Search, Shirking and Labor Market Volatility

Chris Martin* University of Bath

Bingsong Wang† University of Warwick

August 24, 2020

Abstract

This paper proposes a modified version of the standard search and matching model of the labour market that includes a shirking mechanism. We show that our model delivers a close match to the simulated volatilities, correlations and autocorrelations of unemployment, vacancies, labour market tightness and the job finding rate with values observed in US data. In doing so, it outperforms prominent alternative models. Our model also has novel policy implications for the impact of income taxes, subsidies on hiring and employment taxes on unemployment and its volatility.

Keywords: search frictions, shirking, unemployment volatilty puzzle

JEL Classification: E23, E32, J23, J30, J64

1 Introduction

Although the currently dominant approach to modelling labour markets, the search frictions model pioneered by, among others, Diamond (1982), Mortensen and Pissarides (1994) and Pissarides (2000), provides a simple framework for the analysis of the labour market and associated policy issues, it has some well-known difficulties. In the most prominent statement of these difficulties, Shimer (2005) compares the volatilities, autocorrelations and correlations of unemployment, vacancies, labour market tightness and the job finding rate from a calibrated and simulated version of the search frictions model with US data for 1951-2003. Two findings stand out. The simulated volatilities of these key labour market variables are much lower than those observed in the data. And the model cannot match the autocorrelation of vacancies or the co-movements of vacancies with other labour market variables. The inability of the search frictions model to match the cyclical behaviour of labour market variables, the unemployment volatility puzzle, has been extensively analysed by a large and

*Department of Economics, University of Bath, Bath BA2 7AY UK; email: c.i.martin@bath.ac.uk

†Department of Economics, University of Warwick, Coventry CV4 7AL, UK; email: b.wang.9@warwick.ac.uk

growing literature (e.g. Hall, 2005, Hall and Milgrom, 2008, Hagedorn and Manovskii, 2008, Gertler and Trigari, 2009, Pissarides, 2009, Rogerson and Shimer, 2010, Christiano et al, 2016 and Ljungqvist and Sargent, 2017). The particular weakness of the search frictions model in explaining vacancies has received less attention.

This paper argues that these weaknesses can be addressed by a modified version of the search frictions model that incorporates a shirking mechanism. Shirking arises because firms have imperfect information about the effort exerted by workers; we model this by assuming firms have an exogenous probability of detecting and firing a shirking worker. This implies that workers must balance the utility benefits of shirking against the costs, in the form of a higher probability of becoming unemployed. In our baseline model, we follow the extensive literature on shirking originated by Shapiro and Stiglitz (1984) and assume that wages are posted by firms. Firms will set the wage at the lowest value that induces the worker to choose not to shirk; the no-shirking constraint. Calibrating and simulating this model using, where possible, standard values from the literature, we can closely match the volatilities of unemployment, vacancies and labour market tightness and can also match the autocorrelation of vacancies and the correlations between vacancies and the other variables. Our calibration assumes a small shirking effect as the utility benefit of shirking is small and the probability of detection is high. This small friction is sufficient to generate a large volatility of unemployment and other labour market variables.

The model generates a large unemployment volatility through a mechanism similar to that outlined by Hall (2005). Firms respond to a positive productivity shock by posting more vacancies, leading to a fall in unemployment and an increase in labour market tightness. In the standard search frictions model, as Shimer (2005) argued, a highly pro-cyclical wage will absorb part of an increase in productivity, reducing the incentive for firms to post vacancies and so dampening cyclical movements in unemployment and vacancies. This does not occur in our model since the wage offered by firms to workers has a low volatility across the business cycle. We can also use the concept of the "fundamental surplus", introduced by Ljungqvist and Sargent (2017), to explore the underlying forces that enable our model to generate a large unemployment volatility. We argue that the fundamental surplus is lower when workers are able to shirk, since firms must pay a wage premium to deter them from doing so. A smaller fundmental surplus implies that the "invisible hand" can allocate fewer resources to vacancy creation, leading, as Ljungqvist and Sargent (2017) argue, to a larger volatility of unemployment.

Our findings are robust to extending our simple baseline model. In section 4), we analyse the case where wages are set through worker-firm bargaining, rather than through wage posting by firms, focusing on the credible bargaining approach of Hall and Milgrom (2008). We show that this version of the model also generates a large volatility of unemployment, since the bargained wage has a low volatility across the business cycle. We also consider the impact of three policy measures: income taxes paid by workers, hiring subsidies paid to firms and payroll taxes. We show that our main results also hold in these extensions of our model.

We also show that our model has novel implications for policy. The literature on labour market policy using the standard search frictions model (eg Pissarides, 2000) argues that the marginal tax rate on income has no direct impact on the cyclicality of wages and unemployment. We show that this is not the case in our model, as an increased marginal rate of income tax increases the volatility of wages and reduces the volatility of unemployment. We also show that an increased hiring subsidy or a payroll tax cut leads to reduced and less volatile unemployment.

There is a robust body of evidence supporting the existence of shirking effects (Wolfers and Zilinsky, 2015). Burda et al (2015) analyse empirical measures of shirking and argue that the data are consistent with a model in which "workers are paid efficiency wages to refrain from loafing on the job." Groshen and Krueger (1990) and Rebitzer (2005) find an inverse relationship between wages and monitoring costs. Capelli and Chauvin (1991) and Reich et al (2003) find that firms take less disciplinary action against workers in workplaces where relative wages are higher. Pfeifer (2010) and Zhang et al (2013) find that absenteeism is inversely related to wages. Malcomson and Mavroeidis (2010) estimate aggregate wage equations on U.S time series data and argue that their estimates are consistent with the shirking model. The potential of a shirking mechanism in explaining the unemployment volatility puzzle has been raised previously in the literature, for example by Rogerson and Shimer (2010). Costain and Jansen (2009) develop a model with a shirking mechanism but, in contrast to our approach, assume that wages are determined through bargaining. They find that this model does not help address the unemployment volatility puzzle. Uhlig and Xu (1996) assess the ability of a different type of efficiency wage model[1] to explain large cyclical movements in unemployment using a real business cycle model without search frictions[2]. A related strand of the literature (e.g. Danthine and Donaldson,1990 and Danthine and Kurmann, 2010) incorporates efficiency wage effects into DSGE models but does not investigate the unemployment volatility puzzle.

The remainder of the paper is structured as follows. We outline our model in section 2). We discuss calibration and present our results in Section 3). We analyse the impact of wage bargaining on our results in section 4); in section 5), we discuss the underlying causes of unemployment volatility and relate our analysis to the “fundamental suplus” of Ljungqvist and Sargent, (2017). We discuss the policy implications of our model in Section 6). Finally, section 7) sumarises our work and raises issues for subsequent research.

[1] They assume that effort is a continuous function of the wage, similar to Solow (1979).

[2] Poeschel (2010) uses a model with shirking and wage posting to analyse the "Diamond Paradox" (Diamond, 1971); his model differs from ours in several respacts, including the possibility that firms might renege on the wage they offer in order to recruit workers.

