benefits and Wages Statistics (<http://www.oecd.org/els/benefitsandwagesstatistics.htm>) show the proportion of net in-work income that is maintained when a worker becomes unemployed, by household composition and unemployment duration. In 2001, the overall average of this ratio across worker types in the U.K. and Germany was 0.42 and 0.63, respectively. While there is no direct evidence on the value of leisure during unemployment or search costs, 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.

#### E. Out of steady state

Under a constant mark-up  $\mu$ , the wage equation in (11) can be written as:

$$w(t) = z + \mu \left[ (r+s) + (r+\phi+s) E_t \int_t^\infty e^{-(r+\phi+s)(\tau-t)} \lambda(\tau) d\tau \right], \quad (15)$$

stating that the current negotiated wage is a mark-up over the outside option,  $z$ , and such mark-up is influenced by future expected labour market conditions,  $E_t \lambda(\tau)$ . Labour market conditions in the near future carry a higher weight than those in the distant future, with the weight depending negatively on the interest rate,  $r$ , and positively on the expected duration of the current negotiated wage. This is inversely related to the separation rate,  $s$ , and the re-negotiation rate,  $\phi$ . Note that wage determination is entirely forward-looking, i.e. existing wages in the labour market play no role in it, because there is no prospect for a worker of getting a job at a pre-existing wage – all new jobs will be at newly-negotiated wages.

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<sup>8</sup> 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 struggle to explain why reservation wages seems strongly correlated with expected wages.

<sup>9</sup> 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.

Integrating (15) by parts finally gives:

$$w(t) = z + \mu \left[ (r + \lambda(t) + s) + E_t \int_t^\infty e^{-(r+\phi+s)(\tau-t)} \lambda'(\tau) d\tau \right], \quad (16)$$

implying that the current wage is influenced by current labour market conditions  $\lambda(t)$  and expected changes in those conditions  $E_t \lambda'(\tau)$ .

#### F. Continuous wage re-negotiation

A special case of interest is the one in which wages are continuously re-negotiated ( $\phi = \infty$ ). In this case the wage equation reduces to (12): when wages are continuously re-negotiated it is only the contemporaneous unemployment rate that matters for wage determination.<sup>10</sup> The assumption that the economy is in steady state is not needed to derive this result, and this version of the model would have the same difficulty as the steady-state model in fitting the empirical data.

These issues with the canonical model are well-known. It has recently been argued (Hall, 2005, Pissarides, 2009, Haefke, Sonntag and Rens, 2008) that it is the cyclicalities of wages on new hires that the theory has predictions about, and that this cyclicalities is higher than the cyclicalities of all wages (e.g. see Devereux and Hart, 2001). Our framework can address whether this solves the wage flexibility puzzle by considering the effect on the wage curve of occasional re-negotiation of the wage.

#### G. Occasional wage renegotiation

When wage negotiation is infrequent, set wages are expected to last for multiple periods, characterized by varying labour market conditions. Thus we need to make assumptions about the expected future path of job finding rates. We make the simplest assumption and that the expected path of  $\lambda(t)$  can be approximated by the continuous time version of an AR(1) process:

$$E_t \lambda(\tau) = e^{-\xi(\tau-t)} \lambda(t) + [1 - e^{-\xi(\tau-t)}] \lambda^*, \quad (17)$$

where  $\lambda^*$  is the steady-state value of  $\lambda$  and  $\xi$  represents the rate of convergence to it, with higher values of  $\xi$  implying lower persistence. Note that stationarity of  $\lambda(t)$  implies that expression (17) is valid for any  $\tau$ , higher or lower than  $t$ , a property which will be useful below. Using (17), (15) can be written as:

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<sup>10</sup> There is one simplification here: out-of-steady state there is no longer a one-to-one mapping between  $\lambda$  and  $u$ . But as Shimer (2005) has shown the difference between the two is tiny in practice, and understanding is greatly aided by ignoring it.

$$\begin{aligned}
w(t) &= z + \mu \left[ (r + \lambda^* + s) + \frac{r + \phi + s}{r + \phi + s + \xi} (\lambda(t) - \lambda^*) \right] \\
&= z + \mu \left[ \left( r + \frac{s}{u^*} \right) + \frac{r + \phi + s}{r + \phi + s + \xi} \left( \frac{s}{u(t)} - \frac{s}{u^*} \right) \right] \\
&= z + \mu \left[ \left( r + \frac{s}{u^*} \right) + \gamma \left( \frac{s}{u(t)} - \frac{s}{u^*} \right) \right],
\end{aligned} \tag{18}$$

where  $\gamma = \frac{r + \phi + s}{r + \phi + s + \xi} \leq 1$ . The earlier special cases considered give  $\gamma = 1$ , and (18) reduces to (12).

Differentiation of (18), and evaluating at  $u(t) = u^*$ , leads to the following expression for the elasticity of wages negotiated at time  $t$  to contemporaneous unemployment:

$$\frac{\partial \ln w(t)}{\partial \ln u(t)} = -\frac{\mu \gamma s}{w^* u^*} = -(1 - \eta^*) \frac{\gamma s}{r u^* + s} \approx -\gamma (1 - \eta^*) \tag{19}$$

As  $\gamma < 1$ , the model now predicts a lower sensitivity of currently negotiated wages to current unemployment than in the case of continual re-negotiation. How much lower depends on the persistence in labour market conditions and the frequency of wage re-negotiation. The intuition for the lower sensitivity is simple. With negotiated wages that are expected to last a long time, but current labour market conditions that are not, negotiated wages are less sensitive to current conditions and will also be influenced by future expected conditions.

One might expect that the model of occasional wage re-negotiation comes closer to the data both because empirically wages in new jobs are found to be more sensitive to current unemployment than old jobs (e.g. Devereux and Hart, 2001), and because the target sensitivity implied by (19) is lower than in (14).

The discussion has so far focused on the sensitivity of newly-renegotiated wages to current unemployment, but the focus of most of the empirical literature in this area is the sensitivity of all wages to unemployment. Let us denote the average wage at time  $t$  by  $\bar{w}(t)$ . This is an average of wages negotiated at different points in time in the past. The distribution of jobs with wages last negotiated  $\tau$  periods ago depends on the number of jobs that had wages re-negotiated at  $\tau$ , which have not subsequently been destroyed or had their wages re-negotiated. Out of a steady state this is quite complicated, but if we assume that the distribution of the time of renegotiation is the same as in a steady-state in which the flow of hires and the unemployment rate is constant, such distribution is exponential with parameter  $s + \phi$ . Using this result and the first line in (18) yields:

$$\bar{w}(t) = z + \mu \left[ (r + \lambda^* + s) + \gamma \int_0^\infty (s + \phi) e^{-(s+\phi)\tau} [\lambda(t - \tau) - \lambda^*] d\tau \right] \tag{20}$$

i.e. current average wages are correlated not just with current labour market conditions but with past labour market conditions. So we would expect lagged unemployment to have explanatory power in wage curve estimates (Beaudry and diNardo, 1991; Hagedorn and Manovskii, 2013).

But if one only regresses current average wages on current unemployment, the

estimated effect of unemployment is driven by its persistence over time, as wages negotiated in the past are correlated with past unemployment. Using (17):

$$\begin{aligned} E_t(\bar{w}(t)|\lambda(t)) &= z + \mu \left[ (r + \lambda^* + s) + \gamma \frac{s + \phi}{s + \phi + \xi} (\lambda(t) - \lambda^*) \right] \\ &= z + \mu \left[ \left( r + \frac{s}{u^*} \right) + \gamma \frac{s + \phi}{s + \phi + \xi} \left( \frac{s}{u(t)} - \frac{s}{u^*} \right) \right]. \end{aligned} \quad (21)$$

Differentiating this gives us the following expression for the sensitivity of the current average wage to current unemployment:

$$\frac{\partial \ln \bar{w}(t)}{\partial \ln u(t)} = -(1 - \eta^*) \frac{\gamma s}{ru^* + s} \frac{s + \phi}{s + \phi + \xi} \approx -\gamma^2 (1 - \eta^*), \quad (22)$$

where the final approximation comes from setting  $r$  to zero. Expression (22) implies that the model now predicts that the average wage is even less sensitive to current unemployment than the wage in new jobs, and the ratio in sensitivity is  $\gamma$ . We next consider whether these predictions are empirically plausible.

### 3. Empirical wage curves

#### A. Wage curve estimates

In the empirical part of this paper we use two data sets - British data from the British Household Panel Study (BHPS) and 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 the volume by 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 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 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 Germany, regional unemployment differentials are very persistent, making it impossible to identify any cyclicity 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 less cyclicity in wages.

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.<sup>11</sup> 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.<sup>12</sup> Columns 5 and 6 control for alternative business cycle indicators, but neither the lagged unemployment rate (column 5) nor the regional unemployment rate (column 6) seem to influence wages.

