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Discount Factor Shocks and Labor Market Dynamics

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Abstract

In this paper we investigate the labor market dynamics in a matching model where fluctuations are driven by movements in the discount factor. A comparison with the standard productivity shock is provided. Movements in the discount factor can be used as a proxy for variations in financial risks, especially the expected payoff from hiring workers. It is shown that the canonical matching model under a very standard calibration is able to generate an important volatility of unemployment and vacancies with respect to output. We estimate the structural model with the two shocks and using the Bayesian methodology. The bulk of variations in unemployment and vacancies is mainly explained by disturbances pertaining to the discount factor. Productivity shocks account for most of the historical output variations but the discount factor plays a more important role over the last two decades.

Keywords: Search and matching, discount factor shock, Bayesian estimation, unemployment volatility puzzle.

JEL Classification: E3, J6

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1 Introduction

The ability of the search and matching model (Mortensen-Pissarides, 1994) to reproduce the cyclical behavior of key labor market variables has received an important attention. Shimer (2005) and Hall (2005) argued that the model, in its standard form, is clearly unable to generate substantial fluctuations in unemployment, vacancies and the labor market tightness as compared to the data. The reason is that wages absorb most of the variations coming from productivity shocks.

This puzzle has led to an important literature trying to modify the matching model using wage rigidities (Shimer (2005), Hall (2005), Gertler et al. (2008), Hall & Milgrom (2008)), small surplus calibration (Hagedorn & Manovskii (2008)), workers and jobs heterogeneity (Krause & Lubik (2006), Chassamboulli (2013)), alternative forms of hiring costs (Yashiv (2006), Fujita & Ramey (2007), Rotemberg (2008), Pissarides (2009)) counter-cyclical payroll taxes (Burda & Weder (2010), etc. The list is far from being exhaustive. All the aforementioned specifications have attempted, directly or indirectly, to prevent wages from adjusting rapidly. A notable exception is a study by Di Pace & Faccini (2012) that introduced deep habits in the matching model. They show that this produces endogenous countercyclical mark-ups and generates amplification in the response of labour market variables to technology shocks. Most of these studies[1] assumed that labor market fluctuations are solely driven by a productivity shock. However, many economists and institutions have cast some doubts on the movements of productivity as a main driver for business cycle fluctuations, especially over the last three recessions in the US. In this paper we study the labor market dynamics but we consider an alternative source of business cycle fluctuations: variations in the discount factor[2]. We argue that disturbances of the discount factor provide an important source of propagation. The relative volatility of unemployment and vacancies is well reproduced.

The discount rate expresses the difference between the remuneration of the risk free bonds and risky bonds also know as the risk premium. In a paper closely related to ours, Hall (2014) wonders what force depresses the payoff to job creation in recession. He noticed that a rise in the discount rate has similar effects to an increase in financial risks. It makes employers less prone to invest in any type of investments, including job creation. A rise in the risk premium reduces the expected payoff from hiring a new worker because the real interest

[1] With few exceptions like Rotemberg (2008) who uses changes in market power as a source of business fluctuations but it still make real wages less procyclical. Faccini & Ortigueira (2010) assume that investment-specific technology fuel up the cycles and found that is helps to solve the unemployment volatility puzzle.

[2] For Cochrane (2011) the real interest rate, discount factor and risk premium are all the same.

rate is simply the rate at which firms discount their future profit streams. The fall in the expected value of a filled job lowers firms' jobs openings which, in turn, increases aggregate unemployment. An adverse shock on the discount factor can then be viewed as a proxy for the financial market turmoil since it impacts the interest rate in a way that mimic the Great Recession.

Most of the studies on the dynamics of the DMP model assumed that TFP shocks track labor market fluctuations. Figure 1 and 2 show the cyclical component of the labor market tightness against that of discount factor[3] rate and that of productivity. While the movements in productivity seems to provide a rational explanation for the labor market dynamics until 1982, the path of productivity and tightness do not really support this view over the last three decades. On the other side, the labor market tightness seems to be highly correlated with the discount rate, particularly over the last two decades. Therefore, the role of disturbances pertaining to the discount factor must be questioned. We do not explain what exacerbates the uncertainty on financial markets. There is an abundant literature on this topic. We simply assume that a shock on the discount rate is a simple proxy for frictions in financial markets. We try to understand how the risk translates in the labor market and how firms react to changes in future flow of profits. Our analysis goes one step further than Hall (2014) since we focus on the volatility puzzle rather than the interactions between labor and financial market and we investigate the respective role of the two shocks for unemployment, vacancies and output dynamics in an estimated model.

It is shown that the discount factor shock can explain a large part of the observed labor market fluctuations but has difficulties to account for the observed output volatility. The productivity shock reaches the opposite conclusions. An estimation of the structural model shows that variations in the discount factor and in productivity are both needed to match empirical moments. However, the bulk of variations in unemployment and vacancies is mainly explained by disturbances pertaining to the discount factor. The productivity shock accounts for most of the output variations but the discount factor has gained an increasingly role over the last two decades. We argue that the introduction of the discount factor shock to proxy financial risk in a very simple way is key to improve the fit of the canonical search and matching model.