2 The Model

2.1 Workers

There is a continuum of identical workers on the unit interval. In period t a worker is in one of three states, employed and not shirking, employed and shirking or unemployed. All employed workers suffer a disutility[3] of χ; workers who do not shirk incur additional disutility of e. The value function for a worker who is employed and not shirking is

$$L_t = w_t - \chi - e + \frac{1}{1+r} E_t[(1-\tau_t)M_{t+1} + \tau_t U_{t+1}] \tag{1}$$

where $M_t = \max(L_t, S_t)$ and S is the value function for a worker who is employed and shirking. This worker earns (and consumes) real wage w_t and experiences disutility of working[4] of $\chi + e$. The job match dissolves at the end of the period with exogenous but time-varying probability τ_t. We assume that the separation rate is stochastic: $\tau_t = \tau e^{\varepsilon_t^\tau}$; ε_t^τ is a separation rate shock where $\varepsilon_t^\tau = \rho^\tau \varepsilon_{t-1}^\tau + \eta_t^\tau$ and η_t^τ is distributed as $N(0, \sigma_\tau^2)$. Although the worker does not currently shirk, they may choose to do so in the next period, if the job match survives. The value function for a worker who is employed and shirking is

$$S_t = w_t - \chi + \frac{1}{1+r} E_t[(1-\tau_t - d)M_{t+1} + (\tau_t + d)U_{t+1}] \tag{2}$$

where the worker is detected as shirking and fired with exogenous probability d. Compared to a non-shirker, this worker incurs less disutility while at work but has a higher probability of becoming unemployed. The value function for an unemployed worker is

$$U_t = b + \frac{1}{1+r} E_t[f_t M_{t+1} + (1-f_t)U_{t+1}] \tag{3}$$

where b denotes real unemployment benefits. If unemployed, an individual finds a job and is employed in the next period with endogenous probability f_t.

The worker will choose not to shirk if and only if $L_t \geq S_t$. This implies the No-Shirking Constraint

$$L_t - U_t \geq (1+r)\frac{e}{d} \tag{4}$$

If the utility premium of workers who are employed and not shirking over unemployed workers does not satisfy this condition, the utility benefit from shirking exceeds the risk-weighted cost from a higher likelihood of becoming unemployed.

[3]Following Hall (2005), this might equivalently be modeled as the utility of leisure enjoyed only by the unemployed.

[4]Our approach differs slightly from Burda et al (2015), who assign a utility benefit to shirking whereas we assign a utility cost to not shirking. This alternative approach leads to the same results.

2.2 Firms

There is a continuum of identical firms on the unit interval. Each firm can hire up to one worker and a firm with an employed and non-shirking worker produces an amount y_t, where $y_t = e^{\varepsilon_t^s}$; ε_t^s is a technology shock, where $\varepsilon_t^s = \rho^s \varepsilon_{t-1}^s + \eta_t^s$ and η_t^s is distributed as $N(0, \sigma_s^2)$. Output is zero if the worker shirks. The value function of a filled job with a non-shirking worker is

$$J_t = y_t - w_t + \frac{1}{1+r} E_t[(1-\tau_t)H_{t+1} + \tau_t V_{t+1}] \tag{5}$$

where V is the value function of a vacancy, $H = J$ if the worker chooses not to shirk and $H = F$ otherwise. F is the value function of a filled job with a shirking worker, given by

$$F_t = -w_t + \frac{1}{1+r} E_t[(1-\tau_t-d)H_{t+1} + (\tau_t + d)V_{t+1}] \tag{6}$$

The value function for a vacant job is

$$V_t = -\gamma + \frac{1}{1+r} E_t[q_{t+1}H_{t+1} + (1-q_{t+1})V_{t+1}] \tag{7}$$

Firms must pay a real cost of γ to post a vacancy. Vacancies are then filled at the start of the next period with probability q. We follow the timing convention of Gertler et al (2009) and assume that new job matches become productive immediately if the worker chooses not to shirk.

We assume free entry of firms, so $V_t = 0$. This implies that the value function for vacancies simplifies to

$$H_t = (1+r)\frac{\gamma}{q_t} \tag{8}$$

and so the value function for a filled job with a non-shirking worker becomes

$$(1+r)\frac{\gamma}{q_t} = y_t - w_t + (1-\tau_t)E_t \frac{\gamma}{q_{t+1}} \tag{9}$$

or

$$y_t = w_t + \lambda_t \tag{10}$$

where $\lambda_t = \gamma[(1+r)\frac{1}{q_t} - (1-\tau_t)E_t \frac{1}{q_{t+1}}]$ is the real cost of hiring a worker.

2.3 The Labour Market

The labour market is characterised by search frictions. Aggregate hiring is determined by the matching function

$$h_t = m u_t^{\alpha} v_t^{1-\alpha} \tag{11}$$

where h is the number of workers hired, u is the unemployment rate and v is the vacancy rate. m and α are parameters characterising the matching function. Defining labour market tightness as

$$\theta_t = \frac{v_t}{u_t} \tag{12}$$

the matching function can also be written as

$$h_t = m u_t \theta_t^{1-\alpha} \tag{13}$$

The vacancy filling rate, the probability of a firm filling a vacancy, is

$$q_t = \frac{h_t}{v_t} = m\theta_t^{-\alpha} \tag{14}$$

while the job finding rate, the probability that an unemployed worker finds a job, is

$$f_t = \frac{h_t}{u_t} = \theta_t q_t \tag{15}$$

2.4 Optimal Wage-Setting

In our baseline model, the firm chooses the wage. We will analyse wage bargaining in Section 4) below. The firm will choose the lowest wage compatible with no shirking, so $L_t = S_t$ and $H_t = J_t$. From (4) the wage is determined by

$$L_t - U_t = (1+r)\frac{e}{d} \tag{16}$$

Combining (1) and (3) to give

$$L_t - U_t = w_t - e - b - \chi + \frac{1}{1+r}(1-\tau_t - f_t)E_t(L_{t+1} - U_{t+1}) \tag{17}$$

and using (16), the wage is

$$w_t = b + \chi + e + \frac{e}{d}(r + \tau_t + f_t) \tag{18}$$

This generalises the wage equation derived by Shapiro and Stiglitz (1984) to account for search frictions.

3 Simulation Results

3.1 Calibration Strategy

In calibration, where possible, we follow earlier studies. Thus all parameters, except those specific to the shirking mechanism, are calibrated using values taken from the literature. The remaining parameters, d and e, are chosen so that our model matches the average values of the unemployment rate and labour market tightness in US data. We simulate our model using stochastic processes for productivity and job separation shocks that match those observed in the data. We then compare simulated volatilities for the unemployment rate, vacancies, labour market tightness and the rate at which unemployed workers find a job with the data based measures presented in Shimer (2005)[5].

[5]There are two approaches to simulation in the literature. In the first (used by, among others, Shimer, 2005 and Hall, 2005), productivity can take a number of discrete values, where

3.2 Calibrated Parameter Values

We normalize a time period to be one quarter. Our calibrated parameter values are outlined in Table 1). The discount rate is set as $r = 1\%$. The average job separation rate is $\tau = 0.1$, following Shimer (2005) and Hall (2005); this implies that on average 3.3% of employed workers exit employment every month[6]. The cost of posting a vacancy is set as $\gamma = 0.213$, following Shimer (2005)[7]. Real unemployment benefits are set as $b = 0.4$. This is the same value as Shimer (2005)[8]. The disutility of labour is assumed to be $\chi = 0.43$. This is the value of leisure estimated by Hall (2006). For the matching function, we follow Pissarides (2009) and assume $m = 2.1$[9] and follow Petrongolo and Pissarides (2001) by assuming $\alpha = 0.5$.

