The Elephant in the Room: the Impact of Labor Obligations on Credit Risk *

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Abstract

We study the impact of labor market frictions on credit risk. Our central finding is that labor market variables are the first-order effect in driving the credit spread fluctuations. Recent studies have highlighted a link between credit risk and macroeconomic variables such as investment growth, financial leverage, volatility, etc. We show that labor market variables (wage growth or labor share) can forecast credit spread as well as or better than alternative predictors. A model with wage rigidity can explain this link as well as produce large credit spreads despite realistically low default probabilities (credit spread puzzle). This is because pre-committed payments to labor make other committed payments (such as debt) more risky; for this reason variables related to pre-committed labor payments forecast credit risk.

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1 Introduction

We study the impact of labor market frictions on credit risk. Our central finding is that labor market variables are the first-order effect in driving the credit spread fluctuations. When wages are rigid, the operating leverage effect caused by smooth wages increases firms' default risk because precommitted wage payments make debt payment more risky. Consistent with this view, we show that labor market variables (wage growth and labor share) which capture the strength of operating leverage when wages are sticky, significantly forecast the Baa-Aaa credit spread in the U.S. More specifically, a 1 percentage point increase in the wage growth (labor share) is associated with a decrease (increase) of 16 (11) basis points in credit spread. The predictability of labor market variables is stronger than the standard credit risk predictors including financial leverage, market volatility, term spread, etc. For example, the adjusted R^2 of wage growth in predicting credit spread is 31%, substantially larger than that of financial leverage (21%) , market volatility (21%) and term spread (2%). Furthermore, wage growth drives out the predictability of investment growth, which is the key variable used in the recent investment-based models to link credit risk to the real economy. This result suggests the crucial role of wage growth as a key determinant of credit risk.

To establish the link between labor market frictions and credit risk, we propose a dynamic stochastic general equilibrium model with heterogeneous firms. The key friction is a staggering of wage contracts or infrequent wage resetting, which prevents firms from immediately adjusting their labor expenses in response to new shocks. In the model, the predictability of labor market variables for the credit spread arise endogenously due to the interaction between operating leverage and financial leverage. In economic downturns productivity and output fall by more than wages, causing an increase in labor leverage. High expected payments to labor make equity more likely to default in bad times, especially when the wage bill is relatively high. Thus, the model implies that labor share (positively) and wage growth (negatively) are natural predictors of credit spreads.

More specifically, in the model firms default if the realized firm value is not big enough to repay the debt due. This occurs if the firm's idiosyncratic productivity is below a cutoff value, which itself depends on the state of the economy. In economic downturns, profit falls more than output, which makes it harder for firms to pay off precommitted debt payment. This raises the default threshold of idiosyncratic productivity, which in turn increases the default probability and the credit risk premium. Thus the model produces large credit spreads despite realistically low default probabilities, providing a novel explanation for the credit spread puzzle. Furthermore, wage growth negatively whereas labor share positively predicts credit spread because times of low wage growth or high labor share are associated with high wage rigidity and hence high credit risk premium. The model endogenously generates time-variations in credit spread.

This intuition is consistent with anecdotal evidence. For example, regarding the bankruptcy of American Airlines in 2012, the Wall Street Journal writes "Bankruptcy seems to be helping American do what practically every other bankrupt airline has done – reduce its labor costs to competitive levels. Those costs are ... the highest of any major airline operating in the U.S. today. American spends $600 million more on wages than its peers."[1] American's CEO Thomas W. Horton said "Achieving the competitive cost structure we need remains a key imperative in this process, and as one part of that, we plan to initiate further negotiations with all of our unions to reduce our labor costs to competitive levels." Similarly, regarding the bankruptcy of United in 2002, a UBS analyst said "Excess debt, burdensome labor contracts, expensive pension obligations... are all high on the list of what ails airlines. Bankruptcy can certainly address these other issues."[2]

The model is calibrated to match aggregate-level quantity moments. The model generates a reasonable distribution of default rates for corporate bonds with different credit ratings, consistent with the data. Most important, the model with wage rigidity (combined with labor adjustment costs) successfully replicates the predictability of wage growth and labor share for the credit spread observed in the data. Furthermore, the model also endogenously generates the positive relation between stock market volatility and credit spread. In contrast, a model with no labor market frictions does not generate any meaningful time variation in credit spread. Moreover, without wage rigidity, wage growth (labor share) positively (negatively) predicts credit spread which is counterfactual. Taken together, our results show that labor market frictions have significant impact for credit risk.

In addition to successfully replicating the observed predictability in credit spread, the model also produces a sizable equity premium and equity volatility consistent with the data (the mechanism is similar to Favilukis and Lin 2013). Thus the model with wage rigidity and corporate debt provides a coherent explanation for the two major asset pricing puzzles in a unified framework–the equity premium puzzle and the credit spread puzzle.

Related literature: While the macroeconomic literature on wages and labor is quite large (e.g., Pissarides 1979, Calvo 1982, Taylor 1983, Taylor 1999, Shimer 2005, Hall 2006,

[1] James K. Glassman, Wall Street Journal Op/Ed, October 16, 2012, "Once It Emerges From Bankruptcy, Let American Airlines Stay American"

[2] Sam Buttrick in interview to CNNMoney, December 9, 2002 "United hits turbulance of bankruptcy"

Gertler and Trigari 2009), there has been little work done relating labor market frictions to credit risk. We fill this gap by integrating labor market frictions with credit risk. In particular, our paper differs from these macro-papers in that we study implications of staggered wage setting on corporate bond pricing, while the models in labor economics fail to match the asset prices observed in the data; this is a problem endemic to most standard models.

The literature of structural models on credit risk highlights the roles of financial leverage and asset volatility as the key determinants of credit spread. Models in this literature usually feature exogenously specified cash flow process (e.g., Collin-Dufresne and Goldstein 2001; Hackbarth, Miao and Morellec 2006; Chen, Collin-Dufresne and Goldstein 2009; Chen 2010). We are complementary to these work by endogenizing cash flows through firms' investment and hiring decisions. More importantly, as is shown in Favilukis and Lin (2013), wage rigidity is crucial to match cash flow dynamics in DSGE models, thus our paper makes structural models of credit risk viable in a production economy. Some recent investment-based models attempt to link credit risk to firms' real investment decisions. In particular, Gomes and Schmid (2010) explore the propagation mechanism of movements in bond markets into the real economy. Gourio (2013) studies the impact of disaster risk on credit risk in a DSGE model. Kuehn and Schmid (2013) study the interaction between investment and credit spread. We are complementary to these papers but break new ground by explicitly modelling the interactions between labor market frictions and corporate bond pricing.

Our empirical findings relate to the empirical literature on the determinants of credit spread. Collin-Dufresne, Goldstein and Martin (2001) show that standard credit spread forecasters have rather limited explanatory power. Elton et al (2001) find that expected default accounts for a small fraction of the credit risk premium. We show that labor market variables, in particular, wage growth, have stronger explanatory power than financial leverage and stock market volatility in predicting the Baa-Aaa spread. Our findings suggests that exploring the link between labor market frictions and credit risk can shed light to the empirical puzzle documented in Collin-Dufresne, Goldstein and Martin (2001).

Our paper also relates to the recent literature exploring the relations between labor frictions and equity returns. Belo, Lin, and Bazdresch (2013) study the impact of labor frictions on the relationship between hiring rates and the cross section of returns. Petrosky-Nadeau, Zhang, and Kuehn (2013) explore how search frictions in the style of Mortensen and Pissarides (1994) affect asset pricing in a general equilibrium setting with production. Gomes, Jermann, and Schmid (2013) study the rigidity of nominal debt which creates long term leverage that works in a similar way to our labor leverage. We differ in that we explicitly study credit risk and wage rigidity.

2 Empirical Analyses

In this section we explore the predictability of labor market variables (wage growth and labor share) for credit spread. We first describe the data, and then the empirical specification and the results.

2.1 Data and Variable Definitions

Credit spread We use the Moody's Baa corporate bond yield in excess of Aaa corporate bond yield from the Federal Reserve. As in Chen, Collin-Dufresne, and Goldstein (2009), the Baa-Aaa spread should be mostly due to credit risk, assuming that the component of the credit spread due to taxes, call/put/conversion options and the lack of liquidity in the corporate bond markets, is of similar magnitude for Aaa and Baa bonds.

Wage growth Wage growth is the growth rate in the real wages and salaries per full-time equivalent employee from NIPA table 6.6.

Labor share Labor share is the ratio of aggregate compensation of employees to GDP.

Controls The empirical finance literature has uncovered a list of variables that forecast credit spread. We measure financial leverage as the book value of corporate bond divided by the market value of equity in the nonfinancial corporate business sector from the Flow of Funds Accounts. Stock market volatility is the annualized volatility of monthly CRSP stock market returns in excess of riskfree rate. Term spread is the difference between the ten-year Treasury bond yield and the three-month Treasury bill yield from the Federal Reserve. Spot rate is the one-year Treasure bill rate. Our sample is from 1948 to 2012.[3]

Panel A in Table 2 reports the descriptive statistics for the variables mentioned above. Credit spread has an annual mean of 95 basis points and a volatility of 41 basis points. It has a first-order autocorrelation at 0.75, suggesting that credit spread is persistent. Wage growth has mean of 2% and a standard deviation of 1%. It has a first-order autocorrelation at 0.45, less persistent than credit spread. Labor share has a mean and standard deviation at 0.55 and 1%, respectively. The mean, standard deviations, and autocorrelations of other

[3] We start in 1948 because financial leverage from Flow of Funds is available after 1946. We do not start in 1946 to avoid the influence of the WWII on our results. However, the predictability of wage growth for credit spread holds in a longer sample starting from 1929.

standard credit spread predictors seem reasonable.

Panel B in Table 2 presents the correlations of all variables of interest with real GDP growth, and their cross correlations. Credit spread has a correlation with GDP growth at -0.52, suggesting that it is countercyclical. Wage growth and investment growth are procyclical with correlations with GDP growth at 0.4 and 0.77, respectively; both of them negatively correlate with credit spread with correlations at -0.52 and -0.5, respectively. But they are only mildly positively correlated at 0.21. This implies that wage growth and investment growth contain different information in explaining credit spread even though both of them negatively correlate with credit spread. Both labor share and financial leverage are negatively correlated with GDP growth with correlations at -0.18 and -0.32, respectively; however labor share and financial leverage themselves are negatively correlated at -0.16, suggesting they contain different information despite both being countercyclical. Consistent with the existing literature, credit spread is positively correlated with financial leverage, market volatility, and the term spread.

It is also evident in Figure 1 that credit spread is highly countercyclical and moves in the opposite direction to the wage growth, while labor share somewhat leads credit spread but moves in the same direction as credit spread.