[3]See appendix A for data description and methodology

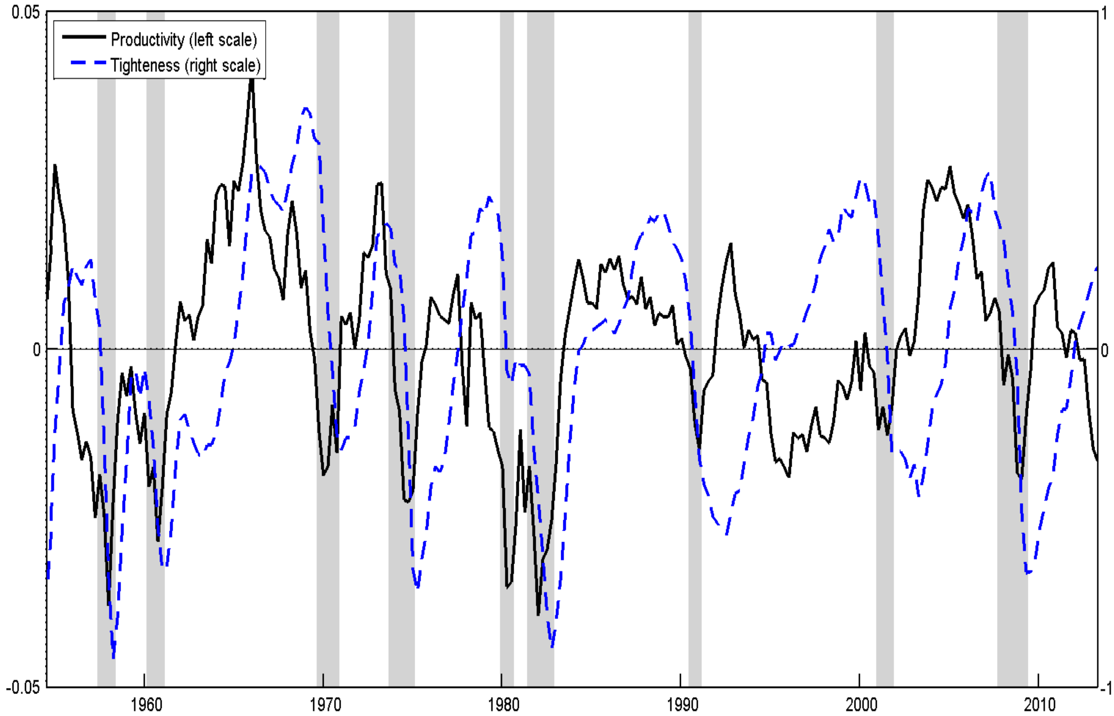

Figure 1: ***Cyclical component of Productivity and the labor market tightness.***

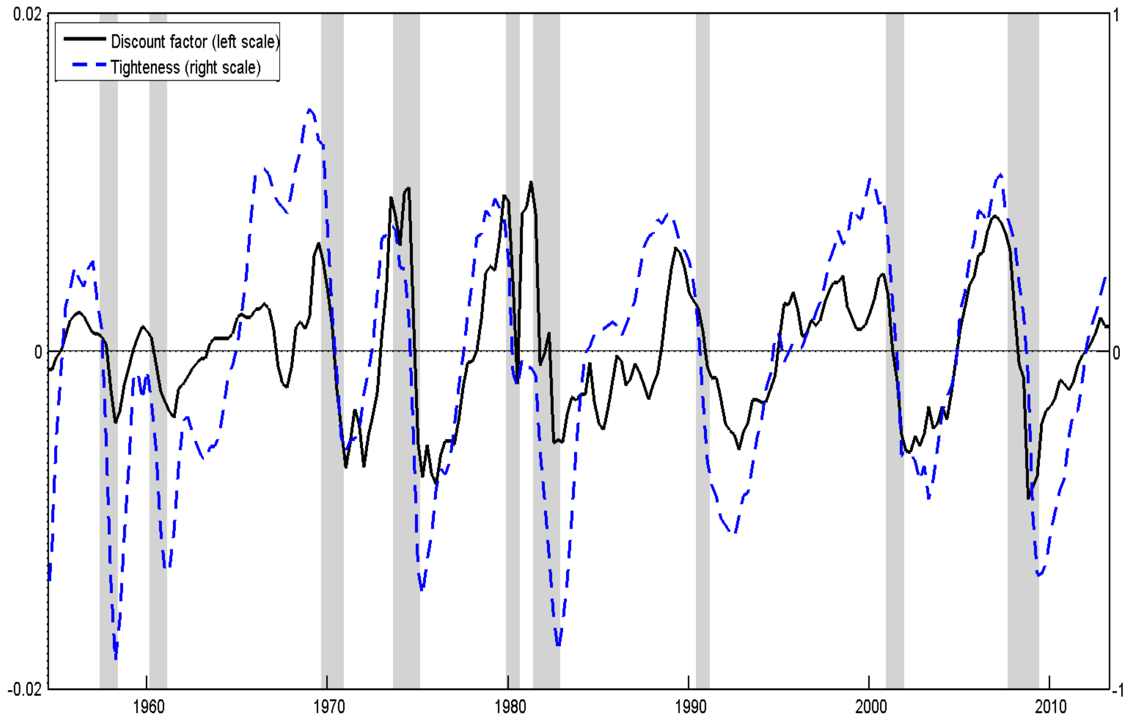

Figure 2: ***Cyclical component of Real interest rate and the labor market tightness.***

The rest of the paper is organized as follows. Section 2 is devoted to the presentation of the dynamic matching model. Section 3 addresses calibration and simulations. An estimation of the structural model using Bayesian methodology is presented in Section 4. Section 5 concludes.

2 The model

We use a discrete time version of the standard matching model. Separations are exogenous. Labor is the only input into the production process and it may be adjusted through the extensive margin (employment). Wages are set according to a Nash bargaining process.

2.1 Matching

A job may either be filled and productive, or unfilled and unproductive. Workers are identical and they may either be employed or unemployed. The number of matches, m_t, is given by the following Cobb-Douglas matching function:

$$m_t = \chi j_t^{\gamma} v_t^{1-\gamma} \leq \min(j_t, v_t) \tag{1}$$

where $v_t \geq 0$ denotes the mass of vacancies, $j_t \geq 0$ represents the mass of searching workers. The matching function (1) is increasing and concave in its two arguments and homogenous of degree 1. A vacancy is filled with probability $q_t = m_t/v_t$ and the job finding probability is $f_t = m_t/j_t$. Total employment is n_t and the number of job seekers is defined by $j_t = 1 - (1-s)n_{t-1}$. The labor force is assumed equal to one such that end-of-period unemployment is $u_t = 1 - n_t$. The employment law of motion is given by:

$$n_t = (1-s)n_{t-1} + m_t \tag{2}$$

which implies that hirings are immediately productive[4].