Columns 7 and 8 distinguish between wages on new and continuing jobs, respectively, to allow for higher cyclicity of newly-negotiated wages, and indeed find that wages on new jobs are twice as cyclical as 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. 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

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<sup>11</sup> 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.

<sup>12</sup> 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.

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. Column 10 controls for the lagged dependent variable, which renders the coefficient on starting unemployment both small and insignificantly different from zero. In other words, the lagged wage is a sufficient statistics 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 cyclicity of wages drops further, but it is still significantly different from zero.

Other aggregate indicators like the output gap of 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 only for regional unemployment, specifications that also include a quadratic trend still deliver a negative and significant unemployment elasticity but its magnitude does not go beyond 5% (see Table A3). In summary, our wage curve estimates obtained on the BHPS are very similar to those obtained by other studies on other datasets.

The corresponding results for 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 wages 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 19% in OLS estimates. A clear similarity between the two countries is that the unemployment elasticity of wages is substantially higher for new hires than for continuing jobs.

### *B. Review of the theory and the evidence.*

We use the estimates presented above to review how well the theory and the evidence can be reconciled. Consider first the version of the canonical model with continual wage re-negotiation, in which case  $\gamma = 1$  (from (19)), and (the absolute value of) the of unemployment elasticity of wages equals one minus the replacement rate. An estimated elasticity in the region of -0.1 would imply a replacement rate of 90%, which is implausible, making the model incompatible with the data.<sup>13</sup>

However, wages are not continually re-negotiated, and the higher cyclicity of wages in new jobs than continuing jobs indeed suggests that there is only occasional re-negotiation. To empirically evaluate the elasticity of newly-negotiated wages to current unemployment using (19), we need an estimate of  $\gamma = \frac{r + \phi + s}{r + \phi + s + \xi}$ . For the UK, appropriate monthly values are  $s = 0.0125$  and  $\xi = 0.003$ .<sup>14</sup> Using a monthly interest rate of  $r = 0.003$ , and an expected

<sup>13</sup> One might also mention the cross-section problem that most studies find greater cyclicity in wages for low-skilled workers for whom the replacement ratio is higher on average, the opposite of the prediction of the model.

<sup>14</sup> Data for the separation rate,  $s$ , are obtained from the Quarterly Labour Force Survey and for the persistence in the unemployment rate,  $\xi$ , from the estimate of a time series model. Flows are lower in the UK than the US and

contract length of 12 months,  $\phi = 0.0833$ . Combining these parameters gives a value of  $\gamma = 0.97$ . Given an elasticity of newly-negotiated wages to unemployment of -0.28 in the UK and of -0.20 in Germany, the required replacement ratio would be 0.71 for the UK and 0.79 for Germany. The basic problem is that unemployment rates are too persistent and contract re-negotiations too frequent for the forces acting to reduce the predicted cyclicalities in wages to be very large. An empirical evaluation of the elasticity of average wages to unemployment according to (20) raises very similar issues, requiring a replacement ratio of 0.89. The ratio of the cyclicalities of wages in continuing and new jobs is also at odds with the evidence. The empirical ratio between the two elasticities is 0.41 and according to the theory this should also be an estimate for  $\gamma$ , but this is way too low to be plausible.

This section has tried to explain, using a novel perspective on a known puzzle, why the canonical model, even with only occasional wage re-negotiation, has difficulties at matching the modest degree of pro-cyclicalities in wages. This problem has often been addressed via alternative modelling of the wage setting process, notably by introducing some backward-looking element into wage determination. While this is likely to be important, the next section argues that an additional problem may lie with the model for the determination of reservation wages.

#### 4. The cyclicalities in the reservation wage: Theory and evidence

##### A. Theory

The theoretical wage curve of Section 2 has been derived without introducing the concept of a reservation wage, which is now helpful to introduce. The reservation wage at time  $t$ , denoted by  $\rho(t)$ , is defined as the minimum wage at which a worker would currently accept a job:

$$W(t; \rho(t)) = U(t). \quad (23)$$

Using (10), this can be expressed as:

$$\rho(t) = z - (r + \phi + s) E_t \int_t^\infty e^{-(r+\phi+s)(\tau-t)} (\phi - \lambda(\tau)) \mu(\tau) d\tau. \quad (24)$$

Using (11) the relationship between newly-negotiated wages and reservation wages can be very simply expressed as:

$$w(t) = \rho(t) + (r + \phi + s) \mu, \quad (25)$$

from which:

$$\frac{\partial \ln \rho(t)}{\partial \ln u(t)} = \frac{w(t)}{\rho(t)} \frac{\partial \ln w(t)}{\partial \ln u(t)} > \frac{\partial \ln w(t)}{\partial \ln u(t)}, \quad (26)$$

i.e. the cyclicalities in reservation wages should be greater than the cyclicalities in wages in new jobs, with the ratio of elasticities given by the ratio of the wage to the reservation wage. We start our empirical investigation of reservation wages by showing that this is not the case in the data.

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unemployment persistence higher, so these are numbers different from those often used in the literature for the analysis of US data.

## B. Evidence

There is no existing literature on the relative cyclicity of wages and reservation wages and the implications for the canonical model. An obvious reason for this gap in the literature is the scarcity of data on reservation wages.<sup>15</sup> In the US, there is no data set that has systematically collected reservation wage data on a regular basis for a long period of time, and there is only a handful of studies analysing reservation wage data that has occasionally been collected.<sup>16</sup>

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 and 1995. The reservation wage information is elicited in monthly terms<sup>17</sup> and is not supplemented by information on expected hours, thus our analysis on Germany refers to monthly reservation wages, and our wage regressions for Germany control for whether an individual is looking for a full-time or part-time job, or a job of any duration.<sup>18</sup>

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 were out of work in the survey week and were 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.

Our empirical specification for the reservation wage is based on the predictions of the theory. This 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 would 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.

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<sup>15</sup> Or the lack of trust of the quality of such data, an argument we address below.

<sup>16</sup> For example, reservation wage data was collected in a CPS supplement in 1976 (Feldstein and Poterba, 1984), the NLSY from 1979-1986 (Holzer, 1986a,b; Petterson, 1998) and the 1984 SIPP Panel (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 cyclicity. Early work on reservation wages for the UK has used cross-section survey data (Lancaster and Chesher, 1983, Jones, 1988).

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

<sup>18</sup> The omitted category is "don't know preferred hours".

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 cyclicity 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). Column 5 controls for regional, as well as aggregate, unemployment, but regional unemployment – whether current or lagged – does not have any explanatory power once one controls for aggregate unemployment. Finally, column 6 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.

We experiment with a number of alternative business cycle indicators to address the possible concern that reservation wages may display stronger cyclicity to other variables not yet considered here. First, we use alternative aggregate indicators, and namely the output gap, the growth rate in output and the (log) labour market tightness. The only one that has a significant impact on the reservation wage in the specification that includes a quadratic trend is labour market tightness, with an elasticity of 0.168 (s.e. 0.029), which is remarkably similar in absolute value to the elasticity with respect to the unemployment rate obtained in column 2. The coefficients on either the output gap or the growth rate in output are very close to zero (0.000, s.e. 0.008; and -0.004, s.e. 0.005, respectively). Second, we estimate reservation wage equations that only control for regional unemployment. The results are reported in Table A5 and show that only when one controls for a quadratic trend is the unemployment elasticity significant, and again lagged unemployment has a stronger impact on reservation wages than current unemployment. Overall, the elasticity of reservation wages to regional unemployment is markedly lower than the elasticity with respect to aggregate unemployment.

We estimate similar reservation wage specifications for Germany,<sup>19</sup> and the results are reported in Table 3. 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. When only regional unemployment is controlled for, the lagged unemployment rate has a negative impact on wages (as for the UK), but the current unemployment rate has actually a positive impact on wages (see Table A6).

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<sup>19</sup> 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 nonlinearities 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 U.K. as the duration of benefits in the UK is determined by job search behaviour rather than previous employment history.

These results can be broadly summarized by noting that, at best, there is fairly limited cyclical in reservation wages and that the cyclical in reservation wages is similar to the cyclical in all wages, and considerably lower than the cyclical of wages in new jobs. This is inconsistent with the theory.

However one potential problem with comparing the cyclical of wages in new jobs with the cyclical in reservation wages is that these equations are estimated on different groups of people so any difference in elasticity may simply reflect the different samples. But, for the UK, we can investigate this further as the BHPS also asks workers about the wage that they expect to get. Specifically, workers looking for jobs are asked 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. We can then construct a measure of the expected hourly wage. Its estimated elasticity 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 it should be higher. In particular, given a mean ratio of (net) expected to reservation wages in our sample equal to 1.21,<sup>20</sup> equation (26) predicts that the reservation wage elasticity should be about 20% higher than the elasticity of expected wages.

