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ABSTRACT

Variable Pay and Risk Sharing Between Firms and Workers*

Firms differ in the extent to which they use variable pay. Using U.S. employeeemployer matched data on variable pay from Glassdoor, we document such dispersion and find workers are exposed to firm-level shocks through variable pay. Credit rating downgrades from investment to speculative grade, negative shocks to financial or operational performance, and greater exposure to a financial crisis, as proxied for by the collapse of Lehman Brothers, induce firms to shift compensation toward base pay. Increased use of variable pay is associated with greater earnings variance for workers but less volatile growth for firms. We rationalize these findings in a model of risk sharing between a risk-averse firm and workers with limited commitment.

JEL Classification: J33, E24

Keywords: risk sharing, bonuses, firm-specific shocks, employment volatility, layoffs

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1 Introduction

A central concern in macroeconomics at the intersection of labor and finance is understanding how firms respond to fluctuations in economic conditions and how such responses impact employee compensation. Conventional wisdom posits risk-neutral employers insulate risk-averse employees from variation in firm performance (e.g., Harris and Holmstrom, 1982). In fact, such rigidity can give rise to operational leverage, in that the wage bill acts like a fixed cost, in turn exposing firms' shareholders to additional risk (e.g., Hartman-Glaser *et al.*, 2019). While there is compelling evidence base wages respond little to economic shocks, reflecting (downward) nominal rigidity (e.g., Altonji and Devereux, 1999), less is known about the behavior of variable compensation. Given the ubiquity of variable pay in the United States (Lemieux *et al.*, 2009; Kruse *et al.*, 2010; Grigsby *et al.*, 2021),[1] understanding how this component of labor compensation responds to economic shocks not only has implications for the labor market outcomes of firms and workers, but also business cycles and our understanding of the relationship between employees and shareholders.[2]

Although variable pay can represent an economically meaningful part of firms' labor bills, especially for compensating high-skilled workers (Eisfeldt *et al.*, 2023), the extent to which firms incorporate variable pay practices varies considerably. For instance, we observe across large U.S. employers, i.e., those in Compustat, that although approximately 40 percent of employees receive variable pay in the median firm, firms that use variable pay the most frequently do so about 70 percentage points more often than those that do so the least frequently (Figure 1). In turn, for rank-and-file employees, even among large employers, variable pay can represent anywhere from 0 to 18 percent of labor income. Motivated by this dispersion, we investigate the economic rationale for firms to incorporate variable pay practices when setting compensation.

While firms may use variable pay to increase productivity (Lazear, 2000), reduce moral hazard (Lemieux *et al.*, 2012), preserve cash (Kim and Ouimet, 2014), or retain and attract talent (Oyer and Schaefer, 2005), we argue one additional reason may be to share risk. Consistent with this mechanism, we find that variable pay responds to economic shocks that are exogenous to the worker, and that firms that use variable pay to a larger extent experience less volatile growth in sales and employment. Our work is among the first to show

[1] For instance, a 2023 Payscale survey found that 78 percent of about 5,000 responding companies compensate employees with variable pay. See `https://www.payscale.com/research-and-insights/cbpr/`.

[2] Most studies in this area focus on executive compensation. See, for instance, Edmans and Gabaix (2016) for a survey of the literature. Rare exceptions include Grigsby *et al.* (2021) who use administrative payroll data to examine the rigidity of wage adjustments in base and variable pay among job stayers and switchers at mid-sized firms, and Eisfeldt *et al.* (2023) who study the importance of equity-based compensation for the skill premium and the decline in the U.S. labor share.

empirically how base and variable pay differentially respond to real and financial shocks to firms, and how variable pay usage is associated with reduced volatility for firms.

We first develop an optimal contracting framework to rationalize why a firm might use variable pay. In our setting, a firm shares production risk with a worker who supplies labor until separated from the firm. The worker has limited commitment, as in Thomas and Worrall (1988), and can leave the firm to take advantage of a time-varying outside option, while the firm maximizes shareholder value.[3] Departing from much of the literature, however, we assume the firm's owner is exposed to firm-specific risk, reflecting for instance credit constraints, managerial agency issues, or costly hedging (e.g., Greenwald and Stiglitz, 1990; Froot *et al.*, 1993; Papanikolaou and Panousi, 2012). As a result, the firm behaves in a risk-averse manner and optimally transmits productivity shocks to the worker through compensation. The ability to share production risk is limited by the worker's outside option, which imposes a form of downward rigidity on pay and induces turnover.

Within this framework, the optimal contract will partition the state space into three segments. The first is a continuation region in which the worker remains employed with the firm and their pay can adjust upward or downward because it is partly comprised of a volatile variable component. Here, the assumption that the firm's owner is risk-averse is crucial, as compensation would instead remain constant in the continuation region if the firm's owner was risk-neutral (e.g., Krueger and Uhlig, 2006; Ai and Bhandari, 2021). With a risk-averse owner, the optimal contract within the continuation region trades off greater conditional variance in compensation with a reduced likelihood of separation. In turn, this trade-off reduces volatility of not only employment but also firm output. The other two regions consist of a renegotiation region, in which the worker's compensation adjusts up permanently as their limited commitment constraint binds, and a separation region, where the worker and firm optimally part ways.

We then present a more elaborate model in which a firm can employ many workers, hold a risk-free asset to self-insure against shocks to cash flows, and have shareholders who have access to financial markets. This richer setting illustrates how shocks to equity returns pass through to compensation and clarifies that, for firm-level shocks to affect pay, firm-specific risk must be priced by investors (e.g., Mehra *et al.*, 2021; David *et al.*, 2022). In contrast with theories of wage insulation (e.g., Hartman-Glaser *et al.*, 2019) and wage stickiness (e.g., Favilukis and Lin, 2016; Favilukis *et al.*, 2020), our risk sharing mechanism predicts that firm-level shocks are passed through to worker compensation rather than fully absorbed by shareholders. In this multi-worker setting, risk sharing also induces two nuanced externalities because each worker's own risk-sharing arrangement affects those of other workers through

[3] Beaudry and DiNardo (1991) show U.S. wage data is consistent with workers having limited commitment.

the limited risk-bearing capacity of shareholders.

To test our empirical predictions, we use data from the online platform Glassdoor. The key advantage to working with these data are that respondents separate their compensation into base and variable pay, reporting both the magnitude and incidence for each type of variable pay, including cash bonuses, stock bonuses, profit sharing, and sales commissions. This decomposition facilitates analyzing variable pay directly without having to impute variable pay incidence or amounts.[4] Each observation reflects an employee-employer match with a rich set of observables, such as the worker's job title. Given that workers seldom provide multiple pay reports, especially for the same firm, our main empirical specifications consider variation over time between workers who share a job title at the same firm. That said, if we were to consider only variation in pay reports within the same match (i.e., worker-firm pair) over time, we would draw similar conclusions (see Internet Appendix E).

We begin our empirical analysis examining how variable pay adjusts to labor market conditions. While other work has shown that changes to workers' outside options pass through to wages (e.g., Oreopoulos *et al.*, 2012; Caldwell and Harmon, 2019), our work emphasizes the separate roles that base and variable pay play in this transmission. Because the Glassdoor data allow us to observe variable pay separately from base pay, our empirical analysis can speak directly to the cyclicality of variable pay as opposed to through proxies along the extensive margin, e.g., variable-pay jobs or variable-pay earners.[5] We find that both base and variable pay are procyclical: A one-percentage-point drop in the local unemployment rate is associated with a 0.2 percent increase in base pay and a 0.9 percent increase in variable pay among workers who receive it. Consistent with our risk sharing framework, as local labor labor markets tighten, base pay rises.

We next examine three firm-level shocks. The first is when a firm's credit rating crosses the threshold between investment and speculative grade. Such credit events are meaningful because many institutional investors and asset managers have strict mandates to buy only investment or speculative-grade bonds. While previous literature has shown a firm's credit conditions (e.g., Michelacci and Quadrini, 2009; Matsa, 2010) and financial distress (e.g., Benmelech *et al.*, 2012; Brown and Matsa, 2016; Graham *et al.*, 2023) impact compensation, we complement these studies by examining how events impacting funding conditions transmit separately to base and variable pay. We find that variable pay primarily, and base pay

[4] For instance, Grigsby *et al.* (2021) identify months in which a worker receives earnings net of overtime premiums that exceed one percent of their annual earnings, and then consider a worker has having received a bonus if this outsize residual payment occurs in at least one month, but no more than three; if such payments occur in more than three months, the worker is classified as receiving sales commissions.

[5] Devereux (2001) finds salaried workers who receive variable pay have procyclical earnings, Makridis and Gittleman (2017) that total earnings for variable-pay jobs are more sensitive to the business cycle, and Lemieux *et al.* (2012) that county unemployment rates affect workers who earn bonus pay.

secondarily, falls after a credit downgrade and rises after a credit upgrade. While average base pay falls 1.5 percent following a downgrade, 2.4-percentage-points fewer workers receive variable pay and among those who do receive it, average variable pay falls 8 percent.

The second shock is deviations in annual operational and financial performance based on a firm's sales per worker, as a proxy for labor productivity (Comin and Philippon, 2005), and its stock return. Although base pay does not respond to changes in annual performance, variable pay does. A one standard deviation boon to a firm's sales per worker is associated with 5 percentage points more workers receiving variable pay and a 12 percent increase in variable pay among those who receive it. We also document significant effects following a positive surprise to a firm's annual stock return, though the effects are an order of magnitude smaller. These results lend empirical support to the findings of Juhn *et al.* (2018), who argue firms mostly insulate workers from idiosyncratic shocks to firm revenue, but there is a greater elasticity for higher-paid workers (who are more likely to receive variable pay), as well as Wallskog *et al.* (2024), who find higher productivity predicts greater within-worker pay volatility for higher-paid workers.

