Financial Risk and Unemployment

Zvi Eckstein
Tel Aviv University and The Interdisciplinary Center Herzliya

Ofer Setty
Tel Aviv University

David Weiss
Tel Aviv University

PRELIMINARY DRAFT: May 2014

Abstract
There is a strong correlation between the corporate interest rate & spread and the unemployment rate. We make two contributions to the literature based on this observation. First, we model the mechanisms by which these financial conditions can affect unemployment in a Diamond-Mortesen-Pissaridies (DMP) model with capital. Second, we quantify these mechanisms, disciplining our model with US data. Financial conditions affect unemployment in four ways. First, high interest rates lower profits. Second, higher interest rates make vacancy posting more costly. Third, higher default rates lower the expected future profits of firm owners. Finally, default can lead directly to a separation between the worker and firm. We quantify these channels following various strategies outlined in the literature. Our results suggest the model is able to produce quantitatively significant fluctuations under all calibration strategies, virtually entirely from the first two channels. These findings show that financial shocks, whatever their source, are an important source of economic volatility through the mechanisms in this paper.

1 Introduction

There is a strong correlation between the interest rate spread, as defined by the difference in yields on BAA grade corporate bonds and US Treasury bonds, and the unemployment rate.[1] This correlation is similar in magnitude to that of unemployment and productivity, the most common force used by economists to study unemployment fluctuations. Despite this strong empirical connection, the search based unemployment literature has done little to analyze how the interest rate spread affects unemployment. We develop an extension of the Search and Matching model, as in Diamond (1982), Mortensen (1982), and Pissarides (1985) (DMP), to allow us to quantify various mechanisms through which financial conditions, as captured by the interest rate spread, may affect unemployment.

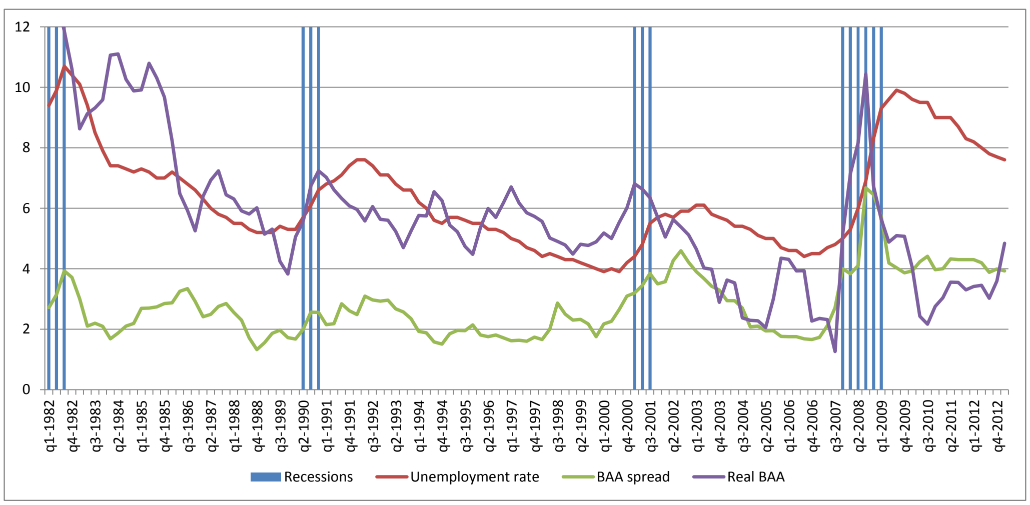

Figure 1: US time-series data

In Figure 1 we use time series data of the interest rate spread and unemployment in the US in the years 1982-2012.[2] The correlation between these series is 0.61. We cannot reject the hypothesis that the interest rate spread Granger-causes unemployment fluctuations.[3] We thus take the corporate interest rate to be an exogenous shock. Additionally the real BAA interest rate has a correlation with unemployment of 0.46, the importance of which is discussed below.

[1]BAA is a credit rating of the risk of default. 75% of US firms are rated BAA or lower, so we use this spread as a basis for exploration. Using other series yield very similar results.

[2]We choose this time period as Gali and van Rens (2014) claims that during this time, labor productivity became less procyclical, opening the door for other mechanisms to be explored.

[3]For the Granger causality test, we use a lag of 2 quarters. We use lags of 2 quarters throughout this paper.

Due to the spread rising in recessions, borrowing costs to firms rise in recessions despite lower Federal Funds Rates. We make two contributions to the literature based on the observation that the interest rate spread and the interest rate to firms (BAA) are countercyclical with a strong correlation with unemployment. First, we explain the mechanisms by which financial conditions, assumed to be exogenous, can affect unemployment in a DMP model with capital. Second, we quantify these mechanisms, disciplining our model with US data.