2.2 Empirical Specification and Results

In this subsection, we explore the predictability of wage growth and labor share for credit spread in three steps. All regressions are at an annual frequency. First, we run univariate regressions of one year ahead credit spread, CS_{t+1}, on current wage growth, ΔW_t, labor share, LS_t, and the controls at year t; second, we run horse race regressions of either wage growth or labor share with a control one at a time; thirdly, we conduct multivariate regressions of wage growth and labor share together with a control, and finally a multivariate regression with all the predictors at the right hand side.

Univariate regressions Panel A in table 3 reports the univariate regression results. Wage growth negatively forecasts credit spread with a slope coefficient at -16.44 which is more than 4 standard deviations away from zero (column one). Furthermore, the adjusted R^2 is 0.31, which is substantially larger than the adjusted R^2 implied by other predictors, suggesting that the explanatory power of wage growth is stronger than most of the conventional predictors including financial leverage and stock market volatility. Labor share positively predicts credit spread with the slope coefficient of 10.97 which is more than 2 standard deviations away from zero (column two). As for the controls, investment growth negatively forecasts credit spread (the third column), but the adjusted R^2 is only

0.03, far below the adjusted R^2 implied by wage growth (it is also smaller than the adjusted R^2 implied by labor share at 0.08). Both financial leverage and stock market volatility positively predict credit spread, consistent with Collin-Dufrene, Goldstein, and Martin (2001). However, price-to-earnings ratio, term spread, and spot rate do not significantly predict credit spread.

Horse race regressions Panel B in table 3 presents the horse race regression results of wage growth with a control one at a time. Wage growth remains statistically significant in predicting credit spread after controlling for all other predictors. Furthermore, investment growth is no longer significant in the joint regression with wage growth (column one).[4] This is perhaps surprising given that the recent literature has emphasized the role of investment in driving credit spread (Gomes and Schmid 2010, Gourio 2011, and Kuehn and Schmid 2013), however our result shows that wage growth drives out the predictive power of investment growth, thus wage growth is more important in explaining the movement of credit spread than investment. Panel C in table 3 presents the horse race regression results for labor share and other predictors. Labor share remains significant after controlling for investment growth, financial leverage, price-to-earnings ratio and the term spread; it is marginally significant when controlling for the spot rate. However, labor share is not significant at 10% when controlling for stock market volatility (column three). This is perhaps not surprising given that Favilukis and Lin (2013) show that labor share and return volatility are highly positively correlated since higher labor share implies higher operating leverage.

Multivariate regressions Panel D presents the multivariate regression results. When both wage growth and labor share are the right hand side variables (the first column), both significantly predict credit spread. In the multivariate regressions with wage growth and labor share together with one additional predictor at a time, wage growth remains significant in all specifications, while labor share is significant or marginally significant in most specifications.

The last column shows a kitchen sink regression that includes all controls but excludes our labor market variables. Given that there are six regressors and 64 years of data, this regression may very well be overfitted. In this regression, the adjusted R^2 is 0.43; recall that wage growth alone attains an R^2 of 0.31. Finally, for parsimony we include a regression with both of our labor market variables and all controls (overfitting is once again a concern). In this all-in regression (the second to last column), wage growth remains significant after controlling for investment growth, financial leverage, market volatility,

[4]This finding also holds in a longer sample starting in 1929.

P/E, term spread, and spot rate; however labor share is no longer significant. Moreover, investment growth is not significant either. The R^2 in this regression is 0.52.[5]

3 Model

The model is similar to Favilukis and Lin (2013) with exogenous corporate debt.[6] We begin with the household's problem. We then outline the firm's problem, the economy's key frictions are described there. Finally we define equilibrium.

In the model financial markets are complete, therefore we consider one representative household who receives labor income, chooses between consumption and saving, and maximizes utility as in Epstein and Zin (1989).

$$U_t = \max\left((1-\beta)C_t^{1-\frac{1}{\psi}} + \beta E_t[U_{t+1}^{1-\theta}]^{\frac{1-\frac{1}{\psi}}{1-\theta}}\right)^{\frac{1}{1-\frac{1}{\psi}}} \tag{1}$$

$$W_{t+1} = (W_t + N_t * \overline{w}_t - C_t)R_{t+1} \tag{2}$$

where $\overline{w}_t$ is the average wage in the economy, C_t is average consumption, W_t is the wealth held by the average household, and R_{t+1} is the return to a portfolio over all possible financial securities. For simplicity, we assume that aggregate labor supply is inelastic: $N_t = 1$. Risk aversion is given by θ and the intertemporal elasticity of substitution by ψ.

3.1 Firms

The interesting frictions in the model are on the firm's side. Firms (indexed by i) choose investment and labor to maximize the present value of future dividend payments where the dividend payments are equal to the firm's output net of investment, wages, operating costs and adjustment costs. Output is produced from labor and capital. Firms hold beliefs about the discount factor M_{t+1}, which is determined in equilibrium.

[5] In the results not tabulated here, we have also controlled for debt growth, employment growth, stock market premium, dividend-to-price ratio, unemployment rate, and past credit spread. We find that wage growth always remains significant.

[6] We will incorporate endogenous defaultable corporate debt soon.

3.1.1 The Wage Contract

In standard production models wages are reset each period and employees receive the marginal product of labor. We assume that any employee's wage will be reset this period with probability $1-\mu$.[7] When $\mu = 0$ our model is identical to models without rigidity: all wages are reset each period, each firm can freely choose the number of its employees, and each firm chooses N_t^i such that its marginal product of labor is equal to the wage. When $\mu > 0$ we must differentiate between the spot wage (w_t) which is paid to all employees resetting wages this year, the economy's average wage ($\overline{w}_t$), and the firm's average wage ($\overline{w}_t^i$). The firm's choice of employees may no longer make the marginal product equal to either average or spot wages because firms will also take into account the effect of today's labor choice and today's wage on future obligations.

When a firm hires a new employee in a year with spot wage w_t, with probability μ it must pay this employee the same wage next year; on average this employee will keep the same wage for $\frac{1}{1-\mu}$ years. All resetting employees come to the same labor market and the spot wage is selected to clear markets. The firm chooses its total labor force N_t^i each period. These conditions lead to a natural formulation of the firm's average wage as the weighted average of the previous average wage and the spot wage:

$$\overline{w}_t^i N_t^i = w_t(N_t^i - \mu N_{t-1}^i) + \overline{w}_{t-1}^i \mu N_{t-1}^i \tag{3}$$

Here $N_t^i - \mu N_{t-1}^i$ is the number of new employees the firm hires at the spot wage and μN_{t-1}^i is the number of tenured employees with average wage $\overline{w}_{t-1}^i$.[8]

Note that the rigidity in our model is a real wage rigidity, although our channel could in principle work through nominal rigidities as well. There is evidence for the importance of both real and nominal rigidities. Micro-level studies of panel data sets comparing actual and notional wage distributions show that nominal wage changes cluster both at zero and at the current inflation rate, with sharp decreases in the density to the left of the two mass points. Barwell and Schweitzer (2007), Devicenti, Maida and Sestito (2007), and

[7] Note that this is independent of length of employment. This allows us to keep track of only the number of employees and the average wage as state variables, as opposed to keeping track of the number of employees and the wage of each tenure. This way of modeling wage rigidity is similar in spirit to Gertler and Trigari (2009), but for tractability reasons, we do not model search and match frictions.

[8] It is possible that $N_t^i < \mu N_{t-1}^i$, in which case μN_{t-1}^i cannot be interpreted as tenured employees. In this case we would interpret the total wage bill as including payments to prematurely laid-off employees. Note that the wage bill can be rewritten as $\overline{w}_t^i N_t^i = \overline{w}_{t-1}^i N_t^i + (\mu N_{t-1}^i - N_t^i)(\overline{w}_t^i - w_t)$, here the first term on the right is the wage paid to current employees and the second term represents the payments to prematurely laid off employees. An earlier version of the paper included the constraint $N_t^i \geq \mu N_{t-1}^i$, the results were largely similar.

Bauer, Goette and Sunde (2007) find that downward real wage rigidity is substantial in Great Britain, Germany, and Italy, and that the fraction of real wage cuts prevented by downward real wage rigidity is more than five times greater than the fraction prevented by downward nominal wage rigidity. In a recent international wage flexibility study, Dickens, Goette, and Groshen (2007) find that the relative importance of downward real wage rigidity and downward nominal wage rigidity varies greatly across countries while the incidences of both types of wage rigidity are about the same.

3.1.2 Technology

Firm i's output is given by

$$Y_t^i = Z_t^i \left(\alpha (K_t^i)^\eta + (1-\alpha)(X_t N_t^i)^{\eta\rho} \right)^{\frac{1}{\eta}}. \tag{4}$$

Output is produced with CES technology from capital (K_t^i) and labor (N_t^i) where X_t is labor augmenting aggregate productivity, Z_t^i is the firm's idiosyncratic productivity, ρ determines the degree of return to scale (constant return to scale if $\rho = 1$), $\frac{1}{1-\eta}$ is the elasticity of substitution between capital and labor (Cobb-Douglas production if $\eta = 0$), and $(1-\alpha)\rho$ is labor share in production.

The process for X_t is non-stationary but its growth rate is stationary, this is in the spirit of the exogenous shock process in long run risk models of Bansal and Yaron (2004), Kaltenbrunner and Lochstoer (2010), and Croce (2012). We specify the growth rate of aggregate productivity $(\Delta \log X_{t+1})$ to be the following

$$\Delta \log X_{t+1} = (1-\rho_X)\,\mu_X + \rho_X \Delta \log X_t + \epsilon_{t+1}^X, \tag{5}$$

which is consistent with long run risk.[9] Δ is the first-difference operator, ϵ_{t+1}^X is an independently and identically distributed (i.i.d.) standard normal shock, and μ_Z and ρ_X are the average growth rate and autocorrelation of the growth rate of aggregate productivity, respectively.

[9] Our process for TFP growth is analogous to a discretized AR(1) process, Bansal and Yaron (2004) use a slightly more complicated formulation where consumption growth is ARMA(1,1). When the short-run and long-run shocks in Bansal and Yaron (2004) are perfectly correlated, their process becomes identical to ours.

Idiosyncratic productivity shocks $\log Z_t^i$ follow an AR(1) process

$$\log Z_{t+1}^i = \rho_Z \log Z_t^i + \epsilon_{t+1}^Z, \tag{6}$$

where ϵ_{t+1}^Z is an i.i.d. standard normal shock that is uncorrelated across all firms in the economy and independent of ϵ_{t+1}^X, and ρ_Z is the autocorrelation of idiosyncratic productivity.