The third shock is deterioration in bank health. On September 15, 2008, Lehman Brothers filed for bankruptcy, making it then the largest bankruptcy in U.S. history. Banks for which Lehman Brothers played an outsize role in the their syndication portfolios appear to have been more exposed to this shock, ultimately decreasing new lending more than other banks (Ivashina and Scharfstein, 2010). Using data on the share of a bank's syndication portfolio for which Lehman Brothers was involved from Chodorow-Reich (2014) for 39 lenders, we test whether, compared with the rest of the finance industry, pay evolved differently for banks that were increasingly exposed to this negative shock. While base pay appears unchanged after 2008 among exposed banks, variable pay falls on average 7 percent for bank lenders with the mean level of exposure. The drag persists throughout the 2010s, consistent with the decline in U.S. bank health persisting long after the Financial Crisis (Chousakos and Gorton, 2017). Evidently, for U.S. banks, as with U.K. banks (Efing *et al.*, 2019), variable pay was a conduit for passing on this negative shock to employees.

Consistent with firms sharing risk when setting pay, firms that use variable pay exhibit greater variance in worker compensation but less volatile growth in sales and employment. While a one-standard-deviation greater share of income attributable to variable pay is associated with 0.35–0.43 standard deviations greater pay variance, it is associated with 0.07 standard deviations less volatility in employment growth. We provide further evidence of this reduction in employment volatility by showing firms that use variable pay more intensively lay off fewer workers through mass layoff (WARN) notices. These results accord with those of Blakemore *et al.* (1987), who show the use of bonuses reduces labor turnover, but contrasts with those of Reizer (2022), who finds variable pay reduces volatility in the growth of firm sales but not necessarily employment using Hungarian survey data. Taken together, from the perspective of workers, variable pay induces a trade-off between two risks. While variable pay results in riskier pay, it leads to less risky employment as separations occur less often. Workers' preferences over variable pay will likely depend then on to which of these two risks workers are more averse, which is not obvious and likely heterogeneous.[6]

Our paper relates to the literature on optimal contracting between firm and workers. We study this in the context of risk sharing between a firm and a risk-averse worker with limited commitment (e.g., Thomas and Worrall, 1988) who share firm-specific risk when the firm is risk-averse.[7] Our work consequently builds on Danthine and Donaldson (2002), who model risk sharing between risk-averse workers and investors without a labor supply decision or limited commitment, and contrasts Berk and Walden (2013) in which risk-averse workers and firms are fully insured through financial markets from firm-specific but not systematic risk. Our risk sharing channel is different from that in Xiaolan (2014) who shows a risk-neutral firm may pass on shocks to workers when they accumulate human capital and have limited commitment, and Berk *et al.* (2010) who show a levered, risk-neutral firm passes on shocks to wages when in financial distress. It is also distinct from wage dynamics with learning (e.g., Harris and Holmstrom, 1982) or moral hazard (e.g., Parlour and Walden, 2011), and from Ai and Bhandari (2021) where both firms and workers have limited commitment and wage adjustments are permanent until either party reaches a renegotiation point. While Lemieux *et al.* (2012) microfounds bonuses based on a moral hazard friction, in turn linking variable pay to individual performance, our risk sharing mechanism ties bonuses to firm performance. Further, our framework helps rationalize evidence that worker protection laws increase the incidence of jobs that use variable pay (Mahlstedt and Weber, 2020), as this would be consistent with improvements in risk sharing through implicit contracting.

Related to our continuous-time duality modeling approach, Grochulski and Zhang (2011) characterize a one-sided principal-agent problem in continuous time and decentralizes the optimal contract with solvency constraints, while Miao and Zhang (2015) develop a continuous time duality characterization of one- and two-sided limited commitment problems. In contrast, we derive empirical predictions when firms are risk averse with a continuum of workers. Unlike Martins *et al.* (2005), we model spillovers across workers through the pricing kernel of shareholders. Compared with other multi-worker models (e.g., Wolinsky, 2000;

[6]This tension is well demonstrated by survey evidence from Davis and Krolikowski (2023). While most unemployment insurance recipients in the survey expressed a willingness to accept a pay cut to preserve their jobs if the option were available, one-half of those who said they would not said they believed they had better outside options and another two-fifths said they would have been insulted by a pay cut.

[7]See Pagano (2020) for a review of this literature.

Elsby and Michaels, 2013; Acemoglu and Hawkins, 2014), we examine optimal contracting among heterogeneous workers instead of (Nash) bargaining among similar workers.

Our paper also contributes to the literature on the transmission of firm-level shocks to worker pay. Kline *et al.* (2019) and Garin and Silvério (2023) find that patent-induced and export shocks, respectively, affect wages. Guiso *et al.* (2005) and Carlsson *et al.* (2019) show Italian and Swedish employers, respectively, insulate employees from idiosyncratic firm shocks. Balke and Lamadon (2022) quantify the incidence of Swedish firms' performance on wages in the presence of search frictions and moral hazard, Friedrich *et al.* (2019) document that transitory and permanent firm-level shocks affect wages, and Kogan *et al.* (2020) show wages for high-skilled workers are highly exposed to technological innovation. Much of this literature, however, abstracts from the distinction between the fixed and variable components of pay, though there are exceptions. Di Maggio *et al.* (2022) show idiosyncratic shocks to stock volatility induce firms to shift toward base pay, Efing *et al.* (2019) that bonuses at European banks absorbed division- and bank-level shocks during the 2008 financial crisis, and Gadgil and Sockin (2020) that firm reputation shocks pass through to workers vis-à-vis stunted variable pay growth. We complement this literature by illustrating firms pass on shocks to performance and to credit conditions primarily through variable pay.

2 Optimal Contracting in Single-Worker Firms

In this section, we present a continuous-time model in which a risk-averse firm enters into a long-term relationship with a risk-averse worker who is subject to limited commitment. We begin with the standard of one principal (the firm's owner) and one agent (the worker). We characterize the optimal contract, which features base and variable pay, and introduce testable predictions. For ease of exposition, we relegate proofs to Internet Appendix A.

2.1 Setting

Time is continuous and the horizon infinite. There is a single firm that is looking to sign a long-term contract with a single worker. The firm generates flow revenue y_t from the worker's labor, $l_t \geq 0$, according to the production technology

$$y_t = e^{A_t} l_t,$$

where A_t is the firm's productivity that follows a continuous-time AR(1) process with rate of mean-reversion $\kappa_A > 0$, long-run mean $\bar{A}$, volatility σ_A, and Brownian shocks Z_t^A.

While employed, the worker searches on the job for an outside employment opportunity that offers present discounted utility value of θ_t/ρ, where θ_t follows a second AR(1) process with rate of mean-reversion $\kappa_\theta > 0$, long-run mean $\bar{\theta}$, volatility σ_θ, and Brownian shocks dZ_t^θ. We associate fluctuations in θ_t/ρ with changes in local labor market conditions. For simplicity, we assume dZ_t^θ is independent of dZ_t^A, although this is not essential and can be easily relaxed. This assumption is instructive for developing empirical implications that do not confound changes in the worker's outside option with changes in their productivity.[8]

The worker remains employed with the firm until they separate at time τ, which is an optimal stopping time chosen by the firm or the worker.

2.2 Problem of the Worker

The worker derives utility $u(c)$ over flow consumption c, which represents the worker's compensation. The workers receives disutility $v(l)$ over the labor l they supply to the firm. We assume u is strictly concave, increasing, and satisfies the Inada condition, while v is strictly convex, increasing and $v(0) = v'(0) = 0$. The worker discounts the future at subjective discount rate $\rho > 0$. The worker has "at-will" employment and cannot commit to any contract. As introduced in Section 2.1, the worker's outside option at time t offers present discounted utility value θ_t/ρ.

The worker optimizes their lifetime utility subject to the limited commitment constraint

$$W_t \geq \frac{\theta_t}{\rho} \quad (LC),$$

where W_t is the worker's continuation value under the current contract. This limited commitment constraint forces the firm to raise the offered wage when the worker has a more appealing outside option — consistent with the empirical observation that the pace of employer-to-employer transitions is important for wage changes, especially among job stayers (e.g., Hall and Krueger, 2012; Moscarini and Postel-Vinay, 2016).

In addition to considering a time-varying outside option, the worker has an initial participation constraint (PC) given by $U_0 \geq \overline{U}$. Here, $\overline{U}$ can be interpreted as the reservation utility the worker attains from their initial best alternative to working for the firm, e.g.,

[8] Formally, the firm's productivity A_t and worker's outside option θ/ρ follow Ornstein-Uhlembeck processes with laws of motion

$$\begin{aligned} dA_t &= -\kappa_A (A_t - \bar{A})\, dt + \sigma_A dZ_t^A, \\ d\theta_t &= -\kappa_\theta (\theta_t - \bar{\theta})\, dt + \sigma_\theta dZ_t^\theta. \end{aligned}$$

working for another firm or enjoying leisure. The worker then chooses how much labor to supply to the firm to maximize their discounted expected lifetime utility according to

$$\begin{aligned} U_0 &= \sup_{\{l\}} E\left[\int_0^\infty e^{-\rho t}\left(u\left(c_t\right) - v\left(l_t\right)\mathbf{1}_{\{t\leq\tau\}}\right)dt\right], \\ s.t. &: (LC), \ (PC). \end{aligned}$$

2.3 Problem of the Firm

The firm generates revenue y_t and splits it with the worker, paying the worker $c_t > 0$ at each instant. The firm, however, can lay off the worker at any point and receive constant output $\bar{y} > 0$ (representing the net profit from hiring a new worker) that has a presented discounted value of $\bar{y}/\rho$. Although the worker no longer provides labor to the firm once laid off, the firm can continue to pay the worker thereafter from the revenue stream $\bar{y}$.

