Financial constraints and the heterogeneous cyclicalities of employment and investment

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May 18, 2016

Abstract

This paper examines the interconnection of financial constraints and cross-sectional dynamics of employment and investment. Using firm-level data, I document that employment growth and investment rates are more sensitive to macroeconomic conditions for more financially constrained firms. I then develop a tractable dynamic general equilibrium model to capture this fact and I analyze the role of credit market frictions for cyclical sensitivities. The key ingredients in my framework are (i) the responsiveness of borrowing costs to expected default rates, and (ii) heterogeneity in the benefits of debt financing. Firms choose different capital structures with associated credit spreads and default risk, and firms with higher spreads respond more strongly to aggregate shocks. I show that the model can account for the cyclical elasticities of employment growth and for a substantial share of the credit spread differential during recessions. Furthermore, I use the model to study the implications of monetary policy, financial shocks and risk shocks for different firms. Finally, I consider other dimensions of firm heterogeneity, such as differences in productivity risk, and I find that the level of leverage does not necessarily imply greater cyclicality.

*New York University. Email: jan.moeller@nyu.edu. I am extremely grateful to my thesis advisor Mark Gertler, and my Ph.D. committee member Jess Benhabib and Edouard Schaal. I also want to thank Jarda Borovička, Katka Borovičková, Daniel Greenwald, Virgiliu Midrigran, Simon Mongey, Diego Perez, and participants at the NYU Macro Student Lunch Seminar for helpful comments.

1 Introduction

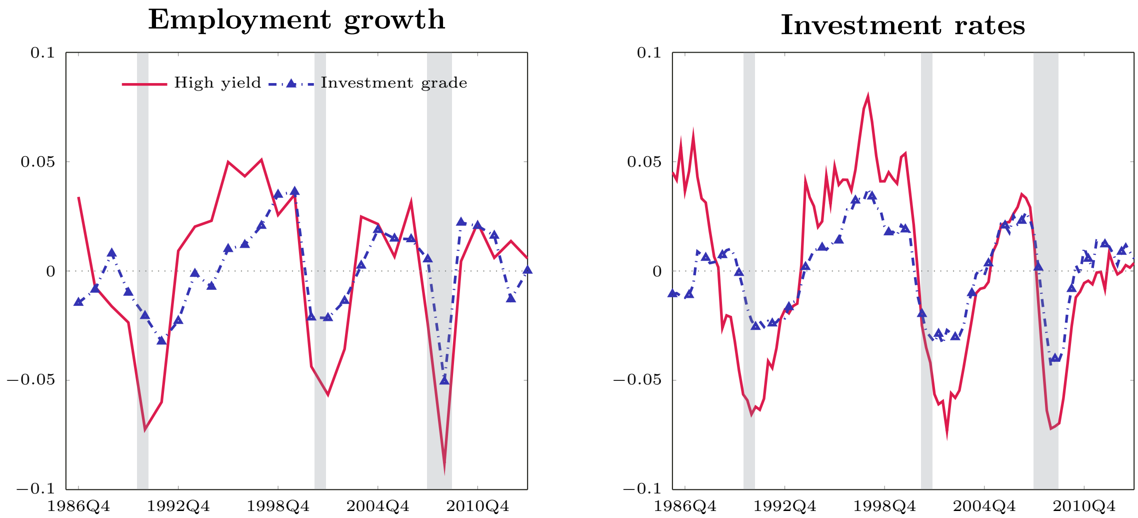
Credit constraints play a key role for the hiring and investment behavior of businesses. The loosening of constraints in periods of economic growth and their tightening in recessions has motivated a large literature on the amplifying effects of financial frictions: easier borrowing conditions reinforce booms, while more restrictive conditions aggravate and prolong downturns. However, much of this research has focused on aggregate outcomes. In this paper I explicitly account for the fact that the severity of financing constraints differs across firms, and I widen the focus to cross-sectional dynamics. How does a recession affect firms which are more and less constrained to begin with? Which of the many dimensions of firm heterogeneity can help understand heterogeneous dynamics of employment and investment in the data? And what role does leverage play in the transmission of aggregate shocks?

The contribution of my paper is twofold. On the empirical side I document that employment growth and investment rates at more financially constrained firms are more sensitive to macroeconomic conditions. Specifically, I consider the dynamics of firms with an investment grade bond rating relative to the group of firms with a speculative grade rating (high yield). High yield firms rank below investment grade firms on a number of indicators for financial constraints. Figure 1 illustrates that the mean employment growth rate and the mean investment rate among more constrained high yield firms drops precipitously during the three recessions 1990-1991, 2001, and 2008-2009. Less constrained investment grade firms see a much less pronounced decline. Moreover, in earlier expansions high yield firms also grew faster. My regression analysis corroborates this impression as I show that the elasticity of employment growth of high yield firms is 1.5 up to 2 times as high as the elasticity of investment grade firms. This finding is not driven by industry effects or age-specific cyclical sensitivities, and it holds up for various cyclical indicators. The analysis of investment rates leads to similar results.

The technical contribution of this paper is the introduction of firm heterogeneity into an otherwise standard general equilibrium model with credit and labor market frictions. Similar to the costly state verification problem in Bernanke and Gertler (1989) and Carlstrom and Fuerst (1997) firms face idiosyncratic productivity risk and may default on their debts. In consequence, they borrow at a premium over the risk free rate and thus compensate lenders for expected default losses. The novelty in my environment is that - in addition to productivity risk - firms exhibit differences in a cash flow cost. Despite this second dimension of heterogeneity, the distribution of firms can be easily characterized because in equilibrium all firms with the same cost choose the exact same capital structure. The tractability of my setup is a major advantage since it allows the model to be estimated on macroeconomic data and makes it suited for policy analysis.

The firm's cost - also referred to as its "type" - is observed by lenders and affects the financing decision via default incentives. In particular, a lower cost diminishes the firm's incentives to default in the future and allows borrowing at lower rates. Provided with cheaper credit, in the stationary equilibrium these firms a capital structure with more debt, higher expected default rates and they pay higher interest rates. Thus, firms of this type correspond to the more constrained high yield firms notwithstanding their cost advantage in borrowing. The idea behind this particular form of heterogeneity is that investment grade firms may be concerned with their credit rating (Graham and Harvey (2001)) and may face distress costs

Figure 1: Employment growth and investment rates



Sources: Compustat Fundamentals Annual and Quarterly. Financial firms (SIC codes 60 to 67) and utilities (SIC code 49) excluded. Rating is S&P long term credit rating ranging from AAA to D. Mean year-on-year employment growth rate (left) and mean investment rate (right) among investment grade firms (AAA to $BBB-$ rating, blue dash-dotted blue line), and high yield grade firms ($BB+$ to D, red solid line). Sample means removed.

even prior to default (Elkamhim et al. (2012)), namely when being downgraded. Given these impending costs they want to use debt more cautiously. High yield firms on the other side are less affected by such considerations, possibly because they are already recognized low credit quality firms. In addition, in the data investment grade firms have higher fixed costs than high yield firms. This relates to the idea that firms with higher operating leverage, i.e., higher fixed costs, attempt to mitigate the risk of default through their choice of financial leverage, i.e., debt.

Under the structure of my model the default risk and the borrowing costs of high yield firms have a greater sensitivity to aggregate shocks. In consequence, these firms reduce debt financing, sell-off more capital, and hire fewer workers compared to investment grade firms. This channel is distinct from the standard balance sheet effect in which the more leveraged firms experience a greater loss of net worth and curtail investment and hiring more strongly.

To evaluate the model performance I consider the model-implied employment and investment dynamics over the last three recessions in the US. The model matches both aggregate employment dynamics and the greater employment cyclicality of high yield firms. The difference in the investment cyclicalities is much less pronounced in the model, in particular because capital is very mobile across the different types of firms. Three features are essential for the success of the model: First, wage rigidity which leads to a noticeable drop in aggregate employment; second, the production cost which is roughly proportional to equity valuations and therefore behaves procyclically; finally, endogenous borrowing costs which drive the sharp capital and employment adjustments at high yield firms.

While the model performs well with regards to the differential employment elasticities, it accounts only for about a third of the credit spread differential during the Financial Crisis. Arguably, the disruption to financial intermediation during and after the Financial Crisis of 2007-2009 has been a key element for recession dynamics. I introduce shocks to credit spreads to proxy for a reduction in intermediation capacity. I find that high yield firms in the model are hit the hardest by such shocks, and I show that that the model generates a rise of default rates during the Financial Crisis that is consistent with the data. In addition, I consider the implications of monetary policy for the different firm types in my model. In line with empirical findings, I obtain that the more financially troubled high yield firms would react more strongly to contractionary monetary policy.

Disproportional employment losses at more financially troubled firms may help explain why employment growth is more dispersed across firms in recessions.[1] Along with the countercyclicality of other cross-sectional dispersion measures - such as sales growth, equity returns, etc. - the literature has related this empirical pattern either to time-variation in the volatility of idiosyncratic shocks, or to real and financial frictions that endogenously generate more dispersed outcomes in bad times.[2] This paper adds to the latter approach and suggests that differences in financing frictions result in heterogeneous cyclical sensitivities and ultimately may generate more dispersed employment growth in a downturn.

However, the model structure also allows me to derive the implications of exogenous fluctuations in idiosyncratic risk (or uncertainty) in the presence of heterogeneity. The role of such shocks for macroeconomic dynamics has been discussed in policy circles and academia alike, and the effects on aggregate investment and employment have been widely documented.[3] I show that an economy-wide increase in idiosyncratic risk leads to larger employment losses among high yield firms in the model. This result has an important implication for quantitative models that use data on cross-sectional dispersion to discipline risk shocks. Namely, I illustrate that a model without heterogeneity in cyclicalities may overpredict the increase in cross-sectional dispersion stemming from risk shocks.

Finally, I explore the relationship between leverage, risk and cyclical elasticities. While in the sample of rated Compustat firms risk and leverage are positively associated, in the broader population of firms the relationship has the opposite sign. Moreover, it is well documented that younger and smaller firms are more sensitive to the business cycle[4], yet they tend have less debt than mature firms. I show that my framework can accommodate a negative relationship between leverage and cyclical sensitivities with the addition of differences in cross-sectional risk. Conditionally on leverage, firms with higher fundamental risk face higher interest rates and prefer lower leverage. Yet, when cost heterogeneity provides them with greater benefits of debt financing they are willing to risk more frequent default. In steady state these firms have low leverage but nevertheless pay high interest rates and default more often. In addition, their default probability and thus their cost of external funds is more responsive to aggregate shocks, resulting in greater contractions of employment and investment in a recession. This illustrates that a firm's level of leverage is not necessarily an indicator for its cyclical sensitivity, and that measures of the firm's default risk, such as the credit rating, may be a more useful gauge.

[1] See Bloom et al. (2012) and Ilut et al. (2014).

[2] The literature discusses mechanisms such as endogenous risk taking as in Tian (2012) and Navarro (2014); Price experimentation as in Bachmann and Moscarini (2012); Learning as in Benhabib et al. (2015); Diversification as in D'Erasmo and Boedo (2013); Asymmetric hiring responses as in Ilut et al. (2014).

[3] See Bloom (2009), Gilchrist et al. (2014), Christiano et al. (2005), Jurado et al. (2013) and others.

[4] See Fort et al. (2013), Haltiwanger et al. (2013), Siemer (2012), Mehrotra and Sergeyev (2015), for instance.

The paper is organized as follows. The remainder of this section summarizes the related literature. In section 2, I corroborate the evidence about differential elasticities. I present the model in section 3. Section 4 contains the main part of the quantitative evaluation, and section 5 the extensions to the model. Section 6 concludes with some observations and directions for future research.

Related Literature: This paper connects to research on macroeconomic models with credit frictions, and to the empirical work on the role of financing constraints for firm-level employment and investment dynamics. The core of my model builds on credit market frictions as in the financial accelerator model by Bernanke et al. (1999), and also used in Christiano et al. (2014), Del Negro et al. (2003), Gilchrist et al. (2009). While I share with these papers the presence of productivity heterogeneity after the capital structure is set (ex-post), I add heterogeneity prior to the capital structure choice (ex-ante). Unlike ex-post heterogeneity which induces default of a share of firms for a given capital structure, ex-ante heterogeneity makes firms choose different debt-to-assets ratios in equilibrium. Model features such as wage rigidity and further extensions are based on the large literature that uses DSGE models to study the driving forces of aggregate fluctuations, including Christiano et al. (2005), Smets and Wouters (2007).

Importantly, under the financial contract in the tradition of Bernanke and Gertler (1989) and Carlstrom and Fuerst (1997) the external finance premium depends on the firm's decision to issue debt. This is in contrast to another line research that builds on collateral constraints in the tradition of Kiyotaki and Moore (1997), for instance Jermann and Quadrini (2012). Brunnermeier et al. (2013) point out that "with costly state verification, the cost of external financing is increasing in the borrowing" but with a collateral constraint the "cost of external financing is constant [...] up to the constraint and then becomes infinite". In the context of a representative firm the propagation effects of the two approaches are very similar, operating through the balance sheet (or net worth) channel. Once heterogeneity is taken into account there are important differences, however. With collateral constraints leverage alone predicts the cyclical sensitivity of a firm and credit costs of all firms move symmetrically with the risk-free rate. In contrast, the mechanism in this paper operates through differences in the sensitivity of default risk across firms. Therefore, the external finance premium responds differentially to aggregate conditions. My framework is more flexible in that - depending on parameters and the nature of heterogeneity - it may be the more leveraged or the less leveraged firms that have greater cyclicality of employment and investment.

There is a number of papers that share the focus on financing frictions and firm-level heterogeneity. The key idea in this line of work is that in a recession the efficiency-enhancing transfer of capital from low to high productivity firms slows down, thereby aggravating misallocation. Gomes et al. (2014) and Khan et al. (2013) study models with equilibrium default and overlap with my work regarding the debt financing decision. Other papers, including Buera et al. (2015), Khan and Thomas (2013), Shourideh and Zetlin-Jones (2014), Cui (2013), feature exogenous collateral constraints which tighten in recessions. Models of either type are governed by life-cycle dynamics, with the small and productive firms being most constrained on average, and also suffering disproportionally in recessions. Abstracting from firm dynamics allows me to reduce the state space dramatically and to keep the model tractable. Therefore, I can address various dimensions of heterogeneity, including but not limited to productivity, and I can study their distinct implications for the capital structure and cross-sectional dynamics.

In most models with credit market frictions - including mine -, default risk affects employment outcomes only indirectly via the complementarity with capital. In contrast, in Gourio (2014) default risk directly affects the hiring decision because workers need to be compensated for expected earnings losses in case of default (analogous to an external finance premium). I see this channel as complementary, yet the lack of capital in Gourio (2014) means that the amplification via investment and asset price dynamics is absent.

On the empirical side, my paper connects to work on the role of leverage for employment dynamics, including Giroud and Mueller (2015), Sharpe (1994), Cantor (1990). Sharpe (1994) documents that firms with a higher level of leverage were more cyclical from the 1960s to the mid-1980s, but Giroud and Mueller (2015) argue that in case of the Financial Crisis it was the increase of leverage prior to the downturn that made some firms more vulnerable. My results can inform this apparent conflict between levels versus changes of leverage as a proxy for financing constraints. Namely, I show that high risk firms would choose low debt but nevertheless react strongly to aggregate shocks. Hence, sorting by the level of leverage may group together firms with high debt but low risk - i.e., the less constrained firms -, while sorting on the changes of leverage as in Giroud and Mueller (2015) may also pick up more volatile firms with lower, but rising debt, - i.e., the more constrained.

Regarding the firm size dimension there is substantial evidence about the greater cyclicality of smaller firms, including Gertler and Gilchrist (1994), Fort et al. (2013). Also, Chodorow-Reich (2014) documents that the employment effects of credit supply shocks in the 2007-2009 crisis were large at small and medium-sized firms. Focusing on the worker side, Duygan-Bump et al. (2015) find that unemployment risk in the 2007-2009 recession increased particularly for workers of smaller firms operating in industries that have high financing needs. Further evidence about the importance of firm financing for capital spending and hiring around the Financial Crisis comes from the survey study by Campello et al. (2010).

2 Employment and investment cyclicalities

Figure 1 suggests that firms with a speculative grade rating are more sensitive to macroeconomic conditions. In this section I present the underlying micro data and discuss firm characteristics in the two subgroups. Then, I estimate cyclical elasticities of employment and investment and I analyze their dependence on the rating status. The regression analysis serves to control for potential compositional effects due to observable characteristics such as industry and age.

The sample consists of US public firms with a bond credit rating, using financial information from the Compustat database and equity returns from CRSP. Firms in the sample have been assigned a bond credit rating, usually from multiple major credit rating agencies, and can raise funds through bond issuance.[5] The bond rating is a credit risk assessment

[5]Issuing bonds without a credit rating is possible, however non-rated bonds are rare in practice. Firms without a rating usually obtain debt financing through bank loans, private debt from other institutions, or - for larger corporations - via the syndicated loan market.

based on a variety of factors, such as earnings, leverage, funding structure, liquidity, cash flow, industry profile, etc. Ratings are expressed as letter grades, ranging from AAA for firms of the highest credit quality to D for firms that are in default on their debts. For the purposes of this paper I only consider two broad categories: investment grade firms which have a rating of $BBB-$ or better and high yield (speculative grade) firms with a rating $BB+$ or below. The sample covers the years 1986 to 2014 since rating information via Compustat is available only since the mid-1980s.

Table 1 compares investment grade and high yield firms in the Compustat database. The table entries refer to means from the pooled sample. The variables related to firm financing all point to high yield firms as the more financially troubled firms. They pay higher interest rates,[6] have more debt, pay dividends less frequently, and score higher on the KZ index proxying for financing constraints. The expected default frequencies derived from a structural default model mirror the default risk assessment by the credit rating agency. The ex-ante default probability for high yield firms is more than three times as large as the probability for investment grade firms. The difference between ex-post (one-year cumulative) default rates is even more pronounced, reflecting the fact that sudden defaults among investment grade firms are very rare.