2.2 Representative household

The representative household maximizes aggregate consumption[5] c_t:

$$\max_{\Omega_t^H} E_0 \sum_{t=0}^{\infty} \left(\prod_{k=0}^{t} \beta_k \right) c_t \tag{3}$$

[4]It should be noticed that our results remain unchanged with an employment law of motion that is entirely backward: $n_t = (1-s)n_{t-1} + m_{t-1}$, $m_t = f_t u_t$

[5]For the sake of clarity, we consider a linear utility function. Results are robust to a more standard CRRA utility function.

subject to the budget constraint:

$$c_t = w_t n_t + j_t b + \Pi_t + T_t \tag{4}$$

the job seekers j_t definition and the law of motion of employment:

$$n_t \;=\; (1-s)n_{t-1} + f_t j_t \tag{5}$$

β_t represents a discount factor shock with $\beta_0 = \beta$. w_t is the wage level. Π_t represents profits from holding shares in firms and T_t is a lump-sum tax. The representative household derives utility b from unemployment (unemployment benefits). Prices are normalized to 1. The program consists of choosing the set of processes $\Omega_t^H = \{c_t, n_t\}_{t=0}^{\infty}$ taking as given the set of processes $\{w_t, f_t\}_{t=0}^{\infty}$ so as to maximize their intertemporal utility. The optimality conditions of the household's problem defines the marginal value of employment for a worker:

$$\varphi_t \;=\; (w_t - b) + E_t \beta_{t+1}(1-s)(1-f_{t+1})\varphi_{t+1} \tag{6}$$

2.3 Firms

The optimization problem of the firm consists of choosing the set of processes $\Omega_t^F = \{v_t, n_t\}_{t=0}^{\infty}$ taking as given the set of processes $\{w_t, q_t\}_{t=0}^{\infty}$ so as to maximize the following intertemporal profit function:

$$\max_{\Omega_t^F} E_0 \sum_{t=0}^{\infty} \left(\prod_{k=0}^{t} \beta_k \right) (y_t - w_t n_t - \kappa v_t) \tag{7}$$

subject to the production function and the law of motion of employment:

$$\begin{aligned} y_t &= z_t n_t \\ n_t &= (1-s)n_{t-1} + q_t v_t \end{aligned}$$

Hiring is costly and incurs a cost κ per vacancy posted. z_t is an aggregate productivity shock. The optimality conditions of the above problem gives the job creation condition which equal expected surplus from a filled job μ_t to the expected cost of search:

$$\frac{\kappa}{q_t} \;=\; \mu_t \tag{8}$$

$$\mu_t \;=\; z_t - w_t + (1-s)E_t \beta_{t+1} \mu_{t+1} \tag{9}$$

Combining the two gives the job creation condition:

$$\frac{\kappa}{q_t} \;=\; z_t - w_t + (1-s)E_t \beta_{t+1} \frac{\kappa}{q_{t+1}} \tag{10}$$

2.4 Wages

The wage is determined every period through an individual Nash bargaining process between each worker and the large firm, who share the total surplus of the match. The standard optimality condition of the above problem is given by: $\xi\mu_t = (1-\xi)\varphi_t$ where $\xi \in [0,1]$ and $1-\xi$ denote the workers and firms bargaining power respectively. Using equation (6), (8) and (9), one has:

$$w_t = \xi\left(z_t + E_t\beta_{t+1}(1-s)\kappa\theta_{t+1}\right) + (1-\xi)b \tag{11}$$

To close the model we define profits as $\Pi_t = y_t - w_t n_t - \kappa v_t$ which, combined with the household budget constraint (4) and the government budget constraint $T_t = j_t b$, yields the following market clearing condition: $c_t = y_t - \kappa v_t$. The discount factor shock and the productivity shock follow an autoregressive process with mean β and z respectively:

$$\log\beta_{t+1} = \rho_\beta\log(\beta_t) + (1-\rho_\beta)\log(\beta) + \varepsilon^\beta_{t+1} \text{ With } \varepsilon^\beta \sim \mathcal{N}(0,\sigma^2_\beta) \tag{12}$$

$$\log z_{t+1} = \rho_z\log(z_t) + (1-\rho_z)\log(z) + \varepsilon^z_{t+1} \text{ With } \varepsilon^z \sim \mathcal{N}(0,\sigma^2_z) \tag{13}$$

2.5 Model calibration

We adopt a very standard calibration based on US data and quarterly frequencies (See Table 1). We set the steady state discount factor to 0.99. The US unemployment rate u is about 6% on average over several decades. We set the probability of being unemployed $s = 6\%$ which correspond to an average between BLS (0.1) and SIPP (0.028)[6]. At the steady state, the number of matches must be equal to the number of separations: $m = sn$ with $n = 1 - u = 0.94$. We get the number of job seekers from the definition $j = 1-(1-s)n$ and a job finding rate $f = m/j \simeq 50\%$. Following den Haan et al. (2000), the rate at which a firm fills a vacancy is about 0.71. Then, we deduce $v = m/q$ and set χ in such a way that $m = \chi j^\gamma v^{1-\gamma}$. We set b to 0.45 which implies that utility from unemployment is about half of the wage at the steady state, consistent with DOLETA replacement ratio. We impose the Hosios condition $\xi = 1-\gamma = 0.5$ from Petrongolo & Pissarides (2000). We deduce κ from the job creation condition. Hiring costs κv represent about 5% of total output which is a little bit higher than the conventional ratio of 1.6% but not too much. We first assume that the persistence and the standard deviations are the same for z_t and β_t. They are equal to 0.9 and 1%. We further investigate these values in section 3.3.

