Labor and Capital Dynamics under Financing Frictions

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March 28, 2014
revised, August 2016

Abstract

How do financial frictions affect employment and wages? To answer this question, we integrate a model of rich firm-level dynamics, including factor adjustment frictions and wage setting, with a theory of costly debt and equity financing. To estimate the model's parameters, we assemble a new quarterly panel dataset that links firms' investment and financing decisions to their employment and wages. The estimation shows that the theory can confront a variety of empirical moments relating to debt, wages, employment growth, and capital investment. Using the estimated parameters, we assess the model's ability to replicate our reduced-form results that wages and leverage are strongly negatively related, while employment and leverage are not. We also address recent reduced-form evidence that external financial frictions can impact labor demand.

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We would like to thank Brent Glover, Nathalie Moyen, and seminar and conference participants at the Vienna University of Finance and Economics, Michigan State University, University of Texas at Austin, LBS, LSE, Tilburg University, Rotterdam School of Management, Emory, Columbia, Norwegian School of Management, Aalto University, Copenhagen School of Business, Berkeley, the 2015 SFS Cavalcade, and the 2015 WFA meetings for helpful suggestions. We are also grateful to Jessica Helfand and Michael LoBue at the Bureau of Labor Statistics for guidance and assistance with the Quarterly Census of Employment and Wages data. This research was conducted with restricted access to Bureau of Labor Statistics (BLS) data. The views expressed here do not necessarily reflect the views of the BLS, the Federal Reserve System, or the U.S. government.

1. Introduction

It is safe to say that several decades of economic research have taught us that financial frictions are important for firm-level investment. From the early descriptive work of Fazzari, Hubbard, and Petersen (1988) to the natural experiments and quantitative exercises in, for example, Chava and Roberts (2008) and Hennessy and Whited (2007), we have learned that financial frictions impact investment and that these effects can be large. Less well understood is the impact of financing frictions on factors of production besides capital. Striking evidence of this impact is documented in Duygan-Bump, Levkov, and Montoriol-Garriga (2015) and Chodorow-Reich (2014), both of which examine the enormous uptick in job loss immediately following the failure of Lehman Brothers in 2008. In addition, several other studies, such as Cantor (1990), Sharpe (1994), Benmelech, Bergman, and Enriquez (2012), and Bakke and Whited (2012), have shown that financing frictions affect labor demand and wage setting outside of extreme credit market failures.

Interestingly, all of this work on labor and finance focuses on the estimation of elasticities, thus leaving room for a deeper understanding of the mechanisms that underly these empirical results. In addition, much of this work focuses on small data sets, thus limiting the inferences one can draw. We enter this picture with a new, broad data set and a new model, both of which illuminate the forces that link employment, wages and finance.

Briefly, in our data, we find a strong negative relation between leverage and average labor earnings but little relation between leverage and employment. We then seek to understand these results by using these data to estimate the parameters of a dynamic model of factor demand in the face of financial frictions. As we explain in more detail below, in the model, the confluence of financial frictions and labor bargaining induces a quantitatively relevant negative relation between leverage and wages. At the same time, the comovement of employment and leverage is limited because much of the time, the firm has sufficient internal funds to shield it from the implications of leverage. Although the reduced-form association between employment and leverage is rather weak in our model, we demonstrate that exogenous changes in financing costs can still, perhaps surprisingly, influence labor demand significantly. We compare the model's implications along these lines with evidence in Chodorow-Reich (2014). We also show that two parameters in our model, bargaining power and deadweight default costs, play a crucial role in mediating the link between financing costs and factor demand.

Understanding these results requires more detail about the data and the model. Our dataset is a quarterly, firm-level panel constructed by merging two sources of data. The first is Compustat, which includes quarterly investment and balance-sheet data. However, Compustat contains only annual observations on employment and virtually no data on wages. We fill in these missing pieces with the Bureau of Labor Statistics' Longitudinal Database of Establishments (LDE), which provides quarterly observations on establishments' total wage bill and employment. To our knowledge, studies of the interaction between financing frictions and labor have lacked a dataset of this scope. The quarterly frequency is important as significant fluctuations in employment regularly occur at a greater than annual frequency. In addition, the information on the wage bill is especially important and novel. As we will see, in the model, the firm's demand for external finance depends, in part, on the size of the wage bill relative to its own internal funds. This feature of the model makes it critical to observe the level and dynamics of the wage bill and to tie these observations directly to the firm's financial position.

With these data, we first characterize and describe firms' observed factor demand policies, focusing in particular on the association between labor earnings per worker, employment, and leverage. Some of our findings reassuringly confirm established facts in the labor economics literature. For example, we find that average labor earnings covary positively with sales (Roys 2016). However, our two most interesting descriptive findings are new. First, labor earnings per worker covary negatively with leverage, both in the cross section and within firms. A non-zero correlation is prima facia evidence that financial frictions exist, as this correlation should be zero in a Modigliani-Miller world. Moreover, the within-firm covariance is larger in firms without bond ratings, suggesting even more strongly a link between this covariance and financial frictions. Second, our evidence linking employment with leverage is much weaker, with no significant relation at the quarterly frequency. Although we do find a negative correlation when we move to an annual frequency, the statistical significance is marginal.

Next we seek to understand the primitive economic forces behind these observed corporate policies. While the explanations for these empirical facts are interesting in their own right, we also wish to acquire a deeper understanding of the salient features of the interaction between labor demand, wage setting, and financial frictions.

Firms in our dynamic model make investment, hiring, and financing choices. In so doing, they confront factor adjustment frictions. We assume in particular that the firm is subject to per-capita costs of hiring, following a literature dating back to Oi (1962).[1] With respect to capital demand, we assume that if a firm chooses to disinvest, it cannot recover the full purchase price. In other words, investment is only partially reversible, consistent with evidence in Ramey and Shapiro (2001), Cooper and Haltiwanger (2006), and Bloom (2009).

The firm can finance its factor demands in many ways. First, it can write a standard debt contract, which takes the form in Townsend (1979) and Bernanke and Gertler (1989). The firm makes a non-contingent payment to the lender if its productivity exceeds a certain threshold. Otherwise, the firm defaults, and the lender receives a share of the firm's assets, where this share can be interpreted as the collateralizable fraction of assets. The contractual loan rate is the price that equates the risk-free return to the expected return from defaultable debt, thereby leaving the lender indifferent. Alternatively, the firm can raise external funds by issuing equity, which incurs underwriting costs. In the model, these costs give rise to equity issuances that are as infrequent as those observed in the data. Indeed, in our setting, issuing equity is the financing option of last resort. Lastly, the firm can attempt to circumvent these financing constraints by accumulating liquid assets and deploying them to finance factor demands. This feature is important, given the point in Midrigan and Xu (2014) that firms can neutralize financing constraints by accumulating savings during good times.

A novel aspect of the model is the treatment of wage setting. A bargaining problem arises in our model because the costs of employment adjustment imply the existence of rents to ongoing firm-worker matches. We assume these rents are divided according to the bargaining protocol developed in Stole and Zwiebel (1996), and also used by Elsby and Michaels (2013). We believe we are the first to show how this surplus sharing rule can be extended to a model where payroll can be financed using risky debt.

This integration of external finance with both labor and capital demand is unique in the literature. Most of the models of financial frictions surveyed in Strebulaev and Whited (2012) abstract from capital adjustment costs, for instance. Further, all assume that workers are hired in a spot market and remunerated concurrently with production. Under these conditions, a firm can always implement the static optimum, so financial constraints have no independent effect on employment (Ejarque 2002). By the same token, prominent models of factor adjustment, such as Bloom (2009) and Cooper, Haltiwanger, and Willis (2007), assume that external financing is frictionless, that is,

[1] Recent estimates of hiring and firing costs, spanning several methods, can be found in Anderson (1993), Barron, Berger, and Black (1997), Cooper, Haltiwanger, and Willis (2007), and Silva and Toledo (2009).

external financing can be obtained at the same rate that the firm discounts its cash flows.

We estimate the model's parameters using a simulated minimum distance estimator in which the structural parameters are chosen to best fit a wide-ranging set of facts on factor accumulation and external funds, such as moments of leverage, employment growth, and capital investment. The identifying information embodied in these moments is often intuitive. For instance, the choice of the variance of idiosyncratic productivity balances evidence on the size of factor adjustments with the incidence of corporate borrowing: a higher variance can account for the dispersion in factor adjustments but also encourages substantial precautionary saving, limiting the incidence of issuing risky (defaultable) debt. In this sense, the cross sections of factor demands help inform the choice of parameters that have significant implications for the prevalence and operation of external financing.

With the estimated parameters in place, we examine the model's comparative statics properties, finding that financing decisions and the wage bargain interact in interesting ways. The existence of financial frictions are a necessary, but by no means sufficient condition for generating the firm policies observed in the data. For example, only modest labor adjustment costs are necessary to decouple the time-series movements in employment and leverage, the latter of which is more closely related to capital, which can serve as collateral. More interesting is the result that with financial frictions in place, wage bargaining engenders an endogenous negative relation between earnings per worker and leverage. This relation bears an intuitive connection to the debt overhang problem in Hennessy (2004). High leverage limits the states of the world in which firms have sufficiently liquidity to pay workers, so average wages are lower. Conversely, when labor has a great deal of bargaining power, firms have an incentive to lever up to keep the wage bill in check, especially in low productivity states. Enabling the firm to bargain a lower wage after adverse productivity realizations represents a potentially important margin of adjustment in models with financial frictions, because it is the firm's desired *payroll* that influences its demand for external funds.

Finally, we shed light on the effect of financial frictions on real decisions by mimicking the effect of being matched with an "unhealthy" lender, as in Chodorow-Reich (2014). In our model, we implement this experiment by matching a sample of firms in our simulations exogenously with a lender that bears a relatively high cost of funds. We then compare the outcomes of these treated firms with those firms that continue to have access to lower-cost lenders. We find marked effects of this shock on labor demand, and parameters that govern both the real and financial sides of the model have pronounced effects on this response. For instance, the estimate of worker bargaining power is crucial to this result. Intuitively, higher bargaining power enables workers to grab more of the bargaining surplus. The firm can mitigate this outcome by increasing leverage and threatening default. As a consequence, though, firms are more highly levered when the shock hits, which amplifies its effect. The role of bankruptcy costs is similar: the lower the cost of default, the higher is leverage, which again amplifies the effect of a shock.

Our interest in an integrated treatment of costly factor adjustment and external finance is perhaps most closely related in recent literature to DeAngelo, DeAngelo, and Whited (2011) and Warusawitharna and Whited (2016), both of which model rich capital adjustment costs. However, their technological assumptions imply a static, frictionless labor choice.

Two additional papers are important antecedents to our study. Monacelli, Quadrini, and Trigari (2011) consider a related wage bargaining problem in the presence of financing constraints. We generalize their setting in several ways. First, we include both capital and labor in our model. Including capital in a model of financial frictions is crucial because capital can serve as collateral, while workers cannot. In addition, we assume decreasing returns, which ensures a well-defined notion of firm size that is essential for our empirical analysis. Finally, separations (firing) are endogenous in our setting, whereas they occur at an exogenous rate in Monacelli, Quadrini, and Trigari (2011). Although their model includes a few features that we omit, such as infrequent wage renegotiation, they find the latter does not notably affect employment dynamics. Quadrini and Sun (2014) estimate the effects of costly external finance on worker bargaining in a dynamic model. Again, however, they do not model capital. Further, although they estimate some of their model parameters, they do not have the rich employment and wage data that we use.

The rest of the paper proceeds as follows. Section 2 describes our new quarterly data set on employment, wages, and firm balance sheet and income statement information. Section 3 presents and analyzes the model. Section 4 describes our estimation procedure and presents our results. Section 5 presents our counterfactual experiments, and Section 6 concludes. The Appendix contains details about data construction and the model.

2. Data

2.1. Data construction

Our quantitative analysis of the theory is made possible by our assembly of a new firm-level dataset that connects observations on employment and labor earnings at the establishment level with information on investment and the balance sheet at the firm level. This section describes the construction of the dataset.

We merge three data sources. Information on standard balance sheet and income statement items, such as sales, operating income, capital investment, the stock of debt, and cash holdings, is from the nonfinancial and unregulated firms in the 2013 quarterly Compustat industrial files. Because equity issuance data in Compustat contains a great deal of employee stock option exercise, we obtain equity issuance data from the SDC Platinum Global New Issuance database. We include Secondary Equity Offerings (SEOs) by U.S. nonfinancial firms, and we exclude rights issues and unit issues, as well as observations with missing values for total proceeds or a launch date. We obtain data on issuance, the total underwriting fee, the CUSIP number, and Ticker symbol of the ultimate parent of the issuer.

Compustat also lacks high-frequency data on employment and wages. Indeed, data on labor earnings are largely missing, with only 5% of nonfinancial firms consistently disclosing labor earnings (item XLR) in Compustat during our sample period.[2] To deal with this issue we turn to the BLS' Longitudinal Database of Establishments (LDE), which is a panel dataset that is, in turn, assembled from the Quarterly Census of Employment and Wages. The latter is derived from employers' Unemployment Insurance (UI) files, which provide a monthly record of the level of employment and the total wage bill at each UI-covered employer in the United States. The LDE is available from 1992 to the present. Although monthly data are available, we aggregate observations over the quarter from the LDE to conform with the structure of the Compustat quarterly files.

The most significant challenge in merging the LDE with Compustat is that Compustat is a panel of *firms*, whereas the LDE is a panel of *establishments*. The main obstacle to merging the two data sources is identifying a parent firm's establishments in the LDE. This matching can be done using *solely* the identifying information available in Compustat and LDE only in special circumstances. Each

[2] An alternative to item XLR is selling, general, and administrative (SGA) expenses. However, SGA omits the "cost of goods sold," which includes the earnings of non-managerial employees. Further, SGA includes many items, such as materials, that we wish to isolate from labor earnings.

establishment in the LDE reports an Employer Identification Number (EIN), which is assigned to it by the Internal Revenue Service. If the individual establishment reports the same EIN that the parent firm uses in its public disclosures, then one can match it to its parent firm's information in Compustat. However, it is common for parents to operate under different EINs in different states (Haltiwanger, Jarmin, and Miranda 2013). Hence, there can be many EINs associated with a parent that operates across multiple states. This problem means that merging on EINs are alone is inadequate.

These problems force us to turn to an auxiliary data source that provides a list of establishments associated with each parent firm. Infogroup is a private data collection company that maintains a database known as ReferenceUSA, which records the names and addresses of individual establishments in the United States. For each establishment, ReferenceUSA records the parent firm and, if applicable, the subsidiary of the parent under which the establishment operates. Infogroup places millions of phone calls to U.S. establishments to compile these data.[3]

Using ReferenceUSA as a bridge, the merge between Compustat and LDE can be done in two steps. First, we merge a list of establishments from ReferenceUSA to their corresponding entries in the LDE, using a character-matching algorithm.[4] The second step aggregates employment and wages across all (matched) establishments within each parent firm. These aggregates are then merged with Compustat. The latter merge is straightforward because Infogroup includes the parent name, as recorded in Compustat, alongside each of the establishments in its list.

Because the ReferenceUSA data are prohibitively costly, we do not carry out this merge for the universe of Compustat firms. Rather, our dataset consists of a random sample of 577 firms listed in Compustat and covers the years 2006 through 2012. The sample is somewhat tilted toward smaller firms, as we exclude large multinationals from our analysis, for two reasons. First, they are less likely to inform us about financial constraints, the topic of our study. Second, because the BLS data cover only U.S. establishments, we want to match domestic employment dynamics to largely domestic operations in Compustat. See Appendix A for further details regarding the merging process, sample construction, and detailed variable definitions.

[3]Infogroup reports that its databases "power the directory services of the top traffic-generating Internet sites including Yahoo!, InfoSpace, and Microsoft."