### C. *The quality of reservation wage data*

One potential explanation for the lack of strong cyclical in our estimates is that the self-reported reservation wage information is not very good quality, so that the estimated cyclical is not reliable. In passing it should be noted that, as Table A2 shows, most of the factors (e.g. age, education and gender) estimated to affect reservation wages are very sensible. Below we 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* we would expect those with higher reservation wages to have a lower probability of finding employment, and thus a higher expected duration on unemployment, but higher entry wages once they do find work.

Table 5 investigates 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, but 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 include a number of explanatory variables, including the unemployment rate (national or local, respectively), and indeed we find that, conditional on such covariates, 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

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<sup>20</sup> This is also very similar to the mean ratio of (net) post-unemployment wages to reservation wages.

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 Germany are presented in Table 6 and they are clearly in line with the results for the U.K., except the negative impact of reservation wages on job-finding rates is stronger for Germany than for the U.K.

The conclusion from this analysis is that the reservation wage data, though undoubtedly noisy, do show the expected correlations with search outcomes for both countries, and therefore there is no particular reason to think that the estimate of its cyclical sensitivity is seriously under-estimated.

#### D. *Replacement ratios conditional on wages*

Evidence presented shows that reservation wages are roughly as cyclical as actual wages and notably less cyclical than wages in new jobs, contrary to the prediction of the canonical model. While this finding is silent about the source of the theoretical flaw, this section explores this question further by decomposing the wage setting condition into two parts. The first part is derived from wage bargaining and relates the bargained wage to the reservation wage and the mark-up of wages over outside options – this is given by (25). The empirical evidence on the relative cyclicity of newly-negotiated wages and reservation wages suggests there is something wrong with this part of the model. The solution to this problem may well be to introduce a more backward-looking part to wages as is the most common approach taken in the existing literature. The second part is derived from the behaviour of the unemployed, and relates the reservation wage to labour market conditions. Our point is that the evidence suggests this part of the model is also wrong. In a recession, the value of having a job rises relative to the value of being unemployed, and as a result reservation wages should fall – this is the case even if wages themselves are not cyclical.

The reservation wage equation (24) is a reduced form, in that it only relates reservation wages to current and future expected labour market conditions and is built on the model of wage determination given by (25). If (25) is incorrectly specified this will mean that (24) is also mis-specified. But, one can avoid this problem by deriving a reservation wage equation that is conditional on the level of wages – this should be satisfied however wages are determined. First, we show in Appendix B1 that the reservation wage can be written as:

$$\rho(t) = z + E_t \int_t^\infty e^{-\int_t^\tau (r + \lambda(x) + s) dx} (w(\tau) - z)(\lambda(\tau) - \phi) d\tau. \quad (27)$$

This result expresses the reservation wage as a function of wages, both present and future, and expected labour market conditions. The overall cyclicity in reservation wages thus has a component driven by the cyclicity in wages and a component driven by the direct effect of labour market conditions.

Second, we show in Appendix B2 that in a steady-state the elasticity of the reservation wage with respect to unemployment can be expressed rate as:

$$\frac{\partial \ln \rho(t)}{\partial \ln u(t)} = \frac{w}{\rho} \frac{\partial \ln w(t)}{\partial \ln u(t)} \frac{\lambda - \phi}{r + s + \lambda + \xi} - \left( \frac{w}{\rho} - 1 \right) \frac{s + \lambda}{r + s + \lambda + \xi}. \quad (28)$$

The two terms in (28) represent the two sources of cyclical in the reservation wage, driven by the cyclical in wages and labour market conditions, respectively.

We discuss this second term first. Its magnitude depends on the gap between wages and reservation wages  $(w/\rho - 1)$ , which is a measure of the attractiveness of work relative to non-work in terms of flow pay-offs. If this term is close to zero, the predicted cyclical in reservation wages from this source is also close to zero. This is essentially a restatement of the result that if the replacement ratio is close to one the model predicts little sensitivity in the reservation wages. But the data suggests that  $(w/\rho - 1)$  is not close to zero. In the BHPS workers reporting reservation wages are also asked about their expected wage, and on average expected wages are 33% higher than reservation wages, implying  $(w/\rho - 1) \approx 0.33$ . This is then multiplied by  $(s + \lambda)/(r + s + \lambda + \xi)$ . As  $\lambda$  (and to a lesser extent  $s$ ) are very large relative to  $r$  and  $\xi$  this ratio is close to 1 (0.97 for the parameter values we have used earlier). So the second term of (28) alone predicts as much or more cyclical in reservation wages than we observe in the data, even if actual wages in new jobs were acyclical.

The first term in (28) derives from the cyclical in newly-negotiated wages. The coefficient on the wage elasticity depends on  $(\lambda - \phi)$ , i.e. the difference between the rate at which unemployed workers receive a wage offer, and the rate at which employed workers re-negotiate their contracts (so they also get a new wage). Plausible parameter values imply  $\lambda > \phi$ , i.e. the expected duration of a spell of unemployment is shorter than the expected duration of a wage contract. But the gap is not so large so that the multiplier on the wage elasticity for our benchmark parameter values is 0.08. This implies that the predicted cyclical in reservation wages at our benchmark parameters values is not very sensitive to the wage elasticity. But if wages are somewhat cyclical, the cyclical in reservation wages would be overpredicted further.

This analysis has been based on the assumption that workers expect that, if they are employed at the reservation wage, their wage will be re-negotiated at the same rate as other wages, and upon renegotiation it will jump to the market rate. That is why if there is continuous wage re-negotiation ( $\phi = \infty$ ) inspection of (28) shows that the cyclical in reservation wages will be the opposite in sign to that of actual wages. The intuition is that if there is continual wage re-negotiation one will accept any job at any wage, safe in the knowledge that it will be instantaneously re-negotiated. To allay concerns that our conclusions might be sensitive to this assumption, we investigate in Appendix B3 the predictions for the cyclical of reservation wages under the extreme opposite assumption, namely that there is no renegotiation on reservation wage jobs. In this case the predicted cyclical of reservation wages and wages in new jobs are very similar, again contrary to what is observed.

Our conclusion is that there seems to a failure in the canonical model for the determination of reservation wages, and this is likely to be one cause of the wage flexibility puzzle, as actual wages are linked to reservation wages. The next section considers some modifications of the reservation wage model as possible routes to address such failure.

## 5. Alternative models for the reservation wage

We have documented that the cyclicity in reservation wages is considerably below the predictions of the canonical model. This section investigates this puzzle further using more general models for the determination of reservation wages, and namely 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

The model used so far assumes 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. As in the previous section, the analysis is conditional on the expected level of wages, without need to specify the process for the determination of wages. 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  $\lambda^e$  and  $\lambda^u$ , respectively, and both depend on labour market tightness, and the corresponding value functions are given by:

$$rW(w) = w - s[W(w) - U] + \lambda^e \int_w [W(x) - W(w)] dF(x), \quad (29)$$

and

$$rU = z + \lambda^u \int_\rho [W(x) - U] dF(w), \quad (30)$$

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

$$\begin{aligned} \rho &= z + (\lambda^u - \lambda^e) \int_\rho [W(w) - U] dF(w) \\ &= z + (\lambda^u - \lambda^e) \int_\rho \frac{1 - F(w)}{r + s + \lambda^e [1 - F(w)]} dw, \end{aligned} \quad (31)$$

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

$$\rho \approx z + (1 - u) \left( 1 - \frac{\lambda^e}{\lambda^u} \right) (\bar{w} - z), \quad (32)$$

where  $\bar{w}$  denotes the average wage across workers (which differs from the average wage offer if there is search on-the-job).<sup>21</sup> Expression (32) can be used to address the cyclicity of the reservation wage, conditional on the average wage.

First, reservation wages are acyclical whenever the job arrival rate functions for employed and unemployed workers are the same. In this case  $\lambda^e = \lambda^u$  and (32) implies that

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<sup>21</sup> If  $\lambda^e = 0$ , equation (32) reduces to the familiar condition in which the reservation wage is a weighted average of  $z$  and  $\bar{w}$ , with the unemployment rate representing the weight on  $z$ , i.e. the reservation wage can be thought of as expected income.

the reservation wage equals the flow of income when unemployed,  $\rho = z$  (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 palatable predictions 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 (Manning 2003, ch 9). 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.<sup>22</sup> Taken to (32), 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, (32) implies that the reservation embodies the cyclicalities in wages, plus a further cyclical component coming from  $(1-u)(1-\lambda^e/\lambda^u)$ . The term  $(1-u)$  is obviously pro-cyclical, but the cyclicalities of  $\lambda^e/\lambda^u$  is less clear. Our path to provide evidence on the cyclicalities of  $\lambda^e/\lambda^u$  – described in Appendix D – consists in assessing the cyclicalities of the fraction of new jobs filled by workers who were previously employed, and to relate this fraction to  $\lambda^e/\lambda^u$ . 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. Using a simple search model to calibrate this statistic, we find that  $\lambda^e/\lambda^u$  is below 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 cyclicalities  $\lambda^e/\lambda^u$  makes the reservation wage more cyclical. The latter effect dominates quantitatively, thus on-the-job search does not seem to be able to solve the puzzle of the modest cyclicalities in the reservation wage.