3.1.3 Accounting

The equation for profit is

$$\Pi(K_t^i) = Y_t^i - \overline{w}_t^i N_t^i - \Psi_t^i \tag{7}$$

$\Pi(K_t^i)$ is profit, given by output less labor and operating costs.[10] Operating costs are defined as $\Psi_t^i = f * K_t$; they depend on aggregate (but not firm specific) capital.[11] Labor costs are $\overline{w}_t^i N_t^i$.

The total dividend paid by the firm is

$$D_t^i = \Pi(K_t^i) - I_t^i - \Phi(I_t^i, K_t^i) - \Xi(N_t^i, N_{t-1}^i), \tag{8}$$

which is profit less investment, capital adjustment costs and labor adjustment costs. Capital adjustment costs are given by $\Phi(I_t^i, K_t^i) = \upsilon_t \left(\frac{I_t^i}{K_t^i}\right)^2 K_t^i$ where $\upsilon_t = \upsilon^+$ if $\frac{I_t^i}{K_t^i} > 0$ and $\upsilon_t = \upsilon^-$ otherwise. Asymmetric costs have been shown to quantitatively help with the value premium by Zhang (2005). Labor adjustment costs are given by $\Xi(N_t^i, N_{t-1}^i) = \xi(N_t^i - N_{t-1}^i)^2 K_t$. The labor adjustment costs include advertising of job positions, training and screening of new workers, as well as output that is lost through time taken to readjust the schedule and pattern of production.

[10] As there are no taxes or explicit interest expenses we do not differentiate between operating profit and net income and simply call it profit.

[11] Because productivity is non-stationary, all model quantities are non-stationary and we cannot allow for a constant operating cost as it would grow infinitely large or infinitely small relative to other quantities. All quantities in the model must be scaled by something that is co-integrated with the productivity level, such as aggregate capital. We have also experimented with using the spot wage (w_t) or aggregate productivity (X_t) and the results appear insensitive to this.

3.1.4 The Firm's Problem

We will now formally write down firm i's problem. The firm maximizes the present discounted value of future dividends

$$V_t^i = \max_{I_t^i, N_t^i} E_t[\sum_{j=0,\infty} M_{t+j} D_{t+j}^i], \tag{9}$$

subject to the standard capital accumulation equation

$$K_{t+1}^i = (1-\delta)K_t^i + I_t^i, \tag{10}$$

as well as equations (3), (4), (7), and (8).

3.2 Financial Leverage

It is standard in the literature to assume that all firms keep leverage constant,[12] however in the data leverage is quite sticky. We have solved the model for both constant and sticky leverage. All return moments we report look very similar for both, however dividends are far too volatile if leverage is constant. Because sticky leverage is both realistic, and improves the model's performance, we assume that the firm's choice of debt is sticky and follows

$$\begin{aligned} B_{t+1} &= \rho^B B_t + (1-\rho^B)B_t^* \\ B_t^* &= \lambda(V_t - D_t) \end{aligned} \tag{11}$$

where B_t is the market value of corporate debt (amount borrowed) and B_t^* is the target debt level. We assume that the target debt level is a constant fraction of the firm's ex-dividend value $V_t - D_t$.

Combining this assumption about the evolution of debt with the Modigliani and Miller (1958) second proposition implies that the equity dividend and the equity return are:

$$D_t^E = D_t + B_t - B_{t-1}R_{t-1}^B \tag{12}$$

$$R_t^E = \frac{V_t - B_{t-1}R_{t-1}^B}{V_{t-1} - B_{t-1} - D_{t-1}} \tag{13}$$

[12] One example is Boldrin, Christiano and Fisher (1999) who provide additional discussion.

where D_t is the total payout to all of the firm's financial stakeholders (debt and equity) and R_t^B is the (risky) return on debt.

3.3 Default and Credit Spread

Let R_{t-1}^P be the $t-1$ promised return, whose derivation is discussed below. Default occurs at t if $V_t < B_{t-1}R_{t-1}^P$, since due to limited liability, equity holders can walk away instead of receiving a net return below -100%. When the firm does not default, $R_t^B = R_{t-1}^P$; when the firm does default, the equity return is -100% and creditors take over the firm, so that $R_t^B = \frac{V_t}{B_{t-1}} < R_t^P$. At this stage the firm's debt is reset to zero and then follows Equation 11. The promised payment R_{t-1}^P is set such that

$$1 = E_t[R_{t+1}^B M_{t+1}] = R_t^p E_t[M_{t+1}|d \neq 1] * (1 - p(d=1)) + E_t[M_{t+1}\frac{V_{t+1}}{B_t}|d=1] * p(d=1) \tag{14}$$

where $d=1$ indicates default and $p(d=1)$ is the probability of default.

We define the credit spread CS_t in the model as the difference between the risky return on debt and the riskfree rate, i.e.,

$$CS_t = R_t^B - R_t^f, \tag{15}$$

where $R_t^f = \frac{1}{E_t M_{t+1}}$.

To gain some intuition for why wage rigidity matters for default risk, we will compare the default decision in the frictionless model to the model with wage rigidities. The firm defaults if its realized firm value V_t is not big enough to repay the debt due $B_{t-1}R_{t-1}^P$. This occurs if the firm's idiosyncratic productivity Z is below a cutoff value Z^*, which itself depends on the state of the economy including the aggregate state variables. Mathematically, the cutoff value Z^* can be characterized as

$$\begin{aligned} & Z^*\left(S_t^i, S_t, X_t; \overline{w}_t^i\right) \\ & = \arg\min_Z \left[V_t > B_{t-1}R_{t-1}^P\right] \\ & = \arg\min_Z \left[Y_t^i - \overline{w}_t^i N_t^i - \Psi_t^i - I_t^i - \Phi(I_t^i, K_t^i) - \Xi(N_t^i, N_{t-1}^i) + E_t M_{t+1} V_{t+1} > B_{t-1}R_{t-1}^P\right] \end{aligned} \tag{16}$$

The default decision can be described as follows

$$
\begin{aligned}
&Z > Z^* \text{ stay} \\
&Z \leq Z^* \text{ default}
\end{aligned}
\tag{17}
$$

When a negative aggregate productivity shock hits the economy, gross profit $Y_t^i - \overline{w}_t^i N_t^i$ in the model without wage rigidity will fall roughly proportional to output, whereas the gross profit will fall by more than output in the wage rigidity model. This implies that all else being equal, the cutoff value of idiosyncratic productivity for default in the frictionless model is lower than that of wage rigidity model, i.e.,

$$
Z^*_{frictionless} < Z^*_{rigidity} \tag{18}
$$

Equation (18) implies that the default region in idiosyncratic productivity for the frictionless model is smaller than the wage rigidity model, which is described in equation (19),

$$
\left(-\infty, Z^*_{frictionless}\right] \subset \left(-\infty, Z^*_{rigidity}\right]. \tag{19}
$$

This relationship will directly translate into a higher default probability for the firm in the wage rigidity model. Wage growth negatively whereas labor share positively predicts credit spread because times of low wage growth or high labor share are associated with high wage rigidity and hence high credit risk premium. As we will show quantitatively in the next section, without wage rigidity default risk is too small to generate any time-variation in credit spread in the frictionless model.

3.4 Equilibrium

We assume that there exists some underlying set of state variables S_t which is sufficient for this problem. Each firm's individual state variables are given by the vector S_t^i. Because the household is a representative agent, we are able to avoid explicitly solving the household's maximization problem and simply use the first order conditions to find M_{t+1} as an analytic function of consumption or expectations of future consumption. For instance, with CRRA utility, $M_{t+1} = \beta \left(\frac{C_{t+1}}{C_t}\right)^{-\theta}$ while for Epstein-Zin utility

$M_{t+1} = \beta \left(\frac{C_{t+1}}{C_t}\right)^{-\frac{1}{\psi}} \left(\frac{U_{t+1}}{E_t[U_{t+1}^{1-\theta}]^{\frac{1}{1-\theta}}}\right)^{\frac{1}{\psi}-\theta}$.[13]

Equilibrium consists of:

- Beliefs about the transition function of the state variable and the shocks: $S_{t+1} = f(S_t, X_{t+1})$
- Beliefs about the realized stochastic discount factor as a function of the state variable and realized shocks: $M(S_t, X_{t+1})$
- Beliefs about the aggregate spot wage as a function of the state variable: $w(S_t)$
- Firm policy functions (which depend on S_t and S_t^i) for labor demand N_t^i and investment I_t^i

It must also be the case that given the above policy functions all markets clear and the beliefs turn out to be rational:

- The firm's policy functions maximize the firm's problem given beliefs about the wages, the discount factor, and the state variable.
- The labor market clears: $\sum N_t^i = 1$
- The goods market clears: $C_t = \sum \left(\Pi_t^i + \Psi_t^i + \overline{w}_t^i N_t^i - I_t^i\right) = \sum D_t^i + \overline{w}_t^i N_t^i + \Phi_t^i + \Xi_t^i + \Psi_t^i$. Note that here we are assuming that all costs are paid by firms to individuals and are therefore consumed, the results look very similar if all costs are instead wasted.
- The beliefs about M_{t+1} are consistent with goods market clearing through the household's Euler Equation.[14]
- Beliefs about the transition of the state variables are correct. For instance if aggregate capital is part of the aggregate state vector, then it must be that $K_{t+1} = (1-\delta)K_t + \sum I_t^i$.

[13] Given a process for C_t we can recursively solve for all the necessary expectations to calculate M_{t+1}. The appendix provides more details.

[14] For example, with CRRA $M_{t+1} = \beta \left(\frac{\sum D_{t+1,i} + \overline{w}_t N_{t+1,i} + \Phi_{t+1,i} + \Xi_{t+1,i} + \Psi_{t+1,i}}{\sum D_{t,i} + \overline{w}_t N_{t,i} + \Phi_{t,i} + \Xi_{t,i} + \Psi_{t,i}}\right)^{-\theta}$

4 Results

We present calibration in section 4.1, frictionless model in section 4.2, and the model with wage rigidity in section 4.3.

4.1 Calibration

We solve the model at an annual frequency using a variation of the Krusell and Smith (1998) algorithm, we discuss the solution method in the appendix. The model requires us to choose the preference parameters: β (time discount factor), θ (risk aversion), ψ (intertemporal elasticity of substitution); the technology parameters: α and ρ (jointly determine labor share in output and degree of return to scale), $\frac{1}{1-\eta}$ (elasticity of substitution between labor and capital), δ (depreciation), f (operating cost); the adjustment cost parameters: ν^+ (upward capital adjustment cost), ν^- (downward capital adjustment cost), and ξ (labor adjustment cost). Finally we must choose our key parameter μ which determines the frequency of wage resetting. Below we justify our choices of these parameters.