[4]We thank (without implicating, of course) Dominic Smith (see Bayard, Byrne, and Smith 2013) for providing the matching code on which we base our analysis. See the Appendix for further details regarding this merging process and related issues.

2.2. Characteristics of the sample

This section describes our data. Our goal is twofold. First, a comprehensive dataset on employment, labor earnings, investment, and finance is new to the literature, so we first simply examine basic reduced-form correlations. Second, this investigation gives us a set of stylized facts upon which our model can shed light.

To begin, we report a few summary statistics on our sample in Table 1. To begin, we emphasize the differences between our sample and the rather select sub-sample of Compustat firms that disclose total labor earnings. Ballester, Sinha, and Livnat (2002) report that few firms in Compustat disclose total labor earnings, and this sample consists disproportionately of large firms in more regulated industries. Table 1 updates their results, using the period 2006-2012. A disclosing firm is defined as one that reports positive labor earnings data in each year of this period. There are 468 disclosing firms, out of a universe of 9309 nonfinancial firms. Table 1 shows that both average employment, revenue and assets among disclosing firms are about 3 times that of non-disclosing companies. In addition, 27% of disclosing firms are classified in the relatively highly regulated transportation and utilities sector, compared to 10% of non-disclosing firms.

Table 1 also contrasts the Compustat universe with our merged sample. Firms in our panel are quite similar to the non-disclosing universe, in terms of sales and employment. With respect to the industry structure, manufacturers make up a larger share in our sample than in Compustat, and natural resource firms are under-represented. The lack of natural resource firms reflects, in part, the fact that we drop many large multinational firms in the extraction industry (oil). We highlight also that in our merged sample, transportation and utilities contribute a share more in line with that in the non-disclosing universe.

Next, it is instructive to compare employment in our merged sample with Compustat's measure of employment for the firms in our sample. To this end, we use the end-of-fiscal-year observations in our merged sample because employment data are only available annually in Compustat. We first regress log employment in our sample on log Compustat employment. Table 2 reports results. The coefficient on Compustat employment is 0.87, and the R^2 is 0.82. In column 2, we restrict the sample to firms that are domestically oriented. This sub-sample consists of about 450 firms that appear to have the vast majority of their activities in the United States, based on their annual reports. (Appendix A discusses this designation in more detail.) The coefficient on log Compustat employment increases to almost 0.94, and the R^2 is now 0.90.

These results are based on a pooled sample and reflect, at least in part, cross-sectional variation in firm size. If we include firm fixed effects and thus restrict attention only to within-firm variation, the quality of the fit naturally deteriorates. As seen in column 4 of Table 2, in the sample of domestically oriented firms, the coefficient on Compustat employment falls to about 0.65. This degree of comovement is consistent with the analysis of employment growth rates in Census and Compustat data in Davis, Haltiwanger, Jarmin, and Miranda (2006). One reason for the low correlation we find is noise in Compustat's measure of annual employment. For example, Baumol, Blinder, and Wolff (2005) remark that a referee of their manuscript cautioned against using Compustat data to study corporate downsizing, because Compustat's measure of the change in employment "did not match up well with census administrative" data. An additional source of discrepancy between Compustat and our merged LDE data, specifically, is that we lack data for several large states, as noted above.

2.3. Labor earnings behavior

In this section, we describe the relation between average labor earnings and other firm characteristics, especially leverage. We calculate average labor earnings as total payroll divided by employment. We refer to this variable as "labor earnings" rather than the "wage" because we do not have data on hours worked.

Table 3 collects a few summary statistics. Panel A shows the coefficients from regressing log labor earnings on dummies for a firm being in the top, middle, or bottom leverage tercile, with the coefficient on the middle tercile normalized to zero. We see that more highly levered firms in our data pay lower labor earnings. In particular, firms whose average leverage is in the bottom one-third of the distribution pay almost 9% higher labor earnings relative to firms in the middle tier of the leverage distribution (whose leverage is between the 33$^{\text{rd}}$ and 67$^{\text{th}}$ percentiles). But the gradient flattens at high leverage: firms in the top one-third of the leverage distribution pay only slightly lower labor earnings than firms in the middle tier.

Panel B summarizes the relation between labor earnings and assets in an exactly analogous way. We find that larger firms, as measured by their average assets, pay higher labor earnings. In particular, firms in the top one-third of the assets distribution pay 15% higher labor earnings than firms in the middle tier (between the 33rd and 67th percentiles). Interestingly, the smallest firms—those in the bottom one-third of the asset distribution—also pay 6.5% higher labor earnings than those in the middle tier.

To distinguish between the effects of size and leverage, we next run a regression of average labor earnings on two dummy variables and their interaction. The first dummy variable equals 1 if a firm's average assets over the sample are less than the median, and the second equals 1 if a firm's average leverage exceeds the median. Note that the coefficient on the interaction measures log average labor earnings at firms whose leverage is high (greater than the median) and whose assets are low (less than the median). It follows that the coefficient on the leverage dummy alone measures log average labor earnings at firms whose leverage is high but whose assets are also high, and the coefficient on the size dummy measures log average labor earnings at firms whose leverage is low but whose assets are also low. Lastly, the intercept measures log average labor earnings at firms whose leverage is low and whose assets are high. This latter group is the reference point; all other groups' labor earnings are expressed relative to this reference.

Panel C of Table 3 reports results. Looking down the right column and comparing average labor earnings among larger firms (that is, controlling for size), we find that the more highly levered pay 7.6% lower labor earnings. Thus, higher leverage is associated with lower average labor earnings even within the large firms. Next, looking across the top row and comparing average labor earnings among less levered firms (that is, controlling for leverage), we find that smaller firms pay 5.4% lower labor earnings. Last, we turn to the southwest quadrant of panel C. It shows that small, highly levered firms are a strongly selected sample. Small firms that *also* choose to be highly levered actually pay average labor earnings comparable to their larger, less levered counterparts. This pattern occurs even though we see depressed average labor earnings in small firms, controlling for leverage, as well as in highly leveraged firms, controlling for size. This finding may reflect the presence of very high returns to some small firms, whose high profitability both supports debt issuance and is partly shared with workers.

Next, we explore the co-movement of average labor earnings with firms' factor demands and financial positions. We begin by projecting log average labor earnings on one-period lagged log employment; lagged log capital; lagged leverage; and current log sales. We also include firm fixed effects and, if the period corresponds to a calendar quarter, seasonal dummies are included (unless otherwise noted). We motivate this specification as a linear approximation to the wage sharing rule we derive later in section 3.3. The use of empirical policy functions to motivate and estimate dynamic models has important precedents in the industrial organization literature (Bajari, Benkard, and Levin 2007), and Bazdresch, Kahn, and Whited (2016) use empirical policy functions as estimation inputs in a simulated minimum distance exercise. While we do not go as far as using these regression results as inputs into a structural estimation, we do use the theory to motivate our description of the data. In addition, below we use these observed policies as external validity tests of the model.

Table 4 summarizes our findings. Column 1 contains our baseline specification just described. Lagged employment enters negatively, although with an imprecisely estimated coefficient. The point estimate implies that if a firm's employment is temporarily high, average labor earnings are temporarily low, conditional on capital and productivity. This finding can thus be read as evidence consistent with decreasing returns.

Next, a 10% increase in sales accompanies a 0.5% rise in average labor earnings. The positive coefficient on sales is consistent with a rent-sharing arrangement in which the surplus from the worker-firm match is shared between the two. Card, Devicienti, and Maida (2014) stress, however, that these estimates are likely a lower bound on rent-sharing, because a good deal of high-frequency variation in sales does not pass to average labor earnings if the latter are smoothed. Consistent with this observation, we find a higher loading on sales and thus a sharper inference when we use annual data, which smoothes out quarterly fluctuations.

Interestingly, the coefficient on capital in our baseline regression is also positive. Card, Devicienti, and Maida (2014) argue that this result is consistent with positive hold-up power among workers. Intuitively, after capital is sunk, workers who are complementary to capital can extract greater rents. This hold-up power is indeed incorporated in the surplus sharing protocol we use in our dynamic model.

Lastly, the coefficient on lagged leverage (the debt to asset ratio) is negative and significant. To interpret this result, one can imagine comparing two points in time, each of which share the same productivity (sales) draw. However, at one of these points, the firm had anticipated much higher sales and levered up to fund its production. As a result, the firm finds itself highly levered relative to its realized productivity. In these states of the world, the firm pays lower average (labor) earnings. Quantitatively, this result implies that a 20 percentage point increase in leverage—roughly, a one standard deviation shift—reduces average labor earnings by almost 3%. This result is prima facia evidence of a link between firm finances and wage setting, as this effect should be zero in the absence of financial frictions. We are not aware of comparable estimates in the literature of this reduced-form effect. Our result is nonetheless consistent with evidence from smaller samples that unions yield concessions when the firm is under pronounced financial distress. See, for instance, Benmelech, Bergman, and Enriquez (2012), who study the airline industry.

Later in the paper, we interpret this result of a negative relation between labor earnings and leverage in the context of a bargaining game in which high leverage implies a higher probability of default, all else equal. This higher default probability reduces the expected marginal value of a worker and thus leads to a lower wage.

The remainder of the columns in Table 4 presents results for variants on our baseline specification. The results are largely unchanged. In column 2, we confine the sample to the domestically oriented firms but find that little changes. In columns 3-5, we investigate the correlation between average labor earnings and leverage in more detail. In column 3, we inspect whether the effect of leverage differs across sectors. In column 4, we ask if the effect of leverage is amplified at smaller firms (in terms of assets). And in column 5, leverage is interacted with log sales.

Our findings are the following. First, the negative association between average labor earnings and leverage appears to be slightly stronger in the service sector relative to the goods sector, where the latter is defined as including mining, construction, and manufacturing (SIC categories between 10 and 39). However, the difference is marginally significant. Second, the interaction between leverage and size (assets) is positive, although imprecisely estimated. The sign on this interaction is consistent with our findings in Table 3, namely, the negative association between leverage and average labor earnings does not appear to change significantly at larger firms. Third, the interaction between leverage and sales is an especially salient addition to the regression. The point estimate says that the marginal effect of higher sales weakens at highly levered firms. Put another way, high leverage attenuates the extent of rent-sharing. As we emphasize below, this finding appears to be consistent with our structural model, where high leverage predicts a higher probability of default. As a result, any given increase in sales is more likely to accrue to debtholders rather than shareholders, and so has less of a positive effect on the wage.

Table 4 includes two more specifications. Column 6 adds quarterly time dummies to control for aggregate fluctuations. This addition has relatively little effect on our results, which is indicative of the size of idiosyncratic relative to aggregate variation. The only coefficient that is notably affected is that on sales, which remains positive but is now estimated more imprecisely. In Column 7, we use annual data, specifically, end of fiscal year observations. We include year effects again to control for aggregate fluctuations. Here, the coefficients are all of the same sign as in our baseline, and are estimated more precisely. In particular, the coefficient on sales is significant, despite the presence of the year effects.

Next, we further explore the negative association between leverage and labor earnings, in particular, examining different groups of firms stratified according to whether they have an investment grade bond rating, a junk bond rating, or no rating at all. The results are in Table 6. Interestingly, we find that the coefficient on lagged leverage is insignificantly different from zero for both groups of firms that have bond ratings. The coefficient even flips sign in the sample of junk-bond firms, although the sample size is tiny. In contrast, the coefficient in the sample of firms without bond ratings remains negative and significant. This finding is suggestive of a world in which financial frictions are important for the ways in which a firm's leverage mediates its bargaining with labor over their earnings.

For the sake of completeness, we repeat these regressions for log employment as the outcome variable. As in the case of the wage regressions, this specification can be thought of as a linear approximation to the employment policy function from the model. These results are shown in the Table 5. The main difference between the employment and labor earnings results has to do with the role of leverage, which plays a far weaker role in accounting for high frequency employment dynamics. We find two exceptions to this general pattern. First, quarterly employment does appear to decline in the goods sector when leverage is high, but the effect is marginally significant. Second, when we use annual data, the coefficient on leverage is negative and marginally statistically significant in the full sample.

These findings may suggest that adjustment frictions in employment dampen its reaction to leverage relative to the response of labor earnings. The latter's reaction, in turn, likely reflects at least in part variation in hours per worker; the latter could be the margin on which firms move first when their debt capacity becomes more limited. Given our data, however, it is hard to disentangle the sources of labor earnings movements—the portion due to hours as opposed to the portion due to wage rates. Georgiadis and Manning (2014) confront the same issue in examining average firm-level labor earnings in the United Kingdom. They consider several reasons for the extent of high-frequency variation in labor earnings and conclude that some of it likely reflects flexibility in wage rates.

To conclude, we run the same labor earnings regressions using the sub-sample of Compustat firms that disclose this information. We construct average labor earnings by dividing item XLR (total staff expenses) by total employment. It is instructive to compare the Compustat findings with the findings from our merged panel. First, for comparison, Column 1 of Table 8 restates column 7 in Table 4, which is from our BLS sample with annual data. Next, confining the years to our sample period, the Compustat data are too noisy to make any inferences, as shown in Column 2 of Table 8. The coefficient on lagged leverage is negative, but insignificantly different from zero. Indeed, all of the coefficients are insignificant. Stretching the Compustat the sample back to 1970 adds 14,000 observations. In this case, the coefficients on lagged capital and current sales are now each significantly positive, and the coefficient on lagged employment is significantly negative. Each of these parallels our findings using our BLS data. However, the coefficient on lagged leverage is positive and insignificantly different from zero. This result may reflect the fact that disclosing firms are vastly larger companies on average, where variation in leverage is less likely to make financial constraints bind. Using disclosing firms in Compustat, Chemmanur, Cheng, and Zhang (2013) also find a positive association. Indeed, Chemmanur, Cheng, and Zhang (2013) find a statistically significant association. One reason for the difference in our results is that we construct leverage by netting off cash holdings. If we do not do this, we also recover a significant and positive coefficient estimate, suggesting that highly levered firms in Chemmanur, Cheng, and Zhang (2013) also tend to be cash-rich firms. The latter may be sharing their surplus with their workers through higher wages.

3. Theory

In this section, we introduce the firm's problem and discuss the determination of the interest and wage rates.

3.1. Optimization problem

We consider an infinitely lived firm in discrete time. Each period has a breakfast-lunch-dinner structure. At the start of each period, the firm's risk-neutral manager decides to default on the firm's outstanding debt. Next, if he decides not to default, he chooses new factor demands and how to finance these purchases, with the goal of maximizing the present value of after-tax cash flows to shareholders. These decision are made with an eye toward their implications for the wage rate and interest rates that will prevail under different scenarios. Finally, after the quantities of factors and financing have been chosen, a risk-neutral lender determines the endogenous interest rate on debt and the firm bargains with the workers over wages. Our timing assumptions imply that at the beginning of each period, the firm chooses the levels of capital, k', and employment, n', that will be used in production at the beginning of *next* period, indicated by a prime. We assume that the compensation of all factors must be determined when hired.

Current output, y is give by a standard Cobb-Douglas production function: $y = zk^{\alpha}n^{\beta}$, in which z is an idiosyncratic productivity draw that follows an $AR(1)$ process in logs:

$$\ln\left(z'\right) = \rho_z \ln\left(z\right) + \varepsilon'. \tag{1}$$

Here, ρ_z is the autocorrelation coefficient, and ε' is an *i.i.d.*, random variable with a normal distribution. It has a mean of 0 and a variance of σ_z.

The outflow of resources from the firm equals the sum of factor payments and the expenses of factor adjustment. Factor payments include the cost of investment and the wage bill, $W(k', n', b', z)$, whose arguments preview its determination via the outcome of a bargaining game. First, we consider investment, which is defined by the usual capital stock accounting identity:

$$i \equiv k' - (1-\delta)\,k,$$

in which δ is the constant rate of capital depreciation. We normalize the price of the capital good to 1, so the cost of purchasing i units of capital is just i if $i \geq 0$. If the firm sells (used) equipment, we assume it cannot recover the full purchase price. This assumption may reflect a lemons problem, that is, buyers require a discount because the quality of used equipment is uncertain (House and Leahy 2004). Machinery might also be highly customized to a firm's operations, so it has limited value on the secondary market. Accordingly, in the case of a sale, the firm earns $-c^k i$ if $i < 0$, with $c^k \in (0,1)$.