The firm is privately-owned by an entrepreneur who maximizes shareholder value with the same subjective discount rate ρ as the worker (for stationarity). The entrepreneur is risk averse and consumes only the firm's profits, $y_t - c_t$, i.e., they are under-diversified. The entrepreneur values these profits according to a non-negative state price deflator $e^{-\rho t}\vartheta_t$ where $\vartheta_t = \vartheta\left(y_t - c_t\right)$ and $\vartheta_0 = 1$ as a normalization. Firm-specific productivity is therefore priced by the entrepreneur and the firm exhibits risk aversion. While models governing optimal contracting between a principal and an agent typically assume that firms are risk-neutral (e.g., Ai and Bhandari, 2021), our model differs in this key respect. A firm may behave in a risk averse manner for a variety of reasons (Froot *et al.*, 1993), for instance because of financial constraints (e.g., Berk *et al.*, 2010) or agency issues with managers (e.g., Papanikolaou and Panousi, 2012). A novelty in our setting is that such hedging of production risk instead occurs through wage setting with workers rather financial markets (as in, for instance, Berk and Walden (2013)).

Unlike the worker, the firm can commit to a contract; otherwise, contracting would reduce to a static spot-contracting problem. As such, the firm must honor any promised compensation schedule, which we refer to as a promise-keeping constraint (PK), or

$$E\left[\int_t^\infty e^{-\rho(s-t)}\left(u\left(c_s\right) - v\left(l_s\right)\mathbf{1}_{\{s\leq\tau\}}\right)ds\right] \geq W_t \ \ \forall\, t \ \ (PK),$$

where W_t is the worker's promised continuation value from the ongoing contract.

The entrepreneur sets the worker's compensation, demand for the worker's labor, and a time at which to lay off the worker, to maximize the firm's discounted expected value,

$$\Pi_0 = \sup_{\{c,l,\tau\}} E\left[\int_0^\tau e^{-\rho t}\vartheta_t\left(y_t - c_t\right)dt + e^{-\rho\tau}\underline{\Pi}_\tau\right],$$

$$s.t \quad : \quad (PK),\ (LC),\ (PC),$$

where we recall ϑ_t is a function of firm profits, i.e., $\vartheta_t = \vartheta\left(y_t - c_t\right)$. Here, τ is an optional stopping time for when the firm and worker separate, and $\underline{\Pi}_\tau$ is the continuation value for the firm after separating, which depends on $\bar{y}$. Since the worker has at-will employment, they may desire to exit the contract even when there is still a positive surplus from being employed with the firm. Consequently, the firm internalizes the worker's limited commitment constraint, so the firm's optimization problem is subject to both the promise-keeping constraint (PK) and the worker's limited commitment constraint (LC).

As a benchmark, suppose instead that the firm was risk-neutral. Under this alternative, we obtain the optimal contract of Thomas and Worrall (1988). The firm offers a permanent wage increase whenever the worker threatens to quit, until eventually the firm chooses to separate with the worker. In contrast with the optimal contact that arises with a risk-averse firm, there is no variable component of worker compensation while the worker is employed in this setting. Proposition 1 summarizes this optimal contract and negative result.

Proposition 1. *If the firm is risk neutral, it pays a piece-wise constant wage that increases when the worker's limited commitment constraint (LC) binds, and does not vary otherwise.*

2.4 Equilibrium

To characterize the optimal contract, we define the auxiliary state variable $\xi_t \geq 0$ that encodes the history dependence of the contract on the limited commitment (LC) constraint

$$\xi_t = \int_0^t \lambda_s ds, \tag{1}$$

where $\lambda_t \geq 0$ is the Lagrange multiplier on the complementary slackness condition

$$\lambda_t \left(W_t - \frac{\theta_t}{\rho}\right) = 0, \tag{2}$$

which increases whenever the (LC) constraint binds. The initial ξ_0 is such that initial promised utility to the worker is U_0, thereby satisfying the promise keeping (PK) constraint.

The following proposition summarizes the optimal contract in equilibrium.

Proposition 2. *The state space* (A, θ, ξ) *of the optimal contract can be divided into three disjoint regions: a continuation region* $\mathcal{C}$ *in which* ξ_t *is constant, a renegotiation region* $\mathcal{R}$ *in which* ξ_t *adjusts upward until* $W = \theta/\rho$*, and a separation region* $\mathcal{S}$ *in which the worker separates from the firm.*

Optimal compensation and labor supply for the worker satisfy

$$c_t = u'^{-1}\left(\vartheta_t/\xi_t\right), \tag{3}$$

$$l_t = v'^{-1}\left(e^{A_t}u'\left(c_t\right)\right). \tag{4}$$

The contract can be characterized by the firm's cost of its relationship with the worker, $e^{-\rho t}K_t$*, where* $K_t = -\Pi_t - \xi_t W_t$*, satisfies the dual-HJB inequality equation (A12).*

Under the optimal contract, as in Danthine and Donaldson (2002), the firm shares risk with the worker by aligning their marginal utilities, ϑ_t and $u'(c_t)$, respectively, subject to a wedge ξ_t from limited commitment. From equation (3), the greater is ξ_t, i.e., the larger the cumulative shadow cost from limited commitment, the permanently higher is the worker's compensation. Whether compensation becomes more or less volatile as ξ_t rises depends on the correlation between $1/\xi_t$ and the volatile ϑ_t.

From Proposition 2, the optimal contract is defined by several boundaries of the (A, θ, ξ) space. For illustrative purposes, we present in Figure 2 visualizations of the three regions of the contract space: the separation region $\mathcal{S}$, the renegotiation region $\mathcal{R}$, and the continuation region $\mathcal{C}$.[9] We present the boundaries for a risk-averse firm owner in panel (a) and a risk-neutral firm owner in panel (b). Two differences are worth highlighting. When the owner is risk-neutral, as in Thomas and Worrall (1988), (i) the separation region $\mathcal{S}$ is smaller for low levels of productivity and (ii) renegotiation occurs more often for higher levels of productivity (i.e., the boundary between $\mathcal{C}$ and $\mathcal{R}$ is upward-sloping) because the owner demands more labor from the worker but does not, all else equal, increase compensation. We further characterize dynamics across the contract space for the risk-averse owner below.

Consider the situation where the firm has high productivity (A_t). Then, the contract will likely lie within the continuation region $\mathcal{C}$.[10] As long as the worker and firm continue to operate within this region, the worker's compensation will move with changes in firm productivity, thereby rendering it variable, not fixed. The level around which compensation varies is related to how often the worker's limited commitment constraint has bound in the

[9] We solve the model numerically by jointly searching for the firm's dual value function and the worker's continuation value, and apply the splitting method to identify the separation and renegotiation boundaries. We set $\theta = -0.495$ and use the parameter values and functional forms specified in Internet Appendix A.

[10] If the worker's outside option is sufficiently low such that the contract starts in the region $\mathcal{R}$, then the co-state ξ_t jumps until the contract lies along the renegotiation boundary (which varies with firm productivity).

past (i.e., ξ_t). Whenever the worker threatens to quit, i.e., their outside option improves to a point at which (A, θ, ξ) reaches the boundary of the $\mathcal{R}$ region, the worker and firm renegotiate the contract. In this case, the firm raises the worker's compensation (i.e., ξ_t rises) until the worker is indifferent between continuing with the firm and separating for their outside option. This historical account of the worker's outside options thereby induces downward rigidity in compensation akin to a base wage. Optimal compensation therefore features a fixed component, encoded in ξ_t, and a variable component, encoded in ϑ_t.

Consider instead when firm productivity (A_t) is low, implying their are few rents from production to split with the worker. The worker either separates from the firm, because the rigid component of their compensation (captured by ξ_t) is sufficiently high, or renegotiates their compensation because their outside option becomes more appealing when ξ_t is sufficiently low. If the worker's outside option improves or the firm's productivity lessens to a point at which the contract reaches the boundary of the $\mathcal{S}$ region, then the firm and worker part ways. In this case, the firm continues to pay the worker a fixed lifetime compensation akin to a "defined benefit" retirement plan.

In Figure 3, we conduct two-hundred-and-fifty simulations of the model over a twenty-year horizon and summarize the first and second moments of the wage distribution over time conditional on remaining employed with the firm.[11] As is evident in panel (a), conditional on not separating, compensation drifts up over the life cycle as the worker's limited commitment constraint binds. The gradient is steeper under the risk-averse firm owner as workers receive less compensation at the onset of the match since the risk-neutral firm owner can tolerate lower profits for the same level of output. Notably, as shown in panel (b), compared with wages under a risk-neutral owner, wages under a risk-averse owner are considerably more volatile; from five years of firm tenure on, wages under a risk-averse owner (for this parametrization) exhibit triple the standard deviation. The growth in variable pay as workers accumulate human capital may thus help explain the increase in wage variance that is observed over the life cycle (Low *et al.*, 2010; Lagakos *et al.*, 2018).

In sum, similar to theories in which the firm insulates workers from volatility (e.g., Guiso and Pistaferri, 2020), the firm will bear some of the risk of production, and this incidence is increasing over time in the frequency of renegotiation when the worker is tempted to exit for their outside option. Since the firm exhibits risk aversion, however, it does not fully insure the worker from fluctuations in productivity. The more risk averse is the firm, the more it will hedge production risk when contracting with the worker.