Table 4 presents parameter choices for two models of interest: (i) a model with a calibrated elasticity of substitution between labor and capital but where all wages are reset each year; (ii) a model with a calibrated elasticity of substitution between labor and capital where wages are reset once every four years on average and where firms face labor adjustment costs ($\xi = 0.15$).

Preferences We set $\beta = 0.995$ to match the level of the risk free rate. We set $\theta = 6.5$ to get a reasonably high Sharpe Ratio, while keeping risk aversion within the range recommended by Mehra and Prescott (1985). The intertemporal elasticity of substitution ψ also helps with the Sharpe Ratio, it is set to 1.5 as in Bansal and Yaron (2004), who show that values above 1 are required for the long run risk channel to match asset pricing moments as this ensures that the compensation for long-run expected growth risk is positive.

Technology The technology parameters are fairly standard and we use numbers consistent with prior literature. We jointly choose $\alpha = 0.25$ and $\rho = 0.853$ so that labor share and profit share are consistent with empirical estimates.[15] Similarly we set

[15] Labor share is $(1-\alpha)\rho = 0.64$. Profit share is $(1-\alpha)(1-\rho) = 0.11$ implying returns to scale of 0.89. Gomes (2001) uses 0.95 citing estimates of just under 1 by Burnside (1996). Burnside, Eichenbaum, and Rebelo (1995) estimate it to be between 0.8 and 0.9. Khan and Thomas (2008) use 0.896, justifying it by matching the capital to output ratio. Bachmann, Caballero and Engel (2013) use 0.82, justifying it by matching the revenue elasticity of capital.

$\eta = -1$ to match empirical estimates of the elasticity of substitution between labor and capital,[16]. We set $\delta = 0.1$ to match annual depreciation.

Operating Cost $\Psi_t = f * K_t$ is a fixed cost from the perspective of the firm, however it depends on the aggregate state of the economy, in particular aggregate capital. We choose f to match the average market-to-book ratio in the economy, which we estimate to be 1.33 (details of this estimation are in the appendix). While we think it is realistic for this cost to increase when aggregate capital is higher (during expansions), the results are not sensitive to this assumption. The results look very similar when Ψ_t is simply growing at the same rate as the economy.[17]Note that fixed costs in the production process also effectively constitute a form of operating leverage. However, its quantitative effect on credit spread is minimal.

Capital Adjustment Costs Within each model, we choose the capital adjustment costs (ν^+ and ν^-) to match the volatility of aggregate investment. Models with different μ or ξ may require a different adjustment cost for investment volatility to match the data, therefore the level of adjustment cost is different across models. Higher adjustment costs always help increase equity volatility and the value premium but they decrease aggregate investment volatility. This restriction on matching aggregate investment limits how much work capital adjustment costs can do in helping to match financial moments.

We set the asymmetry $\frac{\nu^-}{\nu^+} = 5$. This asymmetry in capital adjustment costs helps our model's cross-sectional distribution of investment rate look similar to the data. In particular, the fraction of firms with negative investment is relatively small, while a significant number of firms have brief periods of large positive investment, referred to as spikes. We have also experimented with symmetric adjustment costs, these lead to similar (though slightly smaller) equity volatility.

Labor Adjustment Costs In the model with no labor adjustment cost ($\xi = 0$) the cross-sectional variation in employment growth is far too high. Therefore, we choose the labor adjustment cost ($\xi = 0.15$) to roughly match this cross-sectional variation. The total cost of adjustment (labor and capital) in our model with the highest costs is less

[16]The elasticity of substitution between labor and capital is $\frac{1}{1-\eta} = 0.5$. In a survey article based on a multitude of studies, Chirinko (2008) argues this elasticity is between 0.4 and 0.6. One concern may be that the estimate of η would itself be affected by frictions, such as the one in our paper. However, several of the studies cited by Chirinko (2008) are done with micro-level data specifically to account for frictions, therefore η is the exact model analog of their estimate. Furthermore, we have repeated the exercise in Caballero (2004) to estimate η from aggregate quantities in our model by regressing $log(Y/K)$ on the cost of capital. The estimate of $\frac{1}{1-\eta}$ is 0.5 if the cost of capital is defined as the return on capital, and 0.41 if it is the interest rate plus the log of Tobin's Q.

[17]Recall that the model is non-stationary, therefore Ψ_t cannot be a constant and must be scaled by something that is cointegrated with the size of the economy.

than 1.5% of output. We view this as reasonable, this also falls towards the low end of estimates provided in Hamermesh and Pfann (1996).

Productivity Shocks In order for the long run risk channel to produce high Sharpe ratios, aggregate productivity must be non-stationary with a stationary growth rate. We specify the growth rate of aggregate productivity ($\Delta \log X_t$) to be a symmetric 3-state Markov process with autocorrelation 0.27, unconditional mean of 0.02, and unconditional standard deviation of 0.055. We choose these numbers to roughly match the autocorrelation, growth rate, and standard deviation of output. Aggregate productivity is then $\log(X_{t+1}) = \log(X_t) + \Delta \log X_{t+1}$ which is consistent with long run risk.[18]

The volatility of idiosyncratic productivity shocks $\log Z_t^i$ depends on the model's scale, that is which real world production unit (firm, plant) is analogous to the model's production unit. There is no consensus on the right scale to use, for example the annual autocorrelation and unconditional standard deviation are 0.69 and 0.40 in Zhang (2005), 0.62 and 0.19 in Gomes (2001), 0.86 and 0.04 in Khan and Thomas (2008), while Pastor and Veronesi (2003) estimate that the volatility of firm-level profitability rose from 10% per year in the early 1960s to 45% in the late 1990s. We have experimented with various idiosyncratic shocks and find that our aggregate results are not significantly affected by the size of these shocks. In our model, $\log Z_t^i$ is a 3-state Markov process with autocorrelation and unconditional standard deviation of 0.75 and 0.23 respectively. We believe these shocks make our production units closest to real world firms because, as will be discussed below, these shocks allow us to match various firm moments, such as the cross-sectional variation of investment rate and stock returns.

Frequency of wage resetting In standard models wages are reset once per period and employees receive the marginal product of labor as compensation. This corresponds to the $\mu = 0$ case. However, wages are far too volatile in these models relative to the data. We choose the frequency of resetting to roughly match the volatility of wages in the data. This results in $\mu = 0.75$ or an average resetting frequency of four years.

We also believe that this number is realistic, for example Rich and Tracy (2004) estimate that a majority of labor contracts last between two and five years with a mean of three years, they cite several major renewals (United Auto Workers, United Steel Workers) which are at the top of the range. Anecdotal evidence suggests that assistant professors, investment bankers, and corporate lawyers all wait approximately this long

[18] Our process for TFP growth is analogous to a discretized AR(1) process, Bansal and Yaron (2004) use a slightly more complicated formulation where consumption growth is ARMA(1,1). When the short-run and long-run shocks in Bansal and Yaron (2004) are perfectly correlated, their process becomes identical to ours.

to be promoted. Even if explicit contracts are written for a shorter period than our calibration (or not written at all), we believe that four years is a reasonable estimate of how long the real wage of many employees stays unchanged. Campbell and Kamlani (1997) conducted a survey of 184 firms and find that implicit contracts are an important explanation for wage rigidity of U.S. manufacturing workers, especially of blue-collar workers. For example, if the costs of replacing employees (for employers) and the costs of finding a new job (for employees) are high, the status quo will remain, keeping wages the same without an explicit contract. Another example are workers who receive small raises every year, keeping their real wage constant or growing slowly; indeed, Barwell and Schweitzer (2007) show that this type of rigidity is quite common. Such workers do not experience major changes to their income until they are promoted, or let go, or move to another job. Hall (1982) estimates an average job duration of eight years for American workers, Abraham and Farber (1987) estimate similar numbers just for non-unionized workers (presumably unionized workers have even longer durations).

Given the importance of this parameter for our model, it is useful to note the difference between job length and the separation rate. As mentioned above, average job length is around eight years for American workers. A separation rate is the probability of a worker separating from her job in any particular period. Estimates of separation rates for the US range from 1.1%/month by Hobijn and Sahin (2009), to 3.4%/month by Shimer (2005), with most being around 3%/month. If separations were equally likely for all workers, this would imply an average job length of around 2.8 years - far shorter than our calibrated contract length or job length in the data. This apparent difference is due to a small number of workers who frequently transition between jobs, while a majority of workers stay in their jobs for a long time. For example, Hall (2005) writes "Separation rates are sensitive to the accounting period because a small fraction of jobs but a large fraction of separations come from jobs lasting as little as a day." Hobijn and Sahin (2009) show that 15% of jobs have a tenure below 6 months; Davis, Faberman, and Haltiwanger (2006) show that if one estimates separations based on workers who have held their job for a full quarter (as opposed to all separations), the quarterly separation rate falls from 24% to 10.7%. On the other hand, as mentioned above, estimates of average job length are around 8 years for U.S. workers.

Since, for computational reasons, in our model separation is equally likely for all workers, we can either relate μ to estimated separation rates which will imply that model job length is too low relative to the data, or to estimated job and contract lengths, which will imply that model separation rates are too low relative to the data. We believe that the later is more relevant for our model. Note that workers who separate frequently are likely to be low paid, temporary or part time workers who do not significantly contribute to the firm's wage bill. The majority of the firm's wage bill is likely paid to high skilled and long-tenured workers and the obligations to these workers are likely to be quite sticky.

Financial leverage We estimate the target debt to equity ratio to be 0.59, which implies that $\lambda = 0.37$. We find debt to be quite sticky, with estimates of ρ^B between 0.46 and 0.99, depending on the specification. Details of these estimates are in the appendix. We set $\rho^B = 0.85$ in all of our models, this allows us to match the dividend volatility in the data. As noted earlier, we have also experimented with $\rho^B = 0$; with this calibration all of our key results are very similar to $\rho^B = 0.85$, however the process for equity dividends is far too volatile. We have also experimented with a more complicated leverage process which explicitly smooths dividends, it is possible to make dividends even smoother without altering the main results.

4.2 The Frictionless Model

In this section we will discuss the frictionless model where production function is CES and wages are reset once per year ($\mu = 0$). Panel B in table 5 presents the aggregate quantity moments; table 6 presents the unconditional asset pricing moments of the frictionless model (second row). As has been shown in Favilukis and Lin (2013), this model does well in matching standard macro moments (i.e., consumption, investment, output, etc.), but fails to produce wage volatility, equity premium and equity volatility.