### B. *The reservation wage and hyperbolic discounting*

The models considered so far 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 and on the exit rate from unemployment, as the search intensity decision involves trading off current and future utility. However, they argue that impatience does not affect the reservation wage as that is not derived by comparing pay-offs at different periods in time. They do not investigate the implication of their model for the cyclicalities of reservation wages, but Appendix E shows

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<sup>22</sup> 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.

that hyperbolic discounting does not have important implications for the cyclical nature 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). For example, Falk, Fehr and Zehnder (2004) show, in an experimental setting, that past minimum wages that are no longer in effect influence reservation wages, leading reservation wages to be less cyclical than in the optimizing job search models.

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 the correlation between past wages and reservation wages is consistent with the existence of reference points, it is clearly also consistent with alternative mechanisms. One possible confounding factor is the direct link, if any, 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 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 thought of 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 (abstracting from wealth effects), 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:

$$\log \rho_{it} = \beta_1 X_{it} + \beta_2 w_{it}^* + \beta_3 \mu_{it-d} + \varepsilon_{it}, \quad (33)$$

Where  $X_{it}$  denotes observable characteristics,  $w_{it}^*$  denotes the underlying ability of the worker, and  $\mu_{it-d}$  denotes the level of rents in the last job observed ( $d$  periods ago). The coefficient of interest is  $\beta_3$ , indicating whether rents lost with past jobs influence current reservation wages.

Assume that the last observed wage is given by:

$$\log w_{it-d} = \gamma_1 X_{it} + w_{it-d}^* + \mu_{it-d} + u_{it-d}, \quad (34)$$

and we simply regress the reservation wage on the last observed wage:

$$\log \rho_{it} = \delta_1 X_{it} + \delta_2 \log w_{it-d} + \varepsilon_{it}. \quad (35)$$

The OLS estimate for  $\delta_2$  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 instrumental variable 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; Gibbons and Katz, 1992, and Benito, 2000; Carruth, A., Collier, W. and Dickerson, A, 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 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 the identifying assumption. 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 instrument for last observed wages.

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 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 estimate of reservation wage equations for the UK, controlling for the last observed wage in the BHPS panel. The sample shrinks to about one half of the original sample of Table 3, and the unemployment elasticity of the reservation wage is slightly higher than in the original sample. 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 5-year old wage realizations have an influence on current reservation wages that is about 60% of one-year old wage realizations.

Column 2 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, consistent with the presence of transitory components and measurement error in the actual wage (see also Manning, 2003, chapter 6). The specification in Column 3 allows for decay of reference points over time, introducing the product between the industry level wage differential and the duration since the last wage was observed as a

further instrument. The speed of the decay is very close quantitatively to that obtained using OLS.

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.

## **6. Conclusions**

In this paper we use a canonical search and matching model to derive a 'wage curve', i.e. a relationship between wages and 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 procyclicality observed in wages if replacement ratios are implausibly high. This wage flexibility puzzle remains even if we allow for only occasional wage re-negotiation, unless unemployment itself has implausibly low persistence.

We then argue that one source of the problem is likely to be the model for the determination of reservation wages. Using British and German data we show that reservation wages are less cyclical than the model would predict, even conditioning on the observed cyclicity in actual wages. We consider a number of possible modifications of the canonical model to resolve the problem and suggest that elements of fairness and reference points in the determination of reservation wages are likely the most plausible set of explanations.

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

	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
Sample	All jobs	All jobs	All jobs	All jobs	All jobs	All jobs	New jobs	Continuing jobs	All jobs	All jobs	All jobs	All jobs
Estimation method	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	FE
Log wage, lagged				0.759*** (0.005)	0.759*** (0.005)	0.759*** (0.005)				0.759*** (0.005)		0.134*** (0.019)
Log unemployment rate	-0.022 (0.032)	-0.165*** (0.044)	-0.155*** (0.043)	-0.123*** (0.017)	-0.106*** (0.025)	-0.125*** (0.017)	-0.279*** (0.077)	-0.116*** (0.038)	-0.144*** (0.040)	-0.123*** (0.017)	-0.092*** (0.021)	-0.053*** (0.016)
Log unemployment rate <i>aggregate, lagged</i>					-0.014 (0.020)							
Log unemployment rate <i>aggregate, at start of job</i>									-0.039*** (0.008)	-0.003 (0.004)	0.004 (0.004)	
Log unemployment rate <i>regional</i>						0.002 (0.009)						
Trend	linear	quadratic	quadratic	quadratic	quadratic	quadratic	quadratic	quadratic	quadratic	quadratic	quadratic	quadratic
Region specific trend	no	no	yes	no	no	no	no	No	no	no	no	no
Observations	96,270	96,270	96,270	70,901	70,901	70,901	25,517	70,753	95,584	70,438	70,438	70,102
R-squared	0.397	0.397	0.398	0.748	0.748	0.748	0.405	0.387	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. Standard errors are clustered at the year level. Estimates in column 12 are obtained using the Arellano Bond (1991) estimator for dynamic panel data models. Source: BHPS.

**Table 2: Estimates of a Wage Equation for the Germany**

	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
Sample	All jobs	All jobs	All jobs	All jobs	All jobs	All jobs	New jobs	Continuing jobs	All jobs	All jobs	All jobs	All jobs
Estimation method	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	FE
Log wage, lagged				0.730*** (0.007)	0.730*** (0.007)	0.730*** (0.007)				0.725*** (0.007)		0.389*** (0.011)
Log unemployment rate <i>aggregate</i>	-0.097 (0.142)	-0.191 (0.145)	-0.171 (0.118)	-0.036** (0.016)	0.020 (0.018)	-0.013 (0.018)	-0.344* (0.170)	-0.155 (0.138)	0.016 (0.023)	-0.023 (0.014)	-0.044*** (0.015)	-0.007 (0.005)
Log unemployment rate <i>aggregate, lagged</i>					-0.068*** (0.013)							
Log unemployment rate <i>aggregate, at start of job</i>									-0.025*** (0.007)	-0.008*** (0.002)	-0.000 (0.002)	
Log unemployment rate <i>regional</i>						-0.022 (0.015)						
Trend	linear	quadratic	quadratic	quadratic	quadratic	quadratic	quadratic	quadratic	quadratic	quadratic	quadratic	quadratic
Region specific trend	no	no	yes	No	no	no	no	No	no	no	no	no
Observations	213,693	213,693	213,693	164,933	164,933	164,933	34,095	179,333	196,616	152,183	152,183	164,933
R-squared	0.603	0.606	0.607	0.849	0.849	0.849	0.596	0.587	0.643	0.851	0.046	

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. Standard errors are clustered at the year level. Estimates in column 12 are obtained using the Arellano Bond (1991) estimator for dynamic panel data models. Source: SOEP.

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

	1	2	3	4	5	6
Dependent variable						
Estimation method	OLS	OLS	OLS	OLS	OLS	FE
Log unemployment rate	-0.095*	-0.175***	-0.164**	0.115	0.075	0.010
<i>aggregate</i>	(0.046)	(0.058)	(0.058)	(0.156)	(0.161)	(0.104)
Log unemployment rate				-0.215*	-0.182*	-0.119
<i>aggregate, lagged</i>				(0.112)	(0.102)	(0.073)
Log unemployment rate					0.030	
<i>regional</i>					(0.029)	
Log unemployment rate					-0.029	
<i>Regional, lagged</i>					(0.030)	
Trend	linear	quadratic	quadratic	quadratic	quadratic	quadratic
Region specific trends	No	No	yes	no	no	no
Observations	14,874	14,874	14,874	14,874	14,873	14,874
R-squared	0.248	0.249	0.249	0.249	0.249	0.110

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. Source: BHPS.

**Table 4: Estimates of a Reservation Wage Equation for Germany, 1991-2009.**

	1	2	3	4	5	6
Dependent variable						
Estimation method	IV	IV	IV	IV	IV	IV+FE
Log unemployment rate	0.136**	-0.005	-0.004	0.136*	0.046	0.117***
<i>aggregate</i>	(0.066)	(0.062)	(0.064)	(0.080)	(0.093)	(0.045)
Log unemployment rate				-0.195***	-0.180***	-0.185***
<i>aggregate, lagged</i>				(0.051)	(0.067)	(0.043)
Log unemployment rate					0.084**	
<i>regional</i>					(0.037)	
Log unemployment rate					-0.026	
<i>Regional, lagged</i>					(0.037)	
Trend	linear	quadratic	quadratic	quadratic	quadratic	quadratic
Region specific trends	No	no	yes	no	no	no
Observations	17,238	17,238	17,238	15,901	15,901	15,901
R-squared	0.356	0.359	0.361	0.362	0.363	

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. Source: GSOEP.