[6] See Nagypál (2008) for a comparison

Variables	Symbol	Value	Source
Discount factor	β	0.99	4% yearly real interest rate
Separation rate	s	0.06	BLS, SIPP
Utility when unemployed	b	0.45	$\simeq$ 0.5 * wage
Worker bargaining power	ξ	0.5	Hosios
Elast. matching w.r.t u	γ	0.5	Hosios
Vacancy posting cost	c	0.66	Deduced
Matching efficiency	χ	0.59	Deduced
Autocorrelation coefficient	ρ_β	0.9	Assumed
Std. of β shock	σ_β	0.01	Assumed
Autocorr. coefficient z_t	ρ_z	0.9	Assumed
Std. of z_t shock	σ_z	0.01	Assumed

Table 1: **PARAMETERS**

3 Results

3.1 Data

Variables	u	v	θ	w	y
Standard deviation	7.70	9.72	17.16	0.46	1.55
Autocorrelation	0.93	0.93	0.93	0.92	0.88
Correlation	u	v	θ	w	y
u	1	-0.94	-0.98	-0.12	-0.87
v		1	0.99	0.19	0.91
θ			1	0.16	0.91
w				1	0.31
y					1

Table 2: **LABOR MARKET STATISTICS - DATA.** *All variables are reported in logs as deviations from an HP trend with smoothing parameter* 1600*. Standard deviations are relative to output except output.*

Table 2 describes the unconditional empirical moments for U.S. data. Unemployment and vacancies are respectively about 8 and 10 times more volatile than output. Both are strongly correlated which implies a labor market tightness that is about 17 times more volatile than output. As shown by Shimer (2005), the wage volatility is low and weakly correlated with others variables. All variables are highly persistent.

3.2 Simulations

The simulated moments are reported in Tables 3 and 4. It is shown that the two shocks involve similar patterns regarding the correlations and the persistence of the variables. They both reproduce a consistent Beveridge curve and enough persistence of the variables. The striking difference between the two shocks concerns the volatility of the labor market. The productivity shock implies tiny variations in labor market quantities. The volatility of unemployment, vacancies and the tightness are far smaller than their empirical counterparts. The productivity shock has no difficulties to generate the observed fluctuations in output. The discount factor shock is the opposite. It generates too much volatility in unemployment and vacancies w.r.t. output[7]. On the other hand, a large standard deviation of the shock is needed to match the volatility of output. Furthermore, it produces a strong volatility in wages due to the expectations term in Equation (11). The mechanism behind the discount factor shock lies in the movements of the expected hiring costs (the last term on the RHS in Equation (10)). It directly impacts the payoff to job creation. As firms experience drastic variations in the expected payoff from hiring a new worker they adjust job openings very sharply. The productivity shock increases the job productivity but also the wage rate due to the Nash structure of wage. The latter effect offsets the former which implies less variations in the expected gain from hiring a new worker.

One may naturally wonder whether combining the two shocks will result in more realistic moments. The previous results are conditional on the parametrization of the shocks and the calibration. But how large is the standard deviation and the persistence of each shock? Which one mainly governs the fluctuations in unemployment, vacancies and output? This we investigate now more formally.

[7]Increasing the volatility of the shock does not impact the relative standard deviation $\sigma_x/\sigma_y, x = u, v, \theta, w$ of the variables. This result holds using a perturbation method of order 2 and 3.

Variables	u	v	θ	w	y
Standard deviation	1.47	1.15	1.71	0.83	2.49
Autocorrelation	0.96	0.75	0.90	0.90	0.91
Correlation	u	v	θ	w	y
u	1	-0.85	-0.97	-0.97	-0.98
v		1	0.95	0.95	0.95
θ			1	1.00	1.00
w				1	1.00
y					1

Table 3: **LABOR MARKET STATISTICS - PRODUCTIVITY SHOCK ONLY.** *All variables are reported in logs as deviations from an HP trend with smoothing parameter* 10^5*. Standard deviations are relative to output except output.*

Variables	u	v	θ	w	y
Standard deviation	15.67	12.27	18.30	5.36	0.28
Autocorrelation	0.96	0.75	0.90	0.90	0.96
Correlation	u	v	θ	w	y
u	1	-0.85	-0.97	-0.97	-1.00
v		1	0.95	0.95	0.85
θ			1	1.00	0.97
f				1	0.97
y					1

Table 4: **LABOR MARKET STATISTICS - DISCOUNT FACTOR SHOCK ONLY.** *All variables are reported in logs as deviations from an HP trend with smoothing parameter* 1600*. Standard deviations are relative to output except output.*

3.3 Estimation

3.3.1 Parameter estimates

We use Bayesian techniques to estimate the model's parameters and shock variances[8]. The posterior density is evaluated using a random-walk Metropolis-Hastings algorithm, for which we generate 2 000 000 draws and we target an acceptance ratio of 0.3. We log-linearize the model around the deterministic steady state and apply the Kalman filter to evaluate the likelihood function. We combine the likelihood function with the prior distribution of the model parameters to obtain the posterior distribution.

We set β to 0.99 and estimate the rest of the parameters. We adopt relatively

[8]See An & Schorfheide (2007) and Lubik & Schorfheide (2005) for a detailed discussion of Bayesian estimation of DSGE models.

loose priors for the model parameters except for the separation rate[9] (see Table 5). We assume a beta-distribution for share parameters defined on unit intervals and a gamma-distribution for positive-valued parameters. The mean of the prior is always set to the value reported in Table 5. The prior means for the persistence of shocks are set to 0.9. Finally, the priors for the standard deviations of shocks follow an inverse-gamma distribution, with a prior mean of 0.01 and an infinite standard deviation. We have two observable variables: the unemployment rate and the real gross domestic product. We take log and use an HP-filter with smoothing parameter[10] 1600.