We are not trying to solve the 'Shimer Puzzle', introduced in Shimer (2005) (henceforth Shimer), of whether *productivity* shocks can explain labor market fluctuations in the DMP model. Rather, we are introducing a new set of shocks, the interest rate and spread, and their associated mechanisms. We then need to show that our approach is quantitatively useful in studying unemployment. To do so, we follow the outline of the 'Shimer Puzzle' literature in measuring the importance of shocks in a DMP setting.

We now discuss four mechanisms by which the interest rate spread, and implied rises in actual interest rates, can generate unemployment in the context of the DMP model. The first channel is what we call the flow profit channel. This is the notion that, if interest rates rise for firms, then profits per worker will be reduced, as the capital the worker uses becomes more expensive. Thus the incentive to post vacancies declines, and unemployment rises. The second we call the direct vacancy channel. If firms need to have some working capital in order to post a vacancy, such as a computer ready for the worker, then a rise in interest rates directly increases the costs of vacancies leading to higher unemployment. The third channel is the ownership channel. Bankruptcy results in the owners of the firm losing their status as the claimants on any future profits. As bankruptcy rates increase, the owners expect fewer future profits, and thus post fewer vacancies. Unemployment rises. The final channel is the closure channel, or the simple notion that bankruptcies often result in a contemporaneous rise in separations between workers and firms, and thus a rise in unemployment. Notice that the first two channels rely simply on the interest rate for firms rising, while the second two mechanisms infer rising firm default rates from the interest rate spread.

We begin by writing the partial model that only includes the first two mechanisms, that is the flow profit channel and the vacancy channel. The model is a standard DMP model, with a fixed amount of capital per worker. We calibrate the model to the US data in two different ways. First, we follow most of the calibration strategy outlined in Hagedorn and Manovskii (2008). The model is able to produce quantitatively significant business cycle fluctuations. More specifically, our model overstates volatility. Our value for the flow utility of leisure is 0.57. This number is higher than that in Shimer, and lower than that of Hagedorn and Manovskii (2008). Our value of the worker's bargaining weight is 0.52, which is similarly between those used by Hagedorn and Manovskii (2008) and Shimer.

Our second approach to calibrating the model is to use the calibration strategy from Shimer. We find very similar results. The reason for this is that much of the driving force for the model comes from the direct vacancy channel. The mechanism used to drive unemployment in the productivity-shock driven versions of the DMP model is the analog of the flow profit channel- an adverse productivity shock decreases future match surplus. It should be noted that no business cycle properties of the US data are targeted in any of the calibration strategies discussed here or in the previous paragraph, and yet the model is able to generate volatility of unemployment, vacancies, and market tightness (U/V) of the same order of magnitude as the US data.

We then expand the model to include the second two channels. We are interested in the default rate of firms in the economy. This can be inferred from the interest rate spread and the probability of firms entering default. That is, the spread implies that financial intermediaries expect a certain level of risk, where the risk is both that of default and the recovery rates from firms in default. Similarly, not all defaulting firms will end up separating from their workers. Some firms, such as American Airlines after their 2010 bankruptcy, continue operating even after a bankruptcy episode despite their equity owners losing all claims to profits. We demonstrate the lack of quantitative power of these channels by taking the aggressive approach that all volatility in the spread is due to default risk, and that all defaults result in separation.

Most of the DMP literature on unemployment focuses on the effects of productivity shocks. Shimer launched a literature on if/how the DMP model could be made consistent with the empirical realities of unemployment volatility given low volatility in productivity. Hagedorn and Manovskii (2008) offer one solution, depending on a high value of unemployment. Petrosky-Nadeau and Zhang (2013) estimate the DMP model in order to be consistent with the US time series, including the Great Depression, and find that it can also explain the Great Recession. They use Hall and Milgrom (2008) style wage setting, and a congestion externality in order to create asymmetric affects of recessions and booms. Numerous other papers take different avenues to address the 'Shimer Puzzle', or how relatively small productivity shocks can drive large unemployment and vacancy volatility. We take a different approach from this research agenda in adding financial conditions to the DMP model, rather than examining productivity shocks, and show that the model is robustly able to explain the US business cycle data.