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

	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 (0.008)	-0.020** (0.008)	-0.022*** (0.007)	0.436*** (0.021)	0.312*** (0.036)	0.308*** (0.037)
Log unemployment rate <i>aggregate</i>		-0.069 (0.069)			-0.216** (0.077)	
Log unemployment rate <i>regional</i>			-0.036 (0.026)			0.015 (0.057)
Year dummies	yes	no	no	yes	no	no
Trend	no	quadratic	quadratic	no	quadratic	quadratic
Further controls	no	yes	yes	no	yes	yes
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 Germany**

	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	0.034*** (0.006)	-0.061*** (0.008)	-0.065*** (0.008)	0.698*** (0.024)	0.393*** (0.029)	0.370*** (0.029)
Log unemployment rate <i>aggregate</i>		-0.091*** (0.031)			-0.208* (0.121)	
Log unemployment rate <i>regional</i>			-0.031*** (0.009)			-0.133*** (0.026)
Year dummies	yes	no	no	yes	no	no
Trend	no	quadratic	quadratic	no	quadratic	quadratic
Further controls	no	yes	yes	no	yes	Yes
Observations	17,789	17,789	17,789	4,718	4,718	4,718
R-squared	0.006	0.066	0.066	0.196	0.306	0.310

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, the log of unemployment benefits, whether an individual looks for a full-time, part-time or any job (the omitted category is “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. Source: GSOEP.

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

	1	2	3	4
Estimation method	OLS	OLS	IV	IV
Last observed log wage	0.087*** (0.005)	0.105*** (0.008)	0.149** (0.016)	0.197*** (0.022)
Last observed log wage * years since observed		-0.009*** (0.002)		-0.019*** (0.022)
Log unemployment rate	-0.204*** (0.083)	-0.204*** (0.082)	-0.174** (0.086)	-0.170** (0.084)
Trend	quadratic	quadratic	quadratic	quadratic
Observations	8,151	8,151	7,790	7,790
R-squared	0.270	0.273		
First stage, F-test <sup>(a)</sup>			928.6	484.7
First stage, F-test <sup>(b)</sup>				269.7

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 duration since the last job was observed, a dummy for married, the number of children in the household, the log of unemployment benefits, and eleven region dummies. *Instruments used:* predicted industry wage (4-digit) for previous job (column 3); predicted industry wage (4-digit) for previous job and its interaction with years since previous job (column 4). <sup>(a)</sup> denotes Angrist and Pischke (2009) first-stage F-statistic for the first equation (last observed log wage) and <sup>(b)</sup> denotes the corresponding statistic for the second equation (last observed log wage\*years since observed). Standard errors are clustered at the year level. Source: BHPS.

## Appendix Tables and Figures

**Table A1: Descriptive statistics**

Variables:	United Kingdom						Germany					
	Reservation wage sample			Wage sample			Reservation wage sample			Wage sample		
	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				17797	1154.44	628.706			
Wage				96270	9.866	6.203				213305	2256.45	1815.43
Female	14874	0.546	0.498	96270	0.526	0.500	17797	0.585	0.493	213305	0.440	0.496
Age	14874	34.666	14.024	96270	38.106	11.691	17797	34.082	11.911	213305	39.130	11.589
Higher education	14874	0.247	0.431	96270	0.117	0.321	17797	0.150	0.357	213305	0.281	0.450
Upper secondary education	14874	0.353	0.478	96270	0.269	0.443	17797	0.592	0.491	213305	0.532	0.499
Lower secondary education	14874	0.314	0.464	96270	0.405	0.491	17797	0.175	0.380	213305	0.154	0.361
No qualifications	14874	0.085	0.280	96270	0.209	0.407	17797	0.077	0.072	213305	0.040	0.040
Married	14874	0.514	0.500	96270	0.717	0.451	17797	0.521	0.500	213305	0.657	0.475
No. Kids	14874	0.917	1.168	96270	0.686	0.965	17797	0.929	1.076	213305	0.716	0.967
Duration in current status (years)	14874	4.387	5.748	96270	4.880	5.969	17797	2.541	3.409	213305	10.182	9.554
Benefits	14874	276.414	318.201				17794	337.660	466.697			
Looking for full-time work							17797	0.542	0.498			
Looking for part-time work							17797	0.287	0.452			
Looking for either							17797	0.147	0.354			
Unsure about working hours							17797	0.024	0.154			
Social insurance contributions (months)							17797	4.837	0.562			
Months to benefit expiry							17241	1.371	4.081			
Entitled to unemployment benefits							17797	0.261	0.439			
Hours worked										213305	38.751	13.000

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

	1	2	3	4
	United Kingdom		Germany	
Dependent variable:	Log res wage	Log wage	Log res wage	Log wage
Log aggregate unemployment rate	-0.175*** (0.058)	-0.165*** (0.044)	-0.062 (0.059)	-0.166 (0.177)
Female	-0.102*** (0.011)	-0.263*** (0.009)	-0.182*** (0.014)	-0.290*** (0.033)
Age	0.033*** (0.002)	0.073*** (0.002)	0.010*** (0.003)	0.082*** (0.002)
Age <sup>2</sup> (/100)	-0.034*** (0.002)	-0.084*** (0.002)	-0.002*** (0.000)	-0.010*** (0.000)
Lower secondary qualification	0.068*** (0.009)	0.193*** (0.008)	-0.007 (0.020)	0.048* (0.020)
Upper secondary qualification	0.157*** (0.011)	0.361*** (0.007)	0.084*** (0.018)	0.279*** (0.029)
Higher education	0.352*** (0.013)	0.710*** (0.004)	0.275*** (0.025)	0.622*** (0.040)
Married	0.042*** (0.006)	0.092*** (0.006)	-0.041*** (0.009)	0.020*** (0.006)
No. kids in household	0.018*** (0.004)	-0.019*** (0.003)	0.000 (0.004)	-0.023*** (0.004)
Duration in current status (years)	-0.002 (0.002)	0.018*** (0.001)	0.012* (0.006)	0.044*** (0.003)
Duration in current status <sup>2</sup> (years/10)	-0.001 (0.002)	-0.010*** (0.001)	-0.012* (0.007)	-0.015*** (0.002)
Duration in current status <sup>3</sup> (years/100)	0.003 (0.003)	0.017*** (0.002)	0.003 (0.002)	0.002*** (0.000)
Log(Unemp benefits + 1)	0.004** (0.001)		-0.001 (0.003)	
Receives housing benefits	0.017** (0.008)		-0.043** (0.019)	
Social insurance contributions (years)			0.004*** (0.001)	
Looking for full-time work			0.101*** (0.027)	
Looking for part-time work			-0.498*** (0.029)	
Looking for any hours			-0.065*** (0.023)	
Log hours worked				0.735*** (0.116)
Year	0.004 (0.007)	-0.009 (0.007)	0.030*** (0.008)	0.024*** (0.007)
(Year-1990) <sup>2</sup>	0.001** (0.000)	0.001*** (0.000)	-1.040*** (0.254)	-0.803*** (0.257)
Observations	14,847	96,270	17,238	213,305
R-squared	0.249	0.397	0.359	0.605

Notes. Wage measures are hourly for the U.K. and monthly for Germany. All regressions include region dummies.

**Table A3: Estimates of a Wage Equation for the UK – further estimates with regional controls**

	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	$\Delta$ Log wage	Log wage
Sample	All jobs	All jobs	All jobs	All jobs	All jobs	All jobs	New jobs	Continuing jobs	All jobs	All jobs	All jobs	All jobs
Estimation method	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	FE
Log wage, lagged					0.759*** (0.005)	0.759*** (0.005)				0.759*** (0.005)		0.139*** (0.020)
Log unemployment rate	0.010 (0.011)	-0.009 (0.022)	-0.036* (0.019)	-0.051*** (0.016)	-0.018 (0.012)	-0.006 (0.012)	-0.003 (0.030)	-0.023** (0.009)	-0.027 (0.018)	-0.018 (0.011)	-0.022** (0.010)	-0.032*** (0.012)
Log unemployment rate <i>regional, lagged</i>						-0.021* (0.011)						
Log unemployment rate <i>regional, at start of job</i>									-0.051*** (0.010)	-0.008* (0.004)	0.001 (0.005)	
Year dummies	Yes	No	no	no	no	no	no	no	no	no	no	no
Trend	No	Linear	quadratic	quadratic	quadratic	quadratic	quadratic	quadratic	quadratic	quadratic	quadratic	quadratic
Region specific trend	No	No	no	yes	no	no	no	no	no	no	no	no
Observations	96,269	96,269	96,269	96,269	70,901	70,901	14,791	56,110	95,583	70,438	70,438	70,102
R-squared	0.399	0.397	0.397	0.397	0.748	0.748	0.638	0.783	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. Standard errors are clustered at the (year\*region) level. Estimates in column 12 are obtained using the Arellano Bond (1991) estimator for dynamic panel data models. Source: BHPS.