Therefore, the cost of investment is given by

$$R(i) \equiv i \cdot \mathbf{1}_{[i \geq 0]} + c^k i \cdot \mathbf{1}_{[i<0]}. \tag{2}$$

This friction serves two purposes in the model. First, it induces realistic investment inaction. Second, it is well-known that dynamic models with Cobb-Douglas technologies cannot produce the small investment variances typically observed in microeconomic data, so some sort of friction is necessary for the model to match the variance of investment.

Next, the firm bears the cost of adjusting labor by $\Delta n \equiv n' - n$ units, denoted by $C(\Delta n)$. We allow $C(\Delta n)$ to take a simple proportional form,

$$C(\Delta n) \equiv c_n \Delta n \cdot \mathbf{1}_{[\Delta n > 0]}, \tag{3}$$

with c_n representing the per-capita cost of hiring. For simplicity, we omit firing costs. Both types of costs induce the firm to hoard labor, which allows for a nontrivial wage bargaining problem. In addition, aside from premiums related to unemployment insurance, firing costs in the United States are arguably less salient.

To finance its factor demands, the firm can issue a one-period discount bond, on which it can default. Let b' be the face value of debt, and let the interest rate on debt be $\tilde{r}(k', n', b', z)$, so debt proceeds are $b'/(1+\tilde{r}(k', n', b', z))$. As we outline below, this interest rate is determined endogenously from the lender's zero-profit condition and is therefore a function of the model state variables. If instead the firm opts to save, which means $b' < 0$, it has access to a safe asset that pays a constant, exogenously given rate of return, $\bar{r}$. Thus, the interest rate on debt can be expressed as

$$r(k', n', b', z) = \begin{cases} \tilde{r}(k', n', b', z) & \text{if} \quad b > 0 \\ \bar{r} & \text{if} \quad b \leq 0 \end{cases} \tag{4}$$

The firm can also distribute excess funds to shareholders or raise funds from shareholders in the equity market. Distributions are the difference between the inflow and outflow of resources to the firm. Cash inflows include current production, while outflows include factor payments, adjustment frictions, and debt repayment. Net debt issuance, $b'/(1+r(k', n', b', z))$, minus net debt repayment, b

can be either an inflow or an outflow.

Putting these pieces together, the distribution before fees is:

$$D = zk^{\alpha}n^{\beta} - b + \frac{b'}{1 + r(k', n', b', z)} - W\left(k', n', b', z\right) - R(i) - C(\Delta n). \tag{5}$$

Negative distributions are interpreted as equity issuance and subject to underwriting fees. If $D < 0$, the firm incurs an underwriting fee of the form, $\Lambda^{-}(D) \equiv \lambda_0 + \lambda_1 |D|$. Hence, the real after-fee distributions are:

$$\hat{D} \equiv D - \Lambda^{-}(D)\mathbf{1}_{[D<0]}. \tag{6}$$

The cost of issuing equity is especially important in the analysis. Without costly equity issuance, the firm never has a reason to issue possibly costly debt, nor does it have an incentive to hoard cash, so the capital structure decision becomes degenerate. Costly equity issuance thus breaks the Modigliani-Miller indeterminacy. This point is particularly easy to see if $\lambda_0 > 0$. To avoid the fixed cost of equity financing, the firm issues debt to fill relatively modest funding gaps (differences between its factor demands and its internal funds). It turns to equity financing as a last resort, in response to a rising interest rate on debt.

Let r_F be the rate at which the firm discounts its cash flows, and let $\rho \equiv (1 + r_F)^{-1}$. We assume that $r_F > \bar{r}$. This assumption is a simple way of capturing the tax benefit of debt. Essentially, both this assumption and a standard tax benefit render the firm impatient relative to the interest rate it pays on its debt, and this impatience is the key force in this class of models that induces the firm to hold debt on its balance sheet. Interestingly, as shown in Li, Whited, and Wu (2016), the wedge between r_F and r does not have to be large to rationalize the demand for debt we observe in the data.

The firm's optimization problem can now be characterized recursively by the Bellman equation,

$$\Pi\left(k, n, b, z\right) = \max_{k', n', b'} \left\{ \hat{D} + \rho \int \Pi\left(k', n', b', z'\right) \mathrm{d}G\left(z' \mid z\right) \right\}, \tag{7}$$

where G is the conditional distribution of next-period productivity given the present z, implied by (1).

This problem is solved taking account of the cost of debt finance, $r(k', n', b', z)$, and the wage bargain, $W(k', n', b', z)$, as well as the evolution of internal funds. Thus, the firm's choices of b, k, and n influence both $r(k', n', b', z)$ and $W(k', n', b', z)$. The loan and wage contracting problems are detailed in the following two sections.

Before turning to the interest contracting problem, it is worth highlighting why labor, which has been relatively neglected in studies of financing frictions, is subject to a financing constraint in this setting. The first reason is that labor is treated as quasi-fixed factor. Accordingly, even if the firm could wait to finance its payroll with internal funds, costs of adjusting labor might induce it to sustain a level of employment over and above what is warranted—and what can be financed—by current profitability. Similarly, costs of adjusting capital can also lead to a labor capital mix that differs from its frictionless optimum. This behavior can spur the firm to take on some default risk in order to borrow its way through (temporarily) bad times. Second, worker bargaining power implies that the wage bill can be higher than it would be in a simple neoclassical setting in which the workers simply receive their outside option as compensation. If neither of these features is present, financing frictions do not bind on labor under decreasing returns (Ejarque 2002) because the firm earns a surplus from its employment of labor, so it can finance the (statically) optimal choice using realized sales.

3.2. Loan contract

We assume the firm can sign a one-period loan contract with a perfectly competitive financial intermediary. In the event that the firm is unable to repay, the lender can seize a fraction, $1-\xi$, of the firm's fixed assets, that is, its resalable capital. The share $\xi \in (0,1)$ can be thought of as a (deadweight) cost of processing the bankruptcy. This contract is inspired by the debt contract that emerges in the seminal costly state verification model in Townsend (1979) and later adapted by Bernanke and Gertler (1989).[5]

What triggers a default? Hennessy and Whited (2007) assume that lenders can extend credit as long as the firm has positive present (market) value. In that case, bondholders can at least obtain shares of the firm as part of a bankruptcy settlement. However, firms do retain some control over the pace of bankruptcy proceedings, and they can use this leverage to induce creditors to partially waive their rights to new shares in exchange for accelerating the settlement Franks and Torous (1989). As a technical matter, moreover, suppressing negotiation over new shares simplifies the interest-rate

[5]We depart from Townsend (1979) in that shocks, z, are persistent. Hence, if a lender did not know z, it could in principle learn it from observed choices of k and n. Rather than solve this problem, we assume z is common knowledge but assert that state-contingent contracts are infeasible. This approach follows, among others, Cooley and Quadrini (2001) and Hennessy and Whited (2007).

contracting problem.

Accordingly, following Gilchrist, Sim, and Zakrajsek (2013), we assume the firm is unable to borrow against its expected future market value. This assumption means that the firm cannot roll over its debt if its current net worth turns negative. Net worth has two components. The first is the firm's internal funds:

$$a \equiv zk^{\alpha}n^{\beta} - b. \tag{8}$$

The second is the fraction of of the capital stock that can be seized by lenders in default: $(1-\xi)(1-\delta)k'$, where $\xi \in (0,1)$. The interpretation of the parameter ξ is worth discussion. The share, $1-\xi$, is less than one for two reasons. First, it is hard to imagine that a firm could sell capital in default for a price greater than the price for used capital it receives in solvency, so $1-\xi$ should be less than c^k. Second, to the extent that $1-\xi < c^k$, the difference, $c^k - (1-\xi)$, can be interpreted as a deadweight default cost, as in Bernanke and Gertler (1989). In our estimation below, we do not impose the condition $1-\xi < c^k$, so the satisfaction of this condition in the estimation serves as a useful external check on the validity of model. Alternatively, motivated by the literature on limited commitment, the quantity $1-\xi$ can be interpreted as the fraction of the capital stock that can be surrendered as collateral.

Noting from (8) that a is increasing in z, so one can define a threshold level of productivity, $\hat{z}$, such that the firm that has chosen the triple (b', k', n') defaults at the beginning of next period if $z' < \hat{z}$:

$$0 \equiv \hat{z}k'^{\alpha}n'^{\beta} - b' + c^k\left(1-\delta\right)k'. \tag{9}$$

Note that our timing assumptions mean that if the firm defaults at the beginning of next period, labor must be paid off before the lender, in accordance with absolute priority rules.

With this default condition, we can now turn to the determination of the contractual interest rate, r, which is pinned down by an expected zero profit condition that must hold under free entry. We construct this condition as follows. The payoff to the lender in the event of default is revenue plus the share, $1-\xi$, of the depreciated capital stock. The payoff outside of default is simply the interest payment. Under free entry and risk-neutrality, the face value of debt discounted at the risky rate $r(k', n', b', z)$ must equal the expected payoff discounted at the risk-free rate. Therefore, $r(k', n', b', z)$

satisfies:

$$\frac{1}{1+\bar{r}}\left[\int_{0}^{\hat{z}}\left(z'k'^{\alpha}n'^{\beta}+(1-\xi)(1-\delta)k'\right)dG\left(z'\mid z\right)+\left(1-G\left(\hat{z}\mid z\right)\right)b'\right]=\frac{b'}{1+r(k',n',b',z)} \tag{10}$$

For a given (b',k',n',z), equations (9) and (10) pin down the loan contract, which can be summarized by $r(k',n',b',z)$. The effect of each argument on the contract is intuitive. For any (k',n',z), $r(k',n',b',z)$ is increasing in b', reflecting the rising default risk. As illustrated in Figure 1, this interest rate schedule shifts down if either k', n', or z rises, in part because each portends greater future output that can be sold to repay the lender. In addition, higher k' means a larger asset base that can be surrendered in default. Hence, each of these variables reduces the riskiness of the loan.

3.3. Wage setting

We introduce endogenous wage setting for two reasons. First, the dynamics of firm-level employment suggest the presence of certain labor adjustment costs, which in turn imply the existence of rents to ongoing firm-worker matches. These rents have to be divided, and the sharing rule from the bargaining protocol in Stole and Zwiebel (1996) provides a tractable way to do so.[6] Second, there is evidence that highly indebted firms, which face a relatively high risk of default, can negotiate lower wages; see Benmelech, Bergman, and Enriquez (2012) and citations therein. This evidence suggests that firms can use the wage bargain to relax its financing constraint. As such, wage setting is an important element of the firm's problem.

The outcome of the wage bargain can be understood heuristically by appealing to the notion of stability in Stole and Zwiebel (1996). Consider a firm that has just completed its desired labor adjustment and has a workforce of size n. Under the protocol, any one worker can request a pairwise bargaining session with the firm, and vice versa. If a wage is agreed, the two divide the marginal surplus implied by their joint production, with the worker receiving a constant share, ψ. Note that the marginal surplus is calculated taking as given the participation of the remaining workers. This calculation reflects the assumption that individual workers are unable to coordinate their decisions to stay or quit. If a wage is not agreed, the worker exits and enjoys a flow payoff from non-employment—reflecting, for

[6] Recently, Brügemann, Gautier, and Menzio (2015) have formalized a static game (which they refer to as a "Rolodex" game) that yields the simple surplus sharing rule in Stole and Zwiebel (1996). We do not attempt to extend this bargaining game to a dynamic setting and instead use this result to motivate our use of a sharing rule.

instance, the flow value of leisure—equal to μ. The marginal contribution of the remaining workers is affected by his departure because there are decreasing returns to scale. Accordingly, the remaining workers will request a bargaining session to revise their agreements. This process continues until a stable outcome is reached in which neither firm nor any worker wishes to reopen the contract.

As detailed in Appendix B, we can solve for the outcome of this protocol in (nearly) closed form under certain circumstances. In particular, if the firm pays positive dividends, then we have the following:

Proposition 1 *The wage bargain is characterized by a differential equation for the wage bill, $W(k', n', b', z)$:*

$$(1-\psi)\frac{W(k',n',b',z)}{n'} + \psi\frac{\partial W(k',n',b',z)}{\partial n'} = \psi\rho\mathbb{E}\left[\frac{\partial a(k',n',b',z')}{\partial n'}\right] + (1-\psi)\mu, \tag{11}$$

where

$$\mathbb{E}\left[\frac{\partial a(k',n',b',z')}{\partial n}\right] \equiv \int_{\hat{z}} \frac{\partial a(k',n',b',z')}{\partial n'} \mathrm{d}G(z' \mid z)$$

is the expected marginal effect of labor on next period's internal funds, $a(k', n', b', z')$, as implied by (8).

The lower limit of integration here is the default threshold, $\hat{z}$ because the worker's contribution in the default regime is zero, with all assets being seized by the lender.[7]

The economics of (11) are straightforward. The left side consists of two parts. The first is the wage rate, $\frac{W(k',n',b',z)}{n'}$, paid to the new hire. The second component, $\frac{\partial W(k',n',b',z)}{\partial n'}$, reflects the marginal effect of a new hire on the (pre-existing) wage bill of his co-workers. The latter term enters because of decreasing returns, which implies the marginal product is declining in n. Hence, the hiring of a worker forces a downward revision to the pre-existing wage rate. Putting these two components together, the weighted average of $\frac{\partial W(k',n',b',z)}{\partial n'}$ and $\frac{W(k',n',b',z)}{n'}$ on the left side can be thought of as the marginal wage. The right side says that the worker's compensation reflects a weighted average of his outside option, μ, and his contribution to the firm's cash flow, as measured by $\mathbb{E}\left[\frac{\partial a(k',n',b',z')}{\partial n'}\right]$. This form is clearly reminiscent of the standard Nash bargain.

Equation (11) simplifies if the firm chooses not to borrow. Indeed, it is straightforward to confirm

[7]The case of strictly negative dividends is similar, with the term, $\partial a(k', n', b', z')\partial n'$ being multiplied by $1+\lambda$. The case of strictly zero dividends is a possibility, given the kink in cost of equity issuance, there is a region of productivity values over which a zero dividend is optimal. However, in quantitative terms, this region is tiny and is rarely, if ever, observed in our simulations.

that if the firm chooses to save, then (11) collapses to the familiar wage bargain in Stole and Zwiebel (1996), where the wage bill is, roughly speaking, a weighted sum of a worker's productivity and his outside option. This simplification happens because the probability of default is zero if the firm chooses to hold cash, so the interest rate is independent of the firm's factor demands. The solution to the wage bargain in this special case resembles that presented in Acemoglu and Hawkins (2014) and Elsby and Michaels (2013), except that a worker's productivity in our setting with capital is also conditioned on k.

However, if the firm borrows, then its choice of n' affects expected internal funds via the financing friction. Fortunately, characterizing $\mathbb{E}\left[\frac{\partial a(k',n',b',z')}{\partial n}\right]$ is straightforward because our timing assumptions for debt imply that the interest rate does not appear in the expression for $a\left(k',n',b',z'\right)$ in (8). Making use of equation (8), it follows that $\mathbb{E}\left[\frac{\partial a(k',n',b',z')}{\partial n'}\right] = \mathcal{Z}\left(k',n',b',z\right)\beta k'^{\alpha} n'^{\beta-1}$, where

$$\mathcal{Z}\left(k',n',b',z\right) \equiv \int_{\hat{z}(k',n',b',z)} z' \mathrm{d}G\left(z' \mid z\right)$$

denotes the expected value of z' (that a firm can appropriate) after accounting for the risk of default. Substituting for $\mathbb{E}\left[\frac{\partial a(k',n',b',z')}{\partial n'}\right]$ in (11), the solution to (11) is straightforward. Thus, we have:

Corollary 1 *The solution to (11) is the wage bill,*

$$W\left(k',n',b',z\right) = \rho n'^{-\bar{\psi}} \int_0^{n'} \mathcal{Z}\left(k',\nu,b',z\right)\beta k'^{\alpha} \nu^{\beta-1+\bar{\psi}} \mathrm{d}\nu + (1-\psi)\,\mu n', \tag{12}$$

where $\bar{\psi} \equiv (1-\psi)/\psi$.