Variables	Symbol	Prior density	Posterior mean	Confidence interval
Separation rate	s	$\beta(0.06, 0.01)$	0.056	[0.04, 0.07]
Worker bargaining power	ξ	$\beta(0.5, 0.1)$	0.34	[0.22, 0.45]
Elast. matching w.r.t u	γ	$\beta(0.5, 0.1)$	0.34	[0.22, 0.46]
Utility when unemployed	b	$\Gamma(0.45, 0.1)$	0.44	[0.28, 0.61]
Vacancy posting cost	κ	$\Gamma(0.66, 0.1)$	0.59	[0.45, 0.74]
Matching efficiency	χ	$\Gamma(0.59, 0.1)$	0.48	[0.42, 0.74]
Discount persistence	ρ_β	$\beta(0.90, 0.3)$	0.71	[0.71, 0.85]
Discount Std.	σ_β	$\Gamma^{-1}(0.01, \infty)$	0.028	[0.0185, 0.0371]
Productivity persistence	ρ_z	$\beta(0.90, 0.3)$	0.70	[0.73, 0.86]
Productivity Std.	σ_z	$\Gamma^{-1}(0.01, \infty)$	0.006	[0.0059, 0.0068]

Table 5: **ESTIMATION RESULTS**

Table 5 reports posterior means of the estimated parameters and the 90% confidence intervals. Not surprisingly, the standard deviation of the discount factor shock is larger than that of the productivity shock. The persistence of the shocks are roughly similar. The Hosios condition is violated. The elasticity of the matching function with respect to unemployment is too low to ensure efficiency of the labor market ($\xi = 1 - \gamma$). More important, the value of b remains low. Estimated parameters are not consistent with the *small surplus calibration* based on a very low level of ξ and a high value of b. In other words, the transmission of the discount factor shock is more likely to reproduce the data than the productivity shock under the small surplus calibration *à la* Hagedorn & Manovskii (2008) which is a proxy for rigid wages.

[9] Due to an identification problem of this parameter we restrict the standard deviation to be equal to 0.01.

[10] The results remain the same with a smoothing parameter 10^5

3.3.2 Moments

Variables	u	v	θ	w	y
Standard deviation	9.39	6.33	8.86	1.32	1.51
Autocorrelation	0.92	0.47	0.78	0.78	0.84
Correlation	u	v	θ	w	y
u	1	-0.66	-0.94	-0.94	-0.77
v		1	0.87	0.87	0.56
θ			1	0.99	0.75
w				1	0.81
y					1

Table 6: **LABOR MARKET STATISTICS - MODE OF PARAMETERS ESTIMATE.***All variables are reported in logs as deviations from an HP trend with smoothing parameter* 1600. *Standard deviations are relative to output except output.*

We report the moments of the simulated variables using the mode of the posterior distribution as a benchmark for the model's parameters (see Table 6). It is shown that the canonical search and matching model generates large fluctuations in the labor market without relying on any form of wage rigidity. The slope of the Beveridge curve is a little bit lower but still broadly consistent with the data. Except for vacancies, the model provides enough persistence of the variables. The volatility of the labor market tightness is not as high as in the data but still widely acceptable (52%). Furthermore, the presence of two shocks results in the correlation of unemployment and output to be no longer equal to -1 as it is the case in a one-shock driven fluctuation setup. The same result holds for vacancies and the tightness.

3.3.3 Dynamics of unemployment and vacancies

In this section, our objective is to use our structural model to investigate which shocks are the drivers of unemployment, vacancies and output. To do so, we analyze the variance decomposition. An inspection of Figures[11] 3 to 6 makes it clear that the bulk of variation in unemployment and vacancy is mainly due to the disturbances pertaining to the discount factor. Only a small fraction of the fluctuations are generated by the productivity shock. Variations in output are mainly driven by the productivity shock (70%) and to a lesser extent by the discount factor shock. However, the discount factor shock has plays a more

[11] The red shaded area at the beginning of the sample corresponds to the gap between the initial steady state and the initial value of the data. The trajectory of endogenous variables is affected by how far from the steady state the system was at first and the shocks arriving subsequently. So, in the decomposition, we need to keep track of initial conditions so that the sum of the effects in the graph sums up to the endogenous variable (less its steady state).

important role for output variations during the recessions: 1953, 1957 and the Great Recession. Furthermore, while the productivity shock tracks the expansion in 1999, the discount factor shock seems to have a stronger impact on the subsequent recession (2001) which is broadly consistent with the conventional view. The productivity shock governs the bulk of variations in output during the rest of the sample, particularly during the 70's and 80's.