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

	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	$\Delta$ Log wage	Log wage
Sample	All jobs	All jobs	All jobs	All jobs	All jobs	All jobs	New jobs	Continuing jobs	All jobs	All jobs	All jobs	All jobs
Estimation method	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	FE
Log wage, lagged					0.730*** (0.004)	0.732*** (0.004)				0.723*** (0.004)		0.389*** (0.011)
Log unemployment rate <i>regional</i>	-0.015 (0.033)	0.050** (0.023)	0.033 (0.023)	0.037** (0.014)	-0.029*** (0.007)	-0.004 (0.007)	-0.044 (0.029)	0.051** (0.022)	-0.017 (0.019)	-0.020*** (0.006)	-0.035*** (0.007)	-0.003 (0.004)
Log unemployment rate <i>regional, lagged</i>						-0.017** (0.007)						
Log unemployment rate <i>regional, at start of job</i>									0.032*** (0.003)	0.006*** (0.002)	-0.003* (0.002)	
Year dummies	Yes	No	no	no	no	no	no	no	no	no	no	no
Trend	No	Linear	quadratic	quadratic	quadratic	quadratic	quadratic	quadratic	quadratic	quadratic	quadratic	quadratic
Region specific trend	No	No	no	yes	no	no	no	no	no	no	no	no
Observations	210,912	210,912	210,912	210,912	164,933	162,977	33,719	176,928	193,947	150,043	150,043	164,933
R-squared	0.630	0.628	0.629	0.631	0.849	0.849	0.618	0.611	0.644	0.851	0.048	

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. Standard errors are clustered at the (year\*region) level. Estimates in column 12 are obtained using the Arellano Bond (1991) estimator for dynamic panel data models. Source: SOEP.

**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	0.007	-0.047	-0.054*	-0.064**	0.028	0.048
<i>regional</i>	(0.026)	(0.031)	(0.028)	(0.028)	(0.039)	(0.031)
Log unemployment rate <i>regional, lagged</i>					-0.100** (0.037)	-0.106*** (0.028)
Year dummies	yes	no	no	no	no	no
Trend	no	linear	quadratic	quadratic	quadratic	quadratic
Region specific trend	no	no	no	yes	no	no
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	0.111

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\*region) level. Source: BHPS.

**Table A6: Estimates of a Reservation Wage Equation for 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	0.011	0.035	0.011	0.018	0.090***	0.058**
<i>regional</i>	(0.029)	(0.025)	(0.021)	(0.021)	(0.027)	(0.029)
Log unemployment rate					-0.091***	-0.073***
<i>regional, lagged</i>					(0.023)	(0.025)
Year dummies	yes	no	no	no	no	no
Trend	no	linear	quadratic	quadratic	quadratic	quadratic
Region specific trend	no	No	no	yes	no	no
Observations	17,238	17,238	17,238	17,238	15,901	15,901
R-squared	0.362	0.356	0.359	0.361	0.362	

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. Source: GSOEP.

## Appendix B

### The reservation wage conditional on wages

#### B.1 Proof of result (27)

In deriving (10) from (9) we used the wage bargaining solution (8). Below we will not impose (8) and derive a value of a job paying a wage  $w$ , conditional on the expected future path of wages. Let's rewrite (9) as:

$$(r + \phi + s)[W(t; w) - U(t)] = w - z + (\phi - \lambda(t))[W(t; w(t)) - U(t)] + E_t \frac{\partial [W(t; w) - U(t)]}{\partial t} \quad (36)$$

which has solution:

$$W(t; w) - U(t) = \frac{w - z}{r + \phi + s} + E_t \int_t^\infty e^{-(r + \phi + s)(\tau - t)} (\phi - \lambda(\tau)) [W(\tau; w(\tau)) - U(\tau)] d\tau \quad (37)$$

Evaluating at  $w = w(t)$  and differentiating yields:

$$\begin{aligned} \frac{\partial [W(t; w(t)) - U(t)]}{\partial t} &= \frac{w'(t)}{r + \phi + s} + (r + \phi + s) E_t \int_t^\infty e^{-(r + \phi + s)(\tau - t)} (\phi - \lambda(\tau)) [W(\tau; w(\tau)) - U(\tau)] d\tau \\ &\quad - (\phi - \lambda(t)) [W(t; w(t)) - U(t)] \\ &= \frac{w'(t)}{r + \phi + s} - (w(t) - z) + (r + \lambda(t) + s) [W(t; w(t)) - U(t)] \end{aligned} \quad (38)$$

with solution:

$$W(t; w(t)) - U(t) = E_t \int_t^\infty e^{-\int_t^\tau (r + \lambda(x) + s) dx} \left[ (w(\tau) - z) - \frac{w'(\tau)}{r + \phi + s} \right] d\tau \quad (39)$$

Integrating the term in  $w'(\tau)$  by parts this can be written as:

$$\begin{aligned} (r + \phi + s) [W(t; w(t)) - U(t)] &= \\ &= (w(t) - z) - E_t \int_t^\infty e^{-\int_t^\tau (r + \lambda(x) + s) dx} (w(\tau) - z) (\lambda(\tau) - \phi) d\tau \end{aligned} \quad (40)$$

From (40) and (37) we can derive the following result:

$$\begin{aligned} E_t \int_t^\infty e^{-(r + \phi + s)(\tau - t)} (\lambda(\tau) - \phi) [W(\tau; w(\tau)) - U(\tau)] d\tau \\ = \frac{1}{r + \phi + s} E_t \int_t^\infty e^{-\int_t^\tau (r + \lambda(x) + s) dx} (w(\tau) - z) (\lambda(\tau) - \phi) d\tau \end{aligned} \quad (41)$$

Imposing  $W(t; \rho(t)) = U(t)$ , (37) and (41) imply (27).

#### B.2 Proof of result (28)

Let's differentiate (27) with respect to  $\lambda(t)$ :

$$\begin{aligned}
\frac{\partial \rho(t)}{\partial \lambda(t)} &= E_t \int_t^\infty e^{-\int_t^\tau (r+\lambda(x)+s)dx} (\lambda(\tau) - \phi) \frac{\partial w(\tau)}{\partial \lambda(\tau)} \frac{\partial \lambda(\tau)}{\partial \lambda(t)} d\tau \\
&+ E_t \int_t^\infty e^{-\int_t^\tau (r+\lambda(x)+s)dx} (w(\tau) - z) \frac{\partial \lambda(\tau)}{\partial \lambda(t)} d\tau \\
&+ E_t \int_t^\infty \left( \int_t^\tau \frac{\partial \lambda(x)}{\partial \lambda(t)} dx \right) e^{-\int_t^\tau (r+\lambda(x)+s)dx} (w(\tau) - z) (\lambda(\tau) - \phi) d\tau
\end{aligned} \tag{42}$$

Assuming that  $\lambda(t)$  follows the process in (17),<sup>23</sup> and evaluating (42) in the steady-state:

$$\begin{aligned}
\frac{\partial \ln \rho(t)}{\partial \lambda(t)} &= \frac{w}{\rho} \frac{\partial \ln w(t)}{\partial \lambda(t)} \frac{\lambda - \phi}{r + s + \lambda + \xi} + \frac{w - z}{\rho} \frac{1}{r + s + \lambda + \xi} \\
&+ \frac{w - z}{\rho} \frac{\lambda - \phi}{\xi} \left( \frac{1}{r + s + \lambda + \xi} - \frac{1}{r + s + \lambda} \right) \\
&= \frac{w}{\rho} \frac{\partial \ln w(t)}{\partial \lambda(t)} \frac{\lambda - \phi}{r + s + \lambda + \xi} + \frac{w - z}{\rho} \frac{1}{r + s + \lambda + \xi} \frac{r + s + \phi}{r + s + \lambda}
\end{aligned} \tag{43}$$

As  $\partial \ln u(t) / \partial \lambda(t) = -1 / (s + \lambda)$ , (43) can be written as:

$$\frac{\partial \ln \rho(t)}{\partial \ln u(t)} = \frac{w}{\rho} \frac{\partial \ln w(t)}{\partial \ln u(t)} \frac{\lambda - \phi}{r + s + \lambda + \xi} - \frac{w(1 - \eta)}{\rho} \frac{r + s + \phi}{r + s + \lambda + \xi} \frac{s + \lambda}{r + s + \lambda}. \tag{44}$$

Note that using (27) and evaluating at a steady-state, we can derive:

$$\frac{\rho}{w} = \frac{\lambda - \phi + (r + \phi + s)\eta}{r + \lambda + s} \tag{45}$$

which can be re-arranged to give:

$$\frac{(r + \phi + s)(1 - \eta)}{r + \lambda + s} = 1 - \frac{\rho}{w}. \tag{46}$$

Substituting (46) into the second term of (44) gives (28).