By contrast, wage adjustments in models with two-sided limited commitment (e.g., Ai and Bhandari, 2021; Balke and Lamadon, 2022) are permanent until either the firm or worker

[11] For details on the parameters used to calibrate the model, see Internet Appendix A.

reaches a renegotiation point. As a result, very volatile outcomes and/or narrow continuation regions are needed to explain the high elasticity of variable pay to economic shocks we find in the data. Models with limited commitment and human capital accumulation (e.g., Xiaolan, 2014) instead imply piece-wise constant wages with downward rigidity, and tie a worker's renegotiation boundary to their maximum historical level of human capital.

2.5 Empirical Predictions

Next, we derive several testable implications of our model. To do so, we assume that the firm has a state price deflator $\vartheta_t = \left(e^{A_t} l_t - c_t\right)^{-\gamma_f}$, which corresponds to the entrepreneur having CRRA preferences, $\frac{(y-c)^{1-\gamma_f}}{1-\gamma_f}$, over firm profits.[12]

Prediction 1. Compensation structure Compensation can be decomposed into a fixed component that responds to the worker's outside option and a variable component that responds to shocks experienced by the firm. Although data show not every worker receives variable pay, we find the high frequency with which variable pay is used reassuring; Grigsby *et al.* (2021), for instance, conclude only one-quarter of workers receive all compensation through base pay.[13]

The following corollary characterizes the evolution of the optimal wage.

Corollary 1: *Assuming optimal worker compensation is twice differentiable in A_t, it has the law of motion*

$$dc_t = \left(\partial_\xi c_t \lambda_t - \partial_A c_t \kappa_A \left(A_t - \bar{A}\right) + \frac{1}{2}\partial_{AA} c_t \sigma_A^2\right) dt + \partial_A c_t \sigma_A dZ_t^A,$$

where $\partial_A c_t$, $\partial_{AA} c_t$, $\partial_\xi c_t > 0$. If the firm is risk-neutral (i.e., $\gamma_f = 0$), then $\partial_A c_t = \partial_{AA} c_t = 0$.

From Corollary 1, changes in optimal compensation arise through three possible channels. The first is a permanent wage increase whenever the limited commitment constraint binds. This may occur through a positive shock to the worker's outside option, which puts upward pressure on base compensation. In the multi-worker model of Section 3, we show that such a shock can also affect the variable component of compensation. The second is a drift term that reflects not only the mean reversion of firm productivity, but also a risk premium for exposing the worker to volatility in compensation. The third is a mean-reverting shock that

[12] Greenwald and Stiglitz (1990) show firms exhibit decreasing absolute risk aversion under various frictions.

[13] Just because a worker does not receive variable pay does not mean the firm does not use variable pay, as this may reflect a \$0 realization of a bonus rather than no possible bonus at all.

traces firm productivity. When such a productivity shock does occur, the firm can flexibly adjust the worker's compensation downwards without having to lay them off. This type of contract, in which pay can be revised up or down at each instant, contrasts that of Ai and Bhandari (2021) in which worker compensation is only infrequently revised up or down when the worker or firm's participation constraint binds.

Prediction 2. Compensation variance Our second key implication compares outcomes under the optimal contract with a risk-averse firm to those under the optimal contract with a risk-neutral firm. Under the former, as highlighted in Prediction 1, compensation includes a variable component. Under the latter, the firm offers a constant piece-wise wage. Worker compensation experiences greater variance when the firm exhibits risk aversion than when it is risk-neutral.

Prediction 3. Firm-level volatility Our third key implication is that firm output and employment will be more volatile under a piece-wise constant wage (which is optimal when the firm is risk neutral) than it will be when compensation includes a variable component. The reduced volatility occurs through two channels. First, the firm separates with the worker less often because compensation can fall to absorb adverse productivity shocks. Second, because of an income effect, when worker compensation is tied to firm productivity, the worker will work less as firm productivity and consequently their compensation rise. Through this income effect, the worker's labor supply reduces output volatility.

These last two implications are summarized in the following corollary.

Corollary 2: *Compared with a piece-wise constant wage (as in Proposition 1), the optimal contract from Proposition 2 features greater variance in worker compensation and less volatility in firm output and employment.*

3 Optimal Contracting in Multi-Worker Firms

To enrich our empirical predictions and highlight two externalities that arise through risk sharing, we incorporate several realistic features into the model.

First, the firm now employs a unit continuum of workers who supply labor $l_{i,t}$ and have correlated productivities $e^{A_{i,t}}$, where $A_{i,t} = A_t + e_{i,t}$ and $e_{i,t}$ is a mean-zero, mean-reverting AR(1) process that is independent across workers and from A_t and θ_t.[14] To shut down

[14] Specifically, $e_{i,t}$ has law of motion

$$de_{i,t} = -\kappa_A e_{i,t} dt + \sigma_e dZ_t^i,$$

direct spillovers across workers, e.g., through peer effects (i.e., Acemoglu and Hawkins, 2014; Guiso and Pistaferri, 2020), we assume the firm has a linear production technology. Since workers are atomistic, the firm's profits depend only on their aggregate productivity, A_t. All workers have the same preferences over consumption and labor as in the single-worker model, $u(c)$ and $\phi(l)$, respectively, and for simplicity, the same outside option θ_t/ρ.[15] In this environment, when a worker separates she receives a one-time lump-sum payment $\bar{c}_i$ consumed as an annuity in perpetuity. The firm pays out this lump-sum payment to hire a replacement worker, whose characteristics are randomly drawn from a time-invariant distribution over productivities and reservation utilities.

Second, the firm now has multiple shareholders who can invest in a risk-free asset and a market portfolio in addition to shares in the firm's equity at price Π_t. As a result, the firm's shareholders' market-implied state price deflator ϑ_t has the law of motion

$$d\vartheta_t/\vartheta_t = -rdt - \sigma_{mkt}dZ_t^{mkt} - \sigma_{\vartheta t}d\hat{Z}_t, \tag{5}$$

where σ_{mkt} is the Sharpe ratio of the market, dZ_t^{mkt} innovations to the market portfolio, $\sigma_{\vartheta t}$ the endogenous Sharpe ratio of the firm's equity (see equation (A19)), and $d\hat{Z}_t$ a standard Wiener process from the perspective of shareholders.[16,17] For simplicity, we assume the market portfolio is uncorrelated with the firm's equity (i.e., $d\hat{Z}_t$ is orthogonal to dZ_t^{mkt}), although this is not essential. What is required is that firm-specific risk is priced by shareholders; otherwise, the worker's compensation would be independent of firm productivity.

Finally, we allow the firm to self-insure against shocks to both its own productivity and the workers' outside options. The firm can save at a risk-free rate r and pay out dividends D_t to shareholders instead of flow profits. As such, the firm can smooth worker compensation and dividends paid to shareholders over time.

In this multi-worker setting, the optimal contract has the following properties.

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with κ_A the same rate of mean reversion as A_t and dZ_t^i a standard Wiener process independent across workers and from A_t and θ_t that aggregates to zero by the Weak Law of Large Numbers.

[15] That workers have the same outside option is not essential and can easily be relaxed at the cost of having another dimension of heterogeneity in the distribution over worker types. Importantly, this assumption does not imply that all workers will have their limited commitment constraints bind at the same times.

[16] Specifically, under a change of measure by Girsanov's Theorem,

$$d\hat{Z}_t = \frac{\partial_A \Pi \sigma_A}{\sqrt{(\partial_A \Pi \sigma_A)^2 + (\partial_\theta \Pi \sigma_\theta)^2}} dZ_t^A + \frac{\partial_\theta \Pi \sigma_\theta}{\sqrt{(\partial_A \Pi \sigma_A)^2 + (\partial_\theta \Pi \sigma_\theta)^2}} dZ_t^\theta. \tag{6}$$

One could extend the model to allow $d\hat{Z}_t$ to depend on other factors, e.g., liquidity shocks to equity markets.

[17] As long as a risk-free asset, the market portfolio, and firm equity are publicly traded, the shareholders' state price deflator necessarily has this functional form. We microfound this in the proof of Proposition 3.

Proposition 3. *The state space* $(\vartheta, A_i, \theta, \xi_i)$ *of the optimal contract can be divided into three disjoint regions as in Proposition 2, and the distribution of workers* $\phi_t(A_i, \xi_i)$ *follows the stochastic law of motion given by equation (A28);*

Optimal worker compensation and labor policies are the same as in Proposition 2, but optimal compensation now has the law of motion

$$d\log c_{i,t} = \left(\frac{r-\rho+\lambda_{i,t}/\xi_{i,t}}{\gamma(c_{i,t})} + \frac{\varphi(c_{i,t})-1}{2}\frac{\sigma_{mkt}^2+\sigma_{\vartheta t}^2}{\gamma(c_{i,t})^2}\right)dt + \frac{\sigma_{mkt}}{\gamma(c_{i,t})}dZ_t^{mkt} + \frac{\sigma_{\vartheta t}}{\gamma(c_{i,t})}d\hat{Z}_t, \qquad (7)$$

where $\gamma(c) = -\frac{u''(c)c}{u'(c)}$ *and* $\varphi(c) = -\frac{u'''(c)c}{u''(c)}$ *are each worker's coefficient of relative risk aversion and prudence, respectively.*

The contract can be characterized by the firm's cost of its relationship with each worker, $e^{-\rho t}k_{i,t}$*, which satisfies the dual-HJB variational inequality (A24).*

The optimal contract in this setting behaves similarly to the simpler case of one risk-averse owner and one risk-averse worker summarized by Proposition 2. In the multi-worker framework, however, worker compensation differs in four regards. First, the optimal contract now specifies that it is the performance of the firm that determines compensation, not that of any singular worker. In this sense, risk sharing between shareholders and workers endogenously gives rise to a preference for pay equity among coworkers, as in Bewley (1995), because the wage of each worker does not depend on their own idiosyncratic productivity.