Turning to credit spread predictability, the frictionless model does not generate time-variations in credit spread either. Panel A in table 8 presents the results. Because there is only one aggregate shock in the model, wage growth and labor share are highly negatively correlated. For this reason we do not present regressions containing both wage growth and labor share from the model. In the univariate regression, wage growth counterfactually positively forecasts credit spread, the opposite to the data (column one). Labor share, investment growth, and stock market volatility all predict credit spread with the opposite sign to the data.

4.3 Infrequent resetting of wages

In this section we will discuss our preferred model, which combines infrequent wage renegotiation, labor adjustment costs, and a calibrated CES production function. Panel C in table 5 presents the aggregate quantity moments; table 6 presents the unconditional asset pricing moments of the wage rigidity model (third row). As in Favilukis and Lin

(2013), our preferred model fixes or greatly reduces all of the problems with the standard model in matching wage volatility, and equity volatility. In the following, we will also focus on the novel empirical predictions of the model on the forecastability of credit spread.

Because wages are set infrequently, the average wage is no longer equal to the marginal product of labor but rather a weighted average of past spot wages, this results in average wages being much smoother than the marginal product of labor. Smother wages imply volatile profit which in turn increases the default probability and credit spread.

Table 7 presents the default probabilities implied by the best model for corporate bonds with different rating and the data counterpart. Overall, the model does a reasonable job matching the cross sectional distribution of default rates. The model predicts zero default probabilities for AAA-AA, A, and BBB rated bonds, slightly below the data. The default probability of BB bonds in the model is 1% and B bonds is 4%, both of which fall into the data range. CCC's default probability is 25%, somewhat higher than the data.

Panel B in table 8 presents the regression results. Wage growth negatively forecasts credit spread with the slope at -17.65, which is fairly close to the data counterpart at -16.44. Similarly, labor share positively forecasts credit spread with the slope coefficient at 9.61, which is also close to the data slope of 10.97. It is worth noting that stock market volatility also positively forecasts credit spread, consistent with the data. Investment growth negatively forecasts credit spread. It is clear that wage rigidity is crucial to generate time-variations in credit spread that is consistent with data. Without wage rigidity, variables predicting credit spread all have the wrong sign.

5 Conclusion

Labor market variables have significant impact in driving the credit spread fluctuations. We show that wage growth and labor share can forecast credit risk as well as or better than the standard predictors including financial leverage and market volatility. We build a DSGE model with labor market rigidities that can explain this link. This is because pre-committed payments to labor make other committed payments (such as debt) more risky; for this reason variables related to pre-committed labor payments forecast credit risk.

Our results have implications for asset pricing, labor economics, and macroeconomics literature. Our findings suggest that labor market frictions, in particular, wage rigidity can have a significant impact on corporate bond prices. Credit market variables, which are typically ignored in the labor economics literature, can thus be a useful source of information for quantifying frictions in labor markets. Our results suggest that incorporating time-varying credit risk in current DSGE models can be important for an accurate understanding of labor market dynamics over the business cycle.

References

Abraham, Katherine, and Henry Farber, 1987, Job duration, seniority, and earnings, *American Economic Review* 77, 278–297.

Bachmann, Ruediger., and Ricardo J. Caballero, Eduardo M.R.A. Engel, 2013, Aggregate Implications of Lumpy Investment: New Evidence and a DSGE Model, *American Economic Journal: Macroeconomics*, 5(4): 29-67

Bansal, Ravi, and Amir Yaron, 2004, Risks for the long run: A potential resolution of asset pricing puzzles, *Journal of Finance* 59, 1481–1509.

Barwell, Richard, and Mark Schweitzer, 2007, The incidence of nominal and real wage rigidities in Great Britain: 1978-98, *Economic Journal* 117, 553–569.

Bauer, Thomas, Lorenz Goette, and Uwe Sunde, 2007, Wage rigidity: Measurement, causes and consequences, *Economic Journal* 117, 499–507.

Belo, Frederico., Xiaoji Lin, and Santiago Bazdresch, 2013, Labor hiring, investment and stock return predictability in the cross section, Forthcoming, *Journal of Political Economy.*

Boldrin, M., L. Christiano, and J. Fisher, 1999, Habit persistence, asset returns, and the business cycle, Federal Reserve Bank of Chicago Working Paper No. 99-14.

Boldrin, M., L. Christinano and J. Fisher. 2001. Habit persistence, asset returns, and the business cycle, *American Economic Review* 91 (1), 149–166.

Burnside, Craig, 1996, Production function regressions, returns to scale, and externalities, *Journal of Monetary Economics* 37, 177–201.

Burnside, Craig, Martin Eichenbaum, and Sergio Rebelo, 1995, Capital utilization and returns to scale, *NBER Macroeconomics Annual* 10, 67–110.

Caballero, R., 1994, Small sample bias and adjustment costs, *The Review of Economics and Statistics* 76, 52–58.

Campbell, John Y., and Robert Shiller, 1988, Stock prices, earnings and expected dividends, *Journal of Finance* 43, 661–676.

Calvo, Guillermo A, 1982, Staggered contracts and exchange rate policy, In: J.A. Frankel, ed., Exchange Rates and International Macroeconomics (University of Chicago Press, Chicago, IL).

Chen, Hui, 2010, Macroeconomic conditions and the puzzles of credit spreads and capital structure, *Journal of Finance* 65, 2171-2212.

Chen, Long, Pierre Collin-Dufresne, and Robert S. Goldstein, 2009, On the relation between credit spread puzzles and the equity premium puzzle, *Review of Financial Studies* 22, 3367-3409.

Collin-Dufresne, Pierre, Robert Goldstein, and J. Spencer Martin, 2001, The determinants of credit spread changes, *Journal of Finance* 56, 2177-2207.

Collin-Dufresne, Pierre, and Robert S. Goldstein, 2001, Do credit spreads reflect stationary leverage ratios? *Journal of Finance* 56, 1929-1957.

Chirinko, Robert, 2008, [sigma]: The long and short of it, *Journal of Macroeconomics* 30, 671–686.

Croce, Marano Massimilliano, 2012, Long-run productivity risk: A new hope for production-based asset pricing, Working Paper, University of North Carolina.

Davis, Steven, Jason Faberman, and John Haltiwanger, 2006, The flow approach to labor markets: New data sources and micro-macro links, *Journal of Economic Perspectives* 20, 3–26.

Devicenti, Francesco, Agata Maida, and Paolo Sestito, 2007, Downward wage rigidity in Italy: Micro-based measures and implications, *Economic Journal* 117, 530–552.

Dickens, William, Lorenz Goette, Erica Groshen, Steinar Holden, Julian Messina, Mark Schweitzer, Jarkko Turunen, and Melanie Ward, 2007, How wages change: Micro evidence from the international wage flexibility project, *Journal of Economic Perspectives* 21, 195–214.

Elton, Edwin J., Martin J. Gruber, Deepak Agrawal, and Christopher Mann. 2001. Explaining the Rate Spread on Corporate Bonds. *Journal of Finance* 56(1), 247-277.

Epstein, L., and S. Zin. 1989. Substitution, risk aversion, and the temporal behavior of consumption and asset returns: a theoretical framework, *Econometrica* 57, 937–969.

Favilukis, Jack, and Xiaoji Lin, 2013, Wage rigidity: a quantitative solution to several asset pricing puzzles, Working Paper.

Gertler, Mark and Antonella Trigari, 2009, Unemployment Dynamics with Staggered Nash Wage Bargaining, *Journal of Political Economy*, 117 (1), 38-86.

Gomes, Joao, 2001, Financing investment, *American Economic Review* 91, 1263–1285.

Gomes, Joao, and Lukas Schmid, 2010, Equilibrium Credit Spreads and the Macroeconomy, Working paper.

Gomes, Joao, Urban Jermann, and Lukas Schmid, 2013, Sticky leverage, Working Paper.

Gourio, Francois, 2013, Credit risk and Disaster risk, *American Economic Journal: Macroeconomics*, 5(3):1-34, 2013

Hackbarth, Dirk, Jianjun Miao, and Erwan Morellec, 2006, Capital structure, credit risk and macroeconomic conditions, *Journal of Financial Economics* 82, 519-550.

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

Hamermesh, Daniel, and Gerard Pfann, 1996, Adjustment costs in factor demand, *Journal of Economic Literature* XXXIV, 1264–1292.

Hobijn, Bart, and Aysegul Sahin, 2009, Job-finding and separation rates in the oecd, *Economic Letters* 104, 107–111.

Kaltenbrunner, Georg, and Lars Lochstoer, 2010, Long-run risk through consumption smoothing, Review of Financial Studies.

Khan, Aubhik., and Julia Thomas, 2008, Idiosyncratic Shocks and the Role of Nonconvexities in Plant and Aggregate Investment Dynamics, *Econometrica* 76 (2): 395 - 436

Krusell, P and Smith, A.A. 1998, Income and Wealth Heterogeneity in the Macroeconomy, *Journal of Political Economy*, 106(5): 867-896.

Kuehn, Lars-Alexander, and Lukas Schmid, 2013, Investment-Based Corporate Bond Pricing, Working Paper.

Kuehn, Lars-Alexander, Nicolas Petrosky-Nadeau, and Lu Zhang, 2013, An equilibrium asset pricing model with labor markets search, Working Paper.

Mehra, Rajnish, and Edward Prescott, 1985, The equity premium: A puzzle, *Journal of Monetary Economics* 15, 145–161.

Modigliani, F., and M. Miller, 1958, The cost of capital, corporation finance and the theory of investment, *American Economic Review* 48, 261–297.

Mortensen, Dale, and Christopher Pissarides, 1994, Job creation and job destruction in the theory of unemployment, *Review of Economic Studies* 61, 397–415.

Newey, Whitney, and Kenneth West, 1987, A simple, positive semi-definite, heteroskedasticity and autocorrelation consistent covariance matrix, *Econometrica* 55, 703–708.

Pastor, Lubos, and Pietro Veronesi, 2003, Stock valuation and learning about profitability, *Journal of Finance* 58, 1749–1789.

Pissarides, Christopher, 1979, Job matchings with state employment agencies and random search, *Economic Journal* 89, 818–833.

Pissarides, Christopher, 2009, The Unemployment Volatility Puzzle: Is Wage Stickiness the Answer? *Econometrica*: 1339-1369

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

Sweeney, Richard, Arthur Warga, and Drew Winters, 1997, The market value of debt, market versus book value of debt, and returns to assets, *Financial Management* 26, 5–21.

Taylor, J.B., 1983, Union wage settlements during a disinflation, *American Economic Review* 73, 981–993.

Taylor, J.B., 1999, Staggered price and wage setting in macroeconomics, In: John B. Taylor and Michael Woodford (Eds.) Handbook of Macroeconomics, North-Holland, Elsevier, 1, Part 2 pp. 1009–1050.