We are not the first to introduce financing to the DMP model. Wasmer and Weil (2004) include financial conditions in a DMP model by adding a search dimension to locating capital. Our study quantifies different mechanisms, and is thus complementary to their paper. Hall (2014) takes an interesting approach to the DMP model in assuming the discount rate is stochastic. This approach is innovative in that it connects the DMP literature to the finance literature that uses stochastic discount rates in order to explain high stock volatility. Yashiv (2013) studies the interaction between frictions in the labor and capital markets. He shows that investment decisions and hiring decisions are intimately related, and that it is necessary to model them jointly in order to explain the US data. Christiano, Eichenbaum, and Trabandt (2013) have an ambitious agenda of incorporating a New Keynesian model with elements of a search model of the labor market in order to explain the Great Recession. In their paper, the interest rate affects unemployment through the standard New Keynesian channel; lower interest rates increase demand for final goods and services. For us, lower interest rates increase profits for the firm, and lower vacancy costs. We thus study different channels through which financial conditions affect unemployment, and do so in different modeling frameworks.

Mitman and Rabinovich (2013) and Hagedorn, Karahan, Manovskii, and Mitman (2013), show how extensions in unemployment benefits can explain persistence in high unemployment rates since the early 1990s and especially in the Great Recession. They do not explain the initial rise in unemployment. Interest rates for firms rose dramatically during this time period, which suggests that our mechanisms are a complement to their papers.

We proceed as follows. In Section 2 we describe the partial model. Section 3 describes the value functions, solution of the model, and the full model with the interest rate spread mechanisms. Section 4 describes the economic mechanisms in the model in full detail. We discuss the calibration strategy and quantitative exercise in Section 5. We conclude in Section 6.

2 The Model

We take the standard DMP model, as in Shimer, and add capital, as in Hagedorn and Manovskii (2008). We replace shocks to productivity with shocks to interest rates. We describe the model in full detail in this section. We start by describing the partial model.

2.1 Workers and Firms

There is a measure one of infinitely lived, risk neutral workers and a continuum of infinitely lived firms. Workers maximize their expected lifetime utility:

$$\mathbb{E}\sum_{t=0}^{\infty}\beta^t y_t, \tag{1}$$

where y_t represents the workers' income in a given time period, and β is the discount factor.

Firms produce using workers and capital. We assume that capital per worker is fixed and that output is linear in the number of workers, making production a Lenotief function. Output is thus given by

$$Q(L, K) = \min\{pL, \frac{K}{\phi}\}, \tag{2}$$

where p is labor productivity and ϕ controls the capital per effective worker, k. However, given that we study *deviations* in the interest rate from trend, this is analogous to a model in which the firm decides capital stock per worker based on interest rate trends, and then cannot adjust in response to fluctuations. Capital is elastically supplied by an exogenous financial market. Suppressing the fixed capital component of production gives us production as a function of labor:

$$q(L) = pL, \tag{3}$$

where K is implied to be $\frac{pL}{\phi}$.

Period accounting profits for the representative firm, matched with a worker, are thus:

$$\Pi = (p - w)L - rK, \tag{4}$$

where w is the wage rate, and r is the capital cost. In contrast to the standard DMP model, where p follows a Markov process, we assume that the interest rate r follows a Markov process $G(r', r) = Pr(r_{t+1} \leq r | r_t = r)$. We take the productivity rate, p, as a constant.[4]

Firms choose how many vacancies to post each period at cost c per vacancy, which is allowed to vary with the interest rate.

2.2 Matching

Vacant jobs (v) and unemployed workers (u) are randomly matched according to a constant returns to scale matching technology. The matching function, $M(u, v)$, represents the number of matches

[4]In future work, we can include productivity shocks and study the interaction between the mechanisms in the rest of the DMP literature and those proposed in this paper.

in a period. We follow Hagedorn and Manovskii (2008) in picking our matching function:

$$M(u,v) = \frac{uv}{(u^l + v^l)^{\frac{1}{l}}}, \tag{5}$$

where l is a parameter that controls the matching technology. This function form has the desirable properties that the job finding rate for a worker, and the job filling rate for a firm, are always being between 0 and 1. The job finding rate for a worker, $\lambda^w = \frac{M(u,v)}{u}$. Similarly, the job filling rate for the firm is $\lambda^f = \frac{M(u,v)}{v}$. Note that the job filling rate depends only on market tightness, $\frac{v}{u}$, denoted by θ. Denote $q(\theta) = \lambda^f_\theta$.

A match separates with exogenous periodic probability σ that is independent of the state for now, but in Section 3.5 will become a function of the interest rate spread. The evolution of the number of unemployed workers, u, can be described by

$$u' = (1 - \lambda^w)u + \sigma(1 - u) \tag{6}$$

where a next period variable is denoted by a prime ($'$).