The solution (12) conveys three useful pieces of intuition. First, the integral has a natural economic interpretation, which can be seen by considering what happens if a worker leaves a firm of size n. This one exit increases the expected marginal product of the other $n-1$ workers, enabling them to bargain for higher wages. However, at this point any of the remaining $n-1$ workers are also free to leave, and an exit would increase the marginal products of the other $n-2$ workers, and so on. Thus, a worker's departure would set off a chain of renegotiations. The implications for the wage are two-fold. First, for a given default threshold, a smaller workforce implies a higher marginal product, which ratchets up the wage at each node of this chain. As a result, a worker is able to "hold up" the firm to demand a portion of all of these infra-margins of production. However, another force is at work.

A smaller workforce implies less future output, which raises the probability of default. As ν falls at each node of this chain, $\hat{z}$ rises, and $\mathcal{Z}(k', \nu, b', z)$ falls. These two forces determine the infra-margins of production, and the integral of the latter is what is shown in (12). The other component of (12) is the outside option. The worker obtains a weighted sum of these two elements.

Second,note that, in (12), the default threshold that enters into $\mathcal{Z}$ is evaluated at ν inside the integral. This feature of solution captures an important force at play in the model. Specifically, if the firm finds itself with ν workers after quits occur, its revenue is depleted and its probability of default is higher. Thus, even if the firm's planned level employment is large enough to enable it to raise risk-free debt, the added debt can still drive down the wage because the wage takes account of off-equilibrium plays, that is, threats by the workers to quit. Thus, even if the extra debt is risk free at the planned level of employment, it can drive down the wage if it leaves the firm more exposed to these threats.

Third, equations (9) and (12) help reveal the effect of financing constraints on the wage bargain. Suppose a firm has already agreed to a loan contract such that it is highly leveraged, that is, b' is large. From (9), this situation implies a higher probability of default, so $\hat{z}$ is higher and $\mathcal{Z}$ is lower for any (k', ν, z). As a result, the expected contribution of a worker to the firm's cash flow, as captured by the integral in (12), is diminished. This bargaining outcome translates in (12) to a lower wage, as illustrated in Figure 2. The negative relation between debt and wages seen here is reminiscent of the result in Perotti and Spier (1993) that outstanding leverage can affect the renegotiation of senior claims. However, our model is more specific to the case of wage setting, as their model does not allow any separation between quantities and prices embodied in the senior claim, and their senior claim does not necessarily represent payments to a factor of production. Our result is also reminiscent of the debt-overhang result in Hennessy (2004), except that we show that this familiar mechanism extends to wage setting, in addition to investment. Our result lies in contrast to the result in Berk, Stanton, and Zechner (2010), in which highly levered firms pay risk-averse workers more highly to compensate for the risk of unemployment that accompanies firm default. However, given our robust empirical finding of a negative within-firm correlation between labor earnings and leverage, we conjecture that our debt overhang mechanism is empirically dominant.

To close, we note that interest rate and wage setting in our model have the virtue of being tractable. In particular, because the wage bill does not enter the default condition, we can solve (9)-(10) for r

and $\hat{z}$ for any given tuple (b', k', n', z). Then, with $\hat{z}$ in hand, we can solve (12) for the wage bargain.

3.4. Optimal policies

To obtain intuition for the underlying mechanisms in the model, we first examine the model's first order conditions.[8] First, we examine optimal investment policy. Under standard differentiability conditions, substituting (5) and (6) into (7) and differentiating with respect to k' gives:

$$\left(\mathbf{1}_{[k'>k]} + c^k \mathbf{1}_{[k'<k]} + \frac{b'}{(1+r(k',n',b',z))^2} \frac{\partial r(k',n',b',z)}{\partial k'} - \frac{\partial W(k',n',b',z)}{\partial k'}\right)\left(1+\lambda \mathbf{1}_{[D<0]}\right) = \rho \int \frac{\partial \Pi\left(k',n',b',z'\right)}{\partial k'} \mathrm{d}G\left(z' \mid z\right). \tag{13}$$

The right side of (13) represents the marginal benefit of an extra unit of capital left side represents the marginal cost, which has three components. The first two terms in parentheses refer to the purchase and sale prices of capital, respectively. The next two terms reveal how the choice of capital interacts with both the cost of debt and the wage bargain. The third term is negative, as a higher choice of k' increases next period's net worth and thus lowers the interest rate the firm is charged for its debt. The fourth term in parentheses captures the effect of capital on the wage bill. Higher capital raises wages for two reasons. First, it increases the marginal product conditional on survival, and second, it increases the surplus to be shared by the firm and workers by lowering the default probability. Equation (12) then implies that the wage should rise. Finally, in those states of the world in which the firm chooses to raise external equity, the marginal cost of capital is naturally higher by an amount $1+\lambda$.

Next, we look at the first-order condition for optimal employment, which is given by:

$$\left(c_n \mathbf{1}_{n'>n} + \frac{b'}{(1+r(k',n',b',z))^2} \frac{\partial r(k',n',b',z)}{\partial n'} - \frac{\partial W(k',n',b',z)}{\partial n'}\right)\left(1+\lambda \mathbf{1}_{[D<0]}\right) = \rho \int \frac{\partial \Pi\left(k',n',b',z'\right)}{\partial n'} \mathrm{d}G\left(z' \mid z\right). \tag{14}$$

Naturally, (14) bears a great resemblance to (13), as both are conditions for optimal factor demand. The one important difference is in the interpretation of the term $\partial W(\cdot)/\partial n'$. Although an increase in

[8] All of the following analysis assumes a non-zero dividend, which, as noted above, is nearly always observed in our simulations.

n reduces the wage rate, the wage bill is nonetheless increasing in n, following (12).

Finally, we examine optimal debt policy, which is characterized by the first-order condition:

$$\left(\frac{1}{1+r(k',n',b',z)} - \frac{b'}{(1+r(k',n',b',z))^2}\frac{\partial r(k',n',b',z)}{\partial b'} - \frac{\partial W(k',n',b',z)}{\partial b'}\right)\left(1+\lambda\mathbf{1}_{[D<0]}\right) = \rho. \tag{15}$$

The right-hand side of (15) comes from applying the Envelope condition. In the absence of default risk, the second and third terms in (15) equal zero, and in this model the optimal policy is to borrow an infinite amount because of the high impatience implied by the assumption that $\rho < (1+\bar{r})^{-1}$. Naturally, as can be seen in the second term of (15), the presence of default risk limits this behavior because $\partial r(\cdot)/\partial b' > 0$. Finally, (12) implies that the term $\partial W(\cdot)/\partial b' < 0$, so the downward pressure on the wage bill from an extra dollar of debt gives the firm an incentive to increase leverage.

We add texture to the preceding analysis by plotting the policy functions for the model in Figure 3. The policy functions map the state variables (z,k,n,b) into optimal policies (n',k',b'). Because this function is multidimensional, we visualize it using level curves. We plot optimal investment (i/k), employment growth $(n'/n-1)$, the wage bill, $W(k',n',b',z)$, distributions (D/k), and leverage (b'/k') as a function of the productivity shock, z, holding capital, labor, and debt (k,n,b), at their median levels in the model simulation. All of these policy functions are evaluated at the parameter estimates that we discuss below.

We emphasize several important features of Figure 3. First, the resale discount on capital induces an investment inaction region for low realizations of z, and the hiring cost induces a similar, but smaller, hiring inaction region for medium realizations of z. Second, leverage increases monotonically with z. As both capital and labor productivity rise, investing in a storage technology, such as cash (negative debt), becomes less appealing, and thus the firm wishes to fund both factor demands with external debt finance. Third, distributions rise monotonically with z because of decreasing returns. For higher realizations of z, the extra profits generated by this shock flow less into capital and labor, and more into the hands of shareholders. Finally, the total wage bill, W, is increasing in z.

4. Estimation

We estimate the model parameters using a simulated minimum distance estimator. This procedure identifies values of the structural parameters that generate outcomes within the model that most closely fit their empirical counterparts. In what follows, we first review the mechanics of the model solution, simulation, and estimation. We note that the solution is conditioned on a number of parameters whose values are chosen based on information outside of the theory. These parameterizations are discussed here. Next, we review the sample moments used in estimation and relate the intuition behind why these moments help identify the structural parameters. We then summarize our results.

4.1. Model solution, estimation, and identification

We solve the model via value function iteration. The grid and transition matrix for the productivity shock, z, are formed using the method in Tauchen and Hussey (1991). Grids for capital and labor are formed to span the range of optimal choices in the simulation. The upper end of the grid for debt is equal to the upper end of the grid for capital, while the lower end is half the opposite of the upper end.

The mechanics of the estimation are straightforward. For a given set of parameters, we solve the model and use the solution to generate simulated data, which ten times the size of our merged LDE-Compustat dataset (Michaelides and Ng 2000). Next, we calculate a set of moments or functions of moments (detailed below). Based on the distance between model-generated moments and their empirical counterparts, the values of the structural parameters are updated. We use the genetic differential evolution algorithm to update the parameters and search for a better fit.

A number of parameters in our model can be easily pinned down based on information outside of our merged panel. Thus, these parameters are not part of our minimum distance estimation. We set the risk-free rate, $\bar{r}$, to 2.5% on an annualized basis, in line with historical evidence. We then set r_F to be 20% higher than $\bar{r}$, in line with an effective corporate tax rate of 20%. Next, we estimate λ_1 using a regression of issuance fees on issuance proceeds, where we scale both of these variables by total firm assets. The slope of the regression is then an estimate of λ_1.With these auxiliary parameters taken care of, we have 10 structural parameters to be estimated: $\left\{\alpha, \beta, \delta, \rho_z, \sigma_z, c^k, c_n, \xi, \psi, \mu\right\}$.

4.2. Identification

While the estimation process is straightforward, the identification of the model parameters requires explanation. We start here with an intuitive discussion, and after we report our estimation results, we present analysis that supports the intuition. Although all of the model parameters affect all of the moments we use in our estimation, the dependence of some parameters on a particular set of moments is sufficiently pronounced that we can provide intuition for how these moments inform and identify our parameters. For example, ρ_z and σ_z are easily identified by including in the list of moments the standard deviation and serial correlation of sales. We estimate this autoregression using the technique in Han and Phillips (2010), which allows for firm-specific intercepts and time trends.

The rate of depreciation, δ is identified by including the mean investment rate. In the absence of stochastic productivity or investment adjustment frictions, the firm simply invests to replace depreciated capital. Although productivity innovations and the partial reversibility that we model both cause the firm to deviate from its frictionless investment policy, average investment still depends strongly on the depreciation rate.

Next, the factor demand distributions speak several different parameters. The cost of firing/hiring, for instance, attenuates the dispersion in employment growth, making the latter moment especially informative about this adjustment cost. Similarly, the lower c^k, the greater the inaction range for optimal investment and the lower the standard deviation of investment. In addition, the covariance of factor demand adjustments, namely employment growth and investment, discipline the model's implications for the elasticities of factor demands. Intuitively, because both factors respond to neutral idiosyncratic technology shifts, z, their covariance encodes information about the factor demand elasticities and thus informs the choices of α and β.

Our external financing moments include average leverage, which we measure as long term debt plus debt in current liabilities less cash-equivalent assets, all divided by total assets. This netting off of liquid assets is a common approach in the literature to identifying a notion of debt that maps most cleanly to that in the model, where b represents the firm's net financial position. Viewed through the lens of our model, this moment reflects several salient parameters. For example, high leverage is deterred by the size of the bankruptcy cost, ξ, which implies a lower repayment in default, thus amplifying risk premia and reducing demand for debt. In addition, the demand for net debt is dampened by the precautionary savings motive, which is increasing in the extent of idiosyncratic risk, σ_z. In addition to mean leverage, we also include the variance and serial correlation of leverage as moments. As we show later, these moments help to discipline key mechanisms in the model relevant to the counterfactual analyses we do. Thus, they are valuable overidentifying moments to include.

Next, we include two additional moments to identify the production function parameters: α and

β. First, note that despite the presence of bargaining, β remains a key influence on labor share. Accordingly, we use average operating income as a fraction of the wage bill to inform the choice of β, where operating income is defined in the model as $zk^{\alpha}n^{\beta} - W(\cdot)$. This ratio is clearly inversely related to labor's share.[9]The next moment is a measure of the average profit rate, defined as the mean of operating income, divided by assets. This moment is naturally decreasing in α. Intuitively, a higher α triggers an expansion in the capital stock relative to the profit flow.

Several moments help identify the bargaining parameter, ψ. For example, as workers have more bargaining power, the mean ratio of operating income to wages falls, as do the mean and standard deviation of the rate of shareholder distributions, measured as distributions per unit of capital. These latter moments are particularly sensitive to ψ. For instance, as ψ increases, the wage bill rises in response to a positive productivity shock, which leaves a smaller residual to be paid to shareholders. Lastly, in models with a constant wage, distributions inherit much of their variability from the productivity shock, z. However, in our model, bargaining implies that the wage bill covaries positively with sales, so the variance of distributions declines as ψ increases. In addition, both the mean and variance of leverage rise with ψ, as in this case, the firm has a strong incentive to use leverage to keep the bargained wage lower.

Finally, we turn to the identification of the outside option, μ. Here, the mean market-to-book ratio is particularly sensitive to μ. As the outside option rises, the wage bill also rises, leaving less for shareholders. Thus, the surplus to holding and using capital "inside" the firm falls relative to its replacement value. In other words, the market-to-book ratio declines.

4.3. Baseline results

We now summarize our baseline results. In Panel A, we report the actual data moments and the model simulated moments. Because of our large sample size, five of the fourteen moment pairs are significantly different from one another, but few are economically different, and several of these pairs match up nicely. Actual and simulated mean leverage are nearly identical, as are the means of investment and distributions and the standard deviations of employment growth, investment, and leverage. We only see one instance in which the simulated and actual moments differ by a factor of

[9]We do not use a direct measure of labor's share, as the value-added concept of output in our model differs from observed total sales in Compustat data. Operating income in Compustat, in contrast, nets off intermediate input purchases from revenue.

two or more. In particular, the model markedly misses the standard deviation of the change in log sales. Overall, however, we believe the fit of the model is remarkably good. Accordingly, it can serve as a useful laboratory later, when we execute counterfactual policy experiments. We emphasize in particular the model's ability to replicate the joint distributions of debt and factor demands. To make a prediction regarding the real effects of default risk, a model should be, at a minimum, consistent with the size and variance of (net) debt, as well as its covariance with factor demands.

Next, we turn to the parameter estimates. In many cases, these seem comparable to related estimates in the literature. For instance, the estimate of the standard deviation of the driving process, z, is in line with the estimate in Hennessy and Whited (2007). In contrast, the estimate of the serial correlation of z is somewhat lower than many comparable estimates in the finance literature but comparable to the results from .Cooper, Haltiwanger, and Willis (2007). Next, we turn to the default cost parameter, ξ. At a level of 50%, it is much larger than the 10% figure from Hennessy and Whited (2007) or the 10-20% estimates from Andrade and Kaplan (1998). Nonetheless, this parameter can be understood in the context of our default threshold, which is essentially a net worth covenant. Thus, one interpretation of $1 - \xi$ is the fraction of the capital stock that can be surrendered to the lender in default as collateral. Given this interpretation, our estimate of this parameter is in line with the estimates of the collateral parameter in Li, Whited, and Wu (2016). Next, at 69%, our estimate of the resale price of capital is nearly identical to the 66% resale price from Bloom (2009). Although our estimat of the linear hiring cost, at 4.6%, is somewhat higher than the 2% figure from Bloom (2009), the latter is measured as a fraction of the wage bill, while our cost is measured as a fraction of the number of workers hired.