Moreover, there is much greater cross-sectional variation of TFP and equity returns[7] among high yield firms, marking them as the more risky group of firms. In addition, they rank lower on a number of productivity and profitability measures. Finally, investment grade firms are larger and older than high yield firms, yet the latter are all but young.[8] There are some changes in the age composition during the sample period. For instance, a rise in risky debt issuance during the 1990s lowered the average age of high yield firms.

The regression analysis is based on the reduced-form specification by Sharpe (1994). The firm-level outcome variable, i.e., employment growth or the investment rate, is regressed on GDP growth, $\Delta Y_t = \log(GDP_t/GDP_{t-1})$, and the interaction between GDP growth and the firm characteristic related to macroeconomic sensitivity. In departure from Sharpe (1994) who used the level of leverage as a continuous variable, I consider a dummy variable for the rating status, $HighYield_{i,t-1}$, which assumes one if firm i was rated below investment grade at time $t-1$. A positive coefficient on the interaction term between GDP growth and the rating status, $\beta_3 > 0$, indicates greater cyclicality of high yield firms.

$$DepVar_{i,t} = \beta_0 \ + \ \beta_1 \Delta Y_t \ + \ \beta_2 HighYield_{i,t-1} + \beta_3 HighYield_{i,t-1} \times \Delta Y_t \ + \ \boldsymbol{\gamma}\mathbf{U}_{i,t-1} \ + \ \epsilon_{i,t},$$

with $DepVar_{i,t} \in \{ \ \Delta Employment_{i,t} \ , \ CAPX_{i,t}/K_{i,t-1} \ \}$. The vector $\mathbf{U}_{i,t-1}$ contains other covariates such as firm i's market-to-book ratio and profitability.

Employment growth from year $t-1$ to year t is defined as $\Delta Employment_{i,t} = \frac{1}{2}(Emp_{i,t} -$

[6]Notice that this interest rate measure is inferred from income statement and balance sheet data. To compare this to yields in the bond market, consider the Aaa (AAA equivalent) (Baa (BBB equivalent)) Corporate Credit Spread relative to the Treasury yield of 130 (230) bps over the period 1986 to 2014.

[7]See section E.1 in the appendix for details on equity returns. The same result is obtained when computing the standard deviation of daily equity returns by firm over a quarter and comparing the mean among investment grade and high yield firms. Alternatively, implied equity volatilities derived from option prices yield a similar picture.

[8]The age variable in Compustat refers to the first appearance in the database rather than the founding year of the company.

Table 1: Descriptive Statistics

	Investment grade	**High yield**
Financing		
Credit spreads	155 bps	367 bps
Default rate (exp.)	3.23	10.97
Default rate (hist.)	0.14	4.49
Leverage	0.58	0.68
KZ score	-1.36	0.90
Dividend payer	0.88	0.44
Productivity		
TFP	0.039	-0.034
Wages	$65,000	$55,000
Return on assets	0.14	0.06
Risk		
Equity return dispersion	0.17	0.32
TFP dispersion	0.36	0.46
Size & Age		
Employment	49,400	11,400
Assets	18,200	2,900
Age	30.8	18.2
Observations (per year)	533	618

Notes: Compustat Fundamentals Annual and Quarterly and CRSP, 1986 to 2014. Financial firms (SIC codes 60 to 67) and utilities (SIC code 49) excluded. I further require assets, liabilities, equity, and sales to be non-negative. Table entries are means in the pooled sample. Credit spreads are interest expenses (`XINT`) divided by total long-term and short-term debt (`DLTT` and `DLC`) minus the yield on a ten year constant maturity Treasury. Default rates (hist.) are average default rates on corporate bonds from Standard & Poor's (2012) (1981 to 2011, includes financial firms). Default rates (exp.) are the expected default frequencies implied by the distance-to-default measure based on Merton's (1974) bond pricing model. Leverage is total liabilities divided by total assets and may not exceed one. KZ score is the Kaplan-Zingales measure for financial constraints, constructed according to Lamont et al. (2001). Dividend payer is the share of firms with positive dividends among total firms in a rating group. TFP is the residual of a regression of log sales (`SALE`) on log employment (`EMP`) and log capital (`PPEGT`) by year and 3-digit NAICS industry. Wages are staff expenses (`XLR`) deflated to 2009 dollars dividend by employees, trimmed at the 99th percentile. Return on assets is operating income before depreciation (`OIBDP`) minus interest expense (`XINT`) divided by total assets. Equity return dispersion is the cross-sectional standard deviation of quarterly equity returns from CRSP (see E.1). Assets are in thousands deflated to 2009 dollars.

Table 2: Cyclicalities of employment and investment

	$\Delta Employment_{i,t}$			$CAPX_{i,t}/K_{i,t-1}$		
	(1)	(2)	(3)	(4)	(5)	(6)
ΔY_t	0.477***	0.585***	0.668***	0.242***	0.360***	0.422***
	(5.04)	(6.59)	(7.07)	(6.69)	(10.83)	(10.69)
$HighYield_{i,t-1}$	0.025***	0.017***	0.008***	0.061***	0.038***	0.025***
	(7.47)	(5.34)	(2.68)	(35.75)	(24.58)	(14.98)
$HighYield_{i,t-1} \times \Delta Y_t$	1.000***	0.668***	0.383***	0.619***	0.292***	0.037
	(6.22)	(4.64)	(2.60)	(8.42)	(4.37)	(0.57)
$Age_{i,t-1}$			-0.016***			-0.022***
			(-7.19)			(-18.06)
$Age_{i,t-1} \times \Delta Y_t$			-0.422***			-0.340***
			(-3.94)			(-6.02)
$Market\text{-}to\text{-}Book_{i,t-1}$	0.044***	0.035***	0.033***	0.074***	0.057***	0.055***
	(16.25)	(13.99)	(13.48)	(41.55)	(35.45)	(34.76)
$Profits_{i,t-1}$	0.194***	0.126***	0.137***	0.393***	0.203***	0.220***
	(6.01)	(4.19)	(4.58)	(7.75)	(4.50)	(4.93)
R^2	0.04	0.03	0.04	0.07	0.05	0.06
N	24,035	24,035	24,035	78,898	78,898	78,898
$Time \times Industry$	No	Yes	Yes	No	Yes	Yes

Notes: Compustat Fundamentals Annual and Quarterly, years 1986 to 2014. Financial firms (SIC codes 60 to 67) and utilities (SIC code 49) excluded. By their definition, employment growth rates are bounded between -2 and 2. Investment rates are trimmed at the 1st and 99th percentile. Market-to-book ratio is the book value of assets (AT/ATQ), plus the market value of equity minus the book value of equity (CEQ/CEQQ), divided by the book value of assets, and trimmed at the 99th percentile. Profits is operating income before depreciation (OIBDP/OIBDPQ) minus interest expense (XINT/XINTQ) divided by the book value of assets. With $Time \times Industry$ controls the mean employment growth rate/investment rate by 3-digit NAICS industry and year/quarter is subtracted. The cyclical indicator is real GDP growth from the Bureau of Economic Analysis, 1986Q1 to 2014Q4. Values in parentheses are t-statistics computed using robust standard errors. (***/**/*) indicate significance at the (1/5/10) percent level.

$Emp_{i,t-1})/(Emp_{i,t} + Emp_{i,t-1})$. Importantly, the rating dummy reflects the credit risk assessment at the beginning of the measurement period. Therefore, this specification does not simply capture failing and shrinking firms being downgraded by the rating agencies. While employment data in Compustat (variable `EMP`) is available only at annual frequency, the fiscal year end differs across firms and I follow Sharpe (1994) by regressing employment growth of firms whose fiscal year ends in quarter q on GDP growth from year $t-1$ quarter q to year t quarter q.

The investment rate is defined as capital expenditures divided by the capital stock, $CAPX_{i,t}/K_{i,t-1}$. Data on capital expenditures is available at quarterly frequency (from variable `CAPXY`). To avoid seasonality issues I aggregate capital expenditures from year $t-1$ quarter q to year t quarter q, and I divide this by net property, plant and equipment (`PPENTQ`) in year $t-1$ quarter q. Notice that the specifications for employment growth and investment rates differ with respect to the number of observations since investment rates are defined for each quarter but employment growth rates only for the quarter in which the fiscal year ends.

Table 2 reports the regression results for employment growth as the dependent variable in columns (1) to (3), and for investment rates in columns (4) to (6). According to column (1), if GDP rises by 1% over a one-year-horizon, employment at investment grade firms increases by 0.48%, while at high yield firms it rises by $0.48 + 1 = 1.48\%$. The coefficient on the interaction term is highly significant and about twice as large as the coefficient on output growth itself. This is surprising given that employment growth at both investment grade and high yield firms dropped precipitously during the three recessions depicted in Figure 1. I add controls for industry to address two main concerns. First, I suspect that cyclical dynamics at the sectoral level may not be well synchronized with aggregate output growth and bias the coefficient downward. Second, the greater cyclicality of high yield firms may be driven by compositional effects. Namely, if high yield firms were concentrated in industries that are more cyclical, for instance durable goods industries, then the greater cyclicality would emerge irrespective of differences in financing constraints (or it may simply reflect differences in financing constraints at the sectoral level). Therefore, in columns (2)-(3) I include time-industry effects, with industry defined at the 3-digit NAICS level. Specifically, for each year t and quarter q I take out the average employment growth rate by 3-digit NAICS industry and add back the average overall employment growth rate. Column (2) shows that with time-industry effects the coefficient on output growth rises to 0.585 while the coefficient on the interaction term drops to 0.668. This indicates that indeed some of the differences in cyclicality are driven by industry. However, a substantial difference in the employment elasticities remains.

I further include age as an explanatory variable and I allow the effect of age to differ over the business cycle. The rationale behind this is twofold: First, evidence by Fort et al. (2013) indicates that young firms have greater cyclicality of employment, possibly related to financing constraints. If the rating status merely captures firm age and the severity of financing frictions that correlates with age, then the interacted rating status dummy should become insignificant. Second, there is concern that the different elasticities suggested by Figure 1 stem from compositional effects, in particular in light of the high employment growth rates among high yield firms during the 1990s. The boom period was characterized by a succinct increase in the number of high yield firms, and the average age among these firms dropped from 19 years in 1991 to 14 years in 1999. In contrast, the increase in the number of investment grade firms was smaller and the average age declined only by little. In column (3) I find that young firms grow faster, consistent with life-cycle behavior. Moreover, employment growth at young firms is more sensitive to changes in aggregate output. Nevertheless, the interaction term between high yield status and output growth remains positive and significant.

Aside from the differential cyclicalities, high yield and investment grade firms also differ in their average growth rates. The coefficient on the rating dummy is positive and significant throughout, even though it declines when adding industry and age as controls. The higher average growth rate underlines that high yield firms are of great interest from a macroeconomic standpoint.[9]

The investment regressions in columns (4) to (6) reveal similar differences between high yield and investment grade firms. The elasticity differential is large even after controlling for industry. However, in column (6) the inclusion of age drives out the rating status. Thus, firm age may partially capture differences in financial constraints that matter with respect to the firm's investment choices. The rating dummy itself is positive and significant in all specifications, emphasizing the above-average growth of high yield firms.

In summary, even after controlling for industry effects the employment elasticity of high yield firms is 1.5 up to 2 times as high as the elasticity of investment grade firms. In Tables A.1 and A.2 in the appendix I show that these results carry over with alternative cyclical indicators such as the Excess Bond Premium by Gilchrist and Zakrajšek (2012) and the VXO volatility index. The Excess Bond Premium reflects movements in credit spreads unrelated to corporate default risk, and it correlates strongly with the capitalization of the financial sector. Bloom (2009) and others argue that market volatility can be a driver of macroeconomic activity. When using these alternative indicators a large and significant elasticity differential regarding investment rates persists even after controlling for age, presumably because the market-based measures map more directly into tightness of financing conditions than GDP growth.

3 Model

Time is discrete and the horizon is infinite. The economy consists of (i) a continuum of firms, (ii) a representative household, (iii) financial intermediaries, (iv) labor agencies, (v) capital goods producers, and (vi) a government sector.

3.1 Firms

There is a unit measure of firms, indexed by $i \in [0, 1]$. Firms produce output using a constant returns technology:

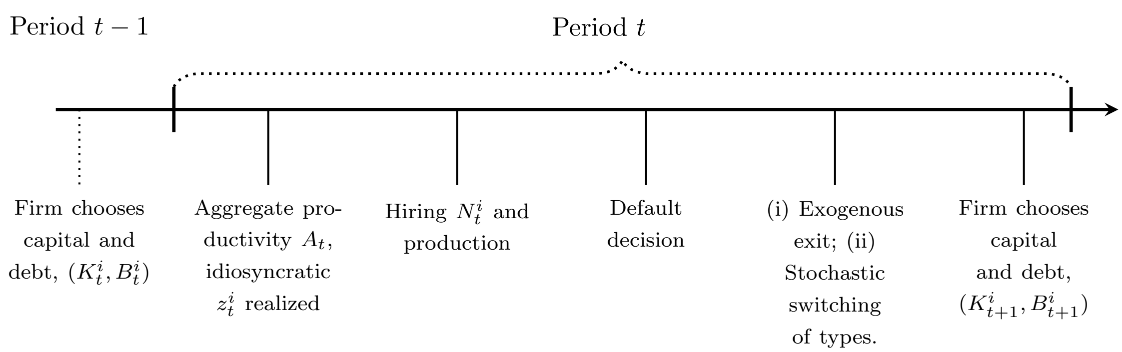
$$Y_t^i = (z_t^i K_t^i)^\alpha (A_t \, N_t^i)^{1-\alpha}.$$

Aggregate productivity A_t follows a first order Markov process, while the idiosyncratic productivity/return component z_t^i is an i.i.d. draw (across firms and across time) from a distribution F.

[9] Recall that in Figure 1 the series were demeaned to focus on cyclicalities.

The timing of events for a firm i is displayed in Figure 2. The capital stock K_t^i is chosen at the end of the previous period. The firm needs to finance capital purchases either through their own end-of-period net worth or through debt issuance B_t^i. Crucially, the firm is not allowed to raise new equity from household to purchase capital, or equivalently, it cannot pay a negative dividend. In the beginning of the period the exogenous state s is revealed, as well as the idiosyncratic component z_t^i. The firm chooses employment N_t^i and produces output and pays wages. Then, it either repays its outstanding debt B_t^i or declares default. Upon default the firm exits the economy immediately and forfeits all claims to the firm's assets. Instead if it does repay its debt, next it is hit by an exogenous exit shock with probability σ. The share σ of non-defaulting firms that is hit by this shock is forced to exit after selling their capital and paying the proceeds to the household. Both defaulting and exiting (though non-defaulting) firms are replaced by new firms as to keep the measure of firms constant. Finally, continuing firms and new firms choose the capital stock for next period and the financing thereof. In case of default, a fraction θ of the firm's output and capital stock is destroyed (deadweight loss) while lenders recover the remaining fraction $1-\theta$.

Figure 2: Timeline for firm i



In departure from this familiar setup, I assume that firms are heterogeneous with respect to a production cost parameter - c^{HY} (for high yield) or c^{IG} (for investment grade). I will refer to a firm's cost parameter as its "type". The production cost is linear in capital and similar to the wage payment it has to be paid before the default decision. For firm i with parameter $c_t^i \in \{c^{IG}, c^{HY}\}$, the time t production cost is $c_t^i Q_t K_{t-1}^i$ where Q_t denotes the price of capital. Importantly, the time t cost parameter of a firm can be observed by lenders at the end of time $t-1$. Since the cost affects default incentives at time t, firms with different costs will face different interest rate menus.

While the cost is linear in capital it does not depend on firm i's employment decision at time t, and thus can be seen as a fixed cost. When a firm of a certain type defaults or exits exogenously, it is replaced by a new firm of the same type. I allow for stochastic switching of types. After the default decision but before the choice of next period's capital stock and debt, firms with type HY (IG) transition to type IG (HY) with probability p. Due to symmetric transition probabilities between types, the two types have equal shares in the population of firms.

Importantly, the draw from the idiosyncratic productivity distribution is independent of the cost type. Since the cost parameter is known prior to the capital structure choice, I refer to this heterogeneity as ex-ante heterogeneity. In contrast, idiosyncratic productivity is realized only after the capital structure has been chosen, namely in the beginning of the next period; therefore it is denoted as ex-post heterogeneity.

3.1.1 The firm's problem

One can separate the firm's problem into a static one - the optimal choice of employment -, and a dynamic one - the optimal choice of capital and the financing decision. Regarding the employment choice, consider a firm with capital stock K_t^i and idiosyncratic productivity z_t^i, and current cost type $c_t^i \in \{IG, HY\}$. It chooses employment N_t^i to maximize profits taking as given the wage W_t:

$$\Pi_t^i = \max_{N_t^i} \; (z_t^i K_t^i)^\alpha (A_t N_t^i)^{1-\alpha} - W_t N_t^i.$$

The optimal choice of employment equates the marginal product of labor with the wage and yields $N_t^{i*} = \left(\frac{A_t(1-\alpha)}{W_t}\right)^{\frac{1}{\alpha}} \frac{z_t^i K_t^i}{A_t}$. The resulting profits are $\Pi_t^i = \Pi_t z_t^i K_t^i$, where $\Pi_t = \alpha \left(\frac{A_t(1-\alpha)}{W_t}\right)^{\frac{1-\alpha}{\alpha}}$. Moreover, I define the gross payoff per unit of capital as the sum of profits plus the residual value of capital: $\Xi_t^i = \Xi_t z_t^i$, where $\Xi_t = \Pi_t + (1-\delta)Q_t$. As in Bernanke et al. (1999) and Christiano et al. (2014) the idiosyncratic component z_t^i also multiplies the residual value of capital, giving the idiosyncratic component the interpretation of a capital quality or return shock.