3 Equilibrium

3.1 Worker Value Function

In this subsection we specify the worker's optimization problem and optimal policy functions.

Let W denote the value function of an employed worker. Let U denote the value function of an unemployed worker. Workers move between employment and unemployment according to the (endogenous) job finding rate (λ^w), and the (exogenous) job separation rate (σ). Workers take both probabilities parametrically.

The worker's wage, which is determined by Nash equilibrium as explained below, is w. Unemployed workers receive a utility value of b. This represents the value of leisure and home-production. The values of employment and unemployment in state s, W_s and U_s are equal to:

$$W_s = w_s + \beta \left\{ (1-\sigma) E_s W_{s'} + \sigma E_s U_{s'} \right\} \tag{7}$$

$$U_s = b + \beta \left\{ \theta_s q(\theta_s) E_s W_{s'} + (1 - \theta_s q(\theta_s)) E_s U_{s'} \right\} \tag{8}$$

3.2 Firm Value Function

Firms create jobs, rent capital from banks, and produce. The firm maximizes the discounted present value of the profits. To create a job, a firm first posts a vacancy. There is a flow cost of posting a vacancy, denoted by c_s, which is allowed to depend on the interest rate. The value of posting a vacancy, V , is

$$V_s = -c_s + \beta \left\{ q(\theta_s) E_s J_{s'} + (1 - q(\theta_s)) E_s V_{s'} \right\}, \tag{9}$$

The firm discounts the future at the rate β. J_s is the value of a job filled by a worker. The value of a filled job, given the wage w, is

$$J_s = p - w_s - r_s k + \beta \left\{ (1 - \sigma) E_s J_{s'} + \sigma_s E_s V_{s'} \right\} \tag{10}$$

3.3 Wage determination

The wage is determined by generalized Nash bargaining. We assume that firms cannot commit to wages, so that wages are set period by period. The Nash bargaining solution solves the problem:

$$\max_{w_s} (W_s - U_s)^{\gamma} (J_s - V_s)^{1-\gamma}, \tag{11}$$

where $\gamma \in (0, 1)$ represents the bargaining power of the worker.

3.4 Solution

The state of the economy is r_s. Define the total surplus as $S_s = (J_s - V_s) + (W_s - U_s)$. With free entry implying $V_s = 0 \; \forall s \in \mathbf{S}$ the surplus is equal to:

$$S_s = p - b - r_s k + \beta \left\{ ((1 - \sigma) E_s S_{s'} - \theta q(\theta) E_s (W_{s'} - U_{s'})) \right\} \tag{12}$$

From Nash bargaining we get that:

$$\frac{W_s - U_s}{\gamma} = S_s = \frac{J_s}{1 - \gamma} \tag{13}$$

Now use the free-entry condition, $\forall s$, using Equation 9, the number of vacancies posted in a given state, v_s, is picked in order that market tightness, θ, satisfies:

$$E_s S_{s'} = \frac{c_s}{(1-\gamma)\beta q(\theta_s)} \tag{14}$$

Using the condition from Equation 14 in Equation 12, we arrive at:

$$S_s = p - b - r_s k + \beta \left\{ (1-\sigma) E_s S_{s'} - \frac{\theta\gamma}{1-\gamma}\frac{c_s}{\beta} \right\} \tag{15}$$

The number of variables is then two times the number of states $\{\theta_s, S_s\}_{s\in\mathbf{S}}$ and there is an equivalent number of equations. The equilibrium conditions must therefore solve Equations 14 and 15, that is, θ_s and S_s must solve these equations.

3.5 Full Model: Adding Default

From the interest rate spread we infer a default rate among firms in the economy.[5] We allow default to affect the model in two ways:

1. When the spread rises, there is an increase in bankruptcy. When a bankruptcy occurs, the firm loses ownership over the profit flow from the match. The effective separation rate from the match for the firm will thus be ψ_s.
2. Some bankruptcies will result in layoffs, or separations for the worker, while others simply allow the match to continue under different ownership. Separations will thus become state dependant as well with σ_s.

We infer default rates from the spread as follows. If we naively think that the entire spread is due to default risk, then:

$$1 + r_f = (1-\psi_n)(1+r_e) + \psi_n(1+r_e)\Omega, \tag{16}$$

where r_f is the risk free interest rate, r_e is the equilibrium firm rate, Ω is the fraction of defaulted loans that banks can recover, and thus ψ_n is the naive default rate. Solving, this yields

$$\psi_n = \frac{r_e - r_f}{1+r_e}\frac{1}{1-\Omega} \tag{17}$$

[5]See the calibration section for specifications on how we infer default rates and separation rates from the spread.