We now return to the question of the identification of the model by computing the sensitivity of parameters to moments, using the scaled metric from Gentzkow and Shapiro (2015), which runs from zero to one. These measures incorporate two factors essential to parameter identification. The first is the intuitive, "partial-derivative" relation between a parameter and a moment. The second operates through the weight matrix, with imprecisely estimated moments having a smaller effect on any given parameter. Thus, a high scales sensitivity requires not only that a moment respond to a parameter but that the moment be well estimated. The results are in Table 10. Each row corresponds to one of the moments, and each column to a parameter. To reduce clutter, we present sensitivities only if they are greater than 0.3 in absolute value.

We find many results that conform to the intuition presented in Section 4.2. For example, the sensitivity of the depreciation rate, δ to the mean rate of investment is over 0.9, and the sensitivity of the serial correlation of $\ln(z)$, ρ_z, to the serial correlation of sales is over 0.8. Similarly, the estimate of default costs, ξ is strongly inversely related to the mean of leverage, and the bargaining power parameter, ψ is negatively related to the mean and standard deviation of distributions. Finally, we note that these sensitivities represent only local responses of moments to parameters, as they are based on first derivatives. As such, some moments appear uninformative when, in fact, they are very useful for providing identification. The most prominent example is the covariance between investment and employment growth. Although the sensitivities from Gentzkow and Shapiro (2015) are small, the effect of β, on this moment is strong over a large range for β.

5. Implications

We can now assess the estimated model's ability to engage our own descriptive results, as well as other recent reduced-form evidence on financing constraints. First, we examine the sensitivity of wages and employment to leverage that we observe in our data. These results are of interest in part because they constitute an out-of-sample test of the model, as neither of these features of the data was used in the estimation of the model. Finally this exercise is of interest because it constitutes an estimate of the model's policy functions. Bazdresch, Kahn, and Whited (2016) note that because all dynamic models have policy functions, the empirical fit of the policy function is a uniform metric for understanding the performance of the model.

Recall that in our data, we find that log labor earnings decrease by 0.14 in response to a one percentage point increase in leverage but that the corresponding sensitivity for employment is, at a quarterly frequency essentially zero. In our model, we find a very low sensitivity of 0.001 for employment and a comparable sensitivity of -0.178 for labor earnings.

Next, we use the model to examine the economic forces that lead to these results. To this end, we conduct several comparative statics exercises, which can be found in Figure 4. Here we present average leverage, as well as the sensitivities of employment and labor earnings to leverage, as functions of two key model parameters: labor bargaining power, ψ, and the deadweight cost of default, ξ. We calculate the sensitivities exactly as in Table 4, except that we omit fixed effects, as there is no firm heterogeneity in our simulated data. Each panel is constructed as follows. First, we set all model parameters equal to their values from our estimation. Next, one at a time, we change a model parameter, solve the model, and recalculate the statistic, which we then plot against the value of the parameter.

We first examine the effects of bargaining power, ψ. Intuitively, we find that average leverage increases with ψ. This results reinforces the intuition in equations (9) and (12). A firm that faces workers with high bargaining power finds it optimal lever up. The benefit of a lower wage bill that accompanies higher leverage dominates the cost of a higher default probability. Not surprisingly, this high leverage translates into a high sensitivity of wages to leverage. If leverage is negative, it has no effect on the bargained wage, as the probability of default is zero. It is only when leverage is high enough to affect default probabilities that wages and leverage interact. Finally, the sensitivity of employment to leverage is largely unaffected by worker bargaining power.

Next, we examine the effects of deadweight default costs, ξ. Here, we find the reassuring result that leverage is lower when ξ is higher, as : a large financial friction deters raising debt. Again, we find that higher leverage is accompanied by a higher sensitivity of wages to leverage, and again, we find a near zero sensitivity of employment to leverage over the entire range of ξ.

Our second experiment is motivated not by our own results but by evidence of financing constraints from the 2008-09 financial crisis. Chodorow-Reich (2014) considers the experiences of firms whose intermediaries suffered the largest declines in lending capacity. For instance, banks that happened to be more heavily invested in mortgage-related securities saw their net worth decline significantly. This, in turn, reduced their capacity for making risky loans. Chodorow-Reich (2014) finds that firms that had a history of borrowing from these intermediaries reduce employment more than comparable firms that had long-standing ties to "healthier" lenders.

We implement this idea by augmenting to include a shock to the risk-free rate, which follows a two-state Markov process. The shock is either zero or 50 basis points. This spread is consistent with the evidence in Chodorow-Reich (2014) regarding the interest rates paid by firms with relatively unhealthy lenders. Our intent is to model an unanticipated shock that is expected to last, so we calibrate the Markov transition matrix so that the shock switches states once every 500 periods. We then compare employment, capital, and wages in the high-cost versus low-cost states.

The model implies a 4.3% decline in labor demand, which nearly replicates the 5.5% drop in employment documented in Chodorow-Reich (2014). Although Chodorow-Reich does not report results for other outcomes, we also note that the model yields a decline in labor earnings of 5.1%, but, perhaps surprisingly, an uptick in capital of nearly 1%.

Which forces in the model contribute to these findings? We begin by discussing the relevant qualitative properties of the model and then comment on the role of certain key parameters in the quantitative outcomes. As a qualitative matter, the decline in labor demand is not necessarily obvious. For example, in a vast majority of instances in our simulations, firms pay positive dividends, that is, they do not finance their marginal factor demands with risky debt. The connection between funding costs and labor demand arises via default risk, the mere presence of which lowers the anticipated marginal product of labor relative to a world in which debt is risk free and thus lowers labor demand. However, the firm can mitigate default risk by "over-hiring" and producing more revenue, which can be used for paying off debt. As such, hiring another worker raises the inframarginal product of labor, by reducing the probability that the output of all preceding workers is lost in bankruptcy. This latter consideration is key to understanding what happens when the firm faces a higher rate of interest. The higher rate induces the firm to de-lever, which mitigates default risk. In this situation, labor is "needed" less as a means of warding off bankruptcy, and, consequently, labor demand declines even when the firm issues positive dividends.

Clearly, this reasoning does not carry over exactly to capital demand because capital can serve as collateral for debt, independent of capital's use in production. A critical observation is that the collateral value of capital is diminished by a run-up in debt because the latter implies a higher probability that the firm will default for any realization z'. Conversely, if the firm de-levers, as it does after a rise in the risk-free rate, the collateral value of capital rises. This collateral effect can counter the negative effect on capital demand that would otherwise occur after a rise in the risk-free rate.

Next, we turn to the role of two key model parameters in shaping the quantitative effect of a higher cost of funds. The results from this counterfactual experiment are in Figure 5, which shows how movements in employment, labor earnings, and capital depend on bargaining power, ψ, and default costs, ξ. Interestingly, we find that the drops in employment and labor earnings are largest when labor has a great deal of bargaining power. This result makes intuitive sense in that high borrowing costs reduce factor demand by more when the firm is already more highly leveraged, as in the case of higher worker bargaining power. We find a similar result, with similar intuition for low default costs.

6. Conclusion

We have sought a quantitative answer to the questions of whether, how, and why financing frictions affect labor demand. Answering this question in a satisfying manner is challenging for several reasons. Labor demand interacts in important ways with the demand for other quasi-fixed factors, in particular, capital. And unlike the case of capital, it is unrealistic to assume that firms are price takers in the labor market. To approach this question while addressing these hurdles, we formulate and estimate a model of labor and capital demand that incorporates realistic adjustment frictions, financial frictions, and wage bargaining. To estimate the model's parameters, we assemble a new data set by merging standard balance sheet and income statement information from Compustat with establishment level data on employment and the wage bill from the Bureau of Labor Statistics. We find that the model can match several relevant features of the data.

An integrated treatment of external financing and factor demands has two important payoffs. First, it admits important interactions between dynamic capital and labor demands. The effect of financing constraints on one factor clearly spill over to the other, via their interaction in production. In particular, the effects of collateral value on capital accumulation have important implications for labor demand, with frictions that lower the value of collateral leading to low debt usage and greater insulation against fluctuations in the cost of external debt financing. Second, a model with employment adjustment frictions brings into sharp relief the role of wage setting in potentially softening financing constraints.

We find that our model can replicate the sensitivity of factor demand to exogenous movements in cash flows and interest rates that have been found previously in the data. We then use the model to understand the economics behind these sensitivities. Interestingly, many factors besides financial frictions affect observed sensitivities of both labor and capital demand to these exogenous shocks. The obvious conclusion is that the response of factor demands to exogenous shocks need not be indicative of financial frictions. In particular, labor bargaining power has a strong affect on the sensitivity of labor demand to cash flows, as it affects both wage stickiness and optimal leverage decisions.

We view the outcome of our research as providing a microeconomic foundation for aggregate equilibrium analysis. An understanding of financing constraints in aggregate equilibrium is vital to our interpretation of aggregate capital and labor market dynamics. The latter, in turn, affects the orientation of monetary and fiscal policy. For instance, financing frictions can influence the response of the economy to money shocks (Bernanke, Gertler, and Gilchrist 1999). Clearly, the monetary authorities would wish to condition their actions on this feedback. Similarly, the appropriate position of fiscal policy in the wake of a recessionary shock will depend on how that shock can be amplified by the presence of financing frictions. We see our work as facilitating research into these topics.

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Table 1: Sample Characteristics

	Compustat		Merged panel
	Disclosing firms	Non-disclosing firms	
Number	468	9,309	577
Means:			
Assets (billion $)	7.18	2.22	4.25
Sales (billion $)	5.12	1.60	1.01
Employment	20,337	5,616	8,001
Industry makeup (%):			
Durable mfg.	14.3	29.0	36.8
Non-durable mfg.	18.7	22.6	21.8
Transportation	34.4	13.4	7.3
Trade (wholesale & retail)	11.4	9.6	18.9
Services	21.2	25.5	15.2

Calculations are based on a broad sample of firms from Compustat, as well as a smaller random samples with labor earnings and employment data from the Bureau of Labor Statistics' Quarterly Census of Employment and Wages. The sample period is first quarter 2006 to fourth quarter 2012. This table presents characteristics of firms in Compustat and in our merged panel. With respect to Compustat, we distinguish between firms that disclose Total Staff Expenses (item XLR) and those that do not. We classify a firm as disclosing if it reports staff expenses in each year.

Table 2: Employment in Compustat and the merged panel

	Dependent variable: Employment in Compustat			
Employment in	0.875	0.935	0.513	0.68
merged panel	(0.026)	(0.020)	(0.076)	(0.064)
Constant	1.61	0.947	0	0
	(0.208)	(0.158)		
R^2	0.820	0.900	0.300	0.394
No. of obs.	2,960	2,105	2,960	2,105
Sample	Full	Domestic	Full	Domestic
Fixed Effects	No	No	Yes	Yes

Calculations are based on a broad sample of firms from Compustat, as well as a smaller random samples with labor earnings and employment data from the Bureau of Labor Statistics' Quarterly Census of Employment and Wages. The sample period is first quarter 2006 to fourth quarter 2012. This table reports the linear projection of log Compustat employment on log employment in our merged panel. In all cases, standard errors are clustered at the firm level.

Table 3: Average Labor Earnings by Size and Leverage

Panel A: Log earnings by terciles of leverage (middle normalized =0)		
Bottom tercile	Middle tercile	Top tercile
0.089	0	−0.026

Panel B: Log earnings by terciles of size (assets)		
Bottom tercile	Middle tercile	Top tercile
0.065	0	0.15

Panel C: Log earnings by terciles of size (employees)		
Bottom tercile	Middle tercile	Top tercile
0.009	0	−0.043

Panel C: Log earnings by size and leverage

	Assets < median	Assets > median
Leverage < median	−0.054	Normalized = 0
Leverage > median	0.003	−0.076

Calculations are based on a sample of firms from Compustat, with labor earnings and employment data from the Bureau of Labor Statistics' Quarterly Census of Employment and Wages. The sample period is first quarter 2006 to fourth quarter 2012. This table shows average earnings according to size and leverage, where we define size both as employment and as book assets. In each panel, one category is normalized to zero, and average earnings in the other categories are expressed as a log difference relative to the normalized category.

Table 4: Dynamics of labor earnings in merged panel

	Dependent variable: Labor earnings						
	I	II	III	IV	V	VI	VII
Lag capital	0.105	0.102	0.106	0.105	0.105	0.063	0.097
	(0.014)	(0.016)	(0.014)	(0.014)	(0.014)	(0.012)	(0.022)
Lag employment	−0.105	−0.063	−0.104	−0.105	−0.105	−0.086	−0.111
	(0.050)	(0.082)	(0.050)	(0.050)	(0.050)	(0.051)	(0.054)
Lag leverage	−0.138	−0.149	−0.203	−0.215	−0.054	−0.121	−0.103
	(0.034)	(0.043)	(0.054)	(0.068)	(0.054)	(0.032)	(0.037)
Sales	0.051	0.039	0.051	0.050	0.059	0.025	0.056
	(0.018)	(0.025)	(0.018)	(0.018)	(0.017)	(0.018)	(0.023)
Lag leverage × 1(goods sector)			0.090				
			(0.059)				
Lag leverage × 1(size < median)				0.122			
				(0.075)			
Lag leverage × Sales					−0.021		
					(0.012)		
R^2	0.0929	0.0693	0.0935	0.0943	0.0941	0.151	0.166
Obs.	13306	9566	13306	13306	13306	13306	3041
Sample	Full	Domestic	Full	Full	Full	Full	Full
Time effects	No	No	No	No	No	Yes	Yes
Frequency	Qtly.	Qtly.	Qtly.	Qtly.	Qtly.	Qtly.	Annual

Calculations are based on a sample of firms from Compustat, with labor earnings and employment data from the Bureau of Labor Statistics' Quarterly Census of Employment and Wages. The sample period is first quarter 2006 to fourth quarter 2012. Estimation is done with OLS. The dependent variable is log labor earnings. The independent variables are once-lagged log capital, once-lagged log employment, once-lagged leverage (net debt divided by assets), and log sales. Column I uses the full quarterly merged panel sales. Column II restricts the sample to domestically oriented firms (see text for definition). Columns III-V add regressors. The indicator 1(goods sector) equals 1 if the firm is classified in a goods-producing industry and zero otherwise. The indicator 1(size < median) equals 1 if the firm's average assets over our sample is less than the median. Dummy variables for each quarter are added in Column VI. Column VII uses annual data, that is, end-of-fiscal-year observations. All regressions use firm fixed effects. Standard errors in all cases are clustered at the firm level.