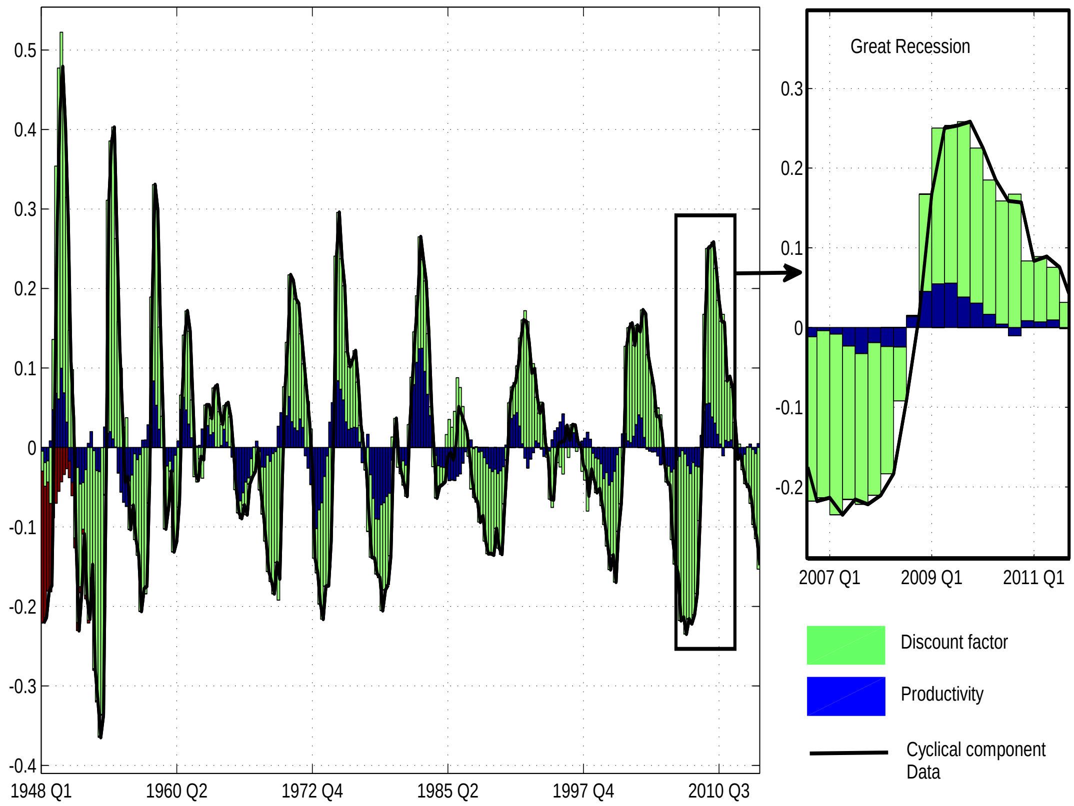

Figure 3: ***Variance decomposition - Unemployment.***

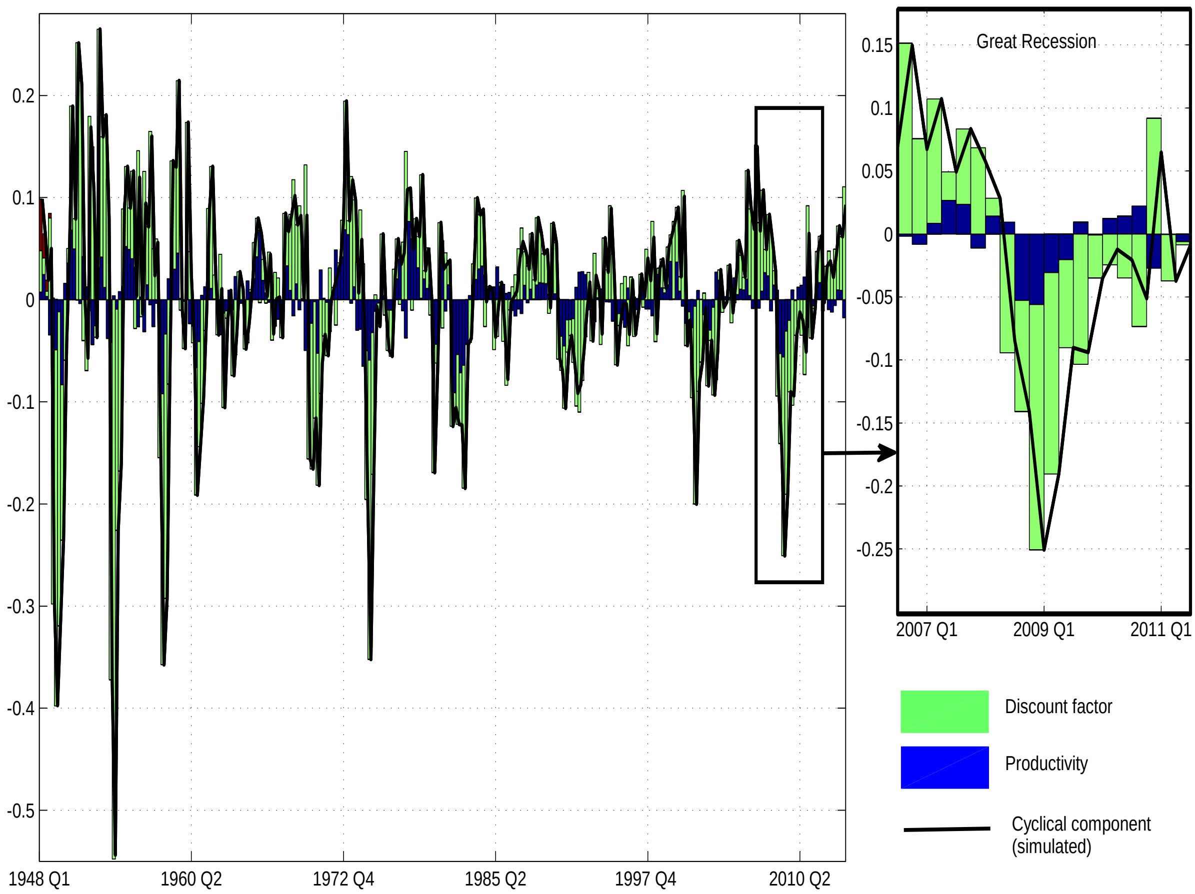

Figure 4: ***Variance decomposition - Vacancies.***

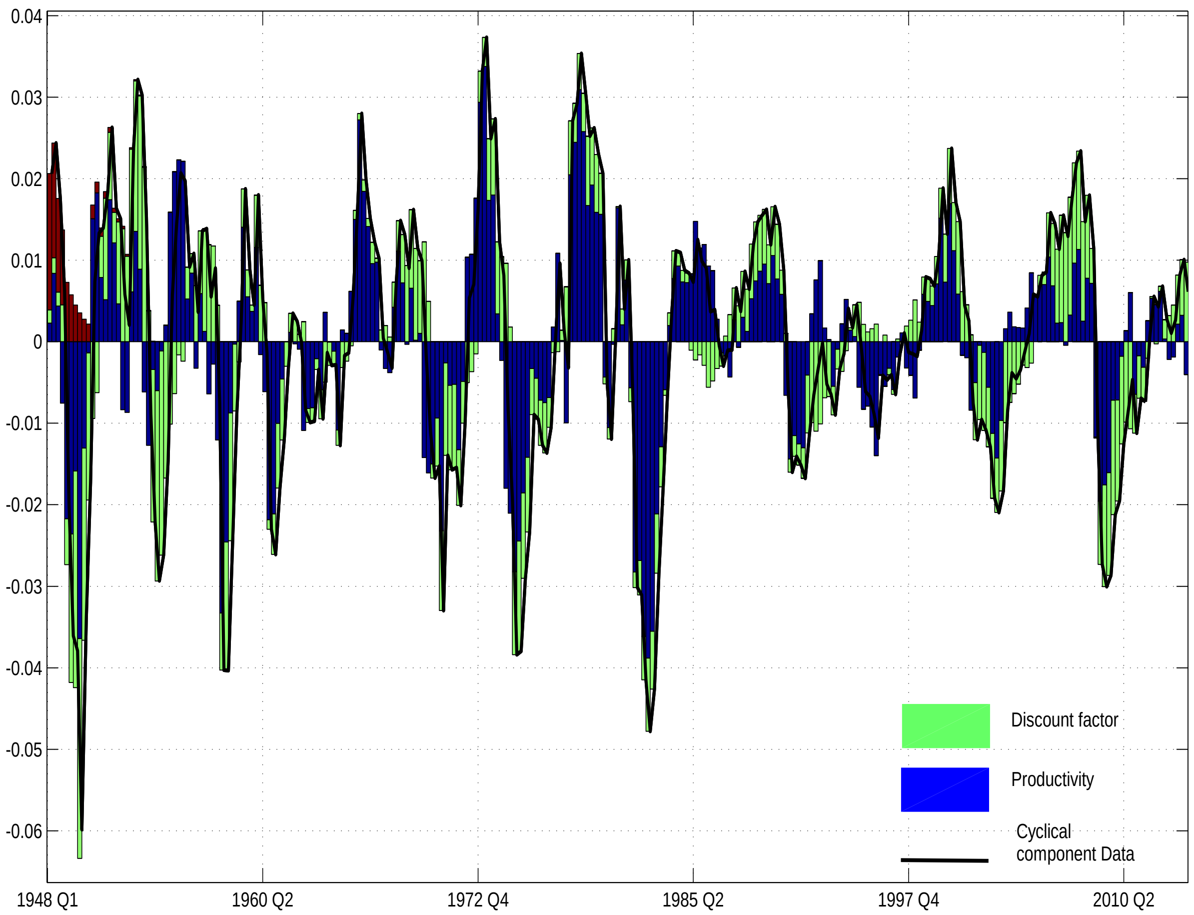

Figure 5: ***Variance decomposition - Output.***

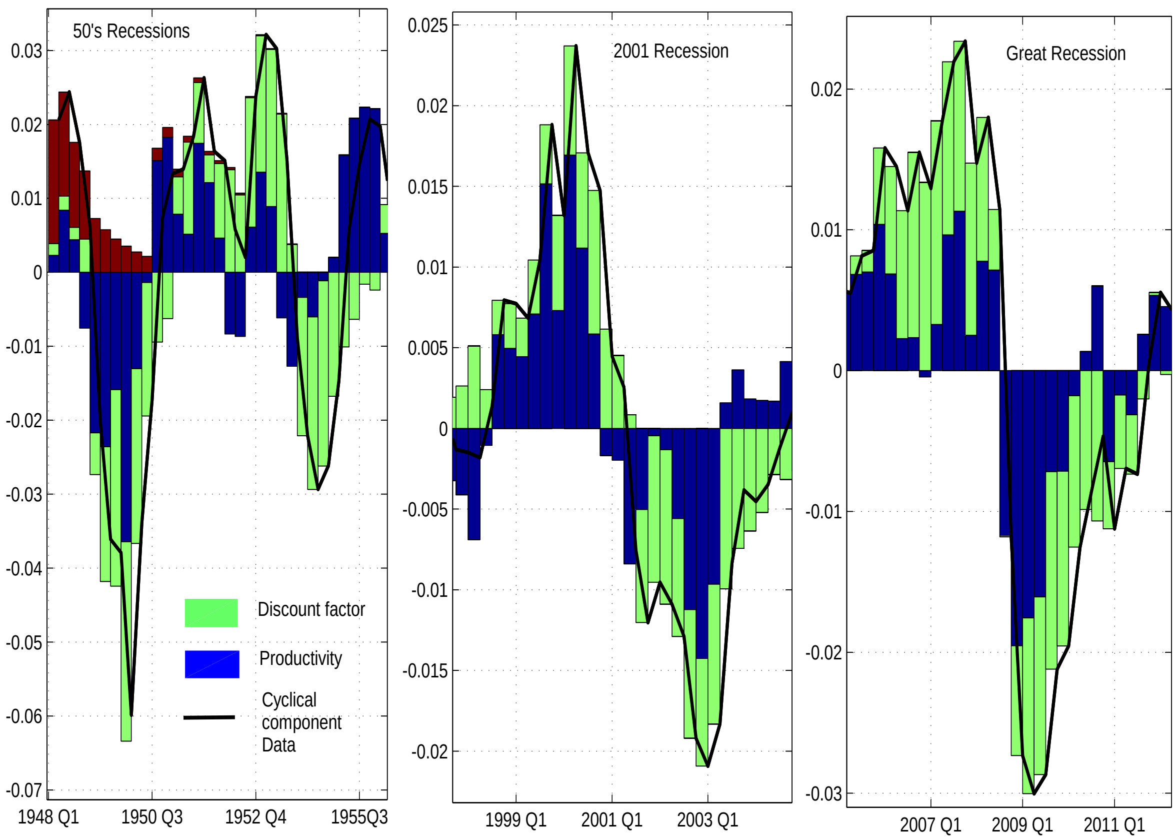

Figure 6: ***Variance decomposition - Output.***

4 Conclusion

Most of the literature on the labor market volatility puzzle has assumed that changes in productivity are the main, and sometimes only, source of business cycle fluctuations. The Nash bargaining structure in the search and matching theory is such that wages reduce the propagation of the productivity shock which translate little into job creation and unemployment.

In contrast, we argue that the canonical search and matching model is able to generate enough volatility in unemployment and vacancies if the fluctuations are not solely driven by the standard productivity shock. The discount factor shock impacts the expected hiring costs in such a way that firms adjust vacancies more sharply. An estimation of the model reveals that the discount factor shock is more likely to explain labor market fluctuations than the productivity associated to the small surplus calibration *à la* Hagedorn &

Manovskii (2008). The bulk of variations in unemployment and vacancies is mainly explained by disturbances pertaining to the discount factor.