We allow for not all of the spread to come from default, using:

$$\psi_s = \bar{\sigma} + \eta_1 \psi_n \tag{18}$$

Accordingly, we do not assume that all defaults result in separation, and use

$$\sigma_s = \bar{\sigma} + (1 - \bar{\sigma})\eta_2 \eta_1 \psi_n \tag{19}$$

We now rewrite Equations 6, 7, and 10.

For Equations 6 and 7, the only difference is that the separation rate now is state dependant. These equations, respectively, become:

$$u' = (1 - \lambda^w)u + \sigma_s(1 - u) \tag{20}$$

and

$$W_s = w_s + \beta \left\{ (1 - \sigma_s) E_s W_{s'} + \sigma_s E_s U_{s'} \right\}. \tag{21}$$

For Equation 10, the only difference is that the separation rate for the firm is now ψ_s, which is the combined probability of an exogenous, non state-dependant separation, plus the probability of a bankruptcy. We call this joint probability ψ_s. Equation 10 thus becomes:

$$J_s = p - w_s - r_s k + \beta \left\{ (1 - \psi_s) E_s J_{s'} + \psi_s E_s V_{s'} \right\} \tag{22}$$

For our equilibrium conditions to hold, we must therefore rewrite 15. This equation becomes:

$$S_s = p - b - r_s k + \beta \left\{ (1 - \psi_s) E_s S_{s'} - \frac{(\theta q(\theta) - \psi_s + \sigma_s)\gamma}{(1 - \gamma) q(\theta)} \frac{c_s}{\beta} \right\} \tag{23}$$

4 Mechanisms

There are four mechanisms in the model presented for the relationship between interest rates and interest rate spread on one hand, and unemployment on the other. In this section, we describe the channels. The first two are related to the interest rate, while the second two are related to default.

1. When the interest rate rises, there is less surplus available to split between the firm and the worker. The decline in surplus reduces the incentives for firms to post vacancies, resulting

in a rise in unemployment. We call this channel the *flow profit channel*.

2. The capital component of vacancy costs rise proportionally with the interest rate. The idea is that if a firm needs working capital in order to have a position available, then when interest rates rise, this component of vacancy costs rises as well. Firms thus post fewer vacancies, and unemployment rises. We call this the *direct vacancy channel*.

3. The bankruptcy rate (inversely) determines how long the owner of the firm expects to remain claimant on the profits generated by the match. When this rate increases, the expected profits the owner receives decreases. As a result, the incentive to post vacancies declines, thus increasing unemployment. We call this channel the *ownership channel*.

4. When firms enter bankruptcy, they may downsize or shut down entirely. This results in an immediate increase in the separations between workers and firms, causing an increase in unemployment. We call this channel the *closure channel*.

5 Quantitative Exercise

We will do two calibration exercises. The first is to calibrate the model along the lines of Hagedorn and Manovskii (2008). As described below, we will set some parameters based on a priori information, and some based on matching model moments to data moments. The second calibration exercise will be to pick parameter values in accordance with Shimer.

First we begin with normalizing the model, then we proceed with the exercises.

5.1 Normalization

We normalize $p - r_s k = 1$ when $r_s = \bar{r_s}$. Thus we can write flow match surplus to be $1 - (r_s - \bar{r_s})k$, or $1 - \Delta r_s k$, where $\Delta r_s = r_s - \bar{r_s}$. We now rewrite equation 23 accordingly.

$$S_s = 1 - b - \Delta r_s k + \beta \left\{ (1 - \psi_s) E_s S_{s'} - \frac{(\theta q(\theta) - \psi_s + \sigma_s)\gamma}{(1-\gamma)\, q(\theta)} \frac{c_s}{\beta} \right\} \tag{24}$$

We normalize this model in accordance with the normalization strategy outlined in Hagedorn and Manovskii (2008) for the DMP model with capital. Shimer follows a very similar normalization for the DMP model without capital. In those two papers, as well as the current one, labor productivity is on average 1. The difference between the current paper and Hagedorn and Manovskii (2008) or Shimer is that, for this paper, labor productivity is *always* 1.

5.2 Calibration- First Exercise

We now outline the calibration strategy used in this paper. We begin by setting a week as a time period in order to account for aggregation bias.

We estimate a weekly AR(1) process of the real BAA interest rate. We find the persistence and unconditional standard deviation to be 0.9707 and 0.0835, respectively.