For studying the dynamic problem I define the net worth after wages, production costs, and debt repayment. Notice that the production cost $c_t^i Q_t K_t^i$ enters in the net worth equation as a cash flow cost:

$$NW_t^i = \Xi_t z_t^i K_t^i - B_t^i - c_t^i Q_t K_t^i.$$

Let $V_t^{type}(NW_t^i)$ denote the value in the end of period t for a firm with net worth NW_t^i and period $t+1$ cost parameter $c_{t+1}^i = c^{type}$, $type \in \{IG, HY\}$. The firm now chooses capital K_{t+1}^i and debt B_{t+1}^i to maximize the present discounted value of dividends, using the stochastic discount factor of the household, $m_{t,t+1}$, to price future cash flows.

$$V_t^{type}(NW_t^i) = \max_{\{K_{t+1}^i, B_{t+1}^i\}} \left\{ Div_t^i + \mathbb{E}_t \left[m_{t,t+1} \int \max(0, \bar{V}_{t+1}^{type}) dF \right] \right\}, \tag{1}$$

where the dividend paid today, Div_t^i, must be non-negative and is the sum of current net worth and new borrowing minus expenditures for capital purchases. The price of debt with face value B_{t+1}^i is $q_t^{type}(K_{t+1}^i, B_{t+1}^i)$ and is taken as given by firms.

$$Div_t^i = NW_t^i - Q_t K_{t+1}^i + q_t^{type}(K_{t+1}^i, B_{t+1}^i) B_{t+1}^i \geq 0. \tag{2}$$

Depending on the realizations of aggregate and idiosyncratic uncertainty the firm may want to default in period $t+1$. If it does so it obtains a zero payoff while continuation yields

$\bar{V}_{t+1}^{type}$.

$$\bar{V}_{t+1}^{type} = (1-\sigma)\left((1-p)\, V_{t+1}^{type}(NW_{t+1}^i) + p\, V_{t+1}^{\neg type}(NW_{t+1}^i)\right) + \sigma NW_{t+1}^i. \tag{3}$$

The continuation value reflects that the firm is forced to exit with probability σ in which case the net worth NW_{t+1}^i is paid as a dividend to the household. With the complementary probability it continues beyond period $t+1$, either retaining its type with probability $1-p$ or switching to the opposite type with probability p.

3.1.2 Characterizing the default decision

I now characterize the default decision and subsequently turn towards the optimal choice of capital and debt. I proceed by a guess and verify approach that broadly follows Nuño and Thomas (2012).

I first guess that the firm's value function is linear in net worth NW_t^i and that there exists a non-negative λ_t^{type} such that

$$V_t^{type}(NW_t^i) = \lambda_t^{type} NW_t^i.$$

The multiplier λ_t^{type} is a forward-looking variable summarizing the value of a dollar net worth inside the firm. It depends only on aggregate conditions and the firm-specific type for period $t+1$ but not on current idiosyncratic variables, i.e., the period t cost parameters and idiosyncratic productivity z_t^i.

Under the guess the default decision follows a simple cutoff rule. According to (1), the firm will default whenever the continuation value $\bar{V}_{t+1}^{type}$ is negative, or equivalently, whenever net worth is negative, $NW_{t+1}^i < 0$. Conditional on the aggregate state in period $t+1$, the cutoff for idiosyncratic productivity z_{t+1}^i writes as

$$z_{t+1}^i < \bar{z}_{t+1}^i = \frac{l_{t+1}^i + c_t^i Q_{t+1}}{\Xi_{t+1}},$$

where I define (book) leverage l_{t+1}^i as debt over assets $l_{t+1}^i = \frac{B_{t+1}^i}{K_{t+1}^i}$. All else equal, firms with higher leverage l_{t+1}^i have a higher likelihood of default, $F(\bar{z}_{t+1}^i)$. Moreover, conditional on leverage firms with a larger cost parameter have a higher likelihood of default as well. In fact, this feature will play a key role in the pricing of debt and the capital structure choice.

3.1.3 Characterizing the debt and capital choice

In the appendix I show that under the guess for the value function the dynamic problem (1) can be restated as a problem with the choice variables leverage l_{t+1}^i and capital growth $\iota_{t+1}^i = \frac{K^i t+1}{K_t^i}$. The solution consists of a first order condition for leverage and a corner solution for capital growth. First, the optimality condition for leverage choice l_{t+1}^i balances the benefits and costs of debt issuance:

$$[l^i_{t+1}:]\ \lambda^{type}_t\left(q^{type}_t(l^i_{t+1})+\frac{\partial q^{type}_t(l^i_{t+1})}{\partial l^i_{t+1}}l^i_{t+1}\right)$$
$$-\mathbb{E}_t\left[m_{t,t+1}(1-F(\bar{z}^i_{t+1}))((1-\sigma)((1-p)\lambda^{type}_{t+1}+p\lambda^{\neg type}_{t+1})+\sigma)\right]=0. \quad (4)$$

While the second term reflects the expected discount repayment tomorrow, the first term summarizes the benefits and cost of debt today. More debt allows purchasing more capital, but it also changes the price of debt via expected default risk, $\frac{\partial q^{type}_t(l^i_{t+1})}{\partial l^i_{t+1}}<0$. Notice that the first order condition does not depend on the current realization of idiosyncratic productivity z^i_t but only on the expectation over future values z^i_{t+1}. This means that the capital structure choice will be the same for all firms that share the same cost type for period $t+1$, but firms with different cost types may choose different capital structures. I denote the leverage decision for each type as l^{type}_{t+1}.

Second, the firm sets ι^i_{t+1} as high as possible, the only constraint being the requirement for non-negative dividends. Thus, the firm retains all earnings to purchase more capital rather than paying out dividends to the household:

$$\iota^i_{t+1}=\frac{nw^i_t}{Q_t-q^{type}_t(l^{type}_{t+1})l^{type}_{t+1}}. \quad (5)$$

In contrast to the leverage decision the acquisition of capital does depend on the realization z^i_t. Firms with a higher z^i_t and higher net worth $nw^i_t=\frac{NW^i_t}{K^i_t}$ and can buy more capital. The interpretation of the denominator is the fraction of assets that is financed with internal funds.

This concludes the description of the firm's static and dynamic problems.

3.2 Representative household

The representative household maximizes present discount utility $\sum_{\tau=t}^{\infty}\beta^{\tau-t}U(C_\tau,N_\tau)$ by choosing consumption C_t, labor supply N_t, and savings in deposits D_{t+1}. The choice is subject to the following budget constraint:

$$\tilde{W}_tN_t+D_tR_{t-1}+\Pi_t+Div_t\geq C_t+D_{t+1}+T_t.$$

Labor is supplied to the employment agencies and compensated at rate $\tilde{W}_t$. Savings in deposits from last period pay the gross risk-free rate R_{t-1}. Besides, the household is the recipient of profits from capital producers, financial intermediaries, and labor agencies: $\Pi_t=\Pi^{CP}_t+\Pi^{Int}_t+\Pi^{LA}$. Moreover, the household pays lump-sum taxes T_t and receives dividends of exiting firms Div_t. The optimality conditions for the household consists of the Euler equation for deposits, $1=\mathbb{E}_t[m_{t,t+1}R_t]$, where $m_{t,t+1}=\beta\frac{U_C(C_{t+1},N_{t+1})}{U_C(C_t,N_t)}$. The labor-consumption trade-off writes as $-\frac{U_N(C_t,N_t)}{U_C(C_t,N_t)}=\tilde{W}_t$. Since the household cannot inject equity into firms there are no firm specific variables in the household's problem, and accordingly no asset pricing equation for equity shares.

3.3 Financial intermediaries

Competitive financial intermediaries channel funds from savers (households) to borrowers (firms). I assume that the firm's debt is non-contingent, thus the promised repayment cannot be conditioned on aggregate or idiosyncratic productivity. The financial contract is motivated by a costly state verification problem in which lenders are unable to observe the idiosyncratic realization z^i_{t+1} unless they pay a monitoring cost, defined as a fraction θ of the firm's assets.

Consider a firm with capital stock K^i_{t+1} when issuing debt of face value B^i_{t+1}. The lender's payoff at time $t+1$ will be of the following form: Either the idiosyncratic realization z^i_{t+1} will be sufficiently large for the firm to continue, $z^i_{t+1} \geq \bar{z}^{type}_{t+1}$, and the lender receives B^i_{t+1}; otherwise, if $z^i_{t+1} < \bar{z}^{type}_{t+1}$, the firm will declare default and the lender recovers the firm's assets net of the monitoring cost, $(1-\theta)(\Xi_t z^i_{t+1} - Q_t c^{type})K^i_{t+1}$.

Since debt is competitively priced, the amount of funds raised by a firm reflects the expected discounted payment to the lender:

$$q^{type}_t(K^i_{t+1}, B^i_{t+1})B^i_{t+1} = \mathbb{E}_t\left[\tilde{m}_{t,t+1}\left(\int_{\bar{z}^i_{t+1}} B^i_{t+1}dF + (1-\theta)\int^{\bar{z}^{type}_{t+1}} (\Xi_t z^i_{t+1} - c^{type}Q_{t+1})K^i_{t+1}dF\right)\right].$$

Notice that the expected repayment depends on the firm's type both via the default cutoff as well as through the recovery value in default. The discount factor used to price future cash flows is denoted as $\tilde{m}_{t,t+1} = m_{t,t+1}e^{\zeta}$, where $m_{t,t+1}$ is the household's stochastic discount factor. When $\zeta < 0$, lenders are more impatient than the household and they charge firms higher interest rates irrespective of expected default costs. Dividing both sides by K^i_{t+1} one can see that the price of debt depends only on leverage, resulting in the following equation for the price of debt:

$$q^{type}_t(l^{type}_{t+1}) = \mathbb{E}_t\left[\tilde{m}_{t,t+1}\underbrace{\left((1 - F(\bar{z}^{type}_{t+1})) + \frac{1-\theta}{l^{type}_{t+1}}(\Xi_t G(\bar{z}^{type}_{t+1}) - F(\bar{z}^{type}_{t+1})c^{type}Q_{t+1})\right)}_{\mathscr{R}^{type}_{t+1}}\right],$$

where $G(\bar{z}^{type}_{t+1}) = \int^{\bar{z}^{type}_{t+1}} zdF$.

Intermediaries raise deposits from household to fund their lending activity. Deposits are non-contingent debt contracts that are due in the end of period $t+1$ and that pay the gross risk-free interest rate R_t. The corporate credit spread, CS^{type}_{t+1}, is defined as the difference between the yield on corporate debt, $-\log(q^{type}_t(l^{type}_{t+1}))$, and risk-free bond yield $\log(R_t)$. The steady state credit spread is derived as $\overline{CS}^{type} = log(\bar{\mathscr{R}}^{type}) + \zeta$, where ζ reflects a premium on corporate debt that is independent of default. Through the default component $\mathscr{R}^{type}_{t+1}$ the credit spread is increasing with leverage for a given cost parameter c^{type}. Moreover, conditional on leverage firms with a higher cost parameter pay higher spreads, i.e., their entire interest rate menu is shifted upwards.

While expected profits of intermediaries are always zero, realized profits are zero only in steady state. With aggregate uncertainty, profits can be positive or negative and will be disbursed to the household. Let D_t (for deposits) denote the amount of deposits raised in the previous period, then

$$\Pi_t^{Int} = \int_0^1 B_t^i \mathbb{I}_{\{z_t^i \geq \bar{z}_t^i\}} di - R_{t-1} D_t,$$

where the first term reflects debt repayments from non-defaulting firms. The cash flows from newly raised deposits and new corporate debt always balance each other.

3.4 Labor agencies

Firms hire workers via monopolistically competitive labor agencies. Each firm i uses a Dixit-Stiglitz composite of different labor varieties $N_t^i = \left(\int_0^1 (n_{g,t}^i)^{\frac{\epsilon_w - 1}{\epsilon_w}} dg\right)^{\frac{\epsilon_w}{\epsilon_w - 1}}$, where $n_{g,t}^i$ is the amount of the variety provided by agency $g \in [0,1]$. Each labor agency purchases raw labor services from the household at price $\tilde{W}_t$ and costlessly differentiates raw labor into its respective variety g. Then, it sells the specialized labor variety to firms at price $W_{g,t}$.

The resulting labor demand from firm i for variety g is $n_{r,t}^i = \left(\frac{W_{g,t}}{W_t}\right)^{-\epsilon_w} N_t^i$. Aggregating over all firms yields

$$n_{g,t} = \left(\frac{W_{g,t}}{W_t}\right)^{-\epsilon_w} N_t,$$

where $n_{g,t} = \int_0^1 n_{g,t}^i di$ and $N_t = \int_0^1 N_t^i di$. The wage index for composite labor, W_t, is defined by $W_t N_t = \int_0^1 W_{g,t} n_{g,t} dg$. Plugging in labor demand this yields $W_t = \left(\int_0^1 W_{g,t}^{1-\epsilon_w} dg\right)^{\frac{1}{1-\epsilon_w}}$.

Labor agencies take as given labor demand from firms and choose the price of their labor variety to maximize the present discounted value of profits, using the household's stochastic discount factor between periods t and $t+j$, $m_{t,t+j}$. Labor agencies can adjust the price of the labor variety only infrequently. Every period a random fraction $1-\lambda_w$ of agencies is allowed to freely reset their price $W_{g,t}$, while the complementary fraction λ_w has to retain the price from last period. When the agency can reset its price it takes into account all future states in which it is stuck with the current price:

$$\max_{W_{g,t}^*} \mathbb{E}_t \left[\sum_{j=0}^{\infty} \lambda_w^j m_{t,t+j} \left(W_{g,t}^* n_{g,t+j} - \tilde{W}_{t+j}(1-\nu_w) n_{g,t+j}\right)\right].$$

The first-order condition for the optimal reset price $W_{g,t}^*$ is

$$\mathbb{E}_t \left[\sum_{j=0}^{\infty} \lambda_w^j m_{t,t+j} N_{t+j} W_{t+j}^{\epsilon_w} \left(W_{g,t}^* - \frac{\epsilon_w}{\epsilon_w - 1}(1-\nu_w)\tilde{W}_{t+j}\right)\right] = 0.$$

The reset price is symmetric for all firms which are able to reset, such that $W_{g,t}^* = W_t^*$, $\forall g$. Parameter ν_w depicts a subsidy to labor agencies that - in steady state - corrects the wage mark-up over marginal costs.[10] Finally, the wage index W_t writes as

$$W_t = \left[(1-\lambda_w)(W_t^*)^{1-\epsilon_w} + \lambda_w (W_{t-1})^{1-\epsilon_w}\right]^{\frac{1}{1-\epsilon_w}}.$$

If $\lambda_w = 0$ all labor agencies can reset the wage every period and the wage is fully flexible. This special case is equivalent to a centralized labor market in which households and firms interact directly and the wage clears the market. Finally, profits of labor agencies, $\Pi_t^{LA} = \left(W_t - (1-\nu_w)\tilde{W}_t\right) N_t$ are rebated to the household.

3.5 Capital producers

Capital producers take the price of capital goods, Q_t, as given, and buy I_t units of the output good to produce new capital. Their production technology $\Phi\left(\frac{I_t}{K_t}\right)$ features positive, but decreasing returns ($\Phi' > 0, \Phi'' < 0$), and output of new capital goods is $\Phi\left(\frac{I_t}{K_t}\right) K_t$. The problem of capital producers is given by

$$\Pi_t^{CP} = \max_{I_t} \left\{ Q_t \Phi\left(\frac{I_t}{K_t}\right) K_t - I_t \right\}.$$

The first order condition yields the optimal investment rate as a function of the price of capital:

$$Q_t = \frac{1}{\Phi'\left(\frac{I_t}{K_t}\right)}.$$

3.6 Government

The government finances the input subsidy ν_w to labor agencies through lump-sum taxes T_t, such that the budget balances period-by-period:

$$T_t = \nu_w \tilde{W}_t N_t.$$

3.7 Aggregation and equilibrium

The resource constraint of this economy is

$$Y_t = C_t + I_t,$$

where Y_t is output net of the deadweight loss due to defaulting firms,

[10] Due to market power agencies set the price of their variety as a mark-up over marginal costs, i.e., the compensation $\tilde{W}_t$ paid to the household, implying that labor in equilibrium would be lower than under perfect competition. This inefficiency is not central to the analysis, so I assume that labor agencies receive a subsidy that resolves the inefficiency and leads to optimal output in steady state. For every unit of labor purchases from the household the agency pays only $(1-\nu_w)\tilde{W}_t$. The subsidy is financed through lump-sum taxes.

$$Y_t = \int_0^1 Y_t^i \left\{ \mathbb{I}_{\{z_t^i \geq \bar{z}_t^i\}} + (1-\theta)\mathbb{I}_{\{z_t^i < \bar{z}_t^i\}} \right\} di.$$

The law of motion for capital writes as

$$K_{t+1} = \int (1-\delta) K_t^i \left(\mathbb{I}_{\{z_t^i \geq \bar{z}_t^i\}} + (1-\theta)\mathbb{I}_{\{z_t^i < \bar{z}_t^i\}} \right) di + \Phi\left(\frac{I_t}{K_t}\right).$$

Dividend payments to the household come from the share σ of non-defaulting firms that are forced to exit exogenously. Each of these firms has positive net worth NW_t^i and pays it out to the household, $Div_t^i = NW_t^i$. Therefore, aggregate dividends are

$$Div_t = \sigma \int_0^1 NW_t^i \mathbb{I}_{\{NW_t^i \geq 0\}} di.$$

Conceptually, the economy features two representative firms indexed by their $type \in \{IG, HY\}$. Each such stand-in firm represents the measure of firms that share the same cost parameter (after transitions) and therefore chooses the same leverage. There is heterogeneity within each stand-in firm due to the idiosyncratic productivity component z_t^i and different levels of capital and net worth. However, the exact distribution of capital and net worth is irrelevant for equilibrium dynamics.