Table 5: Dynamics of employment in merged panel

	Dependent variable: Employment						
	I	II	III	IV	V	VI	VII
Lag capital	−0.001	0.001	−0.001	−0.001	−0.001	0.007	0.009
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.037)
Lag employment	0.819	0.834	0.818	0.819	0.819	0.819	0.463
	(0.029)	(0.034)	(0.029)	(0.029)	(0.029)	(0.029)	(0.050)
Lag leverage	−0.002	0.001	0.044	0.0005	−0.019	0.001	−0.080
	(0.016)	(0.018)	(0.034)	(0.026)	(0.026)	(0.016)	(0.045)
Sales	0.113	0.111	0.113	0.113	0.112	0.112	0.248
	(0.016)	(0.020)	(0.016)	(0.016)	(0.015)	(0.017)	(0.053)
Lag leverage × 1(goods sector)			−0.063				
			(0.037)				
Lag leverage × 1(size < median)				−0.004			
				(0.034)			
Lag leverage × Sales					0.004		
					(0.005)		
R^2	0.754	0.775	0.755	0.755	0.755	0.757	0.37
Obs.	13306	9566	13306	13306	13306	13306	3041
Sample	Full	Domestic	Full	Full	Full	Full	Full
Time effects	No	No	No	No	No	Yes	Yes
Frequency	Qtly.	Qtly.	Qtly.	Qtly.	Qtly.	Qtly.	Annual

Calculations are based on a sample of firms from Compustat, with labor earnings and employment data from the Bureau of Labor Statistics' Quarterly Census of Employment and Wages. The sample period is first quarter 2006 to fourth quarter 2012. Estimation is done with OLS. The dependent variable is log employment. The independent variables are once-lagged log capital, once-lagged log employment, once-lagged leverage (net debt divided by assets), and log sales. Column I uses the full quarterly merged panel sales. Column II restricts the sample to domestically oriented firms (see text for definition). Columns III-V add regressors. The indicator 1(goods sector) equals 1 if the firm is classified in a goods-producing industry and zero otherwise. The indicator 1(size < median) equals 1 if the firm's average assets over our sample is less than the median. Dummy variables for each quarter are added in Column VI. Column VII uses annual data, that is, end-of-fiscal-year observations. All regressions use firm fixed effects. Standard errors in all cases are clustered at the firm level.

Table 6: Subsample dynamics of labor earnings in merged panel

	Dependent variable: Labor Earnings		
	I	II	III
Lag capital	0.108	0.201	0.104
	(0.030)	(0.119)	(0.016)
Lag employment	−0.156	0.257	−0.122
	(0.038)	(0.117)	(0.040)
Lag leverage	−0.079	0.012	−0.133
	(0.061)	(0.211)	(0.035)
Sales	0.107	−0.013	0.055
	(0.035)	(0.057)	(0.016)
R^2	0.154	0.441	0.095
Obs	2125	36	10845
Sample	Investment Grade	Junk	No Rating
Time Effects	Yes	Yes	Yes
Frequency	Qtly.	Qtly.	Qtly.

Calculations are based on a sample of firms from Compustat, with labor earnings and employment data from the Bureau of Labor Statistics' Quarterly Census of Employment and Wages. The sample period is first quarter 2006 to fourth quarter 2012. Estimation is done with OLS. The dependent variable is log labor earnings. The independent variables are once-lagged log capital, once-lagged log employment, once-lagged leverage (net debt divided by assets), and log sales. Column I uses the firms from the quarterly merged panel with an investment grade credit rating. Column II restricts the sample to firms with a below investment grade (junk) credit rating. Column III restricts the sample to firms with with no public credit rating.All regressions use firm fixed effects. Standard errors in all cases are clustered at the firm level.

Table 7: Subsample dynamics of employment in merged panel

	Dependent variable: Employment		
	I	II	III
Lag capital	0.000	−0.018	0.000
	(0.010)	(0.040)	(0.008)
Lag employment	0.811	1.017	0.813
	(0.041)	(0.083)	(0.031)
Lag leverage	−0.029	−0.010	0.005
	(0.020)	(0.073)	(0.018)
Sales	0.106	0.015	0.118
	(0.027)	(0.036)	(0.017)
R^2	0.819	0.904	0.742
Obs	2125	36	10845
Sample	Investment Grade	Junk	No Rating
Time Effects	Yes	Yes	Yes
Frequency	Qtly.	Qtly.	Qtly.

Calculations are based on a sample of firms from Compustat, with labor earnings and employment data from the Bureau of Labor Statistics' Quarterly Census of Employment and Wages. The sample period is first quarter 2006 to fourth quarter 2012. Estimation is done with OLS. The dependent variable is log employment. The independent variables are once-lagged log capital, once-lagged log employment, once-lagged leverage (net debt divided by assets), and log sales. Column I uses the firms from the quarterly merged panel with an investment grade credit rating. Column II restricts the sample to firms with a below investment grade (junk) credit rating. Column III restricts the sample to firms with with no public credit rating.All regressions use firm fixed effects. Standard errors in all cases are clustered at the firm level.

Table 8: Dynamics of labor earnings in Compustat and merged panel

	Merged panel	Compustat, 2006-12	Compustat, 1970-12
Lag capital	0.097	−0.003	0.064
	(0.022)	(0.036)	(0.016)
Lag employment	−0.111	0.033	−0.109
	(0.054)	(0.048)	(0.024)
Lag leverage	−0.103	−0.019	0.015
	(0.037)	(0.073)	(0.030)
Sales	0.056	0.022	0.087
	(0.023)	(0.031)	(0.023)
R^2	0.166	0.082	0.667
No. of obs.	3041	2851	15986
Year effects	YES	YES	YES

Calculations are based on a broad sample of firms from Compustat, as well as a smaller random samples with labor earnings and employment data from the Bureau of Labor Statistics' Quarterly Census of Employment and Wages. The sample period is first quarter 2006 to fourth quarter 2012. This table presents regression results using annual data. The first column, "Merged panel" uses end-of-fiscal-year observations from our quarterly panel. This is the same result show in Column VII of Table 5. The other two columns here show results using two different sample periods of Compustat data on "total staff expenses" (XLR).

Table 9: Simulated Moments Estimation

Panel A. Moments

	Actual Moments	Simulated Moments	T-statistics
Mean investment	0.024	0.024	0.735
Mean net debt	0.079	0.083	-1.280
Mean operating income	0.035	0.031	2.577
Mean distributions	0.011	0.011	-1.479
Mean income/wages	0.908	1.026	-3.668
Mean market-to-book ratio	1.730	1.685	0.502
Std. dev. investment	0.017	0.020	-2.234
Std. dev. employment growth	0.060	0.061	-0.484
Std. dev. leverage	0.102	0.103	-0.685
Std. dev. of operating income	0.019	0.017	1.657
Std. dev. of distributions	0.013	0.009	6.622
Cov. of investment and employment growth ($\times$100)	0.010	0.015	-0.881
Std. dev. change in log sales	0.165	0.072	6.569
Serial correlation of log sales	0.601	0.793	-0.456
Serial correlation of leverage	0.786	0.794	-1.116

Panel B. Parameters

λ_1	α	β	ρ_z	σ_z	δ	c_k	c_n	ξ	ψ	μ
0.0446	0.370	0.527	0.469	0.155	0.089	0.691	0.046	0.507	0.192	1.007
(0.0018)	(0.021)	(0.028)	(0.092)	(0.051)	(0.023)	(0.152)	(0.059)	(0.120)	(0.019)	(0.430)

Calculations are based on our merge panel of the LDE with Compustat. The estimation is done with simulated minimum distance, which chooses structural model parameters by matching the moments (or functions of moments) from a simulated panel of firms to the corresponding moments from the data. Panel A reports the simulated and actual moments and the clustered t-statistics for the differences between the corresponding moments. Panel B reports the estimated structural parameters, with clustered standard errors in parentheses. α and β are the returns to scale with respect to capital and labor, respectively; δ is the capital depreciation rate; ρ_z is the persistence of productivity; σ_z is the standard deviation of the innovation to productivity; ξ is the bankruptcy cost (as a share of a firm's capital stock; λ_0 and λ_1 are the fixed and linear costs of equity issuance; c_k is the resale price of capital outside bankruptcy, and c_n is the per capita hiring cost. ψ is the bargaining power parameter, and μ is the outside option. λ_0 and λ_1 are estimated via linear regressions of issuance fees on issuance proceeds.

Table 10: Local Sensitivity of parameters to moments

Moments	α	β	ρ_z	σ_z	δ	c_k	c_n	ξ	ψ	μ
Mean investment					0.970					
Mean net debt								-0.831		
Mean operating income	-0.880							0.868		-0.469
Mean distributions									-0.496	
Mean income/wages		-0.630								
Mean market-to-book ratio										-0.477
Std. dev. investment						-0.470				
Std. dev. employment growth				0.612		-0.524	-0.493	-0.458		-0.533
Std. dev. leverage										
Std. dev. of operating income				0.511						
Std. dev. of distributions									-0.576	
Cov. of investment and employment growth										
Std. dev. change in log sales										
Serial correlation of log sales			0.744							
Serial correlation of leverage			0.533							

This table presents the sensitivities of parameters to moments from Gentzkow and Shapiro (2015), which is a number that ranges from negative one to one. Blank entries indicate a sensitivity of less than 0.3. α and β are the returns to scale with respect to capital and labor, respectively; δ is the capital depreciation rate; ρ_z is the persistence of productivity; σ_z is the standard deviation of the innovation to productivity; ξ is the bankruptcy cost (as a share of a firm's capital stock; c_n is the per capita hiring cost; ψ is the bargaining power parameter; and μ is the outside option.

Figure 1: Loan Contract

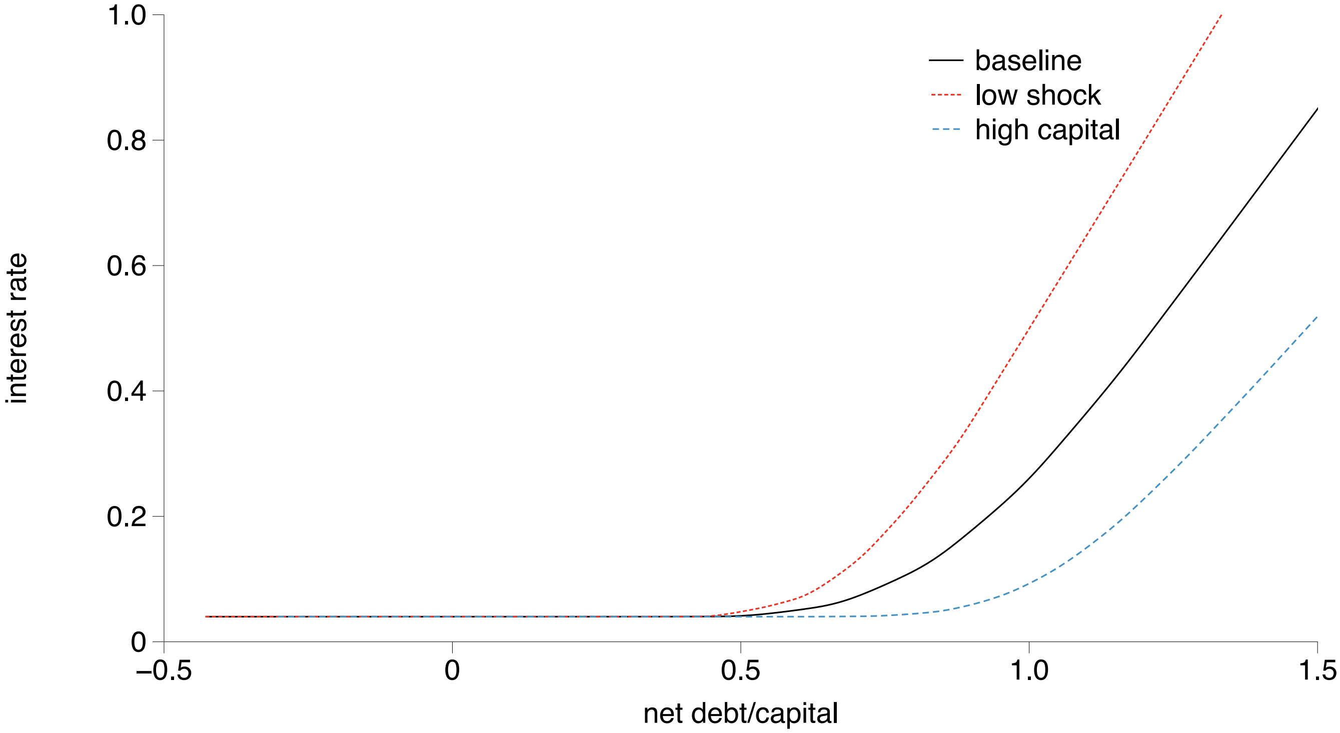


Figure 1 plots the contractual rate of interest in loan agreements for different values of labor, capital, and productivity. The debt levels that run along the horizontal axis are all normalized by the mean capital stock.

Figure 2: Wage Bargain

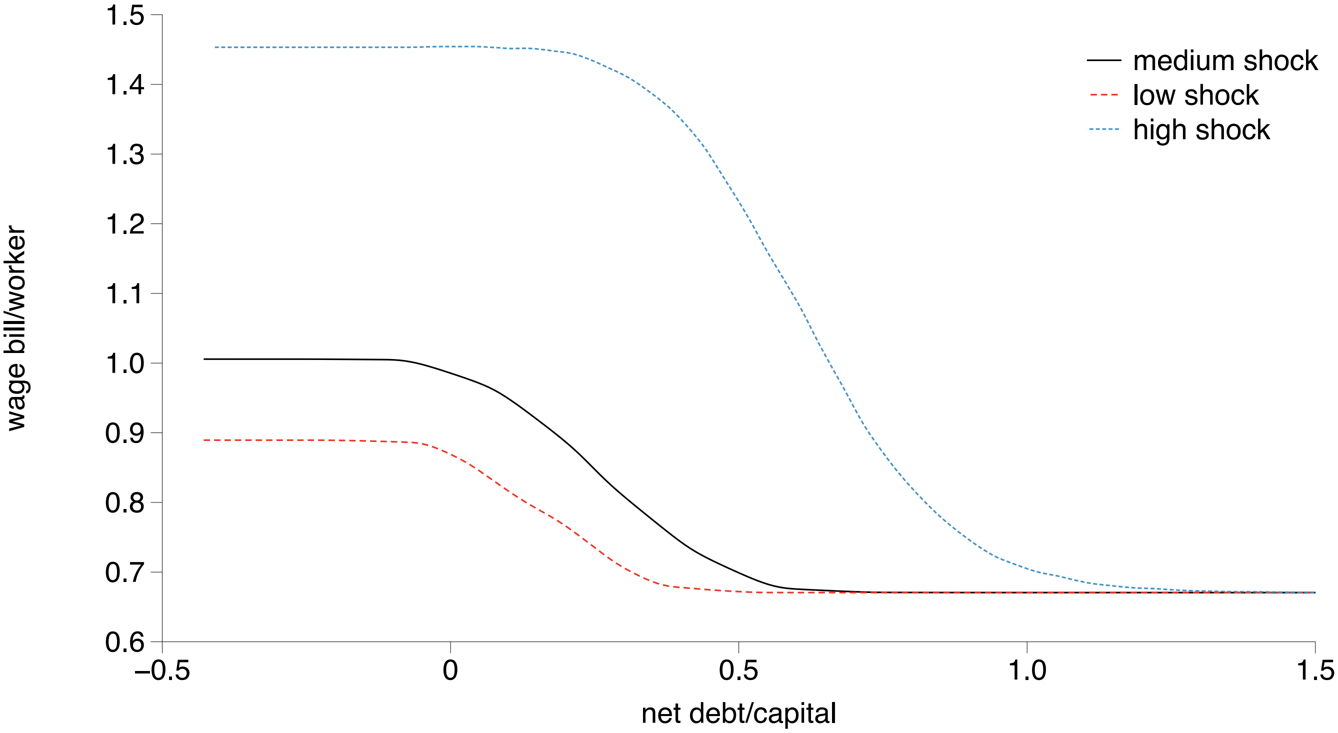


Figure 2 plots the wage bill given common values (in our simulations) of labor, capital, and productivity. The wage bill is normalized by its value over the risk-free region of (small) debt levels.