We follow Hagedorn and Manovskii (2008) in setting some parameter values a priori. The mean weekly separation rate in the US, after accounting for time aggregation, is 0.0081. The discount rate is set to $0.99^{\frac{1}{12}}$, representing a quarterly discount rate of 0.99. The average vacancy cost, c, is 0.584, which is composed of an average capital cost of 0.474 and a fixed labor cost of 0.11.[6] The capital component of this cost varies proportionally with the interest rate. That is, $c = c_k \frac{\Delta r}{\bar{r}} + c_l$. Since we use the same matching function as Hagedorn and Manovskii (2008), we set $l = 0.407$. The fact that we set this parameter to 0.407, and do not target the elasticity of wages with respect to the interest rate, is the difference between our calibration strategy and that outlined in Hagedorn and Manovskii (2008).

We now turn to the remaining parameters, b, and γ, which are picked to match model moments. We follow Hagedorn and Manovskii (2008) in targeting the average job finding rate, 0.139 and the average market tightness, $\frac{v}{u} = 0.634$.[7]

There are state dependent separations, σ_s, and state dependent firm owners lose their claim to the future profits generated by the match. As described in Equations 16, 18, and 19, we need to set η_1, η_2, and Ω. The parameter η_1 captures the pass-through rate from spread to bankruptcy. η_2 captures the fact that only some bankruptcies result in separations. Ω is the recovery rate on defaulted firms. Following Acharya, Bharath, and Srinivasan (2007), we set this to 0.51. As will be shown, the two mechanisms controlled by η_1 and η_2 are very weak. We therefore give them their best chance to perform by setting $\eta_1 = 1$, and $\eta_2 = 1$.

Picking b, and γ to minimize the distance between model and data moments, we arrive at the

[6] Hagedorn and Manovskii (2008) calculate the capital cost of vacancies using, among other things, the fact that capital share of income is approximate $\frac{1}{3}$ in the US.

[7] Notice that Hagedorn and Manovskii (2008) target these two numbers, plus the elasticity of wages with respect to productivity in order to jointly identify b, l, and γ. Since the analog of this last moment is very small empirically, as wages are well known to be sticky and interest rates highly volatile, we do not target the elasticity of wages with respect to interest rates. Instead, we simply set l, and pick γ and b to match model moments.

following parameters. We find the flow utility of an unemployed worker, b, to be 0.565. The bargaining weight of the worker, γ, is 0.520. In Table 1 below we report the model and data moments associated with our calibration.

TABLE 1: MOMENTS: DATA AND MODEL

Moment	*Data*	*Model*
Job Finding Rate	0.139	0.137
Market Tightness	0.634	0.642

The model has succeeded in matching the data moments well. Our calibration is outlined in Table 2.

TABLE 2: PARAMETER VALUES

Parameter	*Meaning*	*Value*	*Identification*
σ	Job separation	0.0081	Exog (HM)
β	Discount rate	$0.99^{\frac{1}{12}}$	Exog (HM)
c	Vacancy Costs	0.5840	Exog (HM)
l	Matching Param	0.407	Exog (HM)
ρ_r	Wkly Persistence interest rate	0.9707	Authors Calculation
σ_r	Std. Deviation interest rate	0.0835	Authors Calculation
γ	Worker Bargaining Weight	0.520	Matching Data Moments
b	Unemployment Flow Utility	0.565	Matching Data Moments
Ω	Recovery Rate	0.51	A Priori
η_1	Spread due to default	1.00	Robustness
η_2	Separations due to default	1.00	Robustness

Notice that the worker bargaining weight, γ, is less than the value obtained by Shimer, 0.72, while greater than that of Hagedorn and Manovskii (2008), 0.052. Similarly, our value of worker's flow utility is higher than Shimer's, based purely on unemployment benefits, and lower than that of Hagedorn and Manovskii (2008), which is close to model's wage rate and labor productivity. For our model, the value works out to be 58% of the average wage.

5.2.1 Results

In this section, we describe the cyclical volatility of unemployment, vacancies, and market tightness as they relate to interest rate shocks. Similar to Hagedorn and Manovskii (2008) and Shimer, we report in Table 3 the US time series data regarding these series, their autocorrelations, standard deviations, and correlations.[8] We use the time period 1982 to 2012. We choose this time period as Gali and van Rens (2014) claims that during this time, labor productivity became less procyclical, opening the door for other mechanisms to be explored.