Table 1— Values of Calibrated Parameters

Parameter	Interpretation	Value
τ	Separation Rate	0.1
r	Risk-Free Interest Rate	0.01
y	Labour productivity	1
b	Unemployment Benefit	0.4
χ	Disutility of Working	0.43
γ	Vacancy Cost	0.213
m	Matching Coefficient	2.1
α	Matching Elasticity	0.5
d	Detection Rate	0.94
e	Disutility of Effort	0.06

For the processes driving productivity and job separations shocks, we assume $\rho^s = 0.733$ and $\rho^\tau = 0.875$ for the autoregressive component and $\sigma_s = 0.05$ and $\sigma_\tau = 0.01$ for the volatilities of the underlying shocks. These values generate shocks that match the autocorrelations and standard deviations of labour productivity and job separation in U.S data for 1951-2003 reported in

transition between productivity values is described by a Markov process. The model is solved for each simulated value of productivity. In the second (used by, among others, Rogerson and Shimer, 2010, Petrosky-Nadeau and Wasmer, 2013 and Gertler et al, 2015), the model is linearised around the steady-state and then simulated. In this paper, we follow the second approach.

[6] In the literature, monthly values of τ vary between 0.03 (Hall and Milgrom, 2008) and 0.036 (Pissarides, 2009).

[7] There is a wide range of alternative calibrated values for γ in the literature. Hagedorn and Manovskii (2008) use a weekly vacancy cost of 0.584. Hall (2005) assumes a monthly cost of 0.986 while Pissarides (2009) assumes 0.420. Our use of a relatively small vacancy posting cost gives firms a greater incentive to post vacancies; our finding of a low rate of vacancy setting, and therefore a high vacancy filling rate, is therefore noteworthy.

[8] In the literature, values of b vary between 0.4 (Shimer, 2005) and 0.955 (Hagedorn and Mankovskii 2008).

[9] Pissarides (2009) sets $m = 0.7$ in his monthly based calibration. The quarterly equivalent of this is $m = 2.1$.

Shimer (2005)[10].

There are no previous calibrations of parameters comparable to e and d in the literature. We solve the model comprising (10)-(15) and (18) in steady-state, together with the condition $fu = \tau(1-u)$, using the parameter values in Table 1). We select values of e and d to hit two calibration targets: an average unemployment rate of $u = 0.058$, the average US unemployment rate from 1955 to 2003; and an average value for labour market tightness of $\theta = 0.5$; this value was used by Hall and Milgrom (2008) based on JOLTS data[11]. This results in $d = 0.94$ and $e = 0.06$[12]. With these calibrated parameter values, we obtain steady-state values of $u = 0.064$ and $\theta = 0.491$, close to the targeted values. We also find a monthly average job finding rate of $f = 0.492$. This is close to the value of $f = 0.517$ reported by Hall and Milgrom (2008)[13]. Thus our model also provides a good fit to this non-targeted variable. Dividing the simulated job finding rate by the simulated value of θ, we obtain the implied average vacancy filling rate in the model as $q = 0.986$. As discussed above, the high rate of vacancy filling implies that variations in the number of vacancies posted leads to large variations in unemployment.

Table 2— Values of Endogenous Variables for Calibration

Parameter	Interpretation	U.S Data	This Paper
u	Unemployment Rate	0.058	0.064
θ	Labour Market Tightness	0.500	0.491
f	Job Finding Rate	0.517	0.492

Source: Unemployment Rate: BLS data, 1955Q1-2003Q4; Labour Market Tightness: JOLTS data, see Hall and Milgrom (2008); Job Finding Rate: JOLTS data, see Hall and Milgrom (2008)

Using our calibrated parameters values and the value of f in Table 2) we obtain $w = 0.99$ from the wage equation in (18). Thus the relatively small friction from shirking effects implied by our values of e and d implies a low

[10]The volatlities of y and s are 0.020 and 0.075 respectively, while their auotcorrelations are 0.878 and 0.733. These are the same as the corresponding values in Shimer (2005).

[11]Labour market tightness is hard to calibrate (Elsby et al, 2013). Shimer (2005) assumes that $\theta = 1$ in steady-state and uses this assumption to derive a measure of vacancy costs.

[12]Combining (10) and (18) in steady-state, the firm's optimality condition is

$$1 - (r+\tau)\frac{\gamma}{m}\theta^{\alpha} = b + \chi + e + \frac{e}{d}(r + \tau + m\theta^{1-\alpha})$$

Substituting the other parameter values from Table 1) and the target value of θ from Table 2), this can be written as

$$0.162 = e(1 + \frac{1.652}{d})$$

The solution to this requires a small value of e and a large value of d.

[13]Hall and Milgrom (2008) report that a daily job finding rate of 2.4%. The monthly equivalent of this is 0.517.

level of profit for firms. The implications of this will be explored in section 3.4) below.

3.3 Volatilities

Column (i) of Table 3) shows the observed volatilities of the unemployment rate, vacancies, labour market tightness and the job finding rate in US data reported in Shimer (2005); column (ii) shows the simulated volatilities from our model; columns (iii) and (iv) show, for comparison, the simulation results reported by Hagedorn and Manovskii (2008) and Shimer (2005). The volatility of unemployment in the data is 0.190; in our simulations it is 0.213. The volatilities of vacancies, labour market tightness and the job finding rate in the data are 0.202, 0.382 and 0.118 respectively; the corresponding simulated volatilities are 0.181, 0.373 and 0.186. It is thus clear that our model is able to match the observed volatilities in the data well[14], much better than the simulations of the standard search frictions model reported in Shimer (2005) and better than the results in Hagedorn and Manovskii (2008)[15]

Table 3— Volatilities of Key Labour Market Variables

	U.S Data	This Paper	H&M	DMP
u	0.190	0.213	0.145	0.031
v	0.202	0.181	0.169	0.011
θ	0.382	0.373	0.292	0.037
f	0.118	0.186	–	0.014

Note: column (i) is from Shimer (2005); column (iii) is taken from Hagedorn and Manovskii (2008) and column (iv) is taken from Shimer (2005)

The simulated job finding rate is more volatile than the data indicates. Therefore the model places too much emphasis on job creation, and too little emphasis on job destruction, in explaining business cycle movements in labour

[14]Similar results are obtained if we supress separations shocks. This is line with the literature, which finds that these shocks have little role in explaining cyclical movements in key labour market variables

[15]Comparison with the volatilities reported by Hagedorn and Manovskii (2008) is complicated by the fact that they use a less volatile (and less autocorrelated) measure of productivity than Shimer (2005). In particular, they follow Shimer (2005) in using a Hodrick-Prescott filter, but use a much smaller smoothing parameter; a feature that lowers the simulated labour market volatilities in their model. The ratio of their simulated unemployment volatility to the volatility of productivity they use is 11.2. This ratio is 9.5 in our simulations. This compares to empirical ratios of 9.5 and 9.6 reported by Shimer (2005) and Hagedorn and Manovskii (2008) respectively.

market variables[16]. Nonetheless, the over-prediction of this volatility on our model is much smaller than the under-prediction in the standard search frictions model.