### B.3 Derivation of model predictions under the assumption of no-renegotiation on reservation-wage jobs.

In the reservation wage model of Section 4, a job that is accepted at the reservation wage is expected to be re-negotiated at the same rate  $\phi$  as other jobs. We now consider an alternative – extreme – assumption, namely that a job accepted at the reservation wage continues to pay that wage until it ends.

Define  $\Omega(t, \rho)$  to be the value of a reservation wage job that pays  $\rho$  at time  $t$  (the notation is changed to reflect the fact that there is no re-negotiation expected). Using (9):

$$\begin{aligned}
r[\Omega(t; \rho) - U(t)] &= \rho - z - s[\Omega(t; \rho) - U(t)] \\
&+ -\lambda(t)[W(t; w(t)) - U(t)] + E_t \frac{\partial [\Omega(t; \rho) - U(t)]}{\partial t}
\end{aligned} \tag{47}$$

The differential equation in (47) has solution:

<sup>23</sup> We will actually assume this process is non-stochastic.

$$\left[\Omega(t; \rho) - U(t)\right] = \frac{\rho - z}{r + s} - E_t \int_t^\infty e^{-(r+s)(\tau-t)} \lambda(\tau) \left[W(\tau; w(\tau)) - U(\tau)\right] d\tau \quad (48)$$

Let us define  $S(\tau) = [W(\tau; w(\tau)) - U(\tau)]$ . Given  $\Omega(t; \rho(t)) = U(t)$ , we obtain:

$$\rho(t) = z + (r + s) E_t \int_t^\infty e^{-(r+s)(\tau-t)} \lambda(\tau) S(\tau) d\tau \quad (49)$$

Differentiating this with respect to  $\lambda(t)$  gives:

$$\frac{\partial \rho(t)}{\partial \lambda(t)} = (r + s) E_t \int_t^\infty e^{-(r+s)(\tau-t)} \left[ S(\tau) + \lambda(\tau) \frac{\partial S(\tau)}{\partial \lambda(\tau)} \right] \frac{\partial \lambda(\tau)}{\partial \lambda(t)} d\tau \quad (50)$$

Using (17) and imposing steady state gives:

$$\frac{\partial \rho(t)}{\partial \lambda(t)} = \frac{r + s}{r + s + \xi} \left[ S + \lambda \frac{\partial S(t)}{\partial \lambda(t)} \right] \quad (51)$$

From (40) we obtain:

$$\begin{aligned} (r + \phi + s) \frac{\partial S(t)}{\partial \lambda(t)} &= \frac{\partial w(t)}{\partial \lambda(t)} - E_t \int_t^\infty A(\tau, t) \frac{\partial w(\tau)}{\partial \lambda(\tau)} \frac{\partial \lambda(\tau)}{\partial \lambda(t)} (\lambda(\tau) - \phi) d\tau \\ &\quad - E_t \int_t^\infty A(\tau, t) \frac{\partial \lambda(\tau)}{\partial \lambda(t)} (w(\tau) - z) d\tau - E_t \int_t^\infty \frac{\partial A(\tau, t)}{\partial \lambda(t)} (w(\tau) - z) (\lambda(\tau) - \phi) d\tau \end{aligned} \quad (52)$$

where:

$$A(\tau, t) = e^{-\int_t^\tau (r + \lambda(x) + s) dx} \quad (53)$$

From (53) we obtain:

$$\frac{\partial A(\tau, t)}{\partial \lambda(t)} = -A(\tau, t) \int_t^\tau \frac{\partial \lambda(x)}{\partial \lambda(t)} dx = -A(\tau, t) \frac{1 - e^{-\xi(\tau-t)}}{\xi} \quad (54)$$

Substituting (54) in (52) and evaluating at a steady-state gives:

$$\begin{aligned} (r + \phi + s) \frac{\partial S(t)}{\partial \lambda(t)} &= \frac{\partial w(t)}{\partial \lambda(t)} \left( 1 - \frac{\lambda - \phi}{r + \lambda + s + \xi} \right) \\ &\quad - \frac{w - z}{r + \lambda + s + \xi} + \frac{(w - z)(\lambda - \phi)}{\xi} \left( \frac{1}{r + \lambda + s} - \frac{1}{r + \lambda + s + \xi} \right) \end{aligned} \quad (55)$$

which can be simplified to:

$$(r + \phi + s) \frac{\partial S(t)}{\partial \lambda(t)} = \frac{\partial w(t)}{\partial \lambda(t)} \frac{(r + \phi + s + \xi)}{(r + \lambda + s + \xi)} - \frac{(w - z)}{(r + \lambda + s + \xi)} \frac{(r + \phi + s)}{(r + \lambda + s)} \quad (56)$$

Also, from (40) we have that in a steady-state:

$$S = \frac{(w - z)}{(r + \lambda + s)} = \frac{w(1 - \eta)}{(r + \lambda + s)} \quad (57)$$

Combining (51), (57) and (56) we can derive:

$$\begin{aligned} \frac{\partial \rho(t)}{\partial \lambda(t)} &= \frac{\lambda(r+s)}{(r+s+\xi)(r+\lambda+s+\xi)} \frac{1}{(r+\phi+s)} \frac{\partial w(t)}{\partial \lambda(t)} \\ &+ \frac{(r+s)}{(r+\lambda+s)} \frac{w(1-\eta)}{(r+\lambda+s+\xi)} \end{aligned} \quad (58)$$

Using  $\frac{\partial \ln u(t)}{\partial \lambda(t)} = -\frac{1}{s+\lambda}$  and converting to elasticities (58) can be written as:

$$\begin{aligned} \frac{\partial \ln \rho(t)}{\partial \ln u(t)} &= \frac{w}{\rho} \frac{(r+s)}{(r+\phi+s)} \frac{(r+s+\xi+\phi)}{(r+s+\xi)} \frac{\lambda}{(r+\lambda+s+\xi)} \frac{\partial \ln w(t)}{\partial \ln u(t)} \\ &- \frac{w}{\rho} (1-\eta) \frac{(r+s)}{(r+s+\lambda+\xi)} \frac{(s+\lambda)}{(r+s+\lambda)} \end{aligned} \quad (59)$$

Using (46) this can then be written as:

$$\begin{aligned} \frac{\partial \ln \rho(t)}{\partial \ln u(t)} &= \frac{w}{\rho} \frac{(r+s)}{(r+\phi+s)} \frac{(r+s+\xi+\phi)}{(r+s+\xi)} \frac{\lambda}{(r+\lambda+s+\xi)} \frac{\partial \ln w(t)}{\partial \ln u(t)} \\ &- \left( \frac{w}{\rho} - 1 \right) \frac{(r+s)}{(r+s+\lambda+\xi)} \frac{(s+\lambda)}{(r+s+\phi)} \end{aligned} \quad (60)$$

In this case – at the benchmark parameter values – the second term is very small (0.03) but the coefficient on the wage elasticity is large (about 0.9) leading to the prediction that the elasticity of the reservation wage and the wage in new jobs should be very similar, something that is at variance with the data.

## 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 (see, for example, Burdett and Mortensen, 1998) that the two are related by:

$$1 - G(w) = \frac{1 - F(w)}{s + \lambda^e [1 - F(w)]} \frac{s + \lambda^e [1 - F(\rho)]}{1 - F(\rho)} \quad (61)$$

Under the usual approximation  $r \approx 0$  (given the size of labour market flows), (31) can be written as:

$$\rho \approx z + \frac{(\lambda^u - \lambda^e) [1 - F(\rho)]}{s + \lambda^e [1 - F(\rho)]} \int_{\rho} [1 - G(w)] dw = z + \frac{(\lambda^u - \lambda^e) [1 - F(\rho)]}{s + \lambda^e [1 - F(\rho)]} (\bar{w} - \rho), \quad (62)$$

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

$$\rho \approx \frac{\{s + \lambda^e [1 - F(\rho)]\} z + (\lambda^u - \lambda^e) [1 - F(\rho)] \bar{w}}{s + \lambda^u [1 - F(\rho)]}. \quad (63)$$

The unemployment rate is given by:

$$u = \frac{s}{s + \lambda^u [1 - F(\rho)]} \quad (64)$$

and substituting this in (63) gives (32).

## Appendix D

### The fraction of jobs filled by the currently employed

We obtain evidence on the fraction of workers who are recruited from previously existing jobs from the UK Quarterly Labour Force Survey for 1993-2012 (the UK equivalent to the US Current Population Survey), by identifying new jobs created each quarter and looking back at the previous quarter's employment status of newly-hired workers.<sup>24</sup> The average fraction of workers in new jobs who were previously employed in the UK is 61%. Figure B1 shows the relationship between this fraction, which we will denote by  $\zeta$ , and unemployment, and Table B1 report the corresponding regression results. Both indicate that  $\zeta$  is pro-cyclical, with a slope coefficient on the unemployment rate of approximately 1.