TABLE 3: QUARTERLY STATISTICS U.S. DATA, 1982:1 TO 2012:4

	u	*v*	*v/u*	*r*
Std Dev	0.110	0.118	0.223	0.263
Quarterly Autocorrelation	0.939	0.908	0.932	0.712
Correlation u	1	-0.894	-0.972	0.417
Correlation v	-	1	0.975	-0.467
Correlation $\frac{v}{u}$	-	-	1	-0.455
Correlation r	-	-	-	1

Table 4 shows the model counterpart for the US economy. It should be emphasized that these moments are *not* targeted, but rather a result of the calibration strategy described above in a DMP model with interest rate and spread shocks. The model is able to produce volatility in all moments of the same order of magnitude as in the data. The volatility of unemployment, vacancies, and market tightness are all higher than that observed in the data.

The persistence of unemployment, vacancies, and tightness, are lower than their empirical counterpart. Similarly, the correlation between unemployment and vacancies is similar in our model to Hagedorn and Manovskii (2008), and somewhat low relative to the data.

It should be noted that the model gets the correlation between the interest rate and unemployment to be almost exactly correct. While the correlation between vacancies and the interest rate is close to zero, this is perhaps to be expected given the low persistence in the model. That is, given the two period lag structure, vacancies must recover quickly from an adverse shock if the persistence of unemployment is low.

[8]The cross correlations between the interest rate and other variables are lagged at 2 quarters. This appears to be a good description of the relationship between the series, and is quite reasonable with respect to the mechanisms explored in this paper. We are consistent in using the same lag process when analyzing model data.

TABLE 4: QUARTERLY STATISTICS MODEL (MAIN CALIBRATION)

	u	*v*	*v/u*	*r*
Std Dev	0.227	0.321	0.492	0.263
Quarterly Autocorrelation	0.688	0.322	0.543	0.712
Correlation u	1	-0.598	-0.852	0.422
Correlation v	-	1	0.929	0.077
Correlation $\frac{v}{u}$	-	-	1	-0.145
Correlation r	-	-	-	1

5.2.2 Breakdown of Mechanisms

In Table 5, we breakdown the strength of the various mechanisms in order to learn their relative strengths. The data is the US data reported in Table 3. The 'All' line is the full model standard deviations reported in Table 4. The 'Profit' line is the standard deviation of each series when only interest rates fluctuate, and vacancy costs remain constant. The 'Vacancy' line is when interest rates fluctuate while vacancy costs and the spread remain constant. The 'ownership' line is when the spread fluctuates, but interest rates and separation rates do not. The 'spread' line is when the spread fluctuates, including separation rate fluctuations, and the interest rate remains constant. Finally, the interest rate line is when the spread remains constant.

While the channels related to default- the Ownership channel and the Closure channel- seem to have little direct effect, they do influence the interest rate perceived by firms. Added default risk increases interest rates, leading to the Profit channel and the Vacancy channel, both of which generate substantial volatility.

TABLE 5: BREAK DOWN OF MECHANISMS
MAIN CALIBRATION

Mechanisms	*u*	*v*	*v/u*
Data	0.110	0.118	0.223
All	0.227	0.321	0.492
Profit	0.110	0.149	0.234
Vacancy	0.117	0.157	0.250
Ownership	0.001	0.001	0.001
Spread	0.026	0.023	0.025
Interest rate	0.228	0.319	0.492

5.3 Calibration - Second Exercise

What if we followed the calibration strategy outlined in Shimer? We do so in what follows, while introducing capital to his model.[9] Shimer sets the flow utility of the unemployed worker to be $b = 0.4$, the workers' bargaining power $\gamma = 0.72$, separations and job-finding rate are the same as in Hagedorn and Manovskii (2008) who use Shimer's separation and job finding rates. Market tightness, θ in Shimer is normalized to one. The matching function (adopted to a weekly frequency) is $0.139\theta^{-0.72}$.

The cost of a vacancy is 0.22 in order to match an average market tightness of 1 in our model. We assume that the vacancy cost is divided between labor cost and capital cost in the same proportions as is in Hagedorn and Manovskii (2008).[10] We introduce capital and normalize the model in the same way described above.

5.3.1 Results

The model still generates substantial volatility, as shown in Table 6. That is, the model is able to produce significant business cycle volatility under both calibration strategies. We consider this to be strong evidence that the DMP model using interest rate shocks, rather than productivity shocks, is quite effective at explaining the US business cycle.

[9] We include two other changes. We continue to use an HP filter of 1600, rather than the 10^5 in Shimer, and we continue to use a weekly model to account for time aggregation issues, rather than the quarterly model in Shimer.

[10] Notice that had we assumed that the cost is purely capital our model would create even stronger volatility.