Second, each worker's compensation now responds directly to developments in their outside options, not just when their limited commitment constraint binds (akin to the return to firm tenure featured in Harris and Holmstrom (1982) and Thomas and Worrall (1988)). This occurs because their outside options, through their own risk-sharing arrangements, pass through to the firm's Sharpe ratio. Third, pay growth is now positively related to the net risk-free rate, $r-\rho$. Access to a risk-free asset consequently provides partial insurance to the firm's shareholders and its workers. Fourth, if a worker's prudence exceeds unity, then expected compensation is also increasing in the sum of the squared Sharpe ratios, $\sigma_{mkt}^2 + \sigma_{\vartheta t}^2$.[18]

Prediction 4. Pass through of shocks to compensation From equation (7), worker compensation now responds to shocks to firm equity, such as to credit conditions, as well as market-wide risk, which one could interpret, for instance, as systematic factors such as industry risk. To the extent that prices of risk move over the business cycle, the sensitivity of compensation to shocks will vary as well. If firm-specific risk is not priced, the firm will insulate its workers from such risk and compensation will not respond to firm performance.

[18]More specifically, this arises when the workers' relative prudence exceeds unity, a condition which is satisfied for standard preferences such as constant relative risk aversion (CRRA).

3.1 Two Risk-Sharing Externalities

We now discuss two nuanced externalities that arise when a firm's shareholders share risk with multiple workers. The first reflects workers' limited commitment constraints. Since a worker's wage is independent of their idiosyncratic productivity, they work more for the same wage when they are more productive.[19] As a result, they receive lower utility and are more likely to have their constraints bind—in which case their compensation rises permanently to induce them not to quit, adding to the rigid part of the firm's labor bill. However, because idiosyncratic productivity is mean-reverting, they are less productive in the future so the cost of their inflated pay is borne by shareholders through lower profits until they separate from the firm. This, in turn, passes through to other workers through a smaller bonus pool.

The second externality arises because each worker's compensation and labor supply depends on shareholders' preferences through the sensitivity $\sigma_{\vartheta t}$ of the excess return of firm equity to firm-specific risk $d\hat{Z}_t$ (see equation (5)). Through $\sigma_{\vartheta t}$, each worker's contribution to output affects the sensitivity of shocks to the pay and labor supply of other workers. To see this, consider the impact a shift in $\sigma_{\vartheta t}$ has on the expected present value of net income $R_t = \mathbb{E}\left[\int_t^\infty e^{-r(s-t)} EBIT_s ds\right]$, where $EBIT_s$ is total output minus compensation to both active and recently separated workers at time s. To shut off the other externality, we relax the limited commitment constraint so a worker never quits. We have the following corollary.

Corollary 3: *Suppose a mass of workers shift the firm's Sharpe ratio $\sigma_{\vartheta t}$ to $\sigma_{\vartheta t} + \epsilon \tilde{\sigma}_i$. As $\epsilon \to 0$, its impact on the expected present value of future net income R_t is*

$$\partial_{\tilde{\sigma}_i} R_t = \mathbb{E}\left[\int_t^\infty e^{-r(s-t)} \partial_\vartheta EBIT_s \eta_s ds\right],$$

where $\partial_\vartheta EBIT_s > 0$ and η_t is the second-variation process with $\eta_0 = 0$ and law of motion

$$d\eta_t = -\eta_t \left(rdt + \sigma_{mkt} dZ_t^{mkt} + \left(\sigma_{\vartheta,t} + \vartheta_t \partial_\vartheta \sigma_{\vartheta,t}\right) d\hat{Z}_t\right) - \tilde{\sigma}_i d\hat{Z}_t.$$

Corollary 3 reveals how a perturbation to shareholders' state price deflator by a worker affects the expected present value of net income. Since this deflator is history-dependent, such a perturbation compounds over time. This raises the firm's net income (when η_s is positive) by transmitting shareholders' higher marginal utility through to workers.[20] In contrast to the lack of spillovers in the multi-worker limited commitment framework of Martins *et al.* (2005), shareholder value maximization necessitates externalities across workers, even when

[19] That more productive workers work more without being compensated for it could induce moral hazard concerns. We abstract from this issue to focus on risk sharing across workers.

[20] Similar exercises can be performed on workers' indirect utility and the value of firm equity.

each worker has no direct effect on others' marginal products. Such externalities are distinct from the direct spillovers that arise from curvature in a firm's production function (e.g., Acemoglu and Hawkins, 2014), and would be absent if the firm were risk neutral.

4 Data Description

Our data come from the online labor platform Glassdoor, on which users can voluntarily review employers, report their labor earnings, and search for jobs. Workers provide their pay to the website voluntarily and anonymously, and they are incentivized to do so through a give-to-get mechanism, whereby respondents acquire access to the information provided by others to the platform once they themselves contribute. When submitting a pay report, workers provide their: job title, year of salary, employment status, pay frequency (annual, monthly, or hourly), base pay, variable pay, location, years of experience, firm, and gender.[21] Because we do not observe hours, we restrict the sample to employees who report working full-time. For geographic location, there are 858 metropolitan areas (analogous to the 929 designated core-based statistical areas) recorded in Glassdoor, of which 333 can be matched to metropolitan statistical areas (MSAs) with unemployment rates from the Bureau of Labor Statistics (BLS).[22] We restrict our sample to workers employed in one of these MSAs.

Respondents are first asked to enter their base pay and the frequency at which that base income is earned. Respondents are then asked "Do you get bonuses, tips, or sales commission?" to which they can respond yes or no. If they respond yes, they are then prompted to report the amount and frequency with which they receive cash bonuses, stock bonuses, profit sharing, sales commissions, and tips/gratuities. For visual context, a screenshot of the submission form at this stage is provided in Figure B1. We exclude the 0.3 percent of workers who receive tips/gratuities, and define variable pay as the sum of one's cash bonus, stock bonus, profit sharing, and sales commissions. We also consider each variable pay type separately but for brevity of exposition, relegate these results to Internet Appendix C.

To ensure our results are not driven by outliers or misreporting, we take four additional steps to prune the sample. First, we restrict the sample to the 73 percent of workers who are salaried. Second, while pay reports can be submitted for previous years of employment, we restrict our sample to the 87 percent of pay reports submitted contemporaneously. Third, we exclude pay reports reporting less than 200 for any of the four variable pay types to avoid ambiguity in units, e.g., dollars, thousands of dollars, or percentages. Fourth, we truncate the bottom and top 0.1 percent of base-pay earners (effective bounds of $6,500 and

[21]We assign the 32 percent of workers for whom gender is unavailable to an "unknown" category.

[22]There are 358 MSAs in total for which unemployment data are available.

$439,500) and of variable-pay earners (effective bounds of $200 and $636,600). Although survey respondents do tend to overestimate earnings by about 5 percent (Oyer, 2004), the error is smaller for workers compensated annually, which the workers in our sample are.

While Glassdoor does skew toward younger, college-educated workers employed in manufacturing or professional services (Liu *et al.*, 2022), the data are more representative when dis-aggregated. Karabarbounis and Pinto (2019) highlight representativeness within industries and regions, Gibson (2021) within occupations, and Sockin and Sockin (2025) between industry-occupation pairs. These works do not however necessarily demonstrate the external validity of variable pay data from Glassdoor. To this end, we make comparison with administrative payroll data from ADP. Grigsby *et al.* (2021) calculate the share of total earnings attributable to non-commission bonuses for each percentile of the base earnings distribution using ADP data. We do the same for Glassdoor. Figure B2 depicts this relation for Glassdoor alongside that for ADP from Grigsby *et al.* (2021). Visually, the shape of the two plots are nearly identical. The non-commission bonus share of total pay rises with base pay, and the slope steepens around the 85th percentile. Numerically, the two are highly similar as well. The top percentile receives about 18 percent of total pay from non-commission bonuses, the 90th percentile about 8 percent, and the median base pay earner around 2–3 percent. While there are perceptible differences along the bottom quintile of the distribution[23], we interpret the closeness of these two distributions as assurance in our variable pay data.

We incorporate data from four additional sources. The first is metropolitan area unemployment and job vacancy rates from the BLS. The second is Moody's credit ratings from Bloomberg, where a firm's credit rating is investment grade if it is one of ten rungs (Baa3 up to Aaa) and speculative or junk grade if it is one of ten lower rungs (Ca to Ba1). We can assign a credit rating to 690,000 workers, of which 89 percent are in an investment-grade firm. Summary statistics for investment- and speculative-grade firms in our sample are in Table B2. The third is from Chodorow-Reich (2014) on the fraction of a bank's syndication portfolio in which Lehman Brothers played a pivotal role—a measure that negatively correlates with new lending (Ivashina and Scharfstein, 2010). The 39 (of 42) lenders we successfully match with Glassdoor and their respective sample sizes are in Table B3. The fourth is data from Compustat on firm financial characteristics and performance. We assign each worker the Compustat measures for the preceding year since Compustat data are year-end values and if pay responds to firm performance, it likely reflects that of the previous year. Our Compustat sample includes 748,000 workers, for which summary statistics are in Table B4.

Our final sample consists of 2.9 million pay reports for salaried, full-time workers from

[23] This may reflect imperfect overlap between the two samples: Hourly and salaried workers are included in Grigsby *et al.* (2021) whereas our sample includes only salaried workers.

2008 through 2020 covering 153,000 firms from most U.S. private-sector industries.[24] Throughout, we standardize base and variable pay to 2018 dollars using headline U.S. consumer price index (CPI). Table 1 provides summary statistics for our main dependent variables for the full sample (panel A), publicly-traded firms in Compustat (panel B), and publicly-traded firms for which Moody's credit ratings are available (panel C). Our sample skews towards high earners, with average base pay of $80,100 and a standard deviation of $41,400. Given the restriction to publicly-traded firms, mean base pay is higher in the Compustat sub-sample.