I therefore denote as NW_t^{type} the net worth in the end of period t of all firms with period $t+1$ cost parameters c^{type}:

$$NW_t^{type} = (1-\sigma) \int_0^1 NW_t^i \mathbb{I}_{\{c_{t+1}^i = c^{type}, z_t^i \geq \bar{z}_t^i\}}, \quad type \in \{IG, HY\}.$$

Notice that NW_t^{type} encompasses net worth from all firms i for which either (i) $c_{t+1}^i = c_t^i = c^{type}$, or (ii) $c_t^i = c^{\neg type}$, but $c_{t+1}^i = c^{type}$. The share of type-switching firms is given by the switching probability p. The parameter therefore determines how changes in net worth in among one type of firms spill over to the other type.

Moreover, the aggregation of equation (5) yields total capital among firms with period $t+1$ cost parameters c^{type}, denoted as K_{t+1}^{type}:

$$K_{t+1}^{type} = \frac{NW_t^{type}}{Q_t - q_t^{type}(l^{type}) l^{type}}, \quad type \in \{IG, HY\}. \tag{6}$$

The aggregate state S_t consists of (i) aggregate productivity, (ii) the distribution of debt and capital over firms with cost parameters IG and HY, (iii) the wage W_{t-1}, and it is denoted as $S_t = \{A_t, \{l_t^{type}, K_t^{type}\}_{type \in \{IG, HY\}}, W_{t-1}\}$. In equilibrium all agents behave optimally and the markets for labor, capital and deposits clear.

4 Quantitative analysis

In this section I calibrate the model using the sample of rated Compustat firms. Investment grade firms and high yield firms are distinguished through the different cost types c^{IG} and

c^{HY}. I first study the dynamic properties of the model and evaluate the model performance over the last three recessions. Subsequently, I investigate how financial shocks can induce heterogeneous responses across firms, and I study the implications of shocks to cross-sectional risk in the presence of heterogeneity in cyclical elasticities.

4.1 Functional forms and parameter choices

I first list the parameters that assigned are values common in the literature. Subsequently, I discuss the joint calibration of several parameters related to the strength of financial frictions across firms. The parameter values and the relevant targets are displayed in Table 3.

The time period is a quarter. The discount factor β is set such that the risk-free rate is 4% annually, i.e., $\beta = 0.99$. The household utility function is separable in consumption and labor, $U(C_t, N_t) = \frac{C_t^{1-\gamma}}{1-\gamma} - \chi \frac{N_t^{1+\frac{1}{\eta}}}{1+\frac{1}{\eta}}$. I set the risk aversion parameter γ to 1, and the elasticity of labor supply η to 2. The relative disutility of labor, χ, scales the size of the economy and is set to obtain steady state output $\bar{Y}$ of 1.

The capital share in the production function is set to $\alpha = \frac{1}{3}$, and the depreciation rate is chosen as 10% annually. For the production function of new capital I follow Jermann (1998) and specify $\Phi\left(\frac{I_t}{K_t}\right) = \frac{\varphi_2}{1-\varphi_1}\left(\frac{I_t}{K_t}\right)^{1-\varphi_1} + \varphi_3$.[11] Parameters (φ_2, φ_3) are set to yield a steady state investment rate $\frac{\bar{I}}{\bar{K}}$ equal to the depreciation rate, and a steady state price of capital $\bar{Q}$ of 1. The elasticity of the price of capital with respect to the investment rate, $\varphi_1 > 0$, regulates the importance of adjustment costs of capital. High adjustment costs imply less volatile investment but a more volatile price of capital and therefore more net worth volatility. There is some disagreement in the literature about the admissible range of values. I follow Bernanke et al. (1999) with $\varphi_1 = 0.25$, noting that this value delivers a better fit for the relative volatility of investment than the value of 2.5 used by Guvenen (2009).

The switching probability between firm types, p, is related to the incentives for capital accumulation and determines how quickly a shock to the net worth of one firm type spills over to the other type. By setting $p = 0.5$ net worth is equalized across both types in the end of each period, making clear that the model mechanism does not rely on differential balance sheet effects. In section 5 I show that making types persistent actually strengthens the results of the baseline economy. Under $p = 0.5$ the steady state employment share of high yield firms is about 55%.

The Calvo parameter $\lambda_w = 0.75$ implies that wages are set on average every year. Thus, the reset probability is somewhat larger than the estimated value from Smets and Wouters (2007) and Christiano et al. (2005), yet smaller than the value by Christiano et al. (2014).

I now discuss the set of parameters that are jointly calibrated in the steady state. The distribution of the idiosyncratic productivity shock, $F(z_t^i)$, is assumed to be log-normal, $\log z_t^i \sim \mathcal{N}\left(-\frac{1}{2}\sigma_z^2, \sigma_z^2\right)\ \forall i$. I normalize the cost parameter for high yield firms to zero, $c^{HY} = 0$. The dispersion parameter σ_z, together with the remaining cost parameter c^{IG} and the exit probability σ jointly determine the credit spreads for investment grade and high

[11]The optimal investment rate under this specification satisfies $\frac{I_t}{K_t} = (Q_t\varphi_2)^{\frac{1}{\varphi_1}}$.

yield firms, and the average level of leverage. The monitoring cost θ is closely relative to the average bond recovery rate. The targets for leverage and credit spreads are taken from Table 1, and for the recovery rate I use a value of 0.413 as in Almeida and Philippon (2007). The intermediation spread ζ is set such that the share of spreads that cannot be attributed to default risk is 51 basis points, as in Almeida and Philippon (2007).

Finally, aggregate productivity A_t follows an AR(1) process with autocorrelation ρ_a, and the volatility of the productivity innovation is σ_a:

$$a_t = \rho_a a_{t-1} + \eta_{a,t}, \quad \text{with } \eta_{a,t} \sim \mathcal{N}(0, \sigma_a^2).$$

Table 3: Parameters and targets

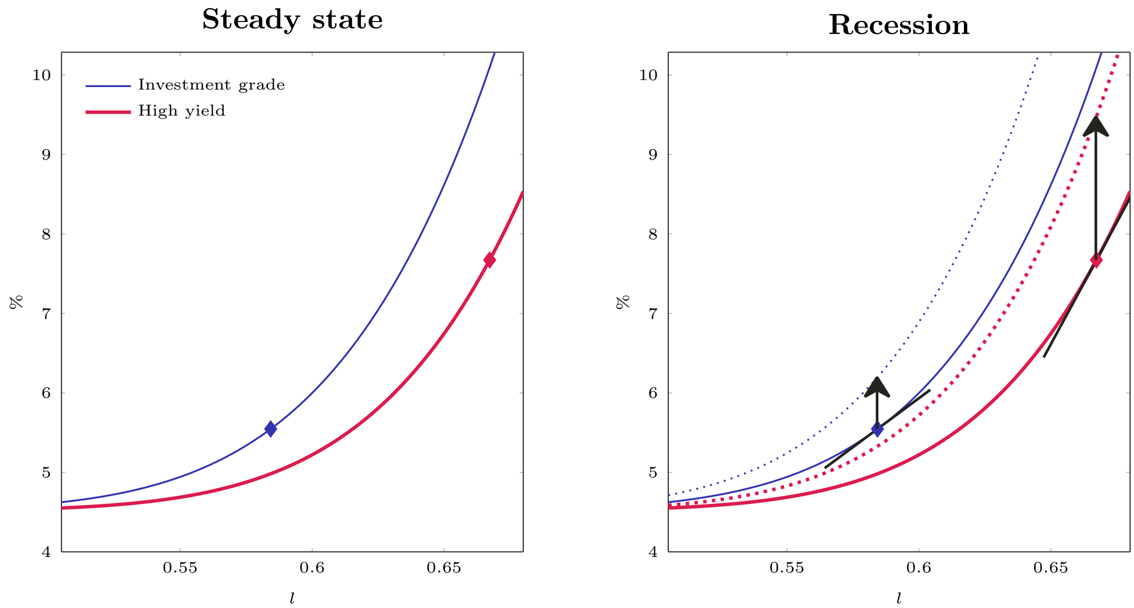
Parameter	**Value**	**Description**	**Target & Source**
β	0.99	Discount factor	Risk-free rate 4% ann.
γ	1	Risk aversion	Standard
η	2	Elasticity of labor supply	Standard
χ	1.98	Disutility of labor	$\bar{Y} = 1$
α	0.33	Capital share	Standard
δ	0.026	Depreciation rate	10% ann.
φ_1	0.25	Elasticity of Q w.r.t. $\frac{I}{K}$	Bernanke et al. (1999)
φ_2, φ_3	0.40,-0.004	Investment technology	$\bar{Q} = 1$, $\bar{I}/\bar{K} = 0.026$
λ_w	0.75	Calvo parameter labor	Av. wage duration 1 year
ϵ_w	6	Elasticity of substitution	Wage markup 20%
ν_w	0.16	Input subsidy	$\nu_w = \epsilon_w^{-1}$, Correct monopoly distortion
σ	0.095	Exogenous exit	$\bar{l}^{av} = 0.63$
σ_z	0.19	Disp idiosyncratic shock	HY spread 367 bps
c^{HY}, c^{IG}	0 , 0.031	Fixed cost	IG spread 155 bps
ζ	-0.0013	Intermediation spread	51 bps, see Almeida and Philippon (2007)
θ	0.44	Bond recovery rate	0.413, see Almeida and Philippon (2007)
p	0.5	Switching probability	Types i.i.d.

4.2 Steady state properties

When deciding on the capital structure firms pick from a menu of debt contracts which links the debt (or leverage) choice to the interest rate. As discussed above firms of different types pick from different menus. In the left panel of Figure 3 I graph the menus faced by the two types in steady state and I mark their respective leverage choice. The position of the two menus illustrates how the production cost drives a wedge between the credit costs of the two types. Namely, conditional on leverage investment grade firms borrow at a higher interest rate, yet in equilibrium, they use debt more cautiously. With lower leverage, they pay lower interest rates and have lower default probabilities.

The calibrated cost parameter for investment grade firms is $c^{IG} = 0.031$. Thus, the cost is 3.1% of total assets value or 6.3% of firm value. This is high relative to the pre-bankruptcy distress costs in Elkamhim et al. (2012), which are reported as 1-2% of firm value. Moreover, in the Compustat data the mean ratio of annual fixed operating costs to total assets is 0.19 for high yield firms and 0.21 for investment grade firms.[12] Again, the cost difference in the model is more pronounced. Notice however, that the cost parameter serves as a stand-in for various frictions and features that are not explicitly modeled. For instance, some of the difference in debt and default risk between investment grade and high yield firms may be related to legacy debt, or else the firm's debt levels may adjust only slowly to some target due to adjustment costs, etc.

Figure 3: Interest rate menus



Notes: Red (blue) line shows interest rate menus of high yield (investment grade) firms. Markers show actual leverage choice and corresponding interest rate in steady state. In the right panel, the dotted line represents the equilibrium interest rate menu following a negative aggregate productivity shock.

Table 4 reports steady state moments for the two types of firms. The credit spreads of 155 bps and 367 bps (in italics) are the only moments directly targeted. Even though average leverage was targeted, the difference between leverage at the two types of firms is an endogenous outcome. Or using Figure 3 to illustrate the point: The vertical distance (i.e., interest rates) between the two markers in Figure 3 was targeted, but the horizontal distance (i.e., leverage) was not. Interestingly, the model comes remarkably close in matching the leverage differential.

The model-implied default rates are 1.73% for investment grade firms and 5.27% for high yield firms. This is higher than the historical default rates (see Table 1) but lower than the expected default frequencies from a structural default model. Aside from the overall level, it is encouraging that the model matches the default rate differential. Namely, default rates at high yield firms in the model are about three times as large as default rates at investment grade firms. The differential of expected default frequencies in the data is only a little larger.

The model abstracts from differences in the average productivity of high yield and investment grade firms. Nevertheless profits differ across the two types because high yield

[12] For fixed costs I use the Compustat variable Selling, General, and Administrative Expense (`XSGA`).

Table 4: Steady state properties

	Data		Model	
	Investment	**High yield**	**Investment**	**High yield**
Financing				
Credit spreads	*155 bps*	*367 bps*	*155 bps*	*367 bps*
Default rate (exp.)	3.23	10.97	1.73	5.27
Leverage	0.58	0.68	0.58	0.67
Productivity				
Return on assets	0.14	0.06	0.18	0.28
Difference	$\Delta = 0.08$		$\Delta = -0.10$	
Risk				
Equity return dispersion	0.17	0.32	0.49	0.55
Difference	$\Delta = 0.15$		$\Delta = 0.06$	
TFP dispersion	0.36	0.46	0.20	0.20
Difference	$\Delta = 0.10$		$\Delta = 0.00$	

Notes: Data moments as in Table 1. In the model, leverage is debt relative to capital. Return on assets is profits (net of fixed cost) divided by capital. Equity return dispersion is the standard deviation of quarterly equity returns (see appendix E.1). TFP dispersion is equal to the standard deviation of the idiosyncratic shock, σ_z.

firms have higher interest costs and investment grade firms pay a higher fixed cost. The latter force outweighs and results in investment grade firms actually being the less profitable firms, in contrast to the data. Not only is the average productivity equal across types, but so is productivity risk σ_z. Thus, unlike in the data there are no differences in cross-sectional TFP dispersion within the two types of firms. However, due to differences in leverage cross-sectional equity return dispersion among high yield firms is larger, even though it can account only for part of the difference in the data.[13] Notice that the level of the cross-sectional equity return dispersion is much higher in the model than in the data. This is in line with the results by Christiano et al. (2014)[14].

4.3 Employment and investment cyclicalities revisited

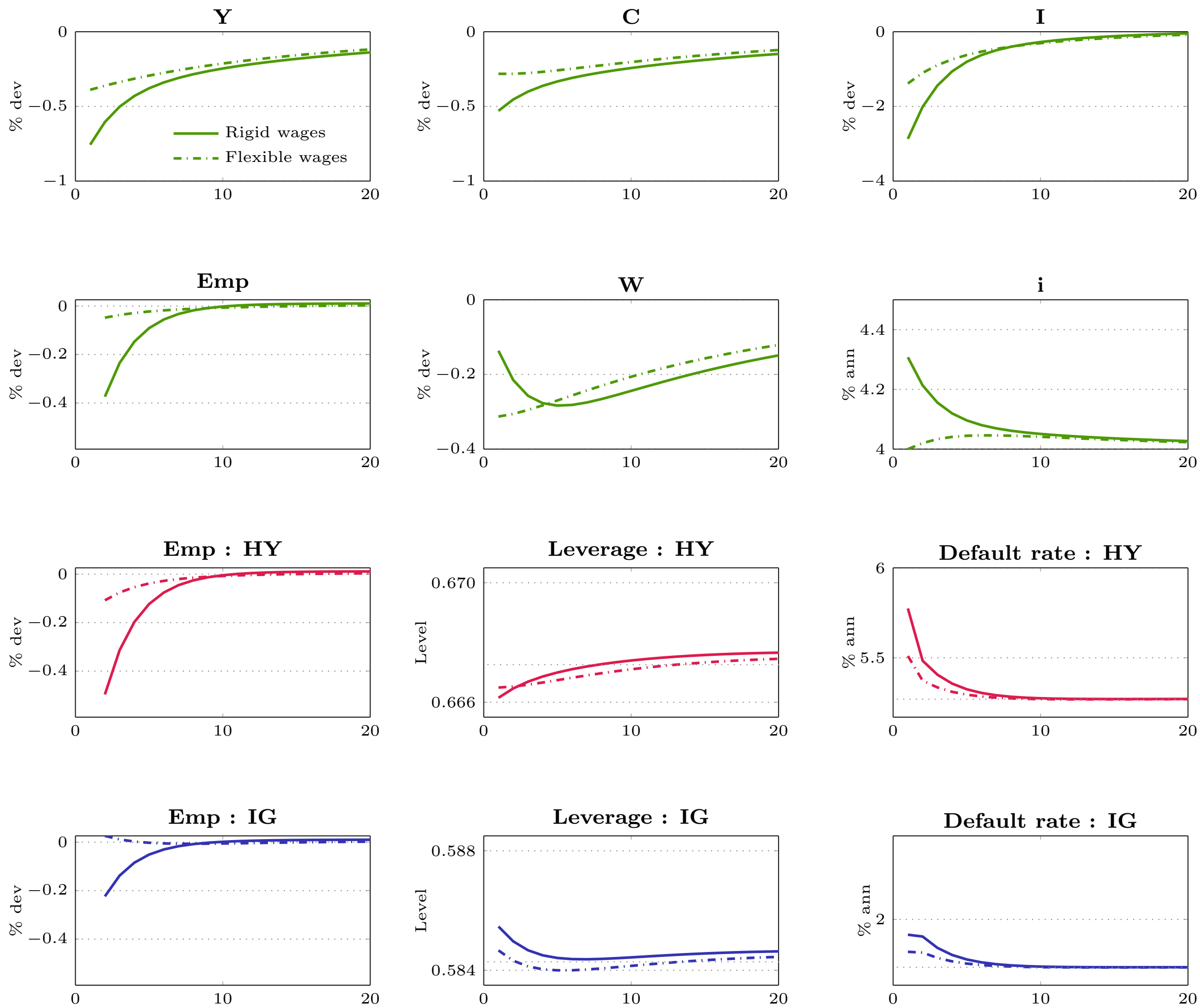
I explore the model dynamics with an impulse response to a 0.5% aggregate productivity shock. Aggregate variables (rows 1&2) respond as in standard DSGE models, i.e., output, consumption, investment, employment, and wages fall, while the risk free rate rises. Notice that under flexible wages (rows 1&2, dash-dotted line) employment does barely decline due to the wealth effect on labor supply. Wage rigidity undoes this effect by preventing the quick downward adjustment of the wage. Consequently, the fall in aggregate variables is more

[13] In section E.1 of the appendix I show that return dispersion in the model consists of two components: First, the dispersion of idiosyncratic productivity, σ_z, which is the same for high yield and investment grade firms. Second, a term related to the leverage of the firm. It is this second term which gives the more leveraged high yield firms greater equity return dispersion.

[14] See their Figure 7 on page 60.

pronounced with rigid wages.