3.4 Autocorrelations and Correlations

Table 4) presents the autocorrelations of key labour market variables. Column (i) shows the observed autocorrelations of the unemployment rate, vacancies, labour market tightness and the job finding rate in US data reported in Shimer (2005); column (ii) shows the simulated autocorrelations from our model; columns (iii)-(iv) show, for comparison, the simulation results reported by Shimer (2005) and Hagedorn and Manovskii (2008). Our model is better able to match the autocorrelation of vacancies observed in the data. Shimer (2005) reports an autocorrelation of 0.291 for vacancies and Hagedorn and Manovskii (2008) report 0.575. The autocorrelation of vacancies in our model is 0.877, closer than alternative models to the observed value. Our model is able to match the high persistence of vacancies in the data because the low rate of profit in our model makes vacancy creation highly sensitive to output and thus the persistence of vacancies matches the high rate of persistence of output.

Table 4— Autocorrelation of Key Labour Market Variables

	U.S Data	This Paper	H&M	DMP
u	0.936	0.814	0.830	0.933
v	0.940	0.877	0.575	0.291
θ	0.941	0.853	0.751	0.878
f	0.908	0.853	—	0.878

Note: column (i) is from Shimer (2005); column (iv) is taken from Hagedorn and Manovskii (2008) and column (v) is taken from Shimer (2005)

Table 5) presents the correlations between unemployment, vacancies, labour market tightness and the job finding rate obtained from simulations of our model and compares these to correlations in US data and to those reported by Shimer (2005) and Hagedorn and Manovskii (2008). Our model produces similar correlations to Hagedorn and Manovskii (2008) and delivers a relatively close match to the data. For example, Shimer (2005) reports a correlation between unemployment and vacancies of -0.427, compared to -0.894 in the data. In our model, this correlation is -0.794, similar to the value of -0.724 reported by Hagedorn and Manovskii (2008). This relatively high correlation reflects the high vacancy filling rate in our model, which implies that variations in vacancies lead to similar variations in unemployment.

[16]Exogenous job separations have little effect on labour market tightness. Therefore highly volatile labour market tightness requires large volatility in job creation. Given the relatively low levels of vacancies in the model, this create the excess volatility in the job finding rate documented in Table 3).

Table 5— Correlations of Key Labour Market Variables

		u	v	θ	f
U.S Data	u	1	-0.894	-0.971	-0.949
This Paper	u	1	-0.794	-0.956	-0.956
Shimer (2005)	u	1	-0.427	-0.964	-0.964
H&M (2008)	u	1	-0.724	-0.916	–
US Data	v	–	1	0.975	0.897
This Paper	v	–	1	0.938	0.938
Shimer (2005)	v	–	1	0.650	0.650
H&M (2008)	v	–	1	0.940	–
U.S Data	θ	–	–	1	0.948
This Paper	θ	–	–	1	1
Shimer (2005)	θ	–	–	1	1
H&M (2008)	θ	–	–	1	–

4 Wage Bargaining

The baseline model analysed above follows the literature on the shirking model by assuming wage posting. As a result, our model differs from the standard search frictions model by including shirking effects and wage posting. In this section, we assess whether wage posting is essential to our results by analysing the effects of wage bargaining. We conclude that wage posting is not essential. Two main types of wage bargaining are popular in the search frictions literature. Early contributions generally assume Nash Bargaining. In an influential contribution, Hall and Milgrom (2008) change the wage bargaining protocol from Nash bargaining to an alternating offer credible bargaining set-up. We consider each in turn.

4.1 Nash Wage Bargaining With Shirking

This case has been analysed by Costain and Jansen (2010), who argue that a shirking model with Nash wage bargaining cannot generate a large volatility of unemployment. To see why in the context of our model, we assume that the wage is chosen to maximise

$$(L_t - U_t)^{\phi} J^{1-\phi} \tag{19}$$

where ϕ is the worker's relative bargaining power, subject to the no shirking constraint. This implies that wages are determined by the condition

$$L_t - U_t = \max\{\phi S_t, \frac{(1+r)e}{d}\} \tag{20}$$

where $S_t = J_t + L_t - U_t$ is the surplus from a job match. In our calibrations, $\frac{(1+r)e}{d}$ is equivalent to 6.4% of output while the average surplus from a job match is 55.1% of output. Therefore, wages will be determined by Nash bargaining, unless the bargaining power of workers is very small. Assuming that the no-shirking constraint does not bind, the Nash bargaining solution for the wage in our model is (e.g. Mortensen and Nagypal, 2007)

$$w_t = \phi(y_t + \gamma\theta_t) + (1-\phi)(b + \chi + e) \tag{21}$$

The wage in (21) is substantially more volatile than (18), due to the high volatility of labour market tightness. The volatility of the wage implies that a shirking model with Nash wage bargaining cannot generate a large volatility of unemployment.

4.2 Credible Wage Bargaining With Shirking

In this section, we argue that a shirking model with credible wage bargaining can generate a large volatility of unemployment. We use the simplified form of the credible wage bargain of Hall and Milgron (2008) proposed by Boitier and Lepetit (2018). Each time interval is divided into a sequence of sub-periods. In the first sub-period, firms make a wage offer to the worker. If the offer is accepted, the game ends. If the offer is rejected, the game goes on to the next sub-period when the worker makes a counter-offer to the firm. During this time interval, the firm incurs a flow cost of γ while the worker receives flow benefits b. Negotiations can breakdown with probability δ. In this case, the worker gets U and the firm gets the value of an open vacancy: nothing. Otherwise, the game continues to the next sub-period.

The surplus from a job match is divided between the worker and the firm using the sharing rule (Hall and Milgron, 2008, Boitier and Lepetit, 2018)

$$L_t = J_t + \frac{b+\gamma}{r+\delta} + \frac{\delta}{r+\delta}U_t \tag{22}$$

Substituting the value functions outlined above into this gives

$$2w_t = y_t + b + \chi + e + \frac{(r+\tau)(b+\gamma)}{(1+r)(r+\delta)} + \frac{\delta}{(r+\delta)}U_t - \frac{(r\tau+\delta)}{(1+r)(r+\delta)}E_t U_{t+1} \tag{23}$$

We follow Boitier and Lepetit (2018) and assume $\delta = \tau$, so the probability of wage negotiations breaking down is the same as the probability that a job match dissolves. This simplifies the wage equation to

$$2w_t = y_t + b + \chi + e + \frac{b+\gamma}{1+r} - \frac{\tau}{(r+\tau)}E_t \Delta U_{t+1} \tag{24}$$

This extends the analysis of credible bargaining to a model with shirking effects.