Zhang, Lu, 2005. The value premium. *Journal of Finance* 60 (1), 67–103

A Estimation of market-to-book and debt-to-equity

The relevant market-to-book ratio is the one for the entire firm value (the enterprise value). From Compustat we calculate the market-to-book ratio for equity to be 1.64 and the book debt to market equity ratio to be 0.59. [**?**] find that outside of the Volcker period aggregate market to book values for debt are very close to one. These numbers imply a market to book of 1.33 for enterprise value. This also implies that the debt to value ratio is $\lambda = \frac{0.59}{1+0.59} = 0.37$; this is the number we use in our calibration. An alternative is to estimate $\lambda = Avg(\frac{B}{B+E})$ where B is the value of debt from the flow of funds and E is the total market value of equity from CRSP (both variables are described in more detail in the next section). This method implies $\lambda = 0.41$, this slightly higher leverage would make our results even stronger.

B Estimation of ρ^B

To estimate the dependence of debt issuance on past issuance we use levels of debt from the flow of funds. In particular, we aim to estimate $B_{t+1} = \rho^B B_t + (1-\rho^B) * \lambda V_t$ where B is the market value of corporate debt and V is the enterprise value of the corporate sector (equity plus debt). We define B to be non-financial credit market instrument liabilities (line 28 from Table L.101 in the Flow of Funds).[19] We define V to be B plus total market value of NYSE/AMEX/NASDAQ from CRSP.[20] Because the values of debt and equity are non-stationary, we cannot directly estimate the equation above.

We use several different specifications to estimate ρ^B. In particular specification 1 simply estimates ρ^B to be the autocorrelation of HP filtered B. In specification 2 we regress $B_{t+1} = a_0 + a_1 B_t + a_2 V_t$ where both B and V are HP filtered; we either define $\rho^B = a_1$ (specification 2a, λ unrestricted) or $\rho^B = 1 - a_2/\lambda$ (specification 2b, $\lambda = 0.37$). However, the HP filter may cause the estimation to miss out on important low frequency dependence of debt on past debt. In specifications 3 and 4 we do not HP filter. In specification 3, we regress $B_{t+1}/B_t = a_0 + a_1 V_t/B_t$ and either define $\rho^B = a_0$ (specification

[19] As an alternative, we defined debt to be credit market liabilities minus assets (line 7 from Table L.101) and the estimated ρ^B is very similar because the credit assets of non-financial corporations are very small relative to liabilities.

[20] Since the set of firms in CRSP is not exactly the same firms as the ones for whom debt is defined in the flow of funds, this definition of V is slightly problematic. However, note that this should mostly affect our estimate of λ but not necessarily ρ^B. For this reason we use other sources to estimate λ, this is described in the previous section. Nevertheless, as discussed in the previous section, the two methods imply similar values for λ. Furthermore, we have redone everything with logs, or by defining V to be just market value, without adding the debt and estimates of ρ^B are very similar.

Table 1: Estimates of ρ^B

This table presents estimates of ρ^B for several different specifications. The specifications are described in detail in the text.

Specification	λ unrestricted	$\lambda = 0.37$
1	0.61	–
2	0.46	0.49
3	0.99	0.94
4	–	0.81

3a, λ unrestricted) or $\rho^B = 1 - a_1/\lambda$ (specification 3b, $\lambda = 0.37$. Finally, in specification 4 we regress $B_{t+1}/B_t - B_t/B_{t-1} = a_0 + a_1(V_t/B_t - V_{t-1}/B_{t-1})$ and define $\rho^B = 1 - a_1/\lambda$ where $\lambda = 0.37$. The different estimates are presented in a Table 1.

C Numerical Solution

C.1 Making the Model Stationary

Note that the model is not stationary. In order to solve it numerically, we must rewrite it in terms of stationary quantities. We will show that a normalizing all non-stationary variables by Z_t^ρ implies a stationary competitive equilibrium. We will do this in two steps. First we will show that if the firm believes that the stochastic discount factor is stationary and that aggregate quantities (in particular the spot wage) normalized by Z_t^ρ are stationary than the firm's policy functions normalized by Z_t^ρ will also be stationary. Second we show that these policy functions imply that these aggregate quantities are indeed stationary when normalized by Z_t^ρ.

The firm's problem is:

$$\begin{aligned} V(Z_t^i, K_t^i, N_{t-1}^i, \overline{W}_{t-1}^i; Z_t, K_t, S_t, \overline{W}_{t-1}) \quad = \quad & \max\nolimits_{I_t^i, N_t^i} Z_t^i \left(\alpha(K_t^i)^\eta + (1-\alpha)(Z_t N_t^i)^{\rho\eta}\right)^{\frac{1}{\eta}} \\ & - \left(\overline{W}_{t-1}^i N_{t-1}^i \mu + W_t(N_t^i - N_{t-1}^i \mu)\right) - W_t f \\ & - \upsilon_t \left(\frac{I_t^i}{K_t^i} - \delta\right)^2 K_t^i - \xi \left(N_t^i - N_{t-1}^i\right)^2 W_t \\ & + E_t[M_{t+1} V(Z_{t+1}^i, K_{t+1}^i, N_t^i, \overline{W}_t^i; Z_{t+1}, K_{t+1}, S_{t+1}, \overline{W}_t)] \end{aligned} \tag{20}$$

Where Z_t^i is the idiosyncratic productivity, K_t^i is the firm's individual capital, N_{t-1}^i is the firm's employment last period, $\overline{W}_{t-1}^i$ is the firm's average wage last period, Z_t is aggregate productivity, $\overline{W}_{t-1}$ is the aggregate average wage from last period, and W_t is the spot wage this period. Following Krusell and Smith (1998) the state space potentially contains all information about the joint distribution of capital and productivity. K_t and S_t summarize this distribution. We explicitly write its first moment K_t as an aggregate state variable and let S_t be a vector of any other relevant moments normalized by the mean (i.e. the normalized second moment is $E[(K_t^i - K_t)^2]/K_t^2$).

On the right of this equation the first line contains output, the second line labor expenses and operating costs, the third line adjustment costs of capital and labor, and the fourth the firm's continuation value.

Households have beliefs about the evolution of the aggregate quantities M_{t+1}, K_t, and S_t and about the spot wage as a function of the aggregate state. Aggregate wage evolves as $\overline{W}_t = \mu\overline{W}_{t-1} + (1-\mu)W_t$. The individual state variables evolve as:

$$\begin{aligned} K_{t+1}^i &= (1-\delta)K_t^i + I_t^i \\ \overline{W}_t^i &= \frac{\overline{W}_{t-1}^i N_{t-1}^i \mu + (N_t^i - N_{t-1}^i \mu)W_t}{N_t^i} \end{aligned} \tag{21}$$

Let us define $k_t^i = \frac{K_t^i}{Z_t^\rho}$, $k_t = \frac{K_t}{Z_t^\rho}$, $i_t^i = \frac{I_t^i}{Z_t^\rho}$, $w_t = \frac{W_t}{Z_t^\rho}$, $\overline{w}_t^i = \frac{\overline{W}_t^i}{Z_{t+1}^\rho}$, and $\overline{w}_t = \frac{\overline{W}_t}{Z_{t+1}^\rho}$ (not that the timing of $\overline{w}_t^i$ and $\overline{w}_t$ differs from the others). We will now show by induction that the value function is linear in Z_t^ρ. Suppose this is true at t+1:

$$V(Z_{t+1}^i, K_{t+1}^i, N_t^i, \overline{W}_t^i; Z_{t+1}, K_{t+1}, S_{t+1}, \overline{W}_t) = Z_{t+1}^\rho V(Z_{t+1}^i, k_{t+1}^i, N_t^i, \overline{w}_t^i; 1, k_{t+1}, S_{t+1}, \overline{w}_t)$$

Than we can rewrite the firm's problem as:

$$\begin{aligned} V(Z_t^i, k_t^i, N_{t-1}^i, \overline{w}_{t-1}^i; 1, k_t, S_t, \overline{w}_{t-1}) \;=\; & \max_{i_t^i, N_t^i} Z_t^i \left(\alpha (k_t^i)^\eta + (1-\alpha)(N_t^i)^{\rho\eta}\right)^{\frac{1}{\eta}} \\ & - \left(\overline{w}_{t-1}^i N_{t-1}^i \mu + w_t (N_t^i - N_{t-1}^i \mu)\right) - w_t f \\ & - \upsilon_t \left(\frac{i_t^i}{k_t^i} - \delta\right)^2 k_t^i - \xi \left(N_t^i - N_{t-1}^i\right)^2 w_t \\ & + E_t[\left(\frac{Z_{t+1}}{Z_t}\right)^\rho M_{t+1} V(Z_{t+1}^i, k_{t+1}^i, N_t^i, \overline{w}_t^i; 1, k_{t+1}, S_{t+1}, \overline{w}_t)] \end{aligned} \tag{22}$$

where the aggregate wage evolves as $\overline{w}_t = (\mu\overline{w}_{t-1} + (1-\mu)w_t)\left(\frac{Z_{t+1}}{Z_t}\right)^{-\rho}$ and the individual state variables evolve as:

$$\begin{aligned} k_{t+1}^i &= ((1-\delta)k_t^i + i_t^i)\left(\frac{Z_{t+1}}{Z_t}\right)^{-\rho} \\ \overline{w}_t^i &= \left(\frac{\overline{w}_{t-1}^i N_{t-1}^i \mu + (N_t^i - N_{t-1}^i \mu) w_t}{N_t^i}\right)\left(\frac{Z_{t+1}}{Z_t}\right)^{-\rho} \end{aligned} \tag{23}$$

As long as $\left(\frac{Z_{t+1}}{Z_t}\right)^\rho$, M_{t+1}, k_{t+1}, and w_{t+1} are stationary this is a well defined stationary problem where the firm's optimal policy (i_t^i and N_t^i) will also be stationary. But this implies that k_{t+1}^i and $k_{t+1} = \sum k_{t+1}^i$ are stationary as well, confirming the firm's beliefs.