Figure 4: Impulse response to a negative productivity shock (0.5%)



Notes: Impulse response to a 0.5% productivity shock. Log productivity follows an AR(1) process with autocorrelation $\rho_a = 0.9187$. Rows 1&2 show responses of aggregate variables. Rows 3&4 show responses for high yield and investment grade firms. In rows 1&2 solid (dashed) line displays IRF with rigid (flexible) wages, $\lambda_W = 0.75$ ($\lambda_W = 0$).

The responses of the two types of firms are in stark contrast as the contraction in employment and the rise of default rates is much larger among high yield firms (rows 3&4). The right panel in Figure 3 illustrates the mechanism behind this asymmetry. Following a negative productivity shock the interest rate menus faced by the firms shift to the left. This means that if firms wanted to retain the same debt contract, i.e., continue paying the same interest rate on its debt, they would need to deleverage. However, in general equilibrium it is not possible that all firms deleverage immediately. First, capital adjustment costs result in a smooth decline of the capital stock. Second, the net worth of firms falls along with asset prices such that the firms' capital holdings have to be financed through more expensive and more risky debt. In brief, the key question for firms is: How much do borrowing costs rise at (or around) the steady state level of leverage? Figure 3 clearly shows that the vertical distance between the interest rate menus in steady state and the ones after the shock is much larger for high yield firms.

With the precipitous increase in borrowing costs high yield firms have the larger benefits from deleveraging. This is why they divest assets and reduce debt in order to rebalance their capital structure. The drop in asset prices makes capital attractive for investment grade firms. Accordingly, they absorb some of the capital that is shed by high yield firms and finance these purchases through debt issuance. Aggregate leverage, i.e., total debt to total assets, falls in response to the negative aggregate productivity shock (not shown). The differential tightening of credit constraints is also reflected in the dynamics of the net worth multiplier (not shown). Namely, it increases more strongly for high yield firms.

Since labor is complementary to capital these divergent responses are also reflected in employment dynamics. High yield firms reduce employment precipitously, while investment grade firms slightly increase employment relative to steady state. Thus, both production factors, capital and labor, shift from financially more constrained high yield firms to less constrained investment grade firms.

I emphasize that the reason for this asymmetry is not the higher level of leverage but the steeper slope of the interest rate menu of high yield firms. Namely, under the assumption of i.i.d. types, $p = 0.5$, the standard balance sheet channel is operational only with respect to aggregate dynamics. To be precise, as in representative firm models such as Bernanke et al. (1999) the fall of total net worth aggravates the recession and lengthens the recovery phase. However, this effect only pertains to the aggregate economy. With $p = 0.5$ net worth is equalized between the two firm types in the end of each period, therefore there is no differential fall in net worth and no *differential* net worth channel. Of course, adding persistence to the types would only reinforce the differential response and strengthen my results. In section 5.2, I present an extension in which leverage is actually negatively related to the cyclical elasticity, thus providing even greater clarity about the differences to standard balance sheet effects.

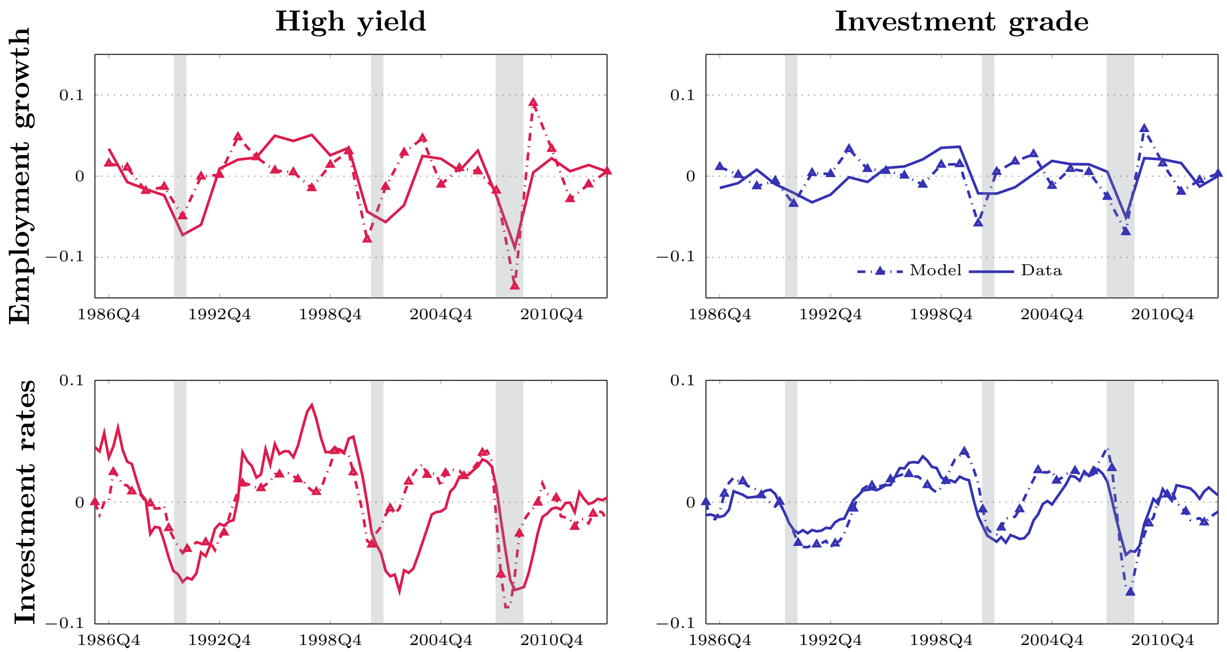
Table 5: Employment and investment volatility

$\frac{std(X)}{std(Y)}$	ΔEmp^{HY}	ΔEmp^{IG}	$\frac{I}{K}^{HY}$	$\frac{I}{K}^{IG}$	I
Data	0.73	0.40	0.69	0.34	1.50/3.69
Baseline	0.80	0.49	0.38	0.36	3.58
Flexible wage	0.25	0.04	0.29	0.30	3.09
Credit spread fix	0.51	0.83	0.33	0.39	3.10
Output cost	0.75	0.55	0.38	0.36	3.70

Notes: Standard deviation of mean year-on-year employment growth/mean investment rate (by rating status) relative to the standard deviation of mean year-on-year sales growth over the sample period (1986Q1 to 2014Q4). In the top right cell, the first number refers to the volatility of year-on-year growth rates of total CAPX among rated Compustat firms, relative to the volatility of sales growth. The second number refers to the volatility of non-residential investment relative to real GDP from the National Income and Product Accounts (NIPA), again in year-on-year growth rates.

Having established the potency of the model mechanism to generate differential employ-

Figure 5: Model fit - Employment growth (top) and investment rates (bottom)



Notes: Mean year-on-year employment growth rate (top row) and mean investment rate (bottom row) among investment grade firms (AAA to $BBB-$ rating, right), and high yield firms ($BB+$ to D, left). Model series inferred from the estimation, sample period 1986Q1 to 2014Q4. Employment growth rates from the model are yearly averages of the quarterly series.

ment responses, I go one step further and ask whether the model can reproduce the employment and investment cyclicalities from the data, displayed in Figure 1. For this exercise I infer aggregate productivity shocks such that aggregate output in the model fits the output dynamics in the data. This is implemented via a Bayesian estimation of the parameters of the productivity process using the mean sales growth rate of rated Compustat firms as an observable. Details on the procedure can be found in appendix F. Subsequently, I extract the implied employment and investment dynamics for the two types of firms, and in Figure 5 I overlay the model implied series with the data. In the top row, the differential cyclicalities of employment growth between high yield (left) and investment grade firms (right) clearly stand out both in the data and in the model. It is striking that the model can replicate the differential drop of employment growth during the three recessions. The main deviation of the model employment series is the too quick recovery after the 1990-1991 and 2008-2009 recessions, particularly among high yield firms.

The investment dynamics pose a greater challenge to the model. For high yield firms the model misses the investment boom of the late 1990s and the steep and persistent fall in the early 2000s. Overall, the model-inferred investment series for investment grade firms is a little more volatile than the data, while the series for high yield firms is clearly too smooth. Notice that there is lag between the fall of investment at high yield and investment grade firms. As an example, consider the 2008-2009 recession in which the trough among high yield firms clearly precedes the trough among investment grade firms. This reflects the different pressure to deleverage across the two types of firms. High yield firms are faced with a much sharper increase in credit costs and are keen to shed capital. Investment grade firms postpone their own deleveraging and make use of their access to debt to absorb some of this capital.

In Table 5 I corroborate the impression from Figure 5 by comparing the relative volatilities. In the first two columns, I compare the volatility of the mean employment growth series (by type) relative to the volatility of the mean sales growth rate among all rated Compustat firms, i.e., the observable in the estimation. In the data as in the model employment growth is less volatile than output growth, and in the data the volatility differential is 0.33. While total employment in the model is a little too volatile, the model comes close in matching the volatility differential with a value of 0.31. As described above, the volatility differential for the investment rate is much less pronounced in the model.[15]

The model's ability to match the employment growth differential is the product of three key ingredients: First, the wage rigidity which permits aggregate employment to drop noticeably in recessions; second, the endogenous price of debt which induces greater capital and employment adjustments at high yield firms; finally, the production cost that is denominated in units of capital and therefore behaves procyclically. I proceed by feeding the shocks recovered in the estimation exercise above through versions of the model in which these channels are switched off one-at-a-time. For each scenario the model dynamics are altered relative to the baseline scenario while the steady state remains unchanged.

As indicated in the impulse response in Figure 4 under flexible wages aggregate employment falls only by little in response to an aggregate productivity shock. The third row in Table 5 reflects this as the employment volatility of both high yield and investment grade firm declines strongly. In fact, the latter can become countercyclical due to the strong response of high yield firms. The magnitude of the volatility differential also falls, yet it appears that while wage rigidity helps reconciling the model with aggregate employment dynamics, it is not instrumental in generating the qualitative difference in the responses of high yield and investment grade firms. Notice that the volatility of wages (relative to the volatility of productivity) is 0.83 under rigid wages and therefore in the range of values that can be derived from aggregate data.[16]

The central decision problem in the model is the firms' debt choice (see equation (4)). Firms trade-off the benefits of debt issuance against the agency cost of borrowing. In the transmission of aggregate shocks the link between default risk and credit costs is a key factor. In the "Credit spread fix" scenario I explore the model dynamics when this link is cut off. To be precise, I assume that borrowing costs remain fixed at the calibrated steady state credit spreads. Yet, with a constant borrowing cost the debt choice (4) does not have a well-defined solution. I therefore assume throughout this exercise that firms maintain leverage as in the steady state of the baseline scenario. The third row in Table 5 shows that the

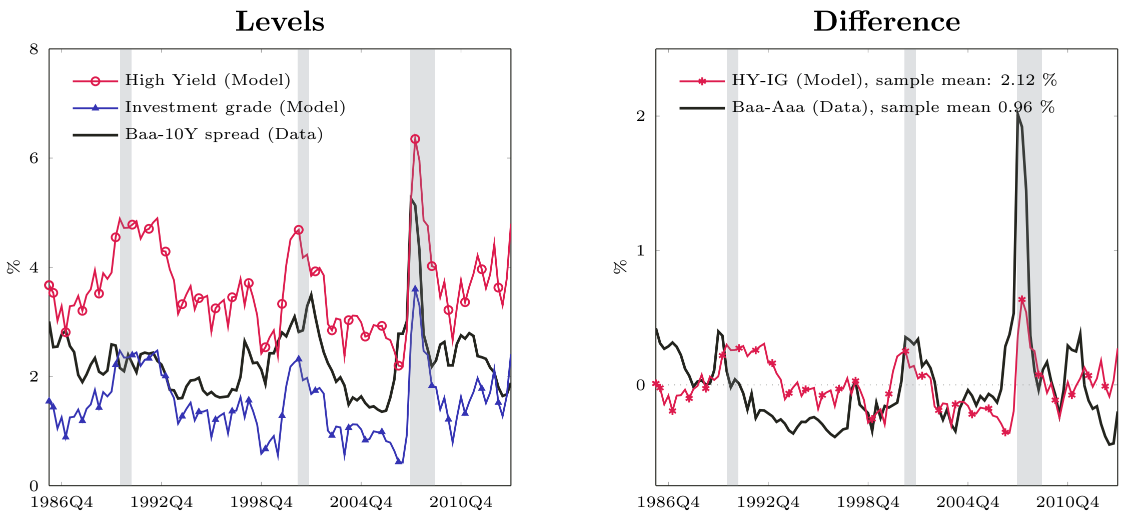
[15] Notice that the volatility of investment rates is different from the volatility of investment. For the latter the model generates a value that is consistent with the volatility of non-residential fixed investment in the NIPA data (3.69 times the volatility of GDP growth). The number derived from total investment of rated Compustat firms, however, is much smaller (1.5 times the volatility of total sales growth).

[16] Labor productivity is real output per person in the nonfarm business sector (BLS series `PRS85006163`). Wages are hourly compensation in the nonfarm business sector (BLS series `PRS85006103`) deflated by the consumer price index (series `CPIAUCSL` via FRED). Sample period 1966Q1 to 2012Q4. Linear detrending/HP filtering yields relative volatility of 0.76/0.88. The latter value is close to the relative volatility reported in Gertler and Trigari (2009).

resulting employment growth cyclicalities in this modified setup are very much in contrast to the baseline case. Investment grade firms have lower employment growth volatility than high yield firms. This pattern emerges because under fixed credit spreads and i.i.d. types higher leverage benefits rather than hurts firms. Specifically, more leveraged firms can take advantage from the drop in asset prices and purchase capital, yet without a negative impact on their borrowing cost.

In the baseline setup the production cost is denominated in units of capital and thus comoves with the price of capital goods Q_t. This captures the idea of a net present value cost as in the analysis by Elkamhim et al. (2012). Effectively, in a boom when firm values are high the associated cost that induces firms to use debt cautiously also rises in sync. In fact, it rises somewhat less than the firm value due to leverage. In the "Output cost" scenario I explore the model dynamics when the cost is instead denominated in terms of the output good. This would be relevant, for instance, if the difference between firms was in their tax rates or in the tax advantage of debt. Tax rates are time-invariant, that is they do not fall in recessions and thus the cost as a share of firm value would become more countercyclical. As it is investment grade firms which face the larger cost, they are hit harder than under the baseline scenario and reduce capital and employment much sharper. The difference between the relative employment growth cyclicalities in the last row of Table 5 declines to about 0.2, much smaller than the 0.33 in the data.

Figure 6: Model fit - Credit Spreads



Notes: Left panel shows level of annualized spreads between corporate debt and the risk free rate. Right panel shows difference between annualized spreads of high yield and investment grade firms. The sample mean is removed and displayed in the legend. Sample period 1986Q1 to 2014Q4.

Aside from the real variables, the model also produces implications for financial variables, such as credit spreads. In the left panel of Figure 6 I consider the level of credit costs for the two types of firms. To compare this to yields in the bond market, I plot the Baa Corporate Credit Spread relative to the Treasury yield. The Baa rating is actually the lowest rating among investment grade firms, and thus at the border between investment grade and high yield. The fact that this series moves in between the model-implied spreads for most of the sample period is encouraging. Also, the magnitudes of the spikes in the 2000-2001 recession and the 2007-2008 Financial Crisis are matched well by the model.

Aside from the satisfying performance regarding the levels, I also investigate the spread differential between high yield and investment grade firms. In the right panel I plot the difference between the two model-implied series from the left panel, and as a data counterpart the difference between the Baa and Aaa Corporate Credit Spreads. This spread has again the interpretation of a risk premium. It captures the risk difference between the two types of corporate debt rather than corporate default risk relative to a risk-free Treasury security as in the left panel. Interestingly, the model matches well the rise in the risk premium during the 1990-1991 and the 2001 recession. In the Financial Crisis, the difference in expected defaults in the model generates only about 1/3-1/2 of the spread increase in the data. Arguably, the disruption to credit supply has been identified as the defining feature of the past recession. To assess whether such disturbances can contribute to the understanding of firm dynamics and their cyclicalities, in the next section I incorporate financial shocks and alternative sources of aggregate uncertainty.

5 Model extensions

5.1 Financial shocks and risk shocks

In the baseline economy credit spreads are determined by expected default rates and the distortion to the intermediaries' discount factor, ζ. Since the latter is time-invariant the dynamics of credit spreads depend on the default rate dynamics alone. However, there is considerable evidence that the component of spreads unrelated to corporate default risk is countercyclical. Gilchrist and Zakrajšek (2012) measure this component, denoted the Excess Bond Premium, and show its strong correlation to the capitalization of financial intermediaries.