We next consider the relationship between  $\zeta$  and  $\lambda^e / \lambda^u$  in a search model with permanent wage dispersion in which workers, when faced with a choice, accept the highest-wage job. 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:

$$[s + \lambda^e (1 - f)] G(f) (1 - u) = \lambda^u u f, \quad (65)$$

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

$$G(f) = \frac{sf}{s + \lambda^e (1 - f)}. \quad (66)$$

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

$$R(f) = \lambda^u u + \lambda^e (1 - u) G(f) = \frac{s \lambda^u}{s + \lambda^u} \frac{s + \lambda^e}{s + \lambda^e (1 - f)} \quad (67)$$

and total recruits in the economy are given by:

$$R = \int_0^1 R(f) df = \frac{s \lambda^u}{s + \lambda^u} \frac{s + \lambda^e}{s + \lambda^e (1 - f)} = \frac{s \lambda^u}{s + \lambda^u} \frac{s + \lambda^e}{\lambda^e} \ln \left( \frac{s + \lambda^e}{s} \right). \quad (68)$$

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:

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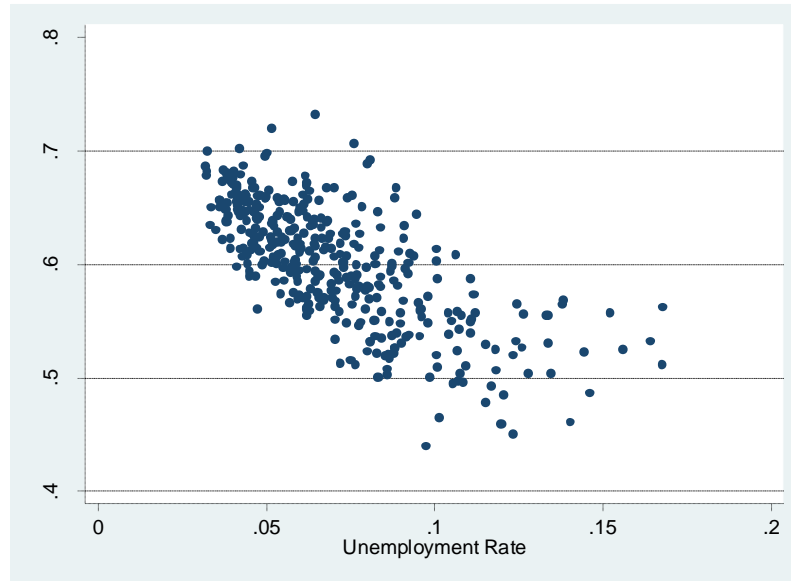
<sup>24</sup> We do not adjust this statistic for time aggregation, so it may be possible that a worker in employment this quarter and 3 quarters ago has had an intervening period of non-employment. Given the outflow rates from unemployment in the UK this makes little difference to the computations.

$$1 - \zeta = \frac{\lambda^e}{(s + \lambda^e) \ln\left(\frac{s + \lambda^e}{s}\right)} = \frac{\lambda^e / \lambda^u}{\left(\frac{u}{1-u} + \frac{\lambda^e}{\lambda^u}\right) \ln\left(1 + \frac{\lambda^e}{\lambda^u} \frac{1-u}{u}\right)}. \quad (69)$$

Using (69), an average unemployment rate in the UK over 1993-2012 of 6.8% and an average  $\zeta$  of 60.1% imply  $\lambda^e / \lambda^u \approx 0.612$ .

As expected,  $1 - \zeta$  is increasing in the unemployment rate and decreasing in  $\lambda^e / \lambda^u$ . Thus (69) implies an inverse relationship between  $\zeta$  and unemployment even if  $\lambda^e / \lambda^u$  does not vary with the cycle. But the strength of the relationship between  $\zeta$  and unemployment shown in Table B1 is weaker than we would expect from (69) if  $\lambda^e / \lambda^u$  were constant. This implies that, as unemployment rises, so does  $\lambda^e / \lambda^u$ . 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 (32), this mechanism acts to make the reservation wage even more sensitive to the unemployment rate.

**Figure B1**  
**The Cyclicalty in the Proportion of New Hires Who Were Previously Employed**



Notes: Each point represents a year-region combination. Cells based on less than 50 observations are omitted.

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

	Dependent variable: Fraction of new hires from previous jobs			
Unemployment rate	-1.51** (0.065)	-1.91** (0.076)	-1.02 (0.081)	-0.97 (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

Here we present a model of how the presence of hyperbolic discounting can affect the reservation wage. This is considered in Della Vigna and Paserman (2005) and Paserman (2008). In order not to change notation too much we use the version of hyperbolic discounting for continuous time developed by Harris and Laibson (2013) rather than the more familiar discrete time version. In this version there is an arrival rate of a shock – here denoted by  $\alpha$  – which turns one into a person (the future self) who one cares less about than one's current self. Let us denote the weight one attaches to the future self by  $\gamma$ . The expectation is that the future self is a straightforward exponential discounter<sup>25</sup>. The value function for being employed (5) is now modified to:

$$rW(w) = w - s[W(w) - U] + \alpha[\psi\tilde{W}(w) - W(w)] \quad (70)$$

where  $\tilde{W}(w)$  is the value of being employed for the future non-hyperbolic self. This value function is the same as (5) i.e. is given by:

$$r\tilde{W}(w) = w - s[\tilde{W}(w) - \tilde{U}] \quad (71)$$

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

$$rU = z + \lambda[W - U] + \alpha[\psi\tilde{U} - U] \quad (72)$$

$$r\tilde{U} = z + \lambda[\tilde{W} - \tilde{U}] \quad (73)$$

From (71) and (73) one can readily derive that:

$$\tilde{W} - \tilde{U} = \frac{[w - z]}{r + s + \lambda} \quad (74)$$

and that:

$$r\tilde{U} = z + \frac{\lambda[w - z]}{r + s + \lambda} \quad (75)$$

From (70) and (72) one can then derive that:

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<sup>25</sup> 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  $[r + \eta(1 - \gamma)]$ . This makes the reservation wage less sensitive to unemployment but just in the standard way of making the weight on the wage very low.

$$W - U = \frac{[w - z] + \alpha\psi(\tilde{W} - \tilde{U})}{r + s + \lambda + \alpha} \quad (76)$$

Using (76), (72) and (74) one can then, after some re-arrangement, derive:

$$rU = \frac{r + \alpha\psi}{r + \alpha} z + \frac{\lambda[w - z][r(r + s + \lambda + \alpha\psi) + \alpha\psi(r + s + \lambda + \alpha)]}{(r + s + \lambda)(r + s + \lambda + \alpha)(r + \alpha)} \quad (77)$$

Now let us derive the reservation wage,  $\rho$ . This is the wage that makes  $W$  equal to  $U$  i.e. from (70) it must satisfy:

$$rU = \rho + \alpha[\psi\tilde{W}(\rho) - U] \quad (78)$$

Now from (71) we have that:

$$\tilde{W}(\rho) = \frac{\rho + s\tilde{U}}{r + s} \quad (79)$$

Combining (78) and (79) leads to the following expression for the reservation wage:

$$\rho = \frac{[(r + s)(r + \alpha)U - \alpha\psi s\tilde{U}]}{(r + s + \lambda + \alpha\psi)} \quad (80)$$

Substituting in (77) and (75) and re-arranging leads to the following expression:

$$\rho = z + \frac{\lambda[w - z]}{(r + s + \lambda)} \left[ \frac{(r + s)}{(r + s + \lambda + \alpha)} + \frac{\alpha\psi}{(r + s + \lambda + \alpha\psi)} \right] \leq z + \frac{\lambda[w - z]}{(r + s + \lambda)} \quad (81)$$

The inequality shows that the effect of hyperbolic discounting is to reduce the reservation wage. It should also be apparent from (81) that hyperbolic discounting reduces the weight on the wage in the determination of the reservation wage. This is what one would expect as hyperbolic discounting makes the individual more present-oriented. This reduced weight on the wage makes the reservation wage less sensitive to the unemployment rate but also makes the weight on the wage lower. So hyperbolic discounting does not really solve the basic problem.

The calibration used by Harris and Laibson (2012) is (at annual level)  $\alpha = 2/3$  and that the arrival rate of a change of self is at least 12. In this case the reservation wage is almost the same as  $z$ . This obviously has the potential to increase dramatically the effective interest rate used by workers and this will make the reservation wage very insensitive to unemployment but at the cost of making it insensitive to the expected wage. These calibrations may be plausible for the application they consider (consumption) but do not seem plausible for our application.

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