In order to assess whether a shirking model with credible wage bargaining can generate a large volatility of unemployment, we simulate our model in this case[17]. Our results are shown in column (ii) of Table 6). The volatility of

[17] We retain our values for e and d for comparability with the results reported in Table 3). In order to hit our calibration targets for u and θ, we use $b = 0.24$ and $\chi = 0.23$.

unemployment is 0.121, the volatility of vacancies is 0.151 and the volatility of labour market tightness is 0.269. These values are somewhat lower than those for the model with wage posting; they are similar to corresponding results in Hagedorn and Manoskvii (2008) and in line with Hall and Milgrom (2008). Table 6) also shows the key autocorrelations and correlations from our simulated model with credible bargaining; they are similar to those from our baseline model with wage posting; in particular, the autocorrelation of vacancies and the correlation between unemployment and vacancies are again a much closer match to the data than with the standard DMP model. To illustrate our results, the left hand panel of Figure 1) compares the impulse response functions for unemployment, vacancies and labour market tightness in this model with those from the baseline model. The impulse responses are quite similar. These results show that extending our model to incorporate credible bargaining does not affect our finding that a search frictions model with shirking effects is able to generate a large volatility of unemployment.

5 Explaining the Volatility Results

5.1 Solutions to the volatility puzzle

Since unemployment, vacancies and the job-finding rate can be expressed as functions of labour market tightness (eg Shimer, 2005), the volatility of labour market tightness relative to the volatility of productivity shocks is at the core of the unemployment volatility puzzle. In steady-state, this relative volatility equals the elasticity of labour market tightness with respect to output (Mortensen and Nagypal, 2007). This elasticity has therefore become central to the debate on the volatility puzzle.

In this debate, emphasis is placed on the elasticity of wages with respect to output (stressed by Shimer, 2005, in his explanation of why the canonical search frictions model failed to match the data, also see Hall, 2005, and Hall and Milgrom, 2008) and on the rate of profit (eg Mortensen and Nagypal, 2007, and Hagedorn and Manovskii, 2008). To analyse the role of these factors, we can express the firm's optimality condition in steady-state as

$$y = w + \lambda \tag{25}$$

where $\lambda = \frac{\gamma(r+\tau)}{q}$. This implies

$$\varepsilon_{y,\theta} = (1-\pi)\varepsilon_{w,\theta} + \pi\varepsilon_{\lambda,\theta} \tag{26}$$

where $\varepsilon_{y,\theta}$ $\varepsilon_{w,\theta}$ and $\varepsilon_{\lambda,\theta}$ are respectively the elasticities of output, wages and hiring costs with respect to labour market tightness and $\pi = \frac{y-w}{y}$ is the rate of profit. Using (14) and the definition of λ, $\varepsilon_{\lambda,\theta} = \alpha$. Since $\varepsilon_{w,\theta} = \varepsilon_{w,y}\varepsilon_{y,\theta}$, (26) can be written as

$$\varepsilon_{y,\theta} = (1-\pi)\varepsilon_{w,y}\varepsilon_{y,\theta} + \alpha\pi \tag{27}$$

and so

$$\varepsilon_{\theta,y} = \frac{1-(1-\pi)\varepsilon_{w,y}}{\alpha\pi} \tag{28}$$

Equation (28) shows how the factors highlighted in the existing literature, the elasticity of wages with respect to output and the rate of profit, interact to determine the elasticity of labour market tightness with respect to output. We note that this elasticity is larger when wages are less responsive to output and when the rate of profit is smaller[18]. We also note that the wage elasticity has a larger impact if the rate of profit is small; this supports Hagedorn and Manovskii's assertion that the wage elasticity only matters relative to the rate of profit.

5.2 Volatility in the shirking model

Using (18), $\frac{\partial w}{\partial \theta} = \frac{e}{d}\frac{\partial f}{\partial \theta}$ or, since $f = \theta q$, $\frac{\partial w}{\partial \theta} = \frac{e}{d} q(1 + \frac{\theta}{q}\frac{\partial q}{\partial \theta})$. Using (14), this implies

$$\varepsilon_{w,\theta} = (1-\alpha)\frac{e}{d}\frac{f}{(1-\pi)} \tag{29}$$

Using the shirking model with wage posting, we can combine this with (26), we obtain

$$\varepsilon_{\theta,y} = \frac{1}{(1-\alpha)\frac{e}{d}f + \alpha\pi} \tag{30}$$

Using our parameter values and the average values of f from Table 2), the elasticity of labour market tightness with respect to the productivity shock is 17.89. This is close to the ratio of the volatility of labour market tightness to the volatility of productivity shocks in Table 2).

In our model, productivity shocks are transmitted to labour market tightness through their impact on wages and on profits (the first term in the denominator of (30) contains the impact of productivity on wages, while the second term in the denominator contains the impact of productivity on profits). Equation (30) shows that our model is able to generate a large volatility of labour market tightness because of a small value of $\frac{e}{d}$ and a small rate of profit. This latter point is consistent with arguments in Hagedorn and Manovskii (2008) that a large volatility of labour market tightness requires a low rate of profit. Low profits induce firms to put relatively few resources into recruiting, leading to a low level of labour market tightness and a high vacancy filling rate. This in turn implies that variations in vacancies in response to productivity shocks are transmitted strongly into variations in unemployment

Using

$$\varepsilon_{w,y} = (1-\alpha)m\frac{e}{d}\frac{\theta}{1-\pi}\varepsilon_{\theta,y} \tag{31}$$

with our calibrated parameters values, we obtain $\varepsilon_{w,y} = 0.9$. This is close to empirical values reported by Pissarides (2009). Thus a weak response of wages

[18]We note that $\frac{\partial \varepsilon_{\theta,y}}{\partial \varepsilon_{w,y}} = -\frac{1-\pi}{\alpha\pi} < 0$ and $\frac{\partial \varepsilon_{\theta,y}}{\partial \pi} = -\frac{1-\varepsilon_{w,y}}{\alpha\pi} < 0$, (if $\varepsilon_{w,y} < 1$).

to output is not central to the ability of our model to generate large volatilities of unemployment and output.

5.3 Volatility in the standard model

The comparison with the standard search frictions model is useful here. The wage implied by Nash bargainining in that model is (e.g. Mortensen and Nagypal, 2007) $w_t = \phi(y_t + \gamma\theta_t) + (1-\phi)(b+\chi)$. This implies

$$\frac{\partial w}{\partial \theta} = \phi \frac{\partial y}{\partial \theta} + \phi\gamma \tag{32}$$

we obtain

$$\varepsilon_{w,\theta} = \frac{\phi}{1-\pi}(\varepsilon_{y,\theta} + \gamma\theta) \tag{33}$$

Combining this with (28), we obtain

$$\varepsilon_{\theta,y} = \frac{1}{\frac{\phi}{(1-\phi)}\gamma\theta + \frac{\alpha}{(1-\phi)}\pi} \tag{34}$$

Using the wage equation, this is

$$\varepsilon_{\theta,y} = \frac{1}{\frac{\phi}{(1-\phi)}(1-\alpha)\gamma\theta + \alpha(1-b-\chi)} \tag{35}$$

Using the calibrated parameters in Table 1) and following Shimer (2005) in assuming $\phi = 0.72$, the elasticity of labour market tightness with respect to the productivity shock is 4.48; if we follow most of the existing literature and assume $\phi = 0.5$, the elasticity is 1.74. Both values are considerably smaller than the volatility observed in the data. As noted by Hagedorn and Makovskii (2008), the standard search frictions model can only match empirical volatilities by making the assumptions that workers have very little bargaining power and that the value of leisure is large. The impact of these assumptions is clear from (35). Low bargaining power of workers makes the first term in the denominator small while high value of leisure reduces the size of the second term[19].