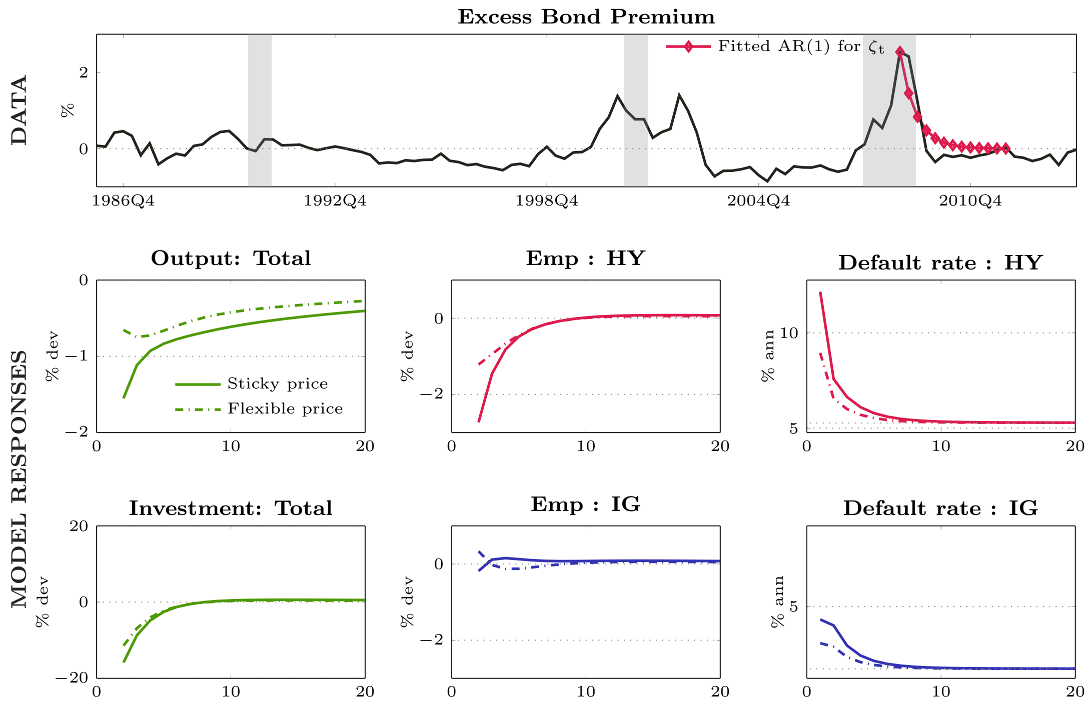
In the literature there are two main approaches to incorporate disruptions to credit supply into DSGE models. Some papers explicitly model financial constraints at the intermediary level and obtain an augmented stochastic discount factor which declines endogenously with a fall in bank capital (see Gertler and Kiyotaki (2010), for instance). Alternatively, one can capture some of these insights with a reduced form approach. I follow Smets and Wouters (2007) and Ajello (2015) who assume a time-varying risk premium or financial intermediation cost. In particular I assume that the distortion to the stochastic discount factor ζ_t follows an AR(1) process:

$$\zeta_t = (1 - \rho_\zeta)\bar{\zeta} + \rho_\zeta \zeta_{t-1} + \eta_{\zeta,t},$$

with $\eta_{\zeta,t} \sim \mathcal{N}(0, \sigma_\zeta^2)$ and $\bar{\zeta}$ is the mean distortion calibrated as in the baseline specification. If ζ_t is negative, the intermediary is more impatient than the household, and the spread between the interest rate on corporate debt and the risk-free rate will increase.

Discount factor shocks essentially raise corporate borrowing costs and depress investment. However, in the baseline economy prices are flexible and thus demand can easily shift from investment to consumption with only small effects on aggregate output and employment. To obtain quantitatively meaningful propagation from discount factor shocks to aggregate activity - as well as from risk shocks and monetary policy shocks that are considered next - I add nominal rigidities via Calvo-type staggered price setting. With sticky prices a reduction in investment demand cannot be fully compensated through consumption since the real interest rate does not fall sufficiently and thus output contracts in equilibrium. The details regarding the setup of the production sector as well as the central bank are contained in section D of the appendix.

Figure 7: Impulse response to a financial shock



Notes: Top panel shows the quarterly average of Gilchrist and Zakrajšek's (2012) monthly Excess Bond Premium (EBP) for non-financial firms, and a fitted AR(1) process to the EBP dynamics during the Financial Crisis. The initial shock size is 2.53%, i.e., $\sigma_\zeta = 0.0253$. Then I determine the autocorrelation ρ_ζ to minimize the squared distance between the EBP and the dynamics of ζ_t over the next 12 quarters, resulting in $\rho_\zeta = 0.5733$. Middle and bottom row display the impulse response to the calibrated ζ_t-process. Under sticky prices the additional parameters are $\lambda_p = 0.75$, $\epsilon_p = 6$, $\nu_p = \epsilon_p^{-1}$, and Taylor rule coefficients $\rho_r = 0.8$, $\alpha_\pi = 2$. With flexible prices $\lambda_p = 0$, i.e., intermediate good firms can adjust prices each period.

The top panel in Figure 7 displays the dynamics of the bond premium over the last three recessions. Evidently, the most pronounced increase coincides with the Financial Crisis. I focus on this particular episode and choose $(\rho_\zeta, \sigma_\zeta)$ to fit a discount factor process ζ_t to the bond premium dynamics, starting from the peak in 2008Q4. The middle and bottom row of Figure 7 show the results from the impulse response to such a discount factor shock. The collapse of investment by about 15% drives the fall in aggregate output. Notice that that with flexible prices the investment drop is comparable, but the output contraction is much reduced. This shows that price rigidity is important to prevent a substitution of investment demand through consumption.

Employment at high yield firms falls very strongly, whereas it is essentially flat at investment grade firms. This reflects that capital is reallocated towards less constrained investment grade firms, allowing the more constrained high yield firms to deleverage. On impact the annualized default rate among high yield firms rises to 12.16% from its steady state level of 5.27%. This change is remarkably close to the dynamics of historical default rates around the Financial Crisis. According to Standard & Poor's (2012), the one-year cumulative default rate among high yield firms in 2009 was 11.35% compared to the long-term average of 4.49%.[17] This points to financial shocks as a powerful driver of default dynamics in the corporate sector. Moreover, the shock widens the gap between default rates at the two types of firms. While the increase of default rates among high yield firms is 6.8% on impact, the increase among investment grade firms is only 2.6%.

According to the credit channel of monetary policy, a rise in the short-term interest rate affects real activity by increasing the external finance premium and diminishing investment demand by firms (see Bernanke and Gertler (1995)). In my framework a contractionary monetary policy shock shifts the interest rate menus faced by the two types of firms upwards. While this upward shift is symmetric, an impulse response shows that nevertheless employment at high yield firms contracts much sharper and default rates rise by more (Figure B.2 in the appendix). This is because in equilibrium assets prices, wages, etc., adjust and lead to a further shift in the interest rate menus. Importantly, this general equilibrium shift is asymmetric and similar to the one depicted in Figure 3. The asymmetric responses of employment are consistent with empirical evidence on firm dynamics after tight monetary policy (Gertler and Gilchrist (1994)). More generally, monetary policy has distributional effects that spread the burden of higher (or benefits of lower) borrowing costs unequally. This can be of particular relevance when heterogeneity in the firms' productivities is taken into account. Namely, the reallocation of production factors induced by monetary policy will either increase or diminish aggregate productivity. Moreover, the effects of monetary policy may fall unevenly on firms in the presence of long-term nominal debt since surprise inflation would provide a greater boost to more leveraged firms (Gomes et al. (2014)).

The heterogeneity in employment and investment elasticities suggests a role for financial frictions in the dynamics of cross-sectional dispersion. As discussed in the introduction, one part of the literature has introduced various mechanisms to understand and explain how dispersion evolves endogenously over the business cycle. In contrast, various other papers use dispersion dynamics as a motivation to introduce exogenous shocks to cross-sectional risk. While the two-type setup is quite restrictive and does not allow to fully assessing the contribution to the endogenous dispersion margin, the model nevertheless offers an angle to confront the exogenous and endogenous margins jointly. The key question is how cross-sectional dispersion is affected by exogenous risk shocks when firms also differ with respect to cyclical elasticities. This is very timely question because some researchers, such as Arellano et al. (2012), use data on cross-sectional dynamics to discipline risk shocks.

As in Christiano et al. (2014) I introduce time-variation in cross-sectional risk via the dispersion of the idiosyncratic productivity shocks, $\sigma_{z,t}$. Unlike in the baseline economy, it is no longer time-invariant, but it follows an AR(1) process around its mean $\bar{\sigma}_z$, calibrated as in the baseline specification:

$$\sigma_{z,t} = (1 - \rho_\sigma)\bar{\sigma}_z + \rho_\sigma \sigma_{z,t-1} + \eta_{\sigma,t},$$

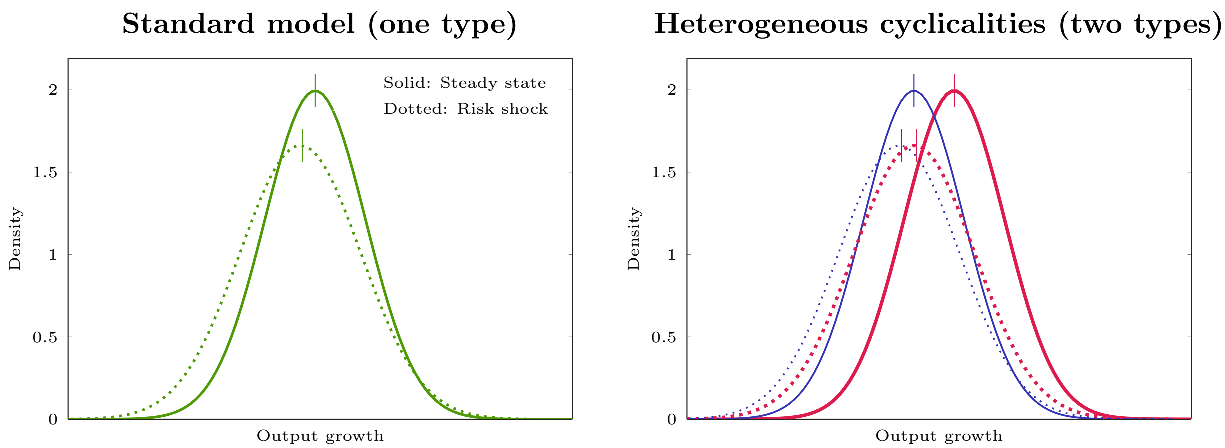
where $\eta_{\sigma,t} \sim \mathcal{N}(0, \sigma_\sigma^2)$. The distribution of idiosyncratic productivity then writes as $\log z_t^i \sim \mathcal{N}\left(-\frac{1}{2}\sigma_{z,t-1}^2, \sigma_{z,t-1}^2\right)$. Notice that the dispersion of productivity in period t is already known in period $t-1$.

[17] As in Table 1 the default rates by rating are only available for all firms, i.e., including financial firms.

The impulse response to a risk shock is displayed in Figure B.1 in the appendix. A mean-preserving spread of the idiosyncratic productivity distribution increases default risk and thus credit spreads rise as in the representative agent setup by Christiano et al. (2014). The very pronounced difference in the response of high yield and investment grade firms reflects risk-sharing between the two types. The shift of production factors to investment grade firms allows high yield firms to deleverage and to reduce default risk. Investment grade firms in turn accept a somewhat higher default risk. Due to the absence of capital adjustment costs at the firm level, the model likely overstates the role of capital and labor reallocation.

The connection between risk shocks and cross-sectional dispersion is illustrated in Figure 8. In the left panel I display the cross-sectional distribution of output growth[18] in a standard model with only one firm type, such as in Christiano et al. (2014). Following a risk shock more mass shifts towards the tails (dotted line). In addition, we know from Christiano et al. (2014) and the IRF in Figure B.1 that a risk shock depresses investment and induces a recession. Therefore, the mean output growth rate declines. However, the shift in the mean does not affect dispersion measures such as the cross-sectional standard deviation. In summary, in a standard model with one type of firm a shock to cross-sectional risk increases measured cross-sectional dispersion one-for-one.

Figure 8: Illustration of cross-sectional dispersion after a risk shock



Notes: Illustrative density plots of output growth in an economy with one type of firm (left panel), and two types with different cyclicalities (right panel). The vertical bar represents the mean of output growth in the economy (left panel), and for the respective type of firm (right panel). Dotted line shows output growth after a mean-preserving spread to cross-sectional risk.

The right panel illustrates the output growth distributions of high yield firms and investment grade firms. Motivated by the empirical results in section 2, the distribution of high yield firms has a higher mean, resulting in a partial overlap of the two distributions. Consequently, total cross-sectional dispersion is larger than dispersion within each type. In response to a risk shock output growth at both high yield firms and investment grade firms becomes more dispersed, i.e., again mass shifts to the tails. But in addition, the greater cyclicality of high yield firms implies that mean output growth among these firms falls by more,

[18] Under the assumption for the idiosyncratic productivity distribution output growth is normally distributed.

creating a greater overlap between the two distributions. Therefore, the rise in measured cross-sectional dispersion would be smaller than the exogenous increase in cross-sectional risk. Or differently: a model without heterogeneity may overpredict the increase in cross-sectional dispersion stemming from risk shocks.

5.2 Leverage and risk heterogeneity

According to the summary statistics in Table 1 high yield firms differ from investment grade firms not only with respect to credit costs and default frequencies but also in various other characteristics such as risk, productivity and size. One puzzling fact in the sample of rated firms is the negative relationship between risk and leverage. Using a wider sample, namely both rated and non-rated firms in Compustat, Frank and Goyal (2009) find that firms with higher stock return volatility tend to have lower leverage. I confirm that in the wider sample this relationship also holds across 3-digit NAICS industries groups. That is, industries in which equity returns across firms are more dispersed have higher average leverage (see Figure E.1 in the appendix). In summary, the empirical evidence suggests that the relation between risk and leverage among rated firms may be circumstantial. Importantly though, this observation does not invalidate the results from the model because - as I argued - the mechanism does not depend on differences in leverage and in the severity of balance sheet effects. In fact, this is what sets the present framework apart from collateral constraints in the tradition of Kiyotaki and Moore (1997).

In this section I explore the interdependence of risk, leverage, and cyclical elasticities by introducing differences in the dispersion of idiosyncratic productivity risk between the two types of firms. In the steady state this generates a negative relation between risk and leverage, counterfactual with regards to the evidence on rated firms but consistent with the general population of firms. I find that if firms differ only in the magnitude of idiosyncratic risk the more risky firms in general do not have a greater cyclicality of employment. In contrast, with heterogeneity in both the cost and the dispersion parameters - and therefore with different slopes of the interest rate menus as in the baseline economy - the more risky firms respond more strongly to aggregate conditions.

For the "Cost & Risk" scenario I assume that firms differ along two dimensions. They have (i) a type-specific cost c^{type}, and (ii) a type-specific dispersion of idiosyncratic productivity σ_z^{type}. Still, there are only two types of firms, called $HDHR$ (for "High Default (Probability) & High Risk") and $LDLR$ (for "Low Default (Probability) & Low Risk"), with parameters $(c^{HDHR}, \sigma_z^{HDHR})$ and $(c^{LDLR}, \sigma_z^{LDLR})$, respectively. $HDHR$ firms correspond to the more risky, high yield firms in the data; $LDLR$ firms to the less risky investment grade firms. I calibrate the model as in the baseline scenario, except that there is one additional parameter, i.e., two dispersion parameters instead of one. The additional target in the calibration is the difference of TFP dispersion among high yield and investment grade firms. Notice that due to the assumed heterogeneity in the fixed cost the credit spread differential is still a calibration target. Compared to the baseline economy, the calibrated value for the exit probability declines, $\sigma = 0.088$, as does the production cost of $LDLR$ firms, $c^{LDLR} = 0.029$. The values for the productivity dispersion parameters are $\sigma_z^{HDHR} = 0.26$, $\sigma_z^{LDLR} = 0.16$.

In the "Risk" scenario there are no differences in the fixed cost but only type-specific dispersion parameters σ_z^{type}, $type \in \{HR, LR\}$ for high risk firms and low risk firms. Since the difference of TFP dispersion is added as an additional target, the calibration cannot match the credit spread differential but only the average credit spread. The resulting value for the exit probability is $\sigma = 0.094$, and the dispersion parameters are $\sigma_z^{HR} = 0.27$ and $\sigma_z^{LR} = 0.17$, respectively.

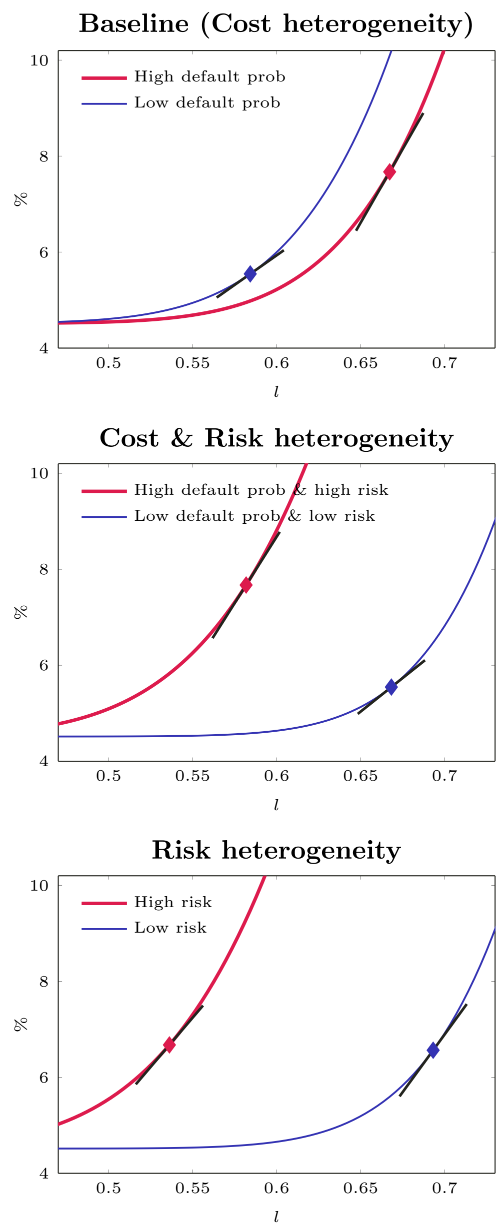
Figure 9 depicts the interest rate menus faced by firms and their respective choices of leverage in steady state. The top panel reproduces the steady state of the baseline economy (see left panel in Figure 3). The cost difference makes investment grade firms more cautious about using debt financing and in steady state they operate with lower default risk and lower leverage. In contrast, with risk heterogeneity but no cost differences (bottom panel) there is no noticeable difference in credit spreads (and thus default risk) but only a large leverage differential. The reason is that conditionally on leverage the default probability is increasing with idiosyncratic productivity risk. This means that the interest rate menu of high risk firms lies above the menu of low risk firms. Yet, without differences in the relative benefits of debt financing low risk firms have no reason to be particularly cautious about debt issuance. Accordingly, the steady state credit spreads are very similar for the two types. Finally, the additional difference in the fixed cost induces high risk firms to expose themselves to higher default risk in steady state (middle panel). Similar to the baseline economy, the slope of the interest menu for these firms is greater than for firms with lower default probabilities and lower fundamental risk.