With respect to variable pay, 39.6 percent of workers in our sample report receiving variable pay.[25] Cash bonuses are by far the most predominant form of variable pay at 32 percent (Table B1, Panel B), compared with commissions (6 percent), stock (5 percent), and profit sharing (3 percent). Mean variable pay earned annually is $21,800 with a standard deviation of $36,600. Again, the mean is larger in the Compustat sub-sample. Combining the extensive and intensive margins of variable pay, workers receive on average 6.0 percent of total pay from variable pay. For those who receive variable pay, the share jumps to 15.1 percent. Additional summary statistics for worker and firm characteristics are in Table B1.

These averages mask significant heterogeneity across firms. Figure 1 arranges Compustat firms in our sample in increasing order according to the intensity with which variable pay is incorporated in compensation. Panel (a) arranges firms by the share of employees receiving variable pay and panel (b) by the variable pay share of total pay. With regards to the incidence of variable pay, while the median firm compensates about two-fifths of employees with variable pay, the difference between firms with the least and most frequent usage is around 70 percentage points. When considering the share of total pay derived from variable pay, about 18 percent of total pay stems from variable pay among Compustat firms in the top decile compared with less than 1 percent among firms in the bottom decile.

5 Variable Pay and Economic Conditions

In this section, we examine how variable pay responds to changes in firm-specific and local labor market conditions. Based on our risk sharing theory, we anticipate variable pay absorbs these shocks with the exception of those to local labor market conditions, which can raise base pay for workers with more attractive outside options while also affecting variable pay.

[24] Pay reports are concentrated in later years, with only 3 percent arriving before 2010. We exclude industries with few observations (agriculture and mining) and employers in the public sector (government, schools, and colleges). We exclude the 33 percent of pay reports for which the firm's industry is unavailable.

[25] This figure is in line with Lemieux *et al.* (2009) for salaried workers in the late-1990s and Kruse *et al.* (2010) for employees holding stock or receiving a gain-sharing bonus from the 2006 General Social Survey, though below Grigsby *et al.* (2021) for salaried, non-commission workers using ADP data.

5.1 Local Labor Market Tightness

Our primary measure here is the metropolitan area unemployment rate. Since workers in our sample are salaried, they may have negotiated pay any time in the last 12 months; so, to assign each worker a measure of labor market tightness that existed when their pay was set, we take the MSA unemployment rate that prevailed the month they submitted their report, that from 12 months prior, and take the average. Given the nature of Glassdoor as a platform for sharing and consuming information about pay and job satisfaction across labor market opportunities, it seems unlikely workers would disclose their pay (and thus satisfy the give-to-get mechanism) immediately after signing a new contract rather than before, when such information could be valuable in the negotiation process. This semi-retrospective approach to assigning labor market tightness is thus our preferred method. Our results, however, are qualitatively robust to instead using contemporaneous labor market tightness or that which prevailed 12 months prior (see Table F1).[26]

We ask how base and variable pay move over the business cycle by estimating

$$Y_{i,k,t} = \beta UR_{m(i,t),t} + \gamma X_{i,t} + \lambda_{k,j(i,t)} + \lambda_{m(i,t)} + \lambda_{\iota(k),t} + \epsilon_{i,k,t},$$

where $Y_{i,k,t}$ represents a measure of compensation for worker i employed at firm k in year t, $X_{i,t}$ is a vector of worker controls including years of experience and gender, and $\lambda_{k,j(i,t)}, \lambda_{m(i,t)}, \lambda_{\iota(k),t}$ are fixed effects for firm-job title, MSA, and industry-year, respectively. Our coefficient of interest β captures the effect local labor market tightness has on pay for workers with the same job and firm, controlling for differences between MSAs and across industries over time.[27] The results are presented in Table 2.

Two key takeaways emerge. First, base pay within a role (i.e., job title and firm) exhibits strong procyclicality, consistent with Grigsby *et al.* (2021) for job stayers. This is true for workers who do and do not receive variable pay. With an elasticity of –0.2, we estimate that a one percentage point reduction in the local unemployment rate is associated with a 0.2 percent increase in base pay. Second, among those who receive variable pay, the amount of variable pay received also rises as unemployment falls. A one percentage point reduction in the unemployment rate is associated with 0.9 percent greater variable pay. Importantly, this does not reflect a rise in commissions, which may have a mechanical relation with local

[26]Generally, our estimates are larger when considering labor market tightness from 12 months prior and weaker when using labor market tightness contemporaneously. Although our estimates for the cyclicality of base pay become statistically indistinguishable from zero using the contemporaneous unemployment rate, they remain strongly procyclical when using the contemporaneous vacancy-rate-to-unemployment-rate ratio.

[27]Because we observe a rich cross-section of workers across job titles and firms rather than a panel of pay reports for the same worker, we consider pay in levels rather than first differences as other work in the earnings cyclicality literature has done (e.g., Devereux, 2001).

economic conditions, but rather increases in cash and stock (Table C1).

Although the magnitude of variable pay (among variable-pay recipients) is more procyclical than base pay, the variable pay share of total pay is largely unaffected since mean variable pay in our sample is roughly one-fourth that of base pay. That variable pay responds to movements in labor market conditions may help rationalize the increased procyclicality in total pay for variable-pay earners documented in the literature (e.g., Devereux, 2001; Lemieux *et al.*, 2012; Makridis and Gittleman, 2017). We observe no clear relation between local labor market conditions and the incidence of variable pay. This result is somewhat in contrast with the finding of Kedia and Rajgopal (2009) that firms with headquarters in tight labor markets offer rank-and-file employees more broad-based stock option plans[28], and of Grigsby *et al.* (2021), who find the receipt of a bonus is procyclical for job stayers. Taken together, total pay is procyclical within our sample, with a one percentage point reduction in the unemployment rate corresponding to a 0.2–0.3 percent increase. For comparison, Devereux (2001) estimates an elasticity of 0.5 for total pay among salaried job stayers, an effect driven primarily by workers with non-salary income.

One may be concerned that our effects are concentrated primarily among less experienced or more junior employees who are more likely to have negotiated pay at prevailing spot wages. However, partitioning workers by years of experience or hierarchical position in the job ladder suggests this is not the case. Base pay and variable pay are procylical for each category of worker (Table D1). One may also be concerned that the unemployment rate imperfectly captures workers' outside options since it overlooks competition for vacancies. If we were to instead use the ratio of the MSA job vacancy rate to the MSA unemployment rate, a measure that more acutely proxies for labor market tightness as modeled by the Beveridge curve or search and matching models (e.g., Mortensen and Pissarides, 1994), we draw the same conclusions (Table F1). Since job opening rates are only available for 18 MSAs, our benchmark measure is the unemployment rate. Finally, one may be concerned that there is differential selection by labor market tightness in which employees choose to disclose their pay on Glassdoor. However, even for the same worker at the same firm, as outside options improve, primarily base pay rises significantly (Table E1).

5.2 Borrowing Conditions

We narrow our focus to public firms for which Moody's credit ratings are available to investigate a firm-specific shock to the cost of borrowing. We consider events in which a firm's credit rating changes from investment to speculative grade, or vice-versa. We focus on such

[28]While we do observe a stronger relation with the local unemployment rate for the incidence of stock bonuses (panel A of Table C1), we cannot reject the hypothesis of a null effect.

events because firms with investment grade credit ratings enjoy materially lower borrowing costs (e.g., Tang, 2009; Chernenko and Sunderam, 2012). This is because institutional investors, such as life insurance companies, pension funds, and asset managers, often have mandates that restrict the minimum credit quality of bonds they can hold to investment-grade bonds. In our sample, workers at investment-grade firms enjoy, on average, 9 percent greater base pay, 26 percent greater variable pay, and a 12 percentage points higher probability of receiving variable pay (Table B2). In turn, workers at investment-grade firms receive 2.5 percentage points more of total pay through variable pay.

Our identification strategy looks within firms and compares pay before and after the firm gains or loses investment-grade status. Myriad factors are likely correlated with a firm's credit rating and its wages. To isolate the causal effect from a change in borrowing costs and to account for possible bias from the staggered timing of events (Cengiz *et al.*, 2019), we conduct a stacked difference-in-differences (DiD) design. A firm is treated if its credit rating is downgraded from investment to speculative grade, or vice-versa. We consider all such events in our sample, of which there are 118. For each event, we look five years before to five years from the switching year. The control sample consists of all firms for which credit ratings data are available that experience neither an upgrade nor a downgrade over the sample period. We then create separate datasets each comprised of one event and all control observations, and stack them. Formally we estimate

$$Y_{i,k,t,s} = \beta InvestmentGrade_{k,t,s} + \gamma X_{i,t}\lambda_s + \lambda_{k,j(i,t)}\lambda_s + \lambda_{m(i,t),t}\lambda_s + \lambda_{\iota(k),t}\lambda_s + \epsilon_{i,k,t,s},$$

where $InvestmentGrade_{k,t,s}$ is an indicator equal to one if firm k's credit rating is investment grade in year t and zero otherwise in stacked sub-sample s. We interact the vector of worker characteristics and industry-year, MSA-year, and firm-job title fixed effects with a fixed effect for each sub-sample s. The coefficient β captures the average premium in employee compensation among workers with the same job in the firm when the firm has an investment-grade rating as opposed to speculative grade, accounting for industry and local labor market trends over time. We cluster standard errors by firm and present the results in Table 3.