5.4 Volatility in the credible bargaining model

As discussed above, one prominent response to the volatility puzzle is credible wage bargaining (eg Hall and Milgrom, 2008). The strategic wage bargain switches the bargainers' threat point from terminating the bargain to extending the bargain. This switch implies that the cost of delay in wage negotiations replaces the worker's outside option as a driving force in wage formation. Assuming a large fixed cost of delay reduces the wage elasticity and so delivers a large

[19] Amaral et al (2016) raise concerns about the parameterisation of Hagedorn and Makovskii (2008), arguing that their results rely on a small elasticity of wages, contrary to evidence including Pissarides (2009).

elasticity of labour market tightness with respect to output. The model might be criticised both for the assumption that the cost of delay is large (Ljungqvist and Sargent, 2017) and for the assumption that this cost is acyclical (if the cost of delay to the firm is pro-cyclical, reflecting lost output, then the threat point becomes pro-cyclical and so the resulting wage becomes more sensitive to output).

5.5 The fundamental surplus

Ljungqvist and Sargent (2017) argue that all proposed solutions to the unemployment volatility puzzle require a small value for the "fundamental surplus", the "upper bound on the fraction of a job's output that the invisible hand can allocate to vacancy creation"; this is equivalent to the lowest value of the wage that is consistent with the no-shirking constraint. Ljungqvist and Sargent (2017) express the elasticity of labour market tightness with respect to the productivity shock as

$$\frac{\partial\theta}{\partial y}\frac{y}{\theta} = \Gamma\frac{y}{y-\xi} \tag{36}$$

where ξ is the fundamental surplus and $\frac{y-\xi}{y}$ is the fundamental surplus share. In our model, the no-shirking constraint gives the lowest wage that is consistent with positive output, so $\xi = w$ and so the fundamental surplus share is simply the rate of profit. We can show that $\Gamma = \frac{(r+\tau)\gamma\theta}{\alpha(r+\tau)\gamma+(1-\alpha)\frac{e}{d}fq}$. As with (30), the low rate of profit in our model generates a large volatility of labour market tightness. In the standard search frictions model, the fundamental surplus is $\xi = b + \chi$, as this is the lowest value of the wage that is consistent with non-zero output. In this case, $\Gamma = \frac{(r+\tau)+\phi f}{\alpha(r+\tau)+\phi f}$. The inability of the standard search frictions model to address the volatility puzzle is reflected in the relatively small values of Γ and ξ obtained by Ljungqvist and Sargent (2017) using standard calibrations. The value of $\frac{y}{y-\xi}$ is only large enough to generate substantial volatility in θ when the value of $b+\chi$ is assumed to be large, following Hagedorn and Makovskii (2008). In the case of the strategic bargaining model of Hall and Milgrom (2008) (see also Christiano et al, 2016), the fundamental surplus is $\xi = b + \chi + \frac{(1-\tau)}{1+r}\gamma$, where γ is the fixed cost of delay incurred by the firm; in this case, $\Gamma = \frac{1}{\alpha}$. Ljungqvist and Sargent (2017) argue that a large cost of delay is required to generate a large volatility of labour market tightness.

6 Policy Implications

In this section, we extend our model to incorporate the effects of policy. We argue that our main results continue to hold in these extensions of our model. We also argue that our model has novel and interesting policy implications. Following chapter 9 of Pissarides (2000), we consider income taxes and subsidies on hiring and taxes on firing workers. We also consider the issue of transparency over worker effort. We follow the literature in focusing on the impact of policy on wages, as this is critical for the analysis of the impact of policy on labour market dynamics.

6.1 Income Taxes

Following Pissarides (2000), consider the income tax function,

$$T(w_t) = \zeta w_t - (1-\zeta)\varphi \tag{37}$$

where ζ is the rate of income tax and φ is a tax subsidy. Introducing income taxes alters the value function for a worker, which becomes

$$L_t = w_t - T(w_t) - \chi - e + \frac{1}{1+r}E_t[(1-\tau_t)M_{t+1} + \tau_t U_{t+1}] \tag{38}$$

The optimal wage chosen by the firm becomes

$$w_t = \frac{1}{1-\zeta}[b + \chi + e + \frac{e}{d}(r + \tau_t + f_t) - \varphi] \tag{39}$$

Comparing this with the wage equation in (18), we note that the income tax increases the elasticity of wages with respect to productivity as the multiplier $\frac{1}{1-\zeta}$ amplifies the impact of the job finding rate on wages. This is a novel finding as the existing literature, based on Nash bargaining, has argued that the marginal tax rate has no direct impact on wage cyclicality[20]. This is an important finding since unemployment variability is a concern for policymakers. Our analysis suggests that an income tax has potential to alleviate unemployment volatility as it increases wage cyclicality[21]. To simulate this extension of our model, we assume a tax rate of 20%. We adjust the calibration of e to ensure that our calibration targets are met. Our results are shown in column (iii) of Table 6). The volatilities, autocorrelations and correlations of unemployment, vacancies and labour market tightness are similar to the baseline model.

6.2 A Hiring Subsidy

To analyse a hiring subsidy, we assume firms receive a subsidy Ψ when a worker is hired. Then the value of a vacancy to the firm in the case where workers never shirk becomes

$$V_t = -\gamma + \frac{1}{1+r}E_t q_{t+1}(J_{t+1} + \Psi) \tag{40}$$

This implies

$$J_t = \frac{(1+r)\gamma}{q_t} - \Psi \tag{41}$$

[20]See for example, equations (9.14) and (9.15) in Pissarides (2000).

[21]this analysis also implies that an income tax does not necessarily increase the pre-tax wage. Whether or not the wage paid by the firm rises depends on the balance between the marginal tax rate (ζ) and the tax subsidy (φ). This finding is in line with Pissarides (2000).

Combining this with (5) gives

$$y_t = w_t + \lambda_t - \frac{r+\tau}{1+r}\Psi \tag{42}$$

The wage is given by (18), so

$$y_t = b + \chi + e + \frac{e}{d}(r + \tau_t + f_t) + \lambda_t - \frac{r+\tau}{1+r}\Psi \tag{43}$$

We can draw three implications about an increased hiring subsidy. First, there is only a small impact on the wage, as the subsidy only affects the wage through the job finding rate. Second, (43) shows that an increased subsidy leads to an increase in λ and hence a reduction in unemployment. Third, the increase in λ leads to a reduction in the volatility of unemployment.This is consistent with the argument of Hagedorn and Manovskii (2008): the subsidy increases λ and so increases the amount firms spend on recruitment; this implies that a productivity shock leads to a smaller percentage change in the resources dedicated to vacancy creation and so the volatility of unemployment is lower.