In Figure 10 I study the employment responses to an aggregate productivity shock. First consider the left column in which firm types are i.i.d., $p = 0.5$. That is, in the end of each period net worth is equalized between the two types and therefore higher leverage does not lead to a persistent and disproportionate fall in net worth among one type of firm.

In all three versions of the model firms with higher default probabilities and/or higher fundamental risk are more sensitive to the aggregate productivity shock. This suggests that the cost heterogeneity is not essential to produce heterogeneous employment cyclicalities. As it turns out, however, this outcome is owed to the assumption of i.i.d. types. This assumption removes a detrimental effect of high leverage, namely the standard balance sheet effect, but it keeps in place a positive effect. The latter emerges because firms that are able to sustain higher leverage benefit to a greater extent from a fall in asset prices. With persistent types both effects of leverage are operational and the negative balance sheet effect dominates. The bottom right panel shows that with risk heterogeneity alone and with the active balance sheet effect, i.e., persistent types, the more risky firms do not have a greater responsiveness to aggregate shocks. In contrast, the top right panel shows that adding type persistence to the baseline economy actually reinforces the heterogeneous responsiveness. This is because the firms with higher default risk are also the ones with higher leverage.

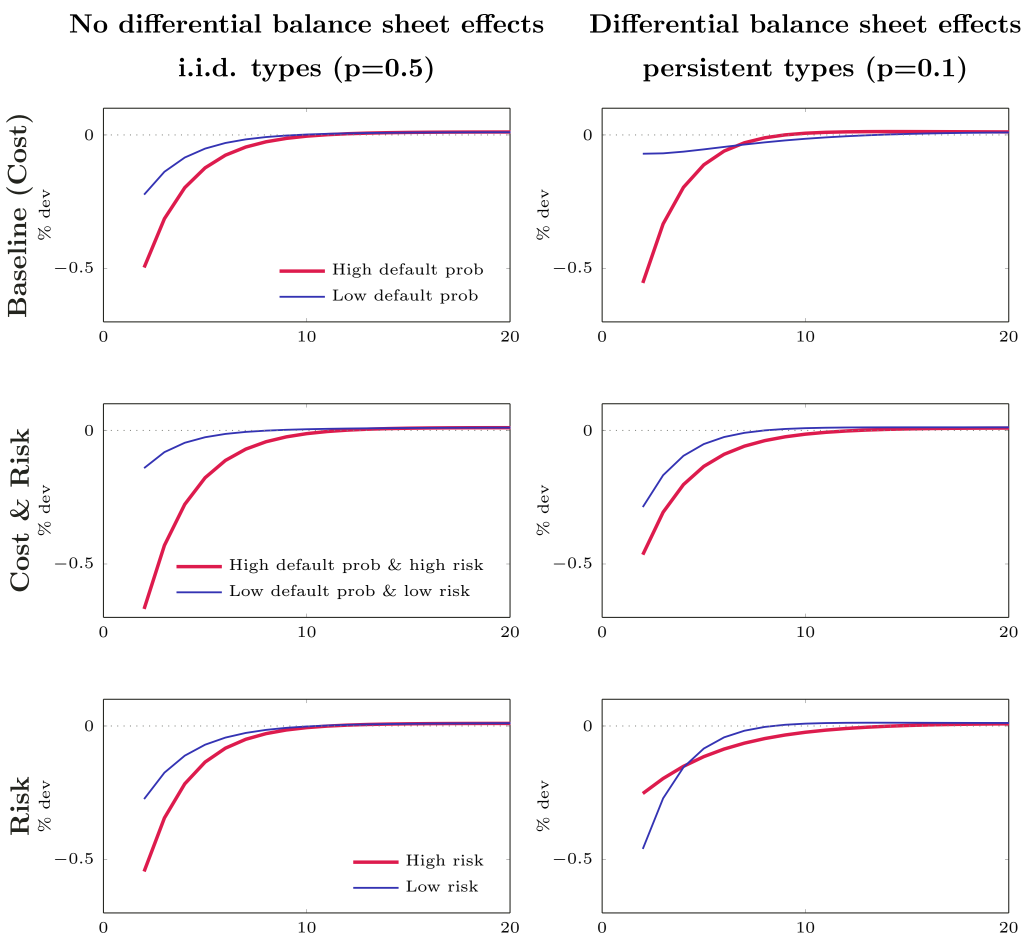
Finally, the middle right panel shows that even after adding type persistence the more risky, but less indebted firms are more sensitive to cyclical shocks. Notice that there are two countervailing effects here. On the one hand, the greater sensitivity of default risk among high risk firms, represented by the steeper slope of the interest rate menu, implies a stronger response to aggregate shocks. On the other hand, higher leverage at low risk firms induces stronger balance sheet effects and amplifies the employment contraction among such firms. The fact that the former effect dominates the standard balance sheet effect shows that the novel mechanism of this paper, i.e., the differential responsiveness of default risk and credit costs, can be a forceful driver for cross-sectional dynamics.

Figure 9: Interest rate menus with cost and/or risk heterogeneity



Notes: Red (blue) line shows interest rate menus of high risk (low risk) firms. Markers show actual leverage choice and corresponding interest rate in steady state.

Figure 10: Employment responses, heterogeneity, and balance sheet effects



Notes: Impulse response of employment to a 0.5% negative productivity shock. For each combination of firm-level heterogeneity and type persistence the model is re-calibrated.

In summary, this exercise shows that even if leverage is low, firms may be very sensitive to macroeconomic conditions. This is very relevant for the analysis of the dynamics of smaller and younger firms. According to Siemer (2012), small and young firms suffered disproportionally from the tightening of financial constraints in the Great Recession. Moreover, Fort et al. (2012) and my regression results indicate greater cyclical sensitivity among young firms. These dynamics cannot be accounted for by leverage and balance sheet effects alone, since smaller firms tend to have less outside financing. Thus, the channel proposed in this paper constitutes a promising alternative that remains tractable and that can be disciplined using firm-level data.

6 Conclusion

In this paper, I have analyzed corporate credit constraints with a particular focus on the interconnection of time series and cross section. High yield firms are shown to have greater cyclicality of employment growth and investment rates. A standard DSGE model with credit market frictions and augmented by firm heterogeneity can reproduce these facts to a large extent, and helps deriving new implications for cross-sectional dynamics and policy.

While aggregate leverage determines the economy's sensitivity to cyclical shocks as in a representative firm model, firm-level leverage does not necessarily predict the cyclical dynamics of a firm. Namely, under the structure of my model riskier firms may have lower leverage, but nevertheless they respond stronger to aggregate shocks. This insight hints at challenges in assessing vulnerabilities in the nonfinancial sector.

In the presence of heterogeneity monetary policy has distributional effects because it relaxes (or tightens) financial constraints differentially. For instance, risky and less productive firms may benefit most from a drop in credit costs and thus the allocation of capital may worsen. Analyzing how monetary policy alleviates or aggravates distortions in the economy is a priority for future work.

Beyond the specific context of this paper, the framework that I develop is applicable to a variety of settings. For instance, it could be useful for studying firm financing in emerging economies where only few firms access foreign debt markets. Provided that the ability to raise funds abroad correlates with the firm's risk profile and capital structure, the modeling framework predicts different employment cyclicalities in such an economy. Additionally, exchange rate dynamics would become relevant as they inflate or deflate the real value of external debt.

Finally, the mechanism presented in this paper can help explain the countercyclicality of cross-sectional dispersion measures. In fact, the model features an endogenous dispersion channel via heterogeneous employment sensitivities, while it also allows incorporating exogenous variation in the magnitude of idiosyncratic shocks. Accordingly, this framework may serve to assess the contributions of the endogenous and exogenous margins to the cross-sectional dispersion dynamics. A quantitative assessment of these channels would require a more fine-grained representation of firm-level heterogeneity than is possible in the current setup. I leave this as a perspective for future research.

A Additional regressions

Table A.1: Cyclicalities of employment and investment (Excess Bond Premium)

	$\Delta Employment_{i,t}$			$CAPX_{i,t}/K_{i,t-1}$		
	(1)	(2)	(3)	(4)	(5)	(6)
EBP_{t-1}	-0.020***	-0.024***	-0.028***	-0.008***	-0.014***	-0.016***
	(-7.47)	(-9.73)	(-10.40)	(-7.33)	(-13.68)	(-12.72)
$HighYield_{i,t-1}$	0.035***	0.022***	0.008**	0.071***	0.043***	0.025***
	(10.62)	(7.20)	(2.50)	(40.52)	(27.17)	(15.86)
$HighYield_{i,t-1} \times EBP_{t-1}$	-0.021***	-0.017***	-0.011***	-0.019***	-0.014***	-0.011***
	(-4.59)	(-4.18)	(-2.79)	(-8.43)	(-6.95)	(-5.48)
$Age_{i,t-1}$			-0.024***			-0.028***
			(-12.27)			(-24.80)
$Age_{i,t-1} \times EBP_{t-1}$			0.011***			0.004**
			(3.48)			(2.43)
$Market\text{-}to\text{-}Book_{i,t-1}$	0.043***	0.034***	0.032***	0.076***	0.057***	0.055***
	(15.23)	(13.00)	(12.46)	(38.34)	(32.31)	(31.73)
$Profits_{i,t-1}$	0.164***	0.085***	0.097***	0.373***	0.178***	0.197***
	(5.65)	(3.26)	(3.78)	(6.81)	(3.65)	(4.09)
R^2	0.04	0.03	0.04	0.08	0.06	0.07
N	20,384	20,384	20,384	67,153	67,153	67,153
$Time \times Industry$	No	Yes	Yes	No	Yes	Yes

Notes: For information on firm-level data see Table 2. The cyclical indicator is the Excess Bond Premium (EBP) by Gilchrist and Zakrajšek (2012), 1986Q1 to 2010Q3. Values in parentheses are t-statistics computed using robust standard errors. (***/**/*) indicate significance at the (1/5/10) percent level.

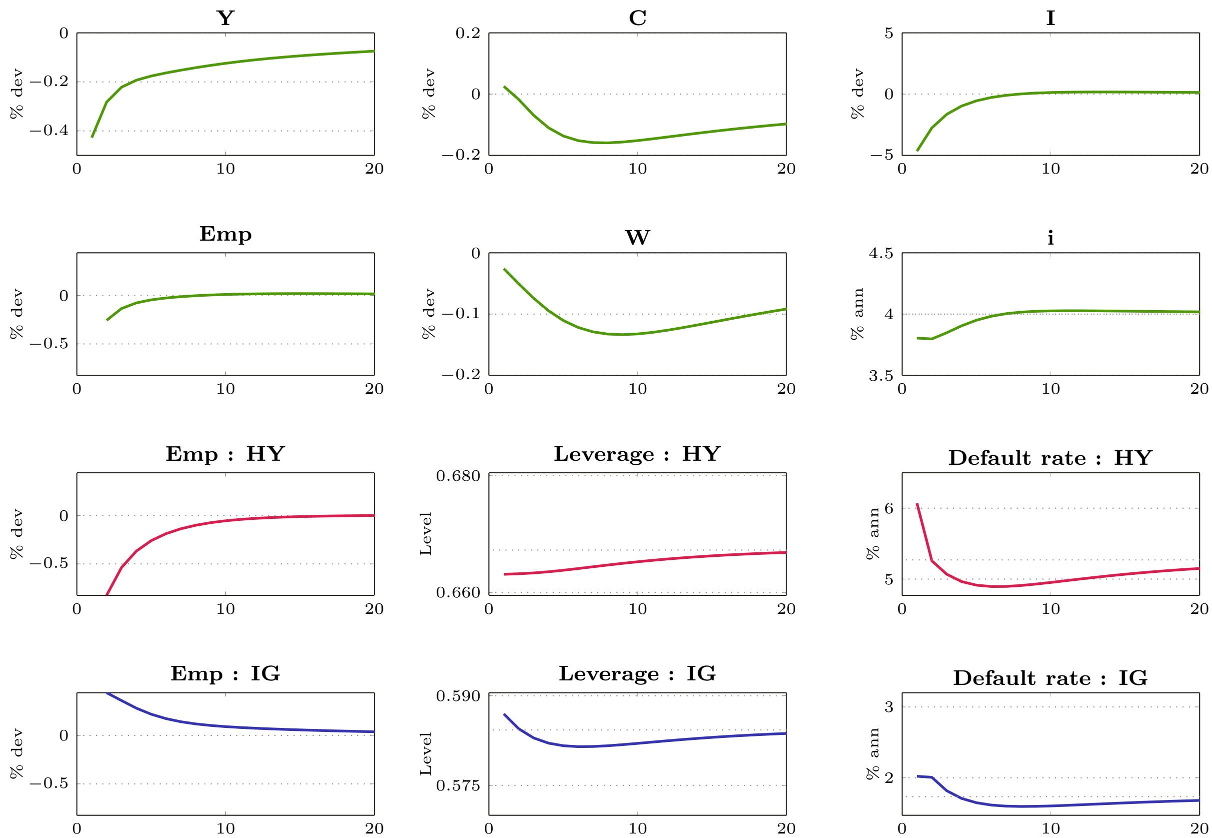
Table A.2: Cyclicalities of employment and investment (Volatility Index)

	$\Delta Employment_{i,t}$			$CAPX_{i,t}/K_{i,t-1}$		
	(1)	(2)	(3)	(4)	(5)	(6)
VXO_{t-1}	-0.043***	-0.065***	-0.082***	-0.035***	-0.049***	-0.053***
	(-3.14)	(-4.97)	(-5.98)	(-4.58)	(-6.95)	(-6.22)
$HighYield_{i,t-1}$	0.065***	0.044***	0.027***	0.083***	0.056***	0.040***
	(9.98)	(7.47)	(4.51)	(23.07)	(17.15)	(12.11)
$HighYield_{i,t-1} \times VXO_{t-1}$	-0.128***	-0.093***	-0.071***	-0.075***	-0.073***	-0.078***
	(-5.08)	(-4.06)	(-3.18)	(-4.99)	(-5.41)	(-5.75)
$Age_{i,t-1}$			-0.032***			-0.027***
			(-7.59)			(-9.46)
$Age_{i,t-1} \times VXO_{t-1}$			0.039**			-0.006
			(2.31)			(-0.51)
$Market\text{-}to\text{-}Book_{i,t-1}$	0.043***	0.034***	0.032***	0.073***	0.056***	0.053***
	(15.67)	(13.32)	(12.71)	(40.75)	(34.54)	(33.76)
$Profits_{i,t-1}$	0.177***	0.112***	0.125***	0.365***	0.177***	0.196***
	(5.47)	(3.71)	(4.17)	(7.17)	(3.90)	(4.35)
R^2	0.03	0.03	0.03	0.07	0.05	0.06
N	24,035	24,035	24,035	78,898	78,898	78,898
$Time \times Industry$	No	Yes	Yes	No	Yes	Yes

Notes: For information on firm-level data see Table 2. The cyclical indicator is the CBOE's S&P 100 Volatility Index (VXO), 1986Q1 to 2014Q4. Values in parentheses are t-statistics computed using robust standard errors. (***/**/*) indicate significance at the (1/5/10) percent level.

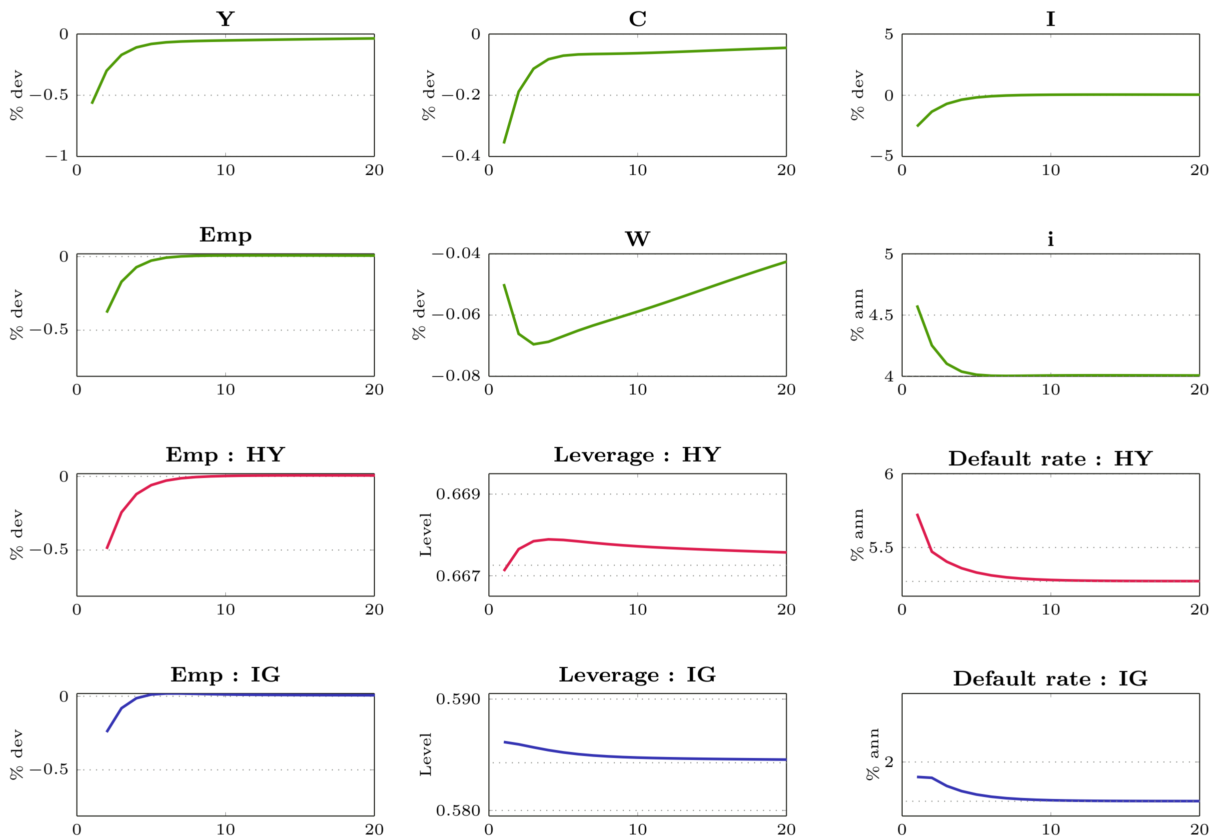
B Additional impulse responses

Figure B.1: Impulse response to a cross-sectional risk shock (2.5%)



Notes: Rows 1&2 show responses of aggregate variables. Rows 3&4 show responses for high yield and investment grade firms. Additional parameters are $\lambda_p = 0.75$, $\epsilon_p = 6$, $\nu_p = \epsilon_p^{-1}$, and Taylor rule coefficients $\rho_r = 0.8$, $\alpha_\pi = 2$. Autocorrelation of risk innovation of 0.9.