It is similarly straight forward to show that the stochastic discount factor is stationary. First of all note that M_{t+1} is related to the growth rate of consumption, so it should be stationary. More formally:

$$\begin{aligned} U_t &= \left(C_t^{1-\frac{1}{\psi}} + \beta E_t[U_{t+1}^{1-\theta}]^{\frac{1-\frac{1}{\psi}}{1-\theta}} \right)^{\frac{1}{1-\frac{1}{\psi}}} \\ M_{t+1} &= \beta \left(\frac{U_{t+1}}{E_t[U_{t+1}^{1-\theta}]^{\frac{1}{1-\theta}}} \right)^{\frac{1}{\psi}-\theta} \left(\frac{C_{t+1}}{C_t} \right)^{-\frac{1}{\psi}} \end{aligned} \tag{24}$$

Define $c_t = \frac{C_t}{Z_t^\rho}$ and $u_t = \frac{U_t}{Z_t^\rho}$ and note that the firm's optimal policy implies that c_t is stationary. Now we can rewrite the above equations as:

$$\begin{aligned} u_t &= \left(c_t^{1-\frac{1}{\psi}} + \beta E_t[\left(\frac{Z_{t+1}}{Z_t}\right)^\rho u_{t+1}^{1-\theta}]^{\frac{1-\frac{1}{\psi}}{1-\theta}} \right)^{\frac{1}{1-\frac{1}{\psi}}} \\ M_{t+1} &= \beta \left(\frac{\left(\frac{Z_{t+1}}{Z_t}\right)^\rho u_{t+1}}{E_t[\left(\frac{Z_{t+1}}{Z_t}\right)^\rho u_{t+1}^{1-\theta}]^{\frac{1}{1-\theta}}} \right)^{\frac{1}{\psi}-\theta} \left(\frac{c_{t+1}}{c_t} \right)^{-\frac{1}{\psi}} \left(\frac{Z_{t+1}}{Z_t} \right)^{-\frac{\rho}{\psi}} \end{aligned} \tag{25}$$

which are stationary as long as c_t is stationary.

Next, we must show that the spot wage is stationary. The firm's first order condition for labor implies:

$$w_t = Z_t^i \left(\alpha(k_t^i)^\eta + (1-\alpha)(N_t^i)^{\rho\eta} \right)^{\frac{1-\eta}{\eta}} (1-\alpha)\rho(N_t^i)^{\rho\eta-1} + E_t[\left(\frac{Z_{t+1}}{Z_t} \right)^\rho M_{t+1} \frac{\partial V_{t+1}}{\partial N_t^i}] \tag{26}$$

For every firm, the right hand side is well defined and stationary, therefore the wage is too. To jointly find the wage and each firm's choice of N_t^i one must solve a system of N equations. N-1 equations where the right hand side of the first order condition for firm 1 is set equal to firm i (i=2,N), and the labor market clearing equation $\sum N_t^i = 1$.

There remains one last complication, is S_t stationary? This is related to a more general problem of the validity and accuracy of the Krusell and Smith (1998) algorithm. We cannot give an explicit answer as it is not clear what exactly S_t must contain. Krusell and Smith (1998) argue that S_t should contain higher order moments of the distribution since they fully describe the distribution. Since we define S_t to be normalized by its first moment, it is likely that these normalized higher moments are stationary. We have also checked the behavior of several simulated higher order moments and they appear stationary. In practice our numerical algorithm (described in the next section) only considers the first moment so S_t is an empty set, which is stationary by definition.

C.2 Numerical Algorithm

We will now describe the numerical algorithm used to solve the stationary problem above. We will first describe the algorithm used to solve a model with CRRA utility and then the extension necessary to solve the recursive utility version. The algorithm is a variation of the algorithm in Krusell and Smith (1998).

The aggregate state space is potentially infinite because it contains the full distribution of capital across firms. We follow Krusell and Smith (1998) and summarize it by the average aggregate capital k_t and the state of aggregate productivity ΔZ_t; because past wages matter, we augment the aggregate state space with the previous period's average wage $\overline{w}_{t-1}$. Each of these is put on a grid, with the grid sizes of 20 for capital and 9 for past wage. Productivity is a 3-state Markov process. We also discretize the firm's individual state space with grid sizes of 25 for individual capital (k_t^i), 11 for last period's labor (N_{t-1}^i), and 5 for last period's average wage ($\overline{w}_{t-1}^i$). Individual productivity is a 2-state Markov process. We chose these grid sizes after careful experimentation to determine which grid sizes had the most effect on Euler equation errors and predictive R^2.

For each point in the aggregate state space $(k_t, \overline{w}_{t-1}, \Delta Z_t)$ we start out with an initial belief about consumption, spot wages, and investment (c_t, w_t, and i_t); note that this non-parametric approach is different from Krusell and Smith (1998).[21] From these we can solve for aggregate capital next period $k_{t+1} = ((1-\delta)k_t + i_t)\left(\frac{Z_{t+1}}{Z_t}\right)^{-\rho}$ for each realization of the shock. Combining k_{t+1} with beliefs about consumption as a function of capital we can also solve for the stochastic discount factor next period: $M_{t+1} = \beta\left(\frac{c_{t+1}}{c_t}\right)^{-\theta}\left(\frac{Z_{t+1}}{Z_t}\right)^{-\theta\rho}$. This is enough information to solve the stationary problem described in the previous section. We solve the problem by value function iteration with the output being policies and market values of each firm for each point in the state space.

The next step is to use the policy functions to simulate the economy. We simulate the economy for 5500 periods (we throw away the initial 500 periods). In addition to the long simulation, we start off the model in each point of the aggregate state space. We must do this because unlike Krusell and Smith (1998), the beliefs in our algorithm are non-parametric and during the model's typical behavior it does not visit every possible point in the state space. From the simulation we form simulation implied beliefs about

[21] The standard [?] algorithm instead assumes a functional form for the transition, such as $log(\overline{k}_{t+1}) = A(Z_t) + B(Z_t)log(\overline{k_t})$ and forms beliefs only about the coefficients $A(Z_t)$ and $B(Z_t)$ however we find that this approach does not converge in many cases due to incorrect beliefs about off-equilibrium situations and that our approach works better. Without heterogeneity and infrequent resetting we would not need beliefs about w_t because it would just be the marginal product of aggregate capital. Similarly, we would not need beliefs about c_t as we could solve for it from $y_t = c_t + i_t$ where y_t is aggregate output, however aggregate output is no longer a simple analytic function of aggregate capital.

c_t, w_t, and i_t at each point in the aggregate state space by averaging over all periods in which the economy was sufficiently close to that point in the state space. Our updated beliefs are a weighted average of the old beliefs and the new simulation implied beliefs.[22] With these updated beliefs we again solve the firm's dynamic program; we continue doing this until convergence.

In order to solve this model with recursive preferences an additional step is required. Knowing c_t and k_{t+1} as functions of the aggregate state is not alone enough to know M_{t+1} because in addition to consumption growth, it depends on the household's value function next period: $M_{t+1} = \beta \left(\frac{C_{t+1}}{C_t}\right)^{-\frac{1}{\psi}} \left(\frac{U_{t+1}}{E_t[U_{t+1}^{1-\theta}]^{\frac{1}{1-\theta}}}\right)^{\frac{1}{\psi}-\theta}$. However this problem is not difficult to overcome. After each simulation step we use beliefs about c_t and k_{t+1} to recursively solve for the household's value function at each point in the state space. This is again done through value function iteration, however as there are no choice variables this recursion is very quick.

We perform the standard checks proposed by Krusell and Smith (1998) to make sure we have found the equilibrium. Although our beliefs are non-parametric, we can still compute an R^2 analogous to a regression; all of the R^2 are above 0.999. We have also checked that an additional state variable (either the cross-sectional standard deviation of capital or lagged capital) does not alter the results.

[22] The weight on the old belief is often required to be very high in order for the algorithm to converge. This is because while rational equilibria exist, they are only weakly stable in the sense described by [?]. However, we find that this is only a problem when capital adjustment costs are very close to zero.

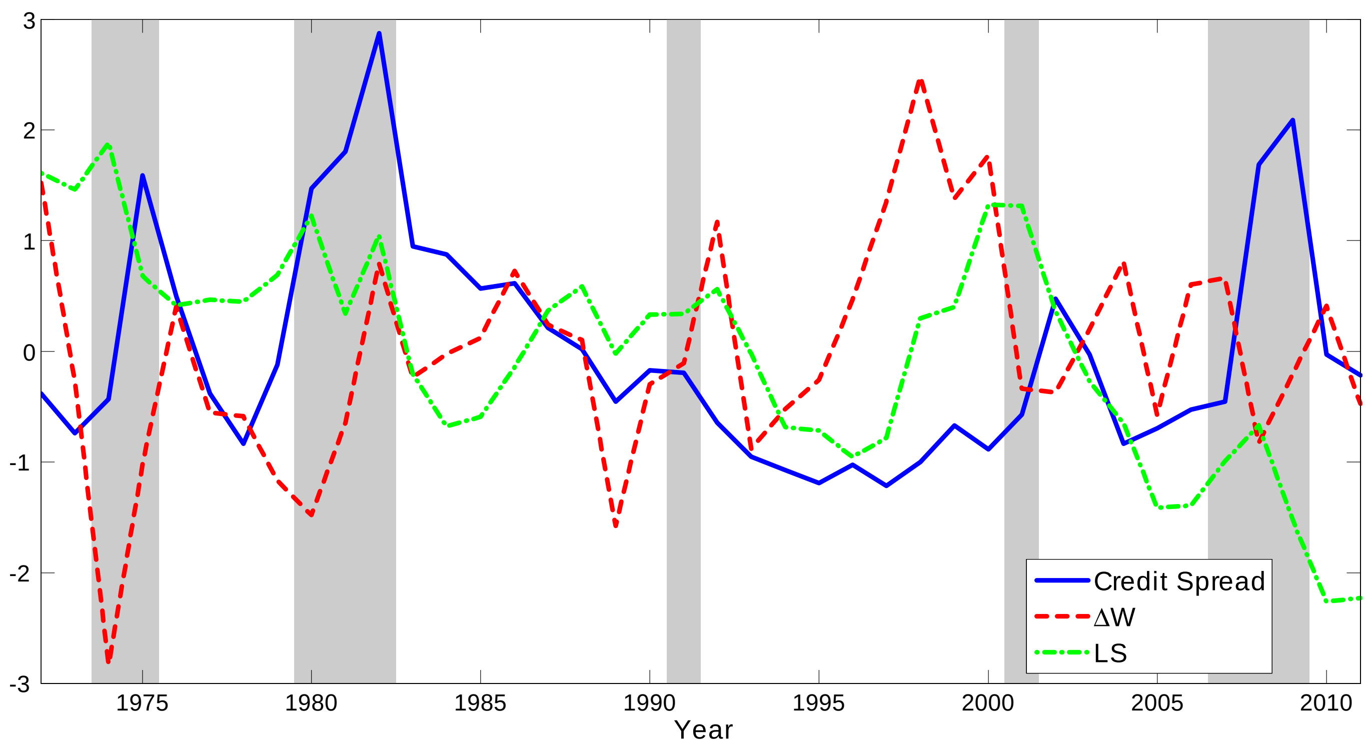

Figure 1: **Labor Market Variables and Credit Spread**

This figure plots the Baa-Aaa credit spread, wage growth (ΔW) and labor share (LS). Wage growth is the growth rate of real wages & salaries per employee; labor share is the total compensation scaled by GDP, and credit spread is the Moody's Baa-Aaa corporate bond yield. Sample is from 1948 to 2012. The grey bars are the NBER recessions. All variables are standardized to allow for an easy comparison in one plot.