To simulate this extension of our model, we assume a hiring subsidy equivalent to 5% of output. We again adjust the calibration of e to ensure that our calibration targets are met. As column (iv) of Table 6) shows, the volatilities, autocorrelations and correlationsof unemployment, vacancies and labour market tightness are similar to the baseline model.

6.3 A Payroll Tax

To analyse the effects of a payroll tax, we assume that firms must pay a payroll tax of $\tau^w w_t$. The value of a filled job to the firm becomes

$$J_t = y_t - w_t(1+\tau^w) + (\frac{1-\tau}{1+r})E_t J_{t+1} \tag{44}$$

Combining this with (8) in the case where workers never shirk gives

$$y_t = w_t(1+\tau^w) + \lambda_t \tag{45}$$

The wage is again given by (18), so

$$y_t = (1+\tau^w)\{b + \chi + e + \frac{e}{d}(r + \tau_t + f_t)\} + \lambda_t \tag{46}$$

This analysis shows that a payroll tax has the opposite effect to a hiring subsidy. The impact on the wage is again small. From (46), the tax leads to a reduction in λ and hence an increase in unemployment. This implies an increase in the volatility of unemployment, through the arguments of Hagedorn and Manovskii (2008).

To simulate this version of our model, we assume a payroll tax of 5%. Our results are in column (v) of Table 6); the volatilities, autocorrelations and correlations of unemployment, vacancies and labour market tightness are again similar to the baseline model.

Table 6) Key Statistics From Alternative Models

	(i) Baseline	(ii) Credible Bargaining	(iii) Income Tax	(iv) Hiring Subsidies	(v) Payroll Tax
σ_u	0.213	0.121	0.194	0.209	0.251
σ_v	0.181	0.151	0.149	0.175	0.234
σ_θ	0.373	0.269	0.321	0.363	0.471
ρ_u	0.814	0.938	0.799	0.811	0.835
ρ_v	0.877	0.817	0.876	0.877	0.879
ρ_θ	0.853	0.878	0.842	0.851	0.864
$\rho_{u,v}$	-0.794	-0.953	-0.748	-0.786	-0.856
$\rho_{u,\theta}$	-0.956	-0.985	-0.952	-0.955	-0.965
$\rho_{v,\theta}$	0.934	0.991	0.912	0.934	0.961

To illustrate our results from these extensions of our baseline model, the right hand panel of Figure 1) shows the impulse response functions for unemployment, vacancies and labour market tightness in the models for the three cases considered in this section. The impulse responses are quite similar to each other and with the impulse responses for the baseline model, shown in the left hand panel. In summary, this analysis has shown that our model has distinctive policy implications. Income taxes affect the volatility of wages, and hence the volatility of unemployment, contrary to the prediction of the Search Frictions model. An increased hiring subsidy or a payroll tax cut leads to reduced and less volatile unemployment. These latter effects are smaller than in the Search Frictions model. In that model, an increased hiring subsidy or a reduction in payroll taxes would lead to larger changes in the bargained wage than in our model, if the worker has a relatively large bargaining power. We would therefore expect a stronger decline in unemployment and its volatility. The predictions from our model seem more credible, since it can match the volatility of unemployment, unlike the Search Frictions model.

6.4 The Detection Rate and Transparency

One novelty of our model is that it highlights the impact of transparency around worker effort on labour market dynamics. If worker effort could be observed perfectly and without cost, then wages and unemployment would become less volatile. This implies that changes in the transparency of worker effort that arise from changes in technology and working practices will have consequences for the volatility of wages and unemployment across the business cycle. These issues therefore have important policy implications.

7 Conclusions

This paper has developed a modified version of the standard search frictions model developed by Diamond (1982), Mortensen and Pissarides (1994) and Pissarides (2000) that introduces a shirking mechanism. Simulations of the

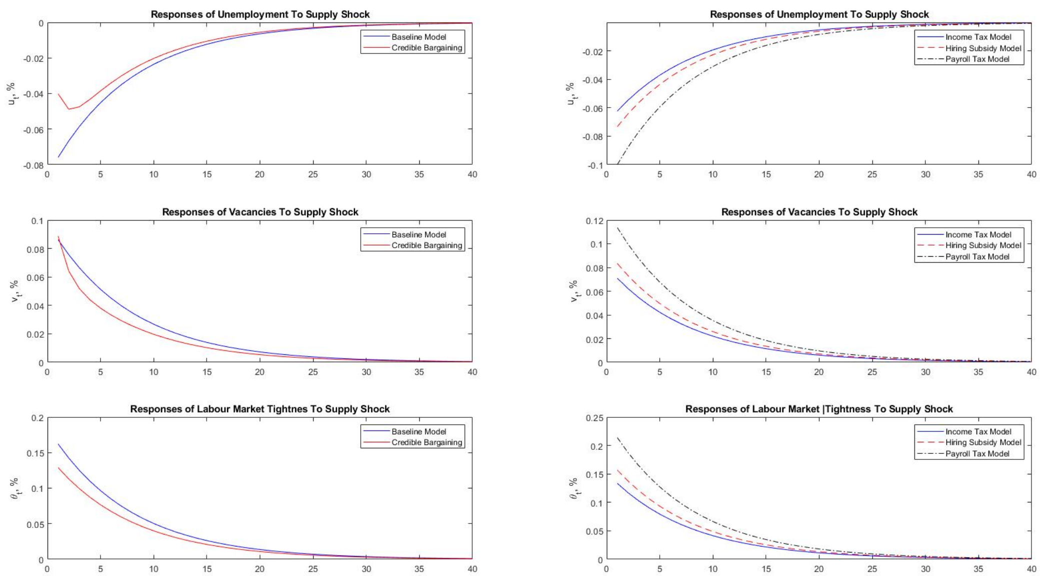

Figure 1: Simulated Impulse Response Functions for Various Models

Notes: The Left Hand panel of this figure plots the impulse response function of unemployment, vacancies and labour market tightness for the baseline model (blue) and the model with credible bargaining (red). The right hand panel depicts the the impulse response function of unemployment, vacancies and labour market tightness for the extension of the model to include income taxes (blue), hiring subsidies (red) and payroll taxes (black) model show a close match to the observed volatilities, correlations and autocorrelations of unemployment, vacancies, labour market tightness and the job finding rate in US data. The model is better able to match key features of the data than prominent alternative models that have been proposed in response to the unemployment volatility puzzle. The key mechanism underlying these results is that even a small shirking effect leads to a small rate of proft. This leads to a low rate of vacancy creation which, since vacancies are low relative to the number of unemployed workers, implies a high vacancy filling rate. This in turn implies that hiring is highly sensitive to the number of vacancies; as a consequence, variations in job vacancies in response to shocks lead to large variations in unemployment. Since a low rate of profit also implies that vacancies are highly sensitive to ouput, unemployment is highly sensitive to productivity shocks.

Our analysis suggests two broad conclusions about the modeling of the labour market. First, the debate on unemployment volatility has largely been conducted in the context of a highly stylised and unrealistic model of the labour market: the standard search frictions model. The search for mechanisms that can generate unemployment volatility has largely been conducted within the context of this model. The results in this paper suggest that the causes of high unemployment volatility may lie outside this restricted environment.