Figure 3: Model Policy Functions

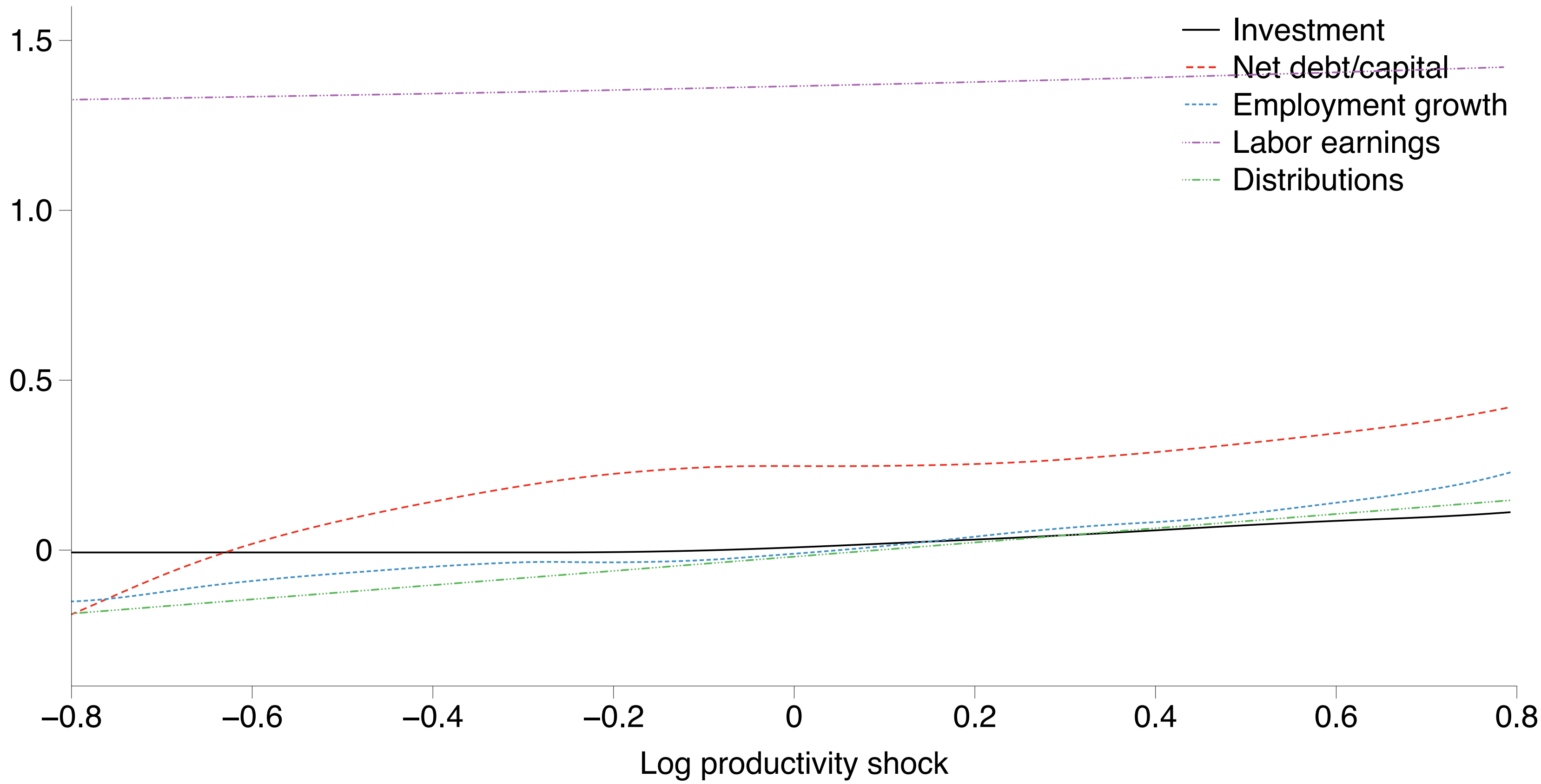
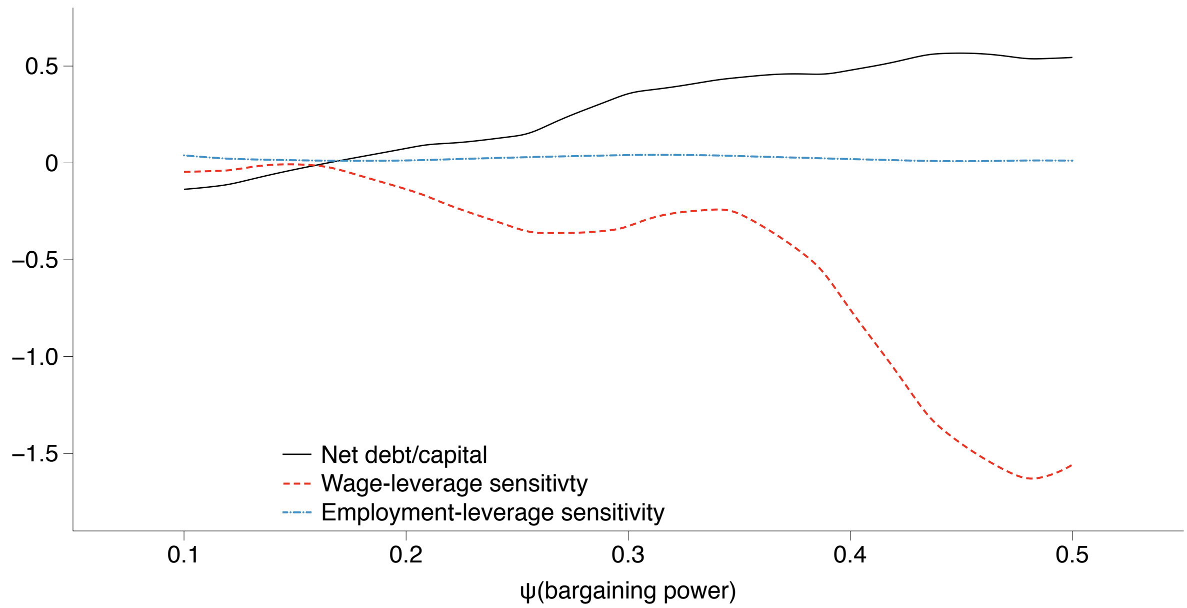


Figure 3 plots optimal investment (i/k), employment growth $(n'/n-1)$, labor earnings, $W(z,k',n',b')$, labor earnings per worker, $(W(z,k',n',b')/n')$, and leverage (b'/k') as a function of the log productivity shock, $\ln(z)$, holding capital, labor, and debt (k,n,b), at their mean levels in the model simulation.

Figure 4: Sensitivity of Labor Earnings and Employment to Leverage

Figure 4 shows how the elasticity of employment and leverage each change with respect to two model parameters: labor bargaining power, ψ and the deadweight cost of default, ξ.



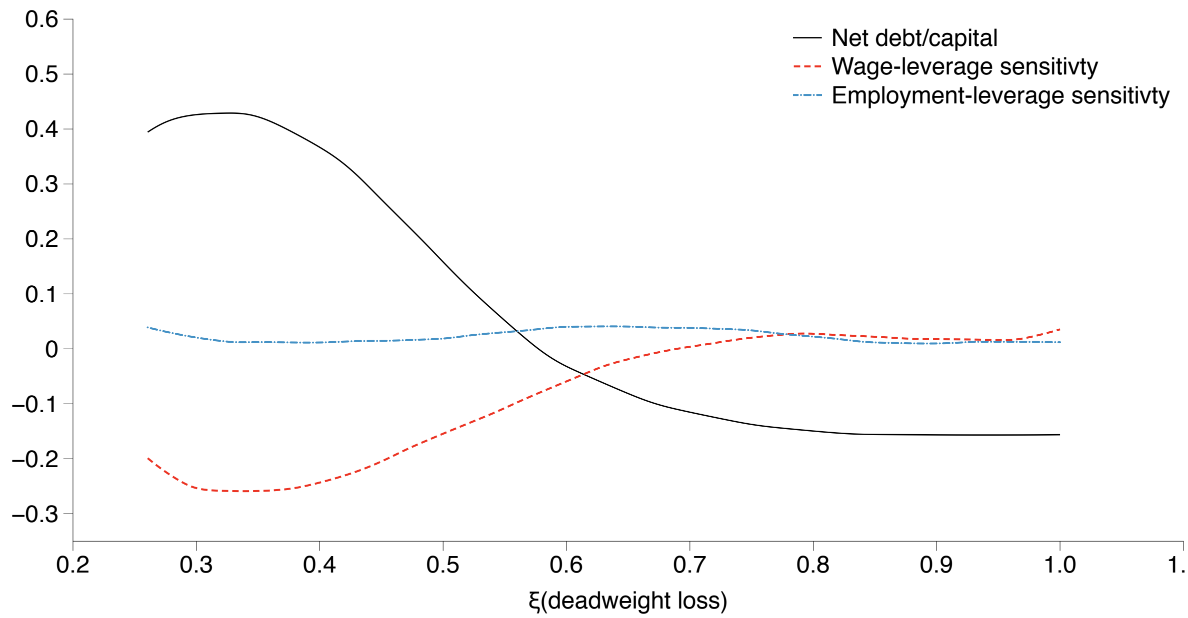
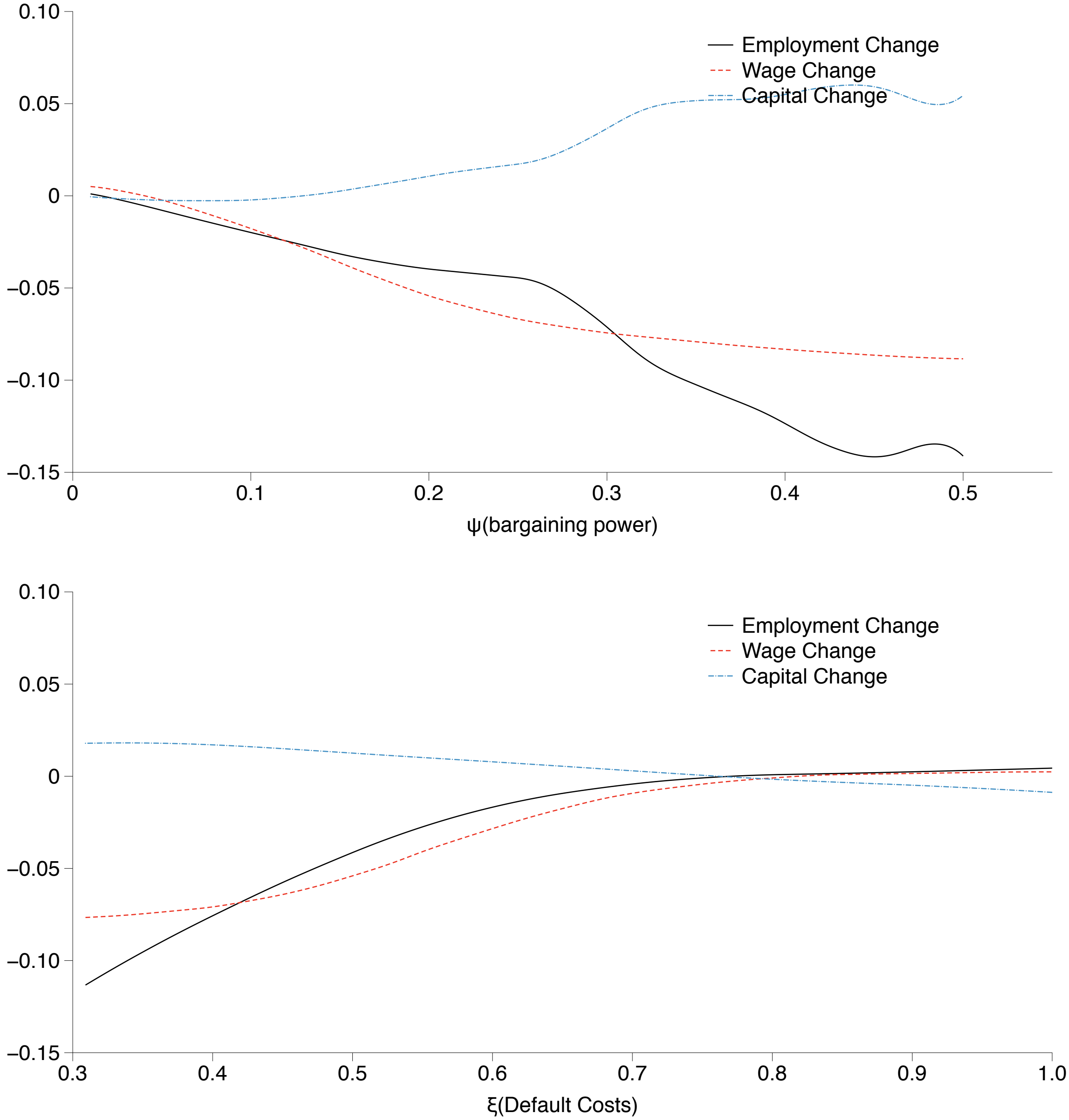


Figure 5: Sensitivity of Counterfactuals to Model Parameters

Figure 5 shows the response of the logs of labor, labor earnings per worker, and capital to a 50 basis point increase in the cost of debt. Each panel plots these responses as a function of a different model parameter: labor bargaining power, ψ and the deadweight cost of default, ξ.



Appendix A

In this appendix, we provide some additional details regarding the construction of the merged panel. Ideally, we would execute this merge for all Compustat parent firms. However, because corporations in Compustat can have hundreds of establishments and Infogroup charges by the establishment, this strategy is too costly. In light of this issue, we have constructed our sample in the following way.

First, we draw a random sample of 1000 firms from Compustat. The universe from which the sample is drawn consists of firms that operated at some point in time since 2000. Some of these firms, however, have workforces based largely outside the U.S. This detail complicates our analysis because we observe the firm's global balance sheet in Compustat but only its U.S. employment and wage bill in LDE. Hence, we discard firms whose workforces are substantially based overseas. To isolate these firms, we investigate firms with annual sales greater than $10 billion because they are the ones most likely to have a large international presence. We then discard those whose U.S. employment makes up less than three-quarters of their total workforce. This criterion eliminates roughly 200 firms.

Second, we deliver our list of parents to Infogroup and request that it pull records on each parent's establishments. To this end, we make the identifying assumption that if two establishments *within* the same state are operated by the same parent, they use the same EIN. This assumption is useful because it implies that for each parent in a given year, we can conserve on costs by requesting information from Infogroup on *one establishment* per state per parent. We chose to ask for the name and address of the oldest establishment. Therefore, using our sample selection, the year-t cross section from Infogroup records the names and addresses of the oldest-operating establishment of each parent in each state in which the parent is active in that year. Note that if we match the oldest establishment to a record in the LDE, then (under our identifying assumption) we can discover the unique EIN that the parent uses in the state. This procedure allows us to pinpoint the remaining establishments in the LDE operating under that parent in the state. Thus, even though the high cost of ReferenceUSA data can be constraining, we can still merge ReferenceUSA to the LDE.

Not surprisingly, we have identified some violations of this identifying assumption, in which different EINs are used within a single state. Because we under-count the parents' establishments in these cases, we typically find that our estimate of the parent's employment is substantially less than the annual Compustat figure. We follow up in these scenarios by doing internet searches to track down the names and addresses of additional establishments operated by the parent in each state. These searches produce (in the LDE) the EINs we are missing. We again "hard-code" an allowance for this type of situation into the matching code.

We have requested two annual cross sections from Infogroup, one from 2006 and another from 2012. We match each to the LDE. The use of the 2006 cross section means that, if a firm operated in a state in 2006 but exited by 2012, we will still be able to identify the firm's establishments in that state in the LDE data.

However, if the firm enters and exits a state between 2007 and 2011, we will miss it and thus under-count employment for those years.

Infogroup retrieves comprehensive data for 771 of the 808 parents on our list. We, in turn, have been able to match 577 of these parents to the LDE, so our panel consists of these firms spanning the period 2006-2012.

Merging ReferenceUSA to LDE

As a first step, we standardize names and addresses. For instance, "Corporation", "Corp.", and "Corp" are all set to the latter value. The conventions for standardization follow practices at the Census Bureau.