Table 2

Descriptive Statistics

Panel A reports the descriptive statistics of the variables of interests. Panel B reports the cross correlations of the variables. Term spread, credit spread, market volatility, and spot rate are in percentage terms. Credit spread (CreditSpd) is the Moody's Baa-Aaa corporate bond yield. Wage growth (ΔW) is the growth rate of real wages & salaries per employee; investment growth (InvGr) is the growth rate of real private nonresidential fixed investment; labor share (LS) is the aggregate compensation divided by GDP; P/E is the equity price to earnings ratio from Shiller; term spread (TS) is the long-term government bond yield (10 year) minus the short-term government bond yield (1 year); financial leverage (FinLev) is book value of nonfinancial corporate bonds divided by the market value of equities of nonfinancial corporate sector. Market volatility (MktVol) is the annual volatility of CRSP value-weighted market premium; spot rate (SpotRate) is the real 1 year government bond yield from Shiller's webpage. Sample is from 1948 to 2012.

Panel A Summary Statistics

	Mean	Std	AC
ΔW	0.02	0.01	0.45
LS	0.55	0.01	0.85
InvGr	0.04	0.06	0.2
FinLev	0.27	0.07	0.75
MktVol	0.14	0.05	0.31
P/E	18.29	7.56	0.91
TS	1.36	1.3	0.44
SpotRate(1yr)	1.68	2.69	0.54
CreditSpd	0.95	0.41	0.75

Panel B Cross Correlation

	GDPGr	ΔW	LS	InvGr	FinLev	MktVol	P/E	TS	SpotRate
ΔW	0.4								
LS	-0.18	-0.17							
InvGr	0.77	0.21	-0.06						
FinLev	-0.32	-0.56	-0.16	-0.29					
MktVol	-0.34	-0.24	0.3	-0.32	0.37				
P/E	0.07	0.23	0.07	0.2	-0.47	0.02			
TS	-0.15	0.03	-0.2	-0.29	0.25	-0.01	-0.05		
SpotRate	-0.16	0.12	0.25	-0.06	-0.18	0.05	-0.02	0.02	
CreditSpd	-0.52	-0.44	0.2	-0.5	0.5	0.45	-0.33	0.25	0.3

Table 3

Labor Market Variables and Credit Spread

This table reports the predictive regression of variables of interests for credit spread. Wage growth (ΔW) is the growth rate of real wages & salaries per employee; investment growth (InvGr) is the growth rate of real private nonresidential fixed investment; labor share (LS) is the aggregate compensation divided by GDP; P/E is the equity price to earnings ratio from Shiller; term spread (TS) is the long-term government bond yield (10 year) minus the short-term government bond yield (1 year); financial leverage (FinLev) is book value of nonfinancial corporate bonds divided by the market value of equities of nonfinancial corporate sector. Market volatility (MktVol) is the annual volatility of CRSP value-weighted market premium; spot rate (SpotRate) is the real 1 year government bond yield from Shiller's webpage. [t] are heteroscedasticity and autocorrelation consistent t-statistics (Newey-West). Sample is from 1948 to 2012.

	Panel A: Univariate							
	1	2	3	4	5	6	7	8
ΔW	-16.44							
[t]	-4.25							
LS		10.97						
[t]		2.03						
InvGr			-1.31					
[t]			-2.46					
FinLev				2.98				
[t]				4.7				
MktVol					3.57			
[t]					4.74			
P/E						-0.01		
[t]						-0.81		
TS							-5.68	
[t]							-1.01	
SpotRate								3.27
[t]								1.48
Adjusted $R^{\hat{2}}$	0.31	0.08	0.03	0.21	0.21	0.02	0.02	0.03

Labor Market Variables and Credit Spread (Contd)

	Panel B: Bivariate (ΔW + predictor)					
ΔW	-15.89	-12.76	-13.88	-15.98	-16.26	-17.28
[t]	-3.86	-2.84	-4.21	-4.88	-4.8	-3.75
InvGr	-0.58					
[t]	-1.08					
FinLev		1.44				
[t]		2.14				
MktVol			2.66			
[t]			5.47			
P/E				0		
[t]				-0.41		
TS					-4.99	
[t]					-1.51	
SpotRate						4.22
[t]						2.29
Adjusted $R^{\hat{2}}$	0.31	0.34	0.42	0.31	0.33	0.38

	Panel C: Bivariate (LS + predictor)					
LS	10.68	13.15	6.73	11.62	10.12	9.79
[t]	2.01	3.28	1.45	1.92	2.01	1.79
InvGr	-1.23					
[t]	-2.5					
FinLev		3.26				
[t]		6.38				
MktVol			3.15			
[t]			4.63			
P/E				-0.01		
[t]				-1.06		
TS					-3.93	
[t]					-0.74	
SpotRate						2.32
[t]						1.01
Adjusted R^2	0.11	0.34	0.23	0.12	0.08	0.09

Labor Market Variables and Credit Spread (Contd)

	Panel D: Multivariate								
ΔW	-15.24	-14.69	-9.57	-13.37	-14.5	-15.24	-16.32	-9.45	
[t]	-4.07	-3.79	-2.52	-4.16	-3.79	-4.35	-3.49	-2.91	
LS	7.28	7.28	10.02	4.48	7.75	6.44	5.15	4.07	
[t]	2.11	2.2	3.1	1.74	1.79	1.8	1.34	1.18	
InvGr		-0.57						-0.17	-0.43
[t]		-1.24						-0.34	-0.76
FinLev			2.04					2.09	3.23
[t]			3.56					2.21	3.32
MktVol				2.42				1.58	1.81
[t]				5.42				2.76	1.98
P/E					-0.01			0	0
[t]					-0.59			0.13	0.26
TS						-3.92		-7.58	-10.45
[t]						-1.14		-2.3	-2.49
SpotRate							3.67	4.2	4.53
[t]							1.76	2.4	3.18
Adjusted R^2	0.34	0.34	0.4	0.43	0.34	0.35	0.39	0.52	0.43

Table 4

Calibration

All model parameters are listed in this table. Note that most parameters are shared by all models and only five parameters (η, υ^{+}, f, μ, and ξ) vary across models.

Parameter	Description	Frictionless Model	Benchmark
		Preferences	
β	Time Preference	0.995	0.995
θ	Risk Aversion	6.5	6.5
ψ	IES	1.5	1.5
		Production	
$(1-\alpha)\rho$	Labor Share	0.64	0.64
$\alpha+\rho-\alpha\rho$	Returns to Scale	0.89	0.89
$\frac{1}{1-\eta}$	Labor Capital Elasticity	0.50	0.50
δ	Depreciation	0.10	0.10
υ^{+}	Upward Adj. Cost	0.07	0.17
$\frac{\upsilon^{+}}{\upsilon^{-}}$	Asymmetry in Adj. Cost	5	5
f	Operating Cost	0.070	0.070
μ	Probability No Resetting	0	0.75
ξ	Labor Adj. Cost	0	0.15

Table 5

Aggregate Macroeconomic Moments

This table compares macroeconomic moments from the data (1929-2011) to several versions of our model. All reported correlations are with HP filtered GDP (y) except for growth rates of variables, in these cases correlations are reported with the growth rate of GDP. In the data w is compensation per hour. The models in Panels B and C have a calibrated elasticity of substitution between labor and capital ($\frac{1}{1-\eta} = 0.5$). Panel B is frictionless models with no wage rigidity ($\mu = 0$) or labor adjustment costs ($\xi = 0$). Panel C presents the model with wage rigidity ($\mu = 0.75$) and labor adjustment costs ($\xi = 0.15$). Note that the table reports the volatility of quantities relative to GDP volatility. The volatility of HP filtered GDP in the data is 3.55%, all models are calibrated to match this number.

	Panel A: Data			Panel B: Frictionless			Panel C: Wage Rigidity		
	$\frac{\sigma(x)}{\sigma(y)}$	$\rho(x,y)$	AC(x)	$\frac{\sigma(x)}{\sigma(y)}$	$\rho(x,y)$	AC(x)	$\frac{\sigma(x)}{\sigma(y)}$	$\rho(x,y)$	AC(x)
y	1.00	1.00	0.55	1.00	1.00	0.45	1.00	1.00	0.45
c	0.45	0.60	0.49	0.64	0.96	0.51	0.66	0.96	0.53
i	3.70	0.19	0.54	3.52	0.94	0.39	3.54	0.93	0.38
w	0.32	0.41	0.46	0.85	1.00	0.47	0.37	0.75	0.67
Δc	0.65	0.70	0.51	0.99	0.96	0.55	0.99	0.96	0.55
Δi	4.17	0.38	0.44	4.47	0.88	0.17	4.48	0.88	0.14
i-k	0.45	0.47	0.45	0.78	0.02	0.84	0.76	0.02	0.83

Table 6

Unconditional Financial Moments

This table presents the unconditional financial moments to several versions of our model.

	$E[R_f]$	$\sigma(R_f)$	$E[R_{exc}]$	$\sigma(R_{exc})$	SR
Data	0.69	3.81	6.84	19.89	0.34
Frictionless Model	0.60	1.18	2.20	4.87	0.45
Wage Rigidity Model	0.64	1.26	6.52	15.76	0.41

Table 7

Default Probability in the Data and the Model

This table reports the default probability for corporate bonds with different ratings in the data and in the model with wage rigidity. Default probabilities in the data are from Elton, Gruber, Agrawal, and Mann (2001).

	AAA+AA	A	BBB	BB	B	CCC
Data	<0.05%	0.05%-0.15%	0.15%-0.5%	0.5%-3%	3%-11%	>11%
Model	0.00%	0.00%	0.00%	1.07%	4.47%	25.53%

Table 8

Simulated Labor Market Variables and Credit Spread

This table reports the predictive regression of variables of interests for credit spread in the model with wage rigidity and the frictionless model. [t] are heteroscedasticity and autocorrelation consistent t-statistics (Newey-West).

	Panel A Frictionless model				Panel B Wage Rigidity Model			
ΔW	0.4				-17.65			
[t]	9.29				-21.54			
LS		-0.73				9.61		
[t]		-3.11				29.93		
InvGr			0.13				-1.42	
[t]			19.91				-22.72	
MktVol				-0.34				2.45
[t]				-1.09				2.64
Adjusted R^2	0.12	0.02	0.19	0	0.76	0.83	0.2	0.02