Figure B.2: Impulse response to a contractionary monetary policy shock (25 bps)



Notes: Rows 1&2 show responses of aggregate variables. Rows 3&4 show responses for high yield and investment grade firms. Additional parameters are $\lambda_p = 0.75$, $\epsilon_p = 6$, $\nu_p = \epsilon_p^{-1}$, and Taylor rule coefficients $\rho_r = 0.8$, $\alpha_\pi = 2$.

C Dynamic problem of the firm

Recall that the guess for the value function is $V_t^{type}(NW_t^i) = \lambda_t^{type} NW_t^i$. Inserting this guess as well as the solution for the default threshold $\bar{z}_{t+1}^{type}$ into the firm's dynamic problem (1) yields the following expression:

$$\begin{aligned}\lambda_t^{type}\ NW_t^i = NW_t^i + \max_{\{K_{t+1}^i, B_{t+1}^i\}} \Bigg\{ & - Q_t K_{t+1}^i + q_t^{type}(K_{t+1}^i, B_{t+1}^i) B_{t+1}^i \\ & + \mathbb{E}_t \left[m_{t,t+1} \int_{\bar{z}_{t+1}^{type}} NW_{t+1}^i dF((1-\sigma)((1-p)\lambda_{t+1}^{type} + p\lambda_{t+1}^{\neg type}) + \sigma) \right] \Bigg\},\end{aligned}$$

with the non-negativity constraint on dividends

$$Div_t^i = \ NW_t^i - Q_t K_{t+1}^i + q_t^{type}(K_{t+1}^i, B_{t+1}^i) B_{t+1}^i \geq 0.$$

I then define net worth per unit of capital $nw_t^i = \frac{NW_t^i}{K_t^i}$ and capital growth $\iota_{t+1}^i = \frac{K_{t+1}^i}{K_t^i}$, and I use that the price of debt depends only of the ratio of debt to capital, i.e., on leverage. Then, I divide both sides by K_t^i and rewrite the problem:

$$\begin{aligned}\lambda_t^{type}\ nw_t^i = nw_t^i + \max_{\{\iota_{t+1}^i, l_{t+1}^i\}} \iota_{t+1}^i \Bigg\{ & - Q_t + q_t^{type}(l_{t+1}^i) l_{t+1}^i \\ & + \underbrace{\mathbb{E}_t \left[m_{t,t+1} \int_{\bar{z}_{t+1}^{type}} nw_{t+1}^i dF((1-\sigma)((1-p)\lambda_{t+1}^{type} + p\lambda_{t+1}^{\neg type}) + \sigma) \right]}_{v_{cont}} \Bigg\},\end{aligned} \tag{7}$$

and associated non-negativity constraint on dividends is

$$nw_t^i - \iota_{t+1}^i (Q_t - q_t^{type}(l_{t+1}^i) l_{t+1}^i) \geq 0.$$

As stated in the text leverage is determined by the first order condition (4). The term inside the max operator in equation (7), v_{cont}, is non-negative[19]. Therefore, the firm wants to set ι_{t+1}^i as high as possible while not violating the non-negative constraint on dividends. This leads to the corner solution (5).

Finally, under this solution the net worth multiplier writes as

$$\lambda_t^{type} = \frac{\mathbb{E}_t \left[m_{t,t+1} \int_{\bar{z}_{t+1}^{type}} nw_{t+1}^i dF((1-\sigma)((1-p)\lambda_{t+1}^{type} + p\lambda_{t+1}^{\neg type}) + \sigma) \right]}{Q_t - q_t^{type}(l_{t+1}^{type}) l_{t+1}^{type}},$$

confirming that it is independent of period t cost type and idiosyncratic productivity.

[19] Formally, this can be shown by deriving the first-order condition for capital K_{t+1}^i and acknowledging that the Lagrange multiplier on the non-negativity constraint on dividends (2) is non-negative.

D Nominal rigidities

Recall that firms of either type produce the same homogeneous good. I relabel this good as "wholesale good", thereby indicating that it is no longer the final output/consumption good. Rather the wholesale good is purchased by intermediate goods producers at price P_t^w. Intermediate good producers are monopolistically competitive, indexed by $r \in [0,1]$ (r for retailers), and each intermediate good firms transforms the wholesale into its respective variety r one-for-one. Finally, a CES aggregate of these different varieties is assembled by competitive final good produces.

D.1 Final goods producers

The final output Y_t is a CES aggregate of intermediate goods, where ϵ_p is the elasticity of substitution between the different varieties:

$$Y_t = \left(\int y_{r,t}^{\frac{\epsilon_p - 1}{\epsilon_p}} dr \right)^{\frac{\epsilon_p}{\epsilon_p - 1}}.$$

Final goods producers choose the amount of each variety r, taken as given the price of output P_t and the price of intermediate goods, $P_{r,t}$, $r \in [0,1]$:

$$\max_{\{y_{r,t}\}} P_t Y_t - \int P_{r,t} y_{r,t} dr.$$

Demand for variety r is

$$y_{r,t} = \left(\frac{P_{r,t}}{P_t} \right)^{-\epsilon} Y_t.$$

Plugging the demand equation back into the firm's problem and imposing the zero profit condition yields the prices index $P_t = \left(\int P_{r,t}^{1-\epsilon} dr \right)^{\frac{1}{1-\epsilon}}$.

D.2 Intermediate good firms

Intermediate good firms take demand from final goods producers as given, and choose their price $P_{r,t}$ to maximize the present discount value of profits. However, they can reset prices only infrequently. Every period a random fraction $1 - \lambda_p$ is selected and can freely reset its price. The remaining fraction λ_p retains the price from the previous period. An intermediate good firm r that is allowed to adjust its price in period t chooses its price taking into account expected profits in all future states in which it is not allowed to adjust its price.

Due to market power intermediate good producers set prices as a mark-up over marginal costs. Therefore, equilibrium quantities would be lower than under perfect competition. I assume that intermediate good producers receive an input subsidy ν_p that eliminates this inefficiency in steady state. Since the subsidy is time-invariant there will be an inefficiency out-of steady state, however. The effective price paid by intermediate good producers per unit of wholesale good is $(1-\nu_p)P_t^w$. The subsidy is financed through lump-sum taxes.

$$\max_{P_{r,t}^*}\mathbb{E}_t\left[\sum_{j=0}^{\infty}\lambda_p^j m_{t,t+j}\frac{P_t}{P_{t+j}}\left(P_{r,t}^* y_{r,t+j}-P_{t+j}^w(1-\nu_p)y_{r,t+j}\right)\right]$$
$$\Leftrightarrow\max_{P_{r,t}^*}\mathbb{E}_t\left[\sum_{j=0}^{\infty}\lambda_p^j m_{t,t+j}\frac{P_t}{P_{t+j}}\left(P_{r,t}^*\left(\frac{P_{r,t}^*}{P_{t+j}}\right)^{-\epsilon_p}Y_{t+j}-P_{t+j}^w\left(\frac{P_{r,t}^*}{P_{t+j}}\right)^{-\epsilon_p}Y_{t+j}(1-\nu_p)\right)\right],$$

where $p_t^w=\frac{P_t^w}{P_t}$, $p_{r,t}=\frac{P_{r,t}}{P_t}$.

The first-order condition to the firm's problem writes as follows:

$$\mathbb{E}_t\left[\sum_{j=0}^{\infty}\lambda_p^j m_{t,t+j}Y_{t+j}P_{t+j}^{\epsilon_p}\left(p_{r,t}^*\frac{P_t}{P_{t+j}}-\frac{\epsilon_p}{\epsilon_p-1}p_{t+j}^w(1-\nu_p)\right)\right]=0$$
$$\Leftrightarrow\mathbb{E}_t\left[\sum_{j=0}^{\infty}\lambda_p^j m_{t,t+j}Y_{t+j}\mathcal{X}_{t,j}^{-\epsilon_p}\left(p_{r,t}^*\mathcal{X}_{t,j}-\frac{\epsilon_p}{\epsilon_p-1}(1-\nu_p)p_{t+j}^w\right)\right]=0,$$

where $\mathcal{X}_{t,j}=\frac{1}{\pi_{t+1}\cdots\pi_{t+j-1}\pi_{t+j}}$ if $j>0$. $\mathcal{X}_{t,j}=1$ if $j=0$. Inflation is defined as $\pi_t=\frac{P_{t+1}}{P_t}$.

All firms which are allowed to adjust their price will choose the same targets P_t^*, or $p_t^*=\frac{P_t^*}{P_t}$.

The aggregate price index writes as:

$$P_t=\left[(1-\lambda_p)P_t^{*(1-\epsilon_p)}+\lambda_p P_{t-1}^{1-\epsilon_p}\right]^{\frac{1}{1-\epsilon_p}}$$
$$1=(1-\lambda_p)p_t^{*(1-\epsilon_p)}+\lambda_p\pi_t^{\epsilon_p-1}.$$

D.3 Central bank

The nominal interest rate is set by the central bank according to a Taylor rule that responds to contemporaneous inflation.

$$\log(R_t)=(1-\rho_r)\log(\bar{R})+\rho_r log(R_{t-1})+(1-\rho_r)\alpha_\pi\log\pi_t+\eta_{r,t},$$

where $\eta_{r,t}\sim\mathcal{N}(0,\sigma_r^2)$ is the interest rate shock.

D.4 Household

The household's Euler equation for deposits now also takes into account inflation:

$$1=\mathbb{E}_t\left[m_{t,t+1}\frac{R_t}{\pi_{t+1}}\right].$$

D.5 Wage rigidity revisited

In the baseline economy labor agencies were essentially setting real wages. With price rigidities labor agencies are now setting nominal wages. This means that wages are not indexed to inflation, and thus unexpected inflation does affect labor costs because not all labor agencies can reset wages.

The equation characterizing the nominal wage target relative to the price level, w_t^*, is given by:

$$\mathbb{E}_t \left[\sum_{j=0}^{\infty} \lambda_w^j m_{t,t+j} N_{t+j} w_{t+j}^{\epsilon_w} \mathcal{X}_{t,j}^{-\epsilon_w} \left(w_t^* \mathcal{X}_{t,j} - \frac{\epsilon_w}{\epsilon_w - 1} (1 - \nu_w) \tilde{w}_{t+j} \right) \middle| S_t \right] = 0,$$

where nominal variables W_t^*, W_t and $\tilde{W}_t$, have been normalized by the price level $w_t^* = W_t^*/P_t$, $w_t = W_t/P_t$ and $\tilde{w}_t = \tilde{W}_t/P_t$.

The nominal and real wage indices are

$$\begin{aligned} W_t &= \left[(1 - \lambda_w)(W_t^*)^{1-\epsilon_w} + \lambda_w W_{t-1}^{1-\epsilon_w} \right]^{\frac{1}{1-\epsilon_w}} \\ w_t &= \left[(1 - \lambda_w)(w_t^*)^{1-\epsilon_w} + \lambda_w (w_{t-1})^{1-\epsilon_w} \pi_t^{\epsilon_w - 1} \right]^{\frac{1}{1-\epsilon_w}} . \end{aligned}$$

E Data appendix

E.1 Equity return dispersion

Equity dispersion in the data is computed from monthly holding returns (including dividends) for a firm's common stock using the CRSP NYSE/AMEX/NASDAQ Monthly Stock File. For the descriptive statistics in Table 1 I aggregate returns to quarterly frequency and compute the cross-sectional standard deviation by group (investment grade and high yield).

In the model, I define the return on equity as the cum-dividend firm value in period t divided by the ex-dividend firm value in the end of period $t-1$:

$$R_{i,t}^{eq,type} = \frac{nw_t^i((1-\sigma)((1-p)\lambda_t^{type} + p\lambda_t^{\neg type}) + \sigma)}{\lambda_{t-1}^{type} nw_{t-1}^{type}}.$$

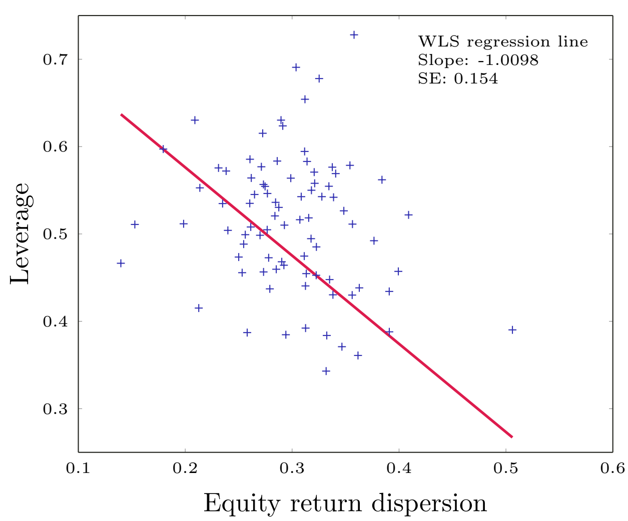
Notice that the idiosyncratic productivity shock z_t^i affects the return only through the profit component $\Xi_t^i = \Xi_t z_t^i$ since debt and production cost are independent of the period t realization of the idiosyncratic component. Therefore, the standard deviation of returns (by type) writes as

$$std(R_{i,t}^{eq,type}) = \Xi_t \; \frac{(1-\sigma)((1-p)\lambda_t^{type} + p\lambda_t^{\neg type}) + \sigma}{\lambda_{t-1}^{type} nw_{t-1}^{type}} \; std(z_t^i),$$

where $std(z_{t+1}^i) = \sqrt{e^{(\sigma_z^{type})^2} - 1}$ under the log-normal assumption for the idiosyncratic productivity shock.

E.2 Equity return dispersion and leverage

Figure E.1: Leverage and equity return dispersion across industries



Sources: Compustat Fundamentals Quarterly and CRSP, sample period 1986Q1 to 2014Q4. All firms (rated and non-rated). Leverage defined as total liabilities (LTQ) divided by total assets (ATQ). Each marker represents mean leverage and the standard deviation of quarterly equity returns in one NAICS 3-digit industry over the sample period. Only industries with at least 50 observations in the sample period. Regression weighted by the number of observations per industry.

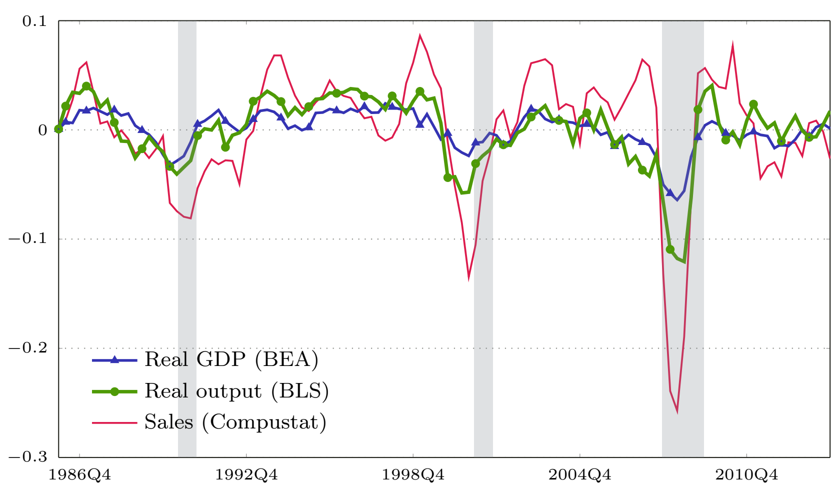
F Model inference

In section 4.3 I use the model to infer employment and investment dynamics for the two types of firms over the past three recessions. More specifically, I use the mean year-on-year sales growth of rated Compustat firms as the observable to estimate the parameters of the productivity process with Bayesian methods. The time series of sales growth is displayed in Figure F.1 along with two other aggregate output measures. Notice that output of firms in the sample tends to be more volatile than the aggregate economy, measured by real GDP or output in the nonfarm business sector. Among others, this reflects that Compustat oversamples firms in more cyclical industries such as manufacturing.

To estimate the parameters, (ρ_a, σ_a), I choose priors as in Christiano et al. (2014). In the first step, the estimation algorithm finds the parameter vector that maximizes the sum of log likelihood and priors on parameters. In the second step, the posterior distribution of the parameters vector is simulated via a Metropolis-Hastings algorithm. Table F.1 reports the priors and moments of the posterior distribution.

The procedure recovers the productivity shocks that rationalize output dynamics in the data. Importantly, the shocks imply dynamics for all other model variables (employment, investment, and credit spreads, etc.). To be consistent with the yearly frequency of employment data from Compustat I take the yearly average of the implied employment series, and then compute year-on-year growth rates for Figure 5 and Table 5. I also feed the shocks recovered with the baseline model through different versions of the model to explore the key driving forces that generate differential cyclical elasticities (see Table 5).

Figure F.1: Output growth



Notes: Year-on-year growth rates of per-capita GDP, real output in the nonfarm business sector, and the mean year-on-year sales growth rate among rated Compustat firms.

Table F.1: Estimated parameters

	Posterior		Prior		
Parameter	**Mean**	**[5%,95%]**	**Distribution**	**Mean**	**Std**
ρ_a	0.9187	[0.8705, 0.9662]	Beta	0.50	0.20
σ_a	0.0179	[0.0160, 0.0194]	Inverse Gamma	0.002	0.0033

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