Next, the character-matching algorithm identifies establishments in the LDE that inhabit the same state and exhibit a "similar" name to the corresponding establishment in ReferenceUSA. Our principal criterion for "similar" is that the first three-quarters of the characters in the ReferenceUSA and LDE names agree identically, although we relax this criterion if establishments match exactly on zip code. We stress agreement on the initial characters of each name because keypunch errors tend to increase as strings advance from left to right (Winkler 2006). If we fail to match several of a parent's ReferenceUSA establishments, we manually examine how these establishments' names are recorded in the LDE (by, for instance, looking up the name in LDE corresponding to the address in ReferenceUSA). One can usually identify a pattern to the discrepancy, in that the LDE consistently reports a variant of the ReferenceUSA name. We then make an allowance for these variations in the matching code.

Missing data in LDE

One remaining challenge is that a seven states— Florida, Massachusetts, Michigan, Mississippi, New Hampshire, New York, and Pennsylvania—do not make their micro data available through the BLS. Thus, in all, we have data for 43 states and territories, including Delaware and Nevada, where most U.S. corporations are incorporated. For this reason, we have been using both LDE and Compustat data to estimate employment and the wage bill. In particular, if we are missing states at random, then LDE provides a consistent estimate of the average wage *rate* and quarterly employment *growth*. We can combine this information with end-of-fiscal-year estimates of the level of employment in Compustat to estimate firm-wide wages and employment in each quarter.

Changes in ownership

A second challenge has to do with changes in ownership. Suppose a parent divests several establishments between 2006 and 2012. If those establishments adopt new EINs, we will, appropriately, exclude them when aggregating across the parent's EINs. However, we have noticed that if the establishments operated as a wholly own subsidiary and if the *entire* subsidiary is divested, then the plants may retain their original EINs. This situation is especially likely if the subsidiary—and its establishments—never shared the same EIN as its original parent's headquarters, and if it continues intact under the new parent. In these cases, we would (wrongly) continue to assign these establishments' employment to the original parent, since they report the same EIN as in 2006. To address this concern, we try to identify likely changes in ownership based on "jumps" in Compustat's data on assets. Using internet searches, we then determine if a change in ownership did occur and make an allowance for this in the matching code.

Data definitions

Our Compustat variables are defined as follows. Investment is given by (CAPXY - SPPEY) / lag(PPENTQ). Because CAPXY and SPPEY are reported cumulatively over the year, we first difference to obtain the actual quarterly expenditures. Net debt is defined as book assets minus book equity minus cash: ATQ - SEQQ + TXDITCQ + PSTKQ - CHEQ. Leverage is book debt scaled by ATQ. Operating income is IOBDPQ.

In the LDE, monthly employment at the establishment is defined as employment in the pay period including the 12th of the month. We average monthly employment over each calendar quarter to create the quarterly panel. The monthly wage bill is total wages paid by the establishment during the month. We calculate the average wage by simply dividing the wage bill by employment and, again, take the quarterly average. For both the LDE and Compustat variables, we winsorize the top and bottom 2.5% of observations.

Appendix B

This appendix derives equation (11) in Proposition 1.

Preliminaries

The wage bargain sets the wage rate to split the match surplus between the firm and worker. Let $\mathcal{J}$ denote the firm's surplus and $\mathcal{W}(k', n', b', z)$ the worker's surplus. The wage then solves:

$$\mathcal{W}(k', n', b', z) = \psi \left(\mathcal{J}(k', n', b', z) + \mathcal{W}(k', n', b', z) \right), \tag{16}$$

where $\psi \in (0, 1)$ is the worker's bargaining power. In what follows, we first assess $\mathcal{J}(k', n', b', z)$ and then turn to the worker's problem.

Throughout, we make use of an approximation to facilitate the analysis. We assume that states of nature where dividends are exactly zero are sufficiently unlikely to be realized that they may be neglected in the calculation of the continuation value. As noted in the main text, this is a good quantitative approximation because these states are rare unconditionally and, if one does occur, it is unlikely to be repeated soon. As a result, the evaluation of the firm's future marginal value of labor assumes that its choice of future debt, b', is unconstrained.

The firm's problem

Because a vacant job yields zero return to the firm, the firm's surplus is the marginal value of labor, which can be expressed as:

$$\mathcal{J}\left(k', n', b', z\right) = -\frac{\partial W\left(k', n', b', z\right)}{\partial n'} + \rho \frac{\partial}{\partial n'} \mathbb{E}\left[\Pi\left(k', n', b', z'\right)\right], \tag{17}$$

in which the expectation is taken with respect to the conditional distribution function $G(z' \mid z)$. Note that the arguments of the wage bill, $W\left(k', n', b', z\right)$, preview the solution below. The first term in (17) represents the effect of a new hire on the wage bill. Note that, for given b' and k', a perturbation to n' affects dividends solely via $W\left(k', n', b', z\right)$. Such a perturbation does not imply a marginal adjustment cost, because these costs are sunk by the time the surplus is divided. The second term in (17) expresses the future marginal value of labor. To evaluate this term, we must explore the firm's labor demand decision in greater detail.

Linear factor adjustment costs imply three regimes for an optimal employment policy. For a low range of productivity realizations, the firm fires; for a high range of productivity draws, the firm hires; and for an intermediate range, the firm does not adjust employment. Non-adjustment is optimal in some states of nature because the marginal cost of adjusting is discretely higher than zero. Therefore, for small fluctuations in productivity, the marginal benefit of adjusting does not exceed marginal cost. In the absence of financial frictions, it can be shown that this structure of adjustment frictions implies an optimal employment policy of this form. See Elsby and Michaels (2013).

In case the firm fires, we conjecture that capital demand is non-increasing, that is, the firm either opts not to undertake gross investment or chooses to disinvest. This policy is optimal under frictionless credit markets if the cost of adjusting capital is sufficiently large relative to the cost of adjusting labor (Dixit 1997; Eberly and Van Mieghem 1997). In the same spirit, we conjecture capital demand is non-decreasing if the firm hires, and that gross investment is zero if the firm chooses not to adjust employment. We then verify in our simulations that this policy obtains.

By Leibniz's rule, this optimal labor demand policy implies that the marginal value of labor is

$$\begin{aligned} \frac{\partial}{\partial n'} \mathbb{E}\left[\Pi\left(k', n', a', z'\right)\right] &= \int_{\text{Firing}} \frac{\partial}{\partial n} \Pi^{f}\left(k', n', b', z'\right) dG\left(z' \mid z\right) \\ &+ \int_{\text{Inaction}} \frac{\partial}{\partial n'} \Pi^{0}\left(k', n', b', z'\right) dG\left(z' \mid z\right) \\ &+ \int_{\text{Hiring}} \frac{\partial}{\partial n'} \Pi^{h}\left(k', n', b', z'\right) dG\left(z' \mid z\right), \end{aligned} \tag{18}$$

where the subscript in a value function, such as Π^f, refers to the labor demand regime. For example, "f" is for firing. Note that it is possible to further decompose the value of firing (hiring) into two regimes: one in which the firm does zero gross investment and one in which z' is low (high) enough to trigger disinvestment (positive investment). However, this decomposition is unnecessary here because under our conjecture concerning the joint dynamics of capital and labor explained above, the Envelope theorem applies to the labor demand decision in both regimes.[10]

To evaluate this continuation value, we consider each of the three regimes in turn.

Firing

Consider a firm that is calculating the marginal (present) value of next period's labor n' in the event that it will be firing in the subsequent period ($n'' < n'$). The value of the firm next period is given by,

$$\Pi^f\left(k', n', b', z'\right) = \max_{b'', k'', n''} \left\{ \begin{array}{c} (a(k', n', b', z') + b''/(1+r(\cdot)) - W\left(k'', n'', a'', z'\right) - R\left(i'\right)) \\ +\rho \int \Pi\left(k'', n'', a'', z''\right) dG\left(z'' \mid z'\right) \end{array} \right\}, \tag{19}$$

Note that, if the firm defaults at the beginning of the period, the firm's output and fixed assets are transferred to the lender such that $a(k', n', b', z')$ is reset to zero. Hence, (19) holds but with $a(k', n', b', z') = 0$.

By the Envelope theorem, a firm this period calculates the future marginal value of labor in this regime to be

$$\frac{\partial}{\partial n'} \Pi^f\left(k', n', b', z'\right) = \frac{\partial a(k', n', b', z')}{\partial n'}. \tag{20}$$

This condition says that because the firm will re-optimize its labor demand next period ($n'' < n'$), the only effect of the labor choice, n', on the firm's future present value is channeled through labor's marginal effect on start-of-next period cash on hand. Clearly, if the firm defaults, then $\partial a(k', n', b', z')/\partial n' = 0$.

Hiring

A hiring firm's present value is

$$\Pi^h\left(k', n', b', z'\right) = \max_{b'', k'', n''} \left\{ \begin{array}{c} (a(k', n', b', z') + b''/(1+r(\cdot)) - W\left(k'', n'', a'', z'\right) - c^n \Delta n'' - R\left(i'\right)) \\ +\rho \int \Pi\left(k'', n'', a'', z''\right) dG\left(z'' \mid z'\right) \end{array} \right\}. \tag{21}$$

[10] Because the cost of adjusting capital is linear in $i \equiv k' - (1-\delta)k$, the Envelope theorem also implies that Π^f is independent of k in periods of capital adjustment. Hence, in these states, Π^f is a function of only three arguments (n', b', z').

Again, if the firm defaults in this state of nature, (21) obtains with $a' = 0$. By the Envelope Theorem, the marginal value of labor is then

$$\frac{\partial}{\partial n'}\Pi^h\left(k', n', b', z'\right) = \left(\frac{\partial a(k', n', b', z')}{\partial n'} + c^n\right), \tag{22}$$

with $\partial a(k', n', b', z')/\partial n' = 0$ in the case of default. As in the firing case, the choice of n' affects the firm's future present value start-of-next period cash on hand. In this case, however, because of the hiring cost, we must account for this extra term.

Inaction

Next, consider a firm that does not adjust next period, that is, $n'' = n'$. Given that, under our conjecture, $\Delta k'' = 0$, as well, the firm's present value is

$$\Pi^0\left(k', n', b', z'\right) = \max_{b''}\left\{\left(a(k', n', b', z') + b''/(1 + r(\cdot)) - W\left(k', n', b'', z'\right)\right) + \rho\int \Pi\left(k', n', b'', z''\right) dG\left(z'' \mid z'\right)\right\}. \tag{23}$$

By the Envelope theorem (as applied to b''), the firm this period calculates the future marginal value of this period's labor to be

$$\begin{aligned}\frac{\partial}{\partial n'}\Pi^0\left(k', n', b', z'\right) &= \left(\frac{\partial a(k', n', b', z')}{\partial n'} - \frac{\partial W\left(k', n', b'', z'\right)}{\partial n'}\right) + \rho\frac{\partial}{\partial n'}\int \Pi\left(k', n', b'', z''\right) dG\left(z'' \mid z'\right) \quad (24)\\ &= \frac{\partial a(k', n', b', z')}{\partial n'} + \mathcal{J}\left(k', n', b'', z'\right).\end{aligned}$$

Summing up

Piecing together (20), (22), and (24) and combining with (17) yields:

$$\begin{aligned}\mathcal{J}\left(k', n', b', z\right) &= -\frac{\partial W\left(k', n', b', z\right)}{\partial n'} \\ &+ \rho\left\{\begin{array}{c}\displaystyle\int_{\text{Non-default}} \frac{\partial a(k', n', b', z')}{\partial n'} dG\left(z' \mid z\right) \\ \displaystyle +c^n \int_{\text{Hiring}} dG\left(z' \mid z\right) + \int_{\text{Inaction}} \mathcal{J}\left(k', n', b'', z'\right) dG\left(z' \mid z\right)\end{array}\right\}.\end{aligned} \tag{25}$$

Note that, as anticipated by the discussion above, the partial effect of n' on cash-on-hand $a(k', n', b', z')$, $\partial a(k', n', b', z')/\partial n'$, is weighted by the probability of survival.

Surplus sharing

The firm and worker split the match surplus according to (16). The worker's surplus is given by

$$\mathcal{W}(k',n',b',z) = w(k',n',b',z) - \mu + \rho \int (1-s') \cdot \mathcal{W}(k',n',b',z')\, dG(z' \mid z), \tag{26}$$

where $w(k',n',b',z) \equiv W(k',n',b',z)/n'$ is the wage per worker, μ is the flow return to non-employment, and s' is the endogenous probability of separation from the firm next period. The surplus-sharing arrangement (16) sets $\mathcal{W}(k',b',n',z') = \frac{\psi}{1-\psi}\mathcal{J}(k',b',n',z)$. Because b' and n' are chosen optimally, the first-order conditions for a firing firm imply that it fires until the marginal value of a worker is zero. That is, differentiating (19) with respect to n' shows:

$$\Delta n' < 0 : \mathcal{J}(k',n',b',z) = 0. \tag{27}$$

By the same logic, a hiring firm expands employment until the marginal value of labor is just offset by the hiring cost, c^{+}. Therefore,

$$\Delta n' > 0 : \mathcal{J}(k',n',b',z) = c^{n}. \tag{28}$$

If the firm does not adjust n, then $\mathcal{J}(k',n',b',z) = \mathcal{J}(k,n,b',z)$.

Combining these expressions, using the mapping from $\mathcal{W}(b',k',n',z')$ to $\mathcal{J}(b',k',n',z')$, and substituting into (26) yields

$$\begin{aligned} \mathcal{W}(k',n',b',z) &= \frac{W(k',n',b',z)}{n} - \mu \\ &+ \rho\frac{\psi}{1-\psi}\left\{\int_{\text{Inaction}} \mathcal{J}(b',k,n,z')\, dG(z' \mid z) + \int_{\text{Hiring}} c^{n} dG(z' \mid z)\right\}. \end{aligned} \tag{29}$$

Next, we substitute (25) and (29) into the surplus-sharing rule (16). After canceling terms and noting that $\frac{\partial W(k',n',b',z)}{\partial n'} = w(k',n',b',z) + \frac{\partial w(k',n',b',z)}{\partial n'}n'$, we have

$$(1-\psi)\frac{W(k',n',b',z)}{n'} + \psi\frac{\partial W(k',n',b',z)}{\partial n'} = \psi\rho\int_{\text{Non-default}} \frac{\partial a'}{\partial n'} dG(z' \mid z) + (1-\psi)\mu. \tag{30}$$

Equivalently, we can recall that default is a single crossing condition, namely, the firm defaults if productivity, z', is less than a threshold, $\hat{z}(k',n',b',z)$. Then (30) becomes

$$(1-\psi)\frac{W(k',n',b',z)}{n'} + \psi\frac{\partial W(k',n',b',z)}{\partial n'} = \psi\rho\int_{\hat{z}(k',n',b',z)} \frac{\partial a'}{\partial n'} dG(z' \mid z) + (1-\psi)\mu.$$

This expression is the same as (11) in Proposition 1.

Remark 1

Our neglect of future zero-dividend states should not be taken to mean that the possibility of a zero-dividend state, conditional on a labor demand policy, is unimportant to the firm's decision. Rather, the key observation is that the continuation values in the surplus-sharing rule reflect the firm's *optimal* response to this possibility. In simulations of the model, this best response appears to reduce the probability that a zero-dividend state is realized to a virtually negligible level. As a result, our solution to the wage represents a very good approximation.

Remark 2

Equation (17) is valid in and out of a zero-dividend state, that is, the solution (30) obtains in a zero dividend state as long as that state recurs so infrequently as to be negligible. To see why, note that debt is "sunk" by the time the firm and its workers implement (16). Suppose, in particular, that debt and factor demands have been chosen under the anticipation of a zero dividend. Now, note that the firm's evaluation of the marginal surplus (17) implicitly takes account of how the departure of a worker, taking as given the participation of the remaining workers, would yield a lower wage bill because $W(k', n', b', z)$, is increasing in n'. This would relax rather than tighten the dividend constraint. As a result, the marginal reduction in the wage bill is passed through as a marginally higher dividend, just as if the dividend was anticipated to be positive.