Evidently, workers are exposed through pay to this firm-specific shock. When a firm's credit rating is downgraded from investment to speculative grade, the average base pay within a job falls 1.5 percent while average variable pay, among those who receive it, falls 8.6 percent.[29] We also estimate a significant 2.4 percentage-points decline along the extensive margin of receiving variable pay. In turn, workers are less levered on variable pay following

[29] Decomposing variable pay into each of its four sub-components, we observe in Table C2 that cash and stock bonuses drive the decline in variable pay, with stock bonuses falling a staggering 44 percent (among workers who receive them) when the firm loses its investment grade credit rating.

the downgrade. For the same role within the firm, the average share of income workers derive from variable pay falls 0.5 percentage points overall and 0.6 percentage points among variable-pay recipients. These effects are observed for both junior and senior employees though the relation with variable pay does appear larger for the latter (Table D2).

These results complement those of Graham *et al.* (2023), where workers' annual earnings fall 10 percent in the year a firm files for bankruptcy and remain stunted thereafter. Although the negative effects are more pronounced for a bankruptcy than for a credit downgrade, both represent a deterioration in a firm's financial position that pass through to worker pay, and we highlight the role of variable pay in this downward adjustment. This effect on variable pay could reflect firms offsetting an increase in borrowing costs, though alternatively, it could reflect a compositional shift toward a lower quality workforce as the firm becomes financially constrained — possibly through increased turnover (Baghai *et al.*, 2021; Gortmaker *et al.*, 2022) or reduced interest among job seekers (Brown and Matsa, 2016).

Whether this shift reflects a causal response requires that our control sample — employers that experienced neither an upgrade nor a downgrade — offers a valid counterfactual for how pay would have evolved at treated firms absent the switching event. To this end, we consider a dynamic specification where we estimate a separate β coefficient for each year before and after a switch. Additionally, to test for asymmetry between upgrades and downgrades, we estimate event studies for the former, of which there are 55, and the latter, of which there are 63, in panels (a) and (b) of Figure 4, respectively. In the five years preceding an event, we observe no significant difference in variable pay between the treated and control samples, supporting the parallel trends assumption underlying the DiD design. Once the upgrade or downgrade occurs, there is a clear divergence: variable pay rises after an upgrade and falls after a downgrade. For firms that remain upgraded or downgraded, since the coefficients in the post-period condition on the rating switch continuing, these shifts in variable pay appear to persist — which is to be expected from our model if such switches constitute permanent shifts in firm-specific productivity.

We consider three sensitivity exercises. First, one may be concerned that firms that never face the possibility of switching between speculative and investment grade are too dissimilar from firms that do.[30] The takeaways, however, are unchanged if the control sample was instead only firms that never switch but experience a rating within one rung of an upgrade (Baa3) or downgrade (Ba1) over the sample period (Table F2). The second considers coarser fixed effects. Since job titles can be quite granular, this specification is quite demanding. If we instead use only firm fixed effects, we draw the same conclusions (Table F3). Third, it is possible the composition of workers in the firm differs as the firm switches between

[30] For 14 percent of workers in our sample, their firm never has a credit rating outside the top five rungs.

investment and speculative grade. However, when we look at compensation before and after a switching event for the same worker within the firm, variable pay responds (Table E2).

5.3 Firm Performance

We next turn to investigating whether firm-specific surprises to productivity pass through to worker compensation. We consider two measures of annual firm performance, one financial and one real. They are the firm's annual stock return and the log ratio of the firm's sales to its employment, i.e., average labor productivity (Comin and Philippon, 2005). To account for the role of financial frictions in limiting firms' risk-sharing capacities, we include log assets (Michelacci and Quadrini, 2009; Petrosky-Nadeau, 2014) and the log difference between liabilities and assets, i.e., log leverage ratio (Dore and Zarutskie, 2018). We also include as controls the logarithm of firm employment, firm age, and Tobin's Q.[31] After normalizing each measure into standardized z-scores within each calendar year, we estimate

$$Y_{i,k,t} = \beta J_{k,t-1} + \gamma X_{i,t} + \lambda_{k,j(i,t)} + \lambda_{\iota(k),t} + \lambda_{m(i,t),t} + \epsilon_{i,k,t}$$

where $J_{k,t-1}$ is the vector of lagged firm performance measures and characteristics. By using firm-job title fixed effects and standardizing $J_{k,t-1}$ annually, the coefficients of interest β can be interpreted as the effect that a one-standard deviation increase in firm performance the previous year, relative to the firm's average performance and the growth rate across its industry in the same labor market each year, has on pay among workers with the same job within the firm. We interpret these firm-specific deviations relative to trend as idiosyncratic shocks to firm productivity and record the results in Table 4.

Most striking is the contrast between base and variable pay. While base pay responds little to annual fluctuations in firm performance, variable pay both in magnitude and incidence responds strongly. Positive shocks to both performance metrics significantly increase the magnitude of variable pay. A one-standard deviation surprise to a firm's average labor productivity translates into 12 percent greater variable pay the following year. The effect is more modest for annual stock return at just over 1 percent. Partitioning workers by years of experience or job hierarchy reveals little difference in the effects between junior and senior employees, suggesting variable pay responds universally throughout the firm (Table D4). While base pay does respond to a rise in average labor productivity for senior employees, the effect is small at about 1 percentage point per standard deviation. Again, we consider the evolution of pay over time with an employee-employer match (Table E4). Under this panel specification, although the relation between variable pay and improved stock returns

[31] Table B4 provides summary statistics for each measure, while Table B5 provides pairwise correlations.

is no longer significant, we still observe that variable pay responds sharply to improvements in average labor productivity while the effects on base pay remain muted.

With respect to firm characteristics, growth in assets and Tobin's Q pass through to variable pay, with one standard deviation increases corresponding to 15 and 8 percent greater variable pay, respectively.[32] While employers with more assets offer larger bonuses, consistent with Michelacci and Quadrini (2009), those with greater leverage do not, at variance with Dore and Zarutskie (2018). As for the receipt of variable pay, a one standard deviation positive shock to labor productivity results in 5.1 percentage points more employees receiving variable pay.[33] For annual stock return, we find a positive albeit weaker effect of 0.7 percentage points per standard deviation.

5.4 Deterioration in Bank Health

We next examine whether an alternative exogenous shock to firm profitability, i.e., firm-specific exposure to the 2008 Financial Crisis, passes through to compensation. Banks were differentially exposed to the Financial Crisis by whether they had co-syndicated credit lines with Lehman Brothers, as such banks ultimately reduced their lending more than other banks (Ivashina and Scharfstein, 2010). While the sharp reduction in credit supply that followed the bankruptcy of Lehman Brothers reduced employment at pre-crisis lenders (Chodorow-Reich, 2014), the dynamics of base and variable pay at affected lenders remains unknown.

Suggestive evidence that exposure to the Financial Crisis led to a reduction in bonuses can be seen looking across industries in our sample over time. When we examine the dynamics of base and variable pay after 2008 separately for the finance and information technology industries, we find that variable pay fell drastically for workers in finance, rose for workers in information technology, and remained flat elsewhere (Figure F1). While these results suggest industry- and firm-level shocks affect variable pay more so than base pay, as variable pay became a significantly smaller share of total income for workers in the finance industry, the identification here is imprecise given the confounding factors affecting the finance industry around this period, e.g., new regulation.

Across firms in the finance industry, we test whether the exogenous negative shock to the health of some, but not all, banks passed through to employee compensation by estimating

$$Y_{i,k,t} = \beta \mathbf{1}\{t > 2008\} Lehman_k + \gamma X_{i,t} + \lambda_{k,j(i,t)} + \lambda_{m(i,t)} + \lambda_t + \epsilon_{i,k,t},$$

[32] Table C4 displays results for the magnitude of each variable pay type. The estimates for cash and profit sharing are significant, while those for stock and commissions are positive but not different from zero.

[33] Decomposing variable pay into each of its four sub-components, we observe in Table C5 that the uptick in incidence is driven largely by cash bonuses but also, to a lesser extent, stock and profit sharing. Importantly, our results are not driven by commissions, which may have a mechanical relation with firm performance.

where $Lehman_k$ is the fraction of bank k's syndicate portfolio in which Lehman Brothers held a lead role. Our control sample consists of pay reports from firms in the finance industry that are not banks which were exposed to Lehman Brothers' bankruptcy through its syndication portfolio.[34] The results are recorded in Table 5.

Consistent with the findings of Efing *et al.* (2019) for the United Kingdom, variable pay appears to have helped absorb the shock to U.S. banks after the Financial Crisis. While base pay appears to have evolved similarly regardless of a firm's exposure to Lehman Brothers, variable pay, and consequently the share of total pay derived from variable pay, fell sharply. Among our bank health sample, for employees who receive variable pay at lenders with the average level of exposure to Lehman Brothers through their syndication portfolio, variable pay fell on average 7 percent after 2008. In turn, the average variable pay share of total pay at such firms with the mean level of exposure declined 0.8 percentage point. Even if we instead consider the evolution of pay within the same worker-firm match for employers in finance over this period, we observe, despite the increased imprecision, the same patterns (Table E3). The decline is driven largely by cash bonuses (Table C3) and is observed for junior and senior employees, though the effect is particularly pronounced for the latter (Table D3). Estimating the effect over time relative to 2008 shows the reduction in variable pay happens immediately and persists over the following decade (Figure F2)—possibly a reflection of the persistent nature of the decline in U.S. bank health (Chousakos and Gorton, 2017).

Although this identification strategy is more illustrative than our between-industry results, empirical limitations remain. Because only Glassdoor began collecting pay reports in 2008, we have a thin pre-bankruptcy sample. As a result, we are unable to test for differences in pay before the Financial Crisis in an event study design. It may be the case that banks with exposure to the Lehman Brothers bankruptcy offered especially outsize bonuses in 2008, which would have fallen after 2008 regardless. Additionally, we do not observe health for all banks, only those of Chodorow-Reich (2014); so other lenders in our sample may have had non-zero exposure though we assign them as such.