Our general conclusion is that the model, even in its standard form, can be used to investigate labor market dynamic issues without relying on an ad-hoc wage rigidity or an implausible calibration. The present model is probably too simple to account for all aspects of the labor market dynamics but alternative sources of uncertainty like the one coming from the discount factor should be considered for future research.

References

An, S. & Schorfheide, F. (2007). Bayesian Analysis of DSGE Models. *Econometric Reviews*, 26(2-4), 113–172.

Barnichon, R. (2010). Building a composite Help-Wanted Index. *Economics Letters*, 109(3), 175–178.

Burda, M. C. & Weder, M. (2010). *Payroll Taxes, Social Insurance and Business Cycles*. SFB 649 Discussion Papers SFB649DP2010-042, Sonderforschungsbereich 649, Humboldt University, Berlin, Germany.

Chassamboulli, A. (2013). Labor-market volatility in a matching model with worker heterogeneity and endogenous separations. *Labour Economics*, 24(C), 217–229.

Cochrane, J. H. (2011). Presidential Address: Discount Rates. *Journal of Finance*, 66(4), 1047–1108.

den Haan, W. J., Ramey, G., & Watson, J. (2000). Job Destruction and Propagation of Shocks. *American Economic Review*, 90(3), 482–498.

Di Pace, F. & Faccini, R. (2012). Deep habits and the cyclical behaviour of equilibrium unemployment and vacancies. *Journal of Economic Dynamics and Control*, 36(2), 183–200.

Faccini, R. & Ortigueira, S. (2010). Labor-market volatility in the search-and-matching model: The role of investment-specific technology shocks. *Journal of Economic Dynamics and Control*, 34(8), 1509–1527.

Fujita, S. & Ramey, G. (2007). Job matching and propagation. *Journal of Economic Dynamics and Control*, 31(11), 3671–3698.

Gertler, M., Sala, L., & Trigari, A. (2008). An Estimated Monetary DSGE Model with Unemployment and Staggered Nominal Wage Bargaining. *Journal of Money, Credit and Banking*, 40(8), 1713–1764.

Hagedorn, M. & Manovskii, I. (2008). The Cyclical Behavior of Equilibrium Unemployment and Vacancies Revisited. *American Economic Review*, 98(4), 1692–1706.

Hall, R. E. (2005). Employment Fluctuations with Equilibrium Wage Stickiness. *American Economic Review*, 95(1), 50–65.

Hall, R. E. (2014). *High Discounts and High Unemployment*. Working Paper 19871, National Bureau of Economic Research.

Hall, R. E. & Milgrom, P. R. (2008). The Limited Influence of Unemployment on the Wage Bargain. *American Economic Review*, 98(4), 1653–74.

Krause, M. U. & Lubik, T. A. (2006). The cyclical upgrading of labor and on-the-job search. *Labour Economics*, 13(4), 459–477.

Lubik, T. & Schorfheide, F. (2005). *A Bayesian Look at New Open Economy Macroeconomics*. Economics Working Paper Archive 521, The Johns Hopkins University,Department of Economics.

Nagypál, E. (2008). Worker Reallocation over the Business Cycle: The Importance of Employer-to-Employer Transitions. *Manuscript*, Northwestern Univ.

Petrongolo, B. & Pissarides, C. (2000). *Looking Into The Black Box: A Survey Of The Matching Function*. CEPR Discussion Papers 2409, C.E.P.R. Discussion Papers.

Pissarides, C. A. (2009). The Unemployment Volatility Puzzle: Is Wage Stickiness the Answer? *Econometrica*, 77(5), 1339–1369.

Rotemberg, J. J. (2008). Cyclical Wages in a Search-and-Bargaining Model with Large Firms. In *NBER International Seminar on Macroeconomics 2006*, NBER Chapters (pp. 65–114). National Bureau of Economic Research, Inc.

Shimer, R. (2005). The Cyclical Behavior of Equilibrium Unemployment and Vacancies. *American Economic Review*, 95(1), 25–49.

Yashiv, E. (2006). Evaluating the performance of the search and matching model. *European Economic Review*, 50(4), 909–936.

Variables	Type	Source	Code
Output	Quantities, s.a, Index numbers, 2005=100	Bureau of Economic Analysis (BEA)	Table 1.1.3
Unemployment	level, s.a, 16 years and over	Bureau of Labor Statistics (BLS)	LNS13000000
Vacancies	level, s.a, Job openings Total nonfarm and Help-wanted index.	Bureau of Labor and Barnichon (2010)	JTS00000000JOL
Real wages	Average Hourly Earnings in $, s.a, Private divided GDP Deflator, s.a, 2009=100	FRED BEA	$\frac{\text{AHETPI}}{\text{GDPDEF}}$
Risky rate	Moody's baa corporate bonds yield.	FRED	BAA
Risk free rate	Federal fund rate	FRED	FEDFUNDS

Table 7: ***Data source and definitions.***

Data used to compute the moments cover the periods 1964Q1-2013Q2. We use the cyclical component of real GDP and unemployment over 1948Q1-2014Q2 for the estimation. All data are taken or built at quarterly frequencies using average over months if necessary. Vacancies in level are built using the job opening rate ($jo_t = v_t/(v_t + n_t)$ and the vacancy index from Barnichon (2010) which is specified as a base 1998=100. We rescale Barnichon' series to get a longer job opening rate series using the first observation of job opening rate (2001Q1). Then, using employment in level, s.a. we recover vacancies in level $v_t = jo_t n_t/(1 - jo_t)$. The tightness is simply equal to vacancies in level divided by unemployment in level. The discount factor is calculated in the following manner:

$$\begin{aligned} R &= \frac{1 + risky\ \ rate}{1 + Risk\ \ free\ \ rate} \\ \beta &= \frac{1}{R} \end{aligned}$$

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