Second, our analysis illustrates the benefits of incorporating insights from the Behavioural Economics literature into Search Frictions models. This reslts in models that are richer and provide better descriptions of actual labour market behaviour but which also retain the rigorous analysis of the processes driving the labour market that characterise the Search Frictions approach. For example, we might investigate whether the ability to generate a large volatility of key labour market variables is a generic property of behavioural models of worker effort. This paper has argued that incorporating a shirking effect into a Search Frictions model can generate a large volatility of unemployment and other labour market variables. One might similarly extend models in which in which effort is a continuous function of the wage rather than binary (Solow, 1979) and examine whether these can also generate high levels of labour market volatility.

References

[1] Amaral, P. and M. Tasci, (2016), "The Cyclical Behavior of Equilibrium Unemployment and Vacancies Across OECD Countries, European Economic Review, 84,184–201

[2] Burda, M., K. Genadek and D. Hamermesh, (2015), "Not Working at Work: Loafing, Unemployment and Labor Productivity, NBER Working Paper 21923

[3] Cappelli, P. and K. Chauvin, (1991), "An Interplant Test of the Efficiency Wage Hypothesis", Quarterly Journal of Economics 106, no. 3, 769-87

[4] Christiano, L., Eichenbaum, M. and Trabandt, M. (2016): "Unemployment and Business Cycles", Econometrica, 84(4), pp. 1523-1569

[5] Costain, J. and M. Jansen, (2009), "Employment Fluctuations With Downward Wage Rigidity: the Role of Moral Hazard", IZA Discussion Papers, No. 4344

[6] Danthine, J.P., and J. Donaldson, (1990), "Efficiency Wages and the Real Business Cycle", European Economic Review , 34,1275–1301.

[7] Danthine, J.-P. and A. Kurmann. 2010. "The business cycle implications of reciprocity in labor relations," Journal of Monetary Economics, vol. 57(7), 837-850

[8] Diamond, P. (1971), "A Model of Price Adjustment," Journal of Economic Theory 3, 156-168

[9] Diamond, P. (1982): "Aggregate Demand Management in Search Equilibrium", Journal of Political Economy, Vol. 90(5), 881-94.

[10] Elsby,M., B. Hobijn and A. Sahin, (2013) "Unemployment Dynamics in the OECD", Review of Economics and Statistics, 95(2), 530–548

[11] Galí, J. and T. van Rens, T., (2014), "The Vanishing Procyclicality of Labor Productivity", working paper 1230, Universitat Pompeu Fabra

[12] Gertler, M. and A. Trigari (2009): "Unemployment Fluctuations With Staggered Nash Wage Bargaining", Journal of Political Economy, 117(1), 38–86.

[13] Gertler, M., C. Huckfeldt, and A. Trigari, (2015), "Unemployment Fluctuations, Match Quality, and the Wage Cyclicality of New Hires", NBER Working Paper No. 22341

[14] Groshen, E. and A. Krueger, (1990), "The Structure of Supervision and Pay in Hospitals", Industrial and Labor Relations Review 43, no. 3, 134–46.

[15] Hagedorn, M. and Y. Manovskii (2008): "The Cyclical Behavior of Unemployment and Vacancies Revisited". American Economic Review, 98(4),1692–1706.

[16] Hall, R. 2005. "Employment Fluctuations with Equilibrium Wage Stickness", American Economic Review, Vol.98, No.4.

[17] Hall, R., and Milgrom, P. (2008), "The Limited Influence of Unemployment on the Wage Bargain", American Economic Review, Vol.95, No.1.

[18] Lemieux, T. and B. MacLeod, (2009), "Performance Pay and Wage Inequality, Quarterly Journal of Economics 124, 1-49.

[19] Ljungqvist, L., and T. Sargent, (2017), "The Fundamental Surplus", American Economic Review, 9, 2630-65

[20] Malcomson, J. and S., (2010), "Nash Bargaining, Credible Bargaining and EfficiencyWages in a Matching Model for the US", working paper 511, Department of Economics, University of Oxford

[21] Mortensen, D. and E. Nagypal, (2007), "More on Unemployment and Vacancy Fluctuations," Review of Economic Dynamics, vol. 10(3), pages 327-347, July.

[22] Mortensen, D. and Pissarides, C. (1994): "Job Creation and Job Destruction in the Theory of Unemployment", The Review of Economic Studies, Vol. 61

[23] Petrongolo, B. and C. Pissarides, (2001), "Looking into the Black Box: a Survey of the Matching Function", Journal of Economic Literature 39 (2), 390–431.

[24] Petrosky-Nadeau, N. and E. Wasmer, (2013), "The Cyclical Volatility of Labor Markets Under Frictional Financial Markets, American Economic Journal: Macroeconomics, 5 (1), 193–221.

[25] Pissarides, C. (2000): "Equilibrium Unemployment Theory", MIT Press.

[26] Pissarides, C. (2009): "The Unemployment Volatility Puzzle: is Wage Stickiness the Answer?" Econometrica, 77(5),1339–1369.

[27] Pfeifer, C., (2010), "Impact of Wages and Job Levels on Worker Absenteeism", International Journal of Manpower, 31, no. 1, 59–72.

[28] Poeschel, F., (2010), "Directed Search, Efficiency Wages and the Diamond Paradox", University of Rome "Tor Vergata"

[29] Rebitzer, J., (1995), "Is There a Trade-Off between Supervision and Wages? An Empirical Test of Efficiency Wage Theory", Journal of Economic Behavior and Organization 28, no. 1, 107–129.

[30] Reich, M., P. Hall, and K. Jacobs, (2003), "Living Wages and Economic Performance: The San Francisco Airport Model", Institute of Industrial Relations, University of California, Berkeley.

[31] Rogerson, R. and R. Shimer: (2010), "Search in Macroeconomic Models of the Labor Market," in Orley Ashenfelter and David Card, eds., Handbook of Labor Economics, Volume 4A, Elsevier, 2010, pp. 619-700.

[32] Shapiro, C and J.E. Stiglitz (1984): "Equilibrium Unemployment as a Worker Discipline Device", American Economic Review, 74(3), 433-44.

[33] Shimer, R, (2005): "The Cyclical Behavior of Equilibrium Unemployment and Vacancies", American Economic Review, Vol. 95(1), 25-49.

[34] Solow, R. (1979): "Another possible source of wage stickiness", Journal of Macroeconomics 1, 79–82.

[35] Uhlig, H. and Y. Xu, (1996), "Effort and the Cycle", CentER Discussion Paper; Tilburg University

[36] Wolfers, J. and J. Zilinsky, (2015), "Higher Wages for Low-Income Workers Lead to Higher Productivity", Peterson Institute for International Economics

[37] Zhang, W., H. Sun, S. Woodcock, and A. Anis, (2013), "Valuing Productivity Loss Due to Absenteeism: Firm-level Evidence from a Canadian Linked Employer-Employee Data", Paper presented at the 12th annual meeting of the Canadian Health Economists' Study Group, Manitoba, Canada.