TABLE 6: QUARTERLY STATISTICS MODEL (SHIMER CALIBRATION)

	u	*v*	*v/u*	*r*
Std Dev	0.159	0.223	0.353	0.263
Quarterly Autocorrelation	0.655	0.390	0.558	0.712
Correlation u	1	-0.703	-0.894	0.348
Correlation v	-	1	0.947	0.012
Correlation $\frac{v}{u}$	-	-	1	-0.149
Correlation r	-	-	-	1

5.3.2 Breakdown of Mechanisms

We repeat the breakdown for this calibration in Table 7.

TABLE 7: BREAK DOWN OF MECHANISMS
SHIMER CALIBRATION

Mechanisms	*u*	*v*	*v/u*
Data	0.110	0.118	0.223
All	0.159	0.223	0.353
Profit	0.067	0.092	0.149
Vacancy	0.093	0.128	0.207
Ownership	0.003	0.003	0.001
Spread	0.026	0.024	0.002
Interest rate	0.159	0.220	0.353

6 Conclusion

Following the Great Recession, there has been renewed interest in how and to what extent financial conditions affect unemployment. The correlation between the interest rate spread and unemployment captures this notion in a concise manner. We offered two contributions based on this observation. First, we have presented four mechanisms by which financial conditions can affect unemployment in a DMP model. Second, we offer a methodology for quantifying these channels. Our results suggest that financial conditions are indeed important to consider when studying unemployment dynamics. As noted in the introduction, we are not trying to solve the so-called

'Shimer Puzzle'. Rather, we are introducing a new set of shocks related to financial conditions and quantifying their associated economic channels.

To this end, we follow the DMP literature in disciplining our model and evaluating quantitative importance. We use both Shimer's calibration strategy as well as targeting data moments in order to pick parameter values. We do not target the data we are looking to explain. The model is robustly able to explain a significant portion of business cycle level volatility, with just the flow profit and direct vacancy channels being most responsible for the volatility.

Our findings suggest that the direct impact of default- owners losing their claims to profits and possible layoffs- have a small impact on unemployment volatility. However, the indirect effects of default on interest rates have a large impact on firms, and thus on unemployment volatility. The calibrated model generates significant volatility in unemployment, vacancies, and market tightness.

A Data Appendix

Data details go here.

References

ACHARYA, V. V., S. T. BHARATH, AND A. SRINIVASAN (2007): "Does industry-wide distress affect defaulted firms? Evidence from creditor recoveries," *Journal of Financial Economics*, 85(3), 787 – 821.

CHRISTIANO, L. J., M. S. EICHENBAUM, AND M. TRABANDT (2013): "Unemployment and business cycles," International Finance Discussion Papers 1089, Board of Governors of the Federal Reserve System (U.S.).

DIAMOND, P. A. (1982): "Aggregate Demand Management in Search Equilibrium," *Journal of Political Economy*, 90(5), 881–94.

GALI, J., AND T. VAN RENS (2014): "The Vanishing Procyclicality of Labor Productivity," Working Papers 489, Barcelona Graduate School of Economics.

HAGEDORN, M., F. KARAHAN, I. MANOVSKII, AND K. MITMAN (2013): "Unemployment benefits and unemployment in the Great Recession: the role of macro effects," Staff Reports 646, Federal Reserve Bank of New York.

HAGEDORN, M., AND I. MANOVSKII (2008): "The Cyclical Behavior of Equilibrium Unemployment and Vacancies Revisited," *American Economic Review*, 98(4), 1692–1706.

HALL, R. E. (2014): "High Discounts and High Unemployment," NBER Working Papers 19871, National Bureau of Economic Research, Inc.

HALL, R. E., AND P. R. MILGROM (2008): "The Limited Influence of Unemployment on the Wage Bargain," *American Economic Review*, 98(4), 1653–74.

MITMAN, K., AND S. RABINOVICH (2013): "Do Changes in Unemployment Insurance Explain the Emergence of Jobless Recoveries?," Discussion paper.

MORTENSEN, D. T. (1982): "Property Rights and Efficiency in Mating, Racing, and Related Games," *American Economic Review*, 72(5), 968–79.

PETROSKY-NADEAU, N., AND L. ZHANG (2013): "Unemployment Crises," GSIA Working Papers 2013-E5, Carnegie Mellon University, Tepper School of Business.

PISSARIDES, C. A. (1985): "Short-run Equilibrium Dynamics of Unemployment Vacancies, and Real Wages," *American Economic Review*, 75(4), 676–90.

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

WASMER, E., AND P. WEIL (2004): "The Macroeconomics of Labor and Credit Market Imperfections," *American Economic Review*, 94(4), 944–963.

YASHIV, E. (2013): "Capital Values, Job Values and the Joint Behavior of Hiring and Investment," Working paper.