6 Implications of Variable Pay Usage

In this section, we investigate whether the use of variable pay relates to meaningful outcomes for firms and their workers. For the latter, we consider variance in pay. For the former, we consider volatility in the growth rates of sales, employment, and the ratio of the two.

[34] While our control sample includes all financial firms, not just lenders, the takeaways are similar if were to restrict the sample to only public firms or subsidiaries of public firms (Table F4), which the lenders exposed to Lehman Brothers under this definition overwhelmingly were.

Although we cannot make causal claims about the effects of variable pay on these outcomes, we nonetheless highlight a relation between compensation practices and firm-level volatility.

6.1 Capturing Variable Pay Intensity Across Firms

If all employers followed the same contracting policies for variable pay, then the lack of variation would imply that variable pay cannot help rationalize differences in firm-level outcomes. Recall from Figure 1, however, that this is not the case; firms differ widely in the intensity with which they use variable pay. While we do not observe the guidelines or human resource practices each firm follows when setting variable pay, we capture relative variable pay intensity using the rich cross-section of workers we observe in our data.

We have two focal measures for capturing variable pay intensity. The first is the share of workers that receive variable pay, the second the variable pay share of total pay. Because we observe only a sub-sample of workers for each firm over time, and want to (partially) isolate variable pay usage from its correlates, we first residualize each variable pay measure across workers before aggregating to the firm level, taking into account industry dynamics (Figure 5.4), labor market conditions (Section 5.1), firm characteristics (Section 5.3), and demographics, e.g., human capital (Sockin and Sockin, 2019).[35] By taking the mean residual for each firm $\widetilde{VP}_k$, we capture the intensity with which firm k uses variable pay relative to all other firms in our sample. To give more import to firms with greater sample coverage and thus less noisy estimates, we weight firms by the square root of their sample sizes.

Although we cannot observe each firm's true variable-pay intensity, as we only observe a subset of employees, our estimates appear stable across samples. To illustrate this, we test the out-of-sample predictive power of our approach. First, we randomly partition the sample into two sets, one with 80 percent of the sample, the other the remaining 20 percent. Within each set, we separately estimate each firm's variable-pay intensity and regress the estimate from the 20 percent sample on that from the 80 percent sample. We repeat this procedure five-hundred times and plot the distributions for the regression coefficient and R^2 in Figure F3. The coefficients are all above 0.94 and average 0.96 — meaning 1 percent greater variable-pay intensity in our calibration (80-percent) sample corresponds to 0.96 percent greater variable pay-intensity in our test (20-percent) sample. Although our measure of firm-level variable-pay intensity is time invariant, our estimates also appear stable over time; if we compute variable-pay intensity separately for odd and even years, we find a correlation between them of nearly 0.8 for the full sample of firms and above 0.9 for those in Compustat.

[35] We do not residualize by job title since doing so may mute meaningful variation in variable-pay practices between firms, e.g., employing predominantly sales-related roles. That said, the results would be qualitatively similar if we did (Table F5 and panel A of Table F6).

6.2 Greater Pay Variance for Workers

For workers, we are interested in whether dispersion in pay is related to the degree with which firms use variable pay. To this end, we calculate the variance in total pay across workers within each firm. We first residualize individual total pay by the same observables used in residualizing variable pay intensity. The firm-level variance of these residuals, $\widetilde{W}_k$, is our outcome of interest. From Prediction 2, we hypothesize that within firms that use variable pay more often, workers experience increased pay dispersion. Such a result would lend empirical support to the findings of Comin *et al.* (2009), who argue the adoption of bonuses has led to the rising pass-through of turbulence in firm sales to volatility in worker earnings, and Juhn *et al.* (2018), who suggest variable pay may act as a countervailing force to wage insurance.

Relating $\widetilde{W}_k$ with our firm-level measure for variable pay intensity $\widetilde{VP}_k$ in Table 6 reveals that, even after accounting for differences between industries, there is a robustly positive relation between the two. A one standard deviation (0.18, Table B6) increase in the share of workers that receive variable pay is associated with 0.06 standard deviation greater variance in (residual) total pay, largely reflecting the receipt of stock bonuses and commissions (Table C6) which on average are much greater in dollars paid out than cash and profit sharing (panel D of Table B1). This specification only highlights though the extensive margin of variable pay, overlooking differences along the intensive margin in which firms may differ in the amount of variable pay offered. Accounting for both margins through the variable pay share of total pay produces an even stronger association, with a one standard deviation (0.046, Table B6) increase corresponding to 0.43 standard deviation greater pay variance.

6.3 Reduced Volatility for Firms

For firms, we are interested in whether dispersion in variable pay helps explain firm-level differences in the volatility of growth. From Prediction 3, our model predicts that the use of variable pay reduces volatility in sales and employment growth. Such a result would be consistent with the findings of Shimer (2004), in that the flexibility variable pay affords firms in adjusting their labor bills produces less extreme fluctuations in unemployment. In other words, more rigid pay exacerbates employment swings over the business cycle.

Volatility in Growth from Compustat. To measure firm-level volatility, we follow Comin and Philippon (2005) and Davis *et al.* (2006). We first calculate the growth rate of measure m for firm k in year t according to

$$g^m_{k,t} = \frac{m_{k,t} - m_{k,t-1}}{(m_{k,t} + m_{k,t-1})/2}$$

where measure $m \in \{\text{sales, employment, productivity}\}$. This measure of growth captures relative changes and offers several advantages over log changes, e.g., being symmetric about zero and bounded. We calculate annual growth rates over the period 2010 to 2020.[36] To account for firms potentially having missing years of data, we calculate a modified volatility measure as in Davis *et al.* (2006).

To this end, let $z^m_{k,t} = (m_{k,t} - m_{k,t-1})/2$ represent firm k's size of measure m in year t and $P^m_k = \sum_t \mathbf{1}\{z^m_{k,t} > 0\}$ the number of years for which the firm's measure is non-missing. We then calculate firm k's volatility of growth for measure m as

$$\nu^m_k = \Big[\sum_t (\frac{\hat{z}^m_{k,t}}{P^m_k - 1})(g^m_{k,t} - \bar{g}^m_k)^2\Big]^{\frac{1}{2}}$$

where $\bar{g}^m_k = \sum_t z^m_{k,t} g^m_{k,t} / P^m_k$ is the size-weighted average growth rate of measure m and $\hat{z}^m_{k,t} = z^m_{k,t} \times (P^m_k / \sum_t z^m_{k,t})$. While Davis *et al.* (2006) calculate time-varying volatility over rolling windows, given the recency of the Glassdoor data, our volatility measures are cross-sectional and do not vary over time. With these measures in hand, we relate firm-level volatility with variable pay usage by estimating, for each measure m,

$$\nu^m_k = \beta^m \widetilde{VP}_k + \gamma^m J_k + \lambda^m_{\iota(k)} + \epsilon_k,$$

where J_k is the vector of Compustat firms' characteristics at the beginning of the sample period. The coefficients β^m are reported in Table 7.

For all three measures, the coefficients are universally negative. For employment growth, one-standard-deviation more workers receiving variable pay is associated with 0.07 standard deviation less volatility. Cash, profit sharing, and commissions, but not stock, drive this relation (Table C7). We find a similarly negative and significant relation of 0.07 standard deviation for volatility in sales growth. For productivity growth, while the estimate is negatively signed and of similar magnitude to sales and employment, we cannot statistically rule out a zero relation. Considering instead the variable pay share of total pay, we again observe consistently negative albeit less precise estimates. The estimate for employment volatility

[36] We consider two alternatives. The first calculates growth rates from 2007 to 2020 to align with the full Glassdoor sample. This approach has the advantage of including the Great Recession, a period during which we would expect a shock transmission mechanism to be most acute, but has the disadvantage of Glassdoor data being sparse in early years. The results (Table F6, panel B) are qualitatively the same. The second instead uses three-year growth rates from 2007 to 2020. Again, the results (Table F6, panel C) are similar.

remains statistically significant and large, with one-standard-deviation greater variable pay share of total pay corresponding to 0.07 standard deviation less employment volatility.

Volatility in Growth from WARN Notices. Further evidence that variable pay affords firms a hedge against having to revise down employment after a negative shock can be observed through mass layoff notices. The Worker Adjustment and Retraining Notification (WARN) Act of 1988 requires U.S. firms with at least one-hundred employees to provide sixty days notice before a mass layoff or plant closure if at least fifty employees at a single plant are affected.[37] Looking at 73,000 WARN notices made by U.S. firms since 1996[38], we are able to assign 55 percent to firms in Glassdoor by matching on the firm's name.[39] Narrowing in on our Compustat sample — since such employers are large and we observe their annual employment levels — we observe 6,700 WARN notices from nearly eight-hundred firms over the period 2011 to 2020.

Although we cannot observe all of the layoffs a firm implements each year, since the legislation only applies if a threshold for total affected employees is crossed, we interpret more employees laid off through WARN notices as proxying for a greater propensity to be laid off by the firm more broadly. Empirical evidence appears consistent with this interpretation: In years where firms produced more WARN announcements or announced a greater number of employees were laid off through WARN announcements, there is more negative year-over-year growth in total firm employment in Compustat (Table F8).

To capture the intensity with which firm k relies on layoffs each year t, $l_{k,t}$, we first sum the number of employees laid off by the firm each year through WARN notices and then take the ratio of that sum to the firm's employment at the end of the previous calendar year, which is available through Compustat. Firm-years in which there are no WARN announcements are assigned zeros. We then regress our measure of variable-pay intensity $\widetilde{VP}_k$ on $l_{k,t}$, incorporating industry-year fixed effects to isolate firm-level variation in layoff intensity that is orthogonal to industry-specific shocks. The results, using the share of workers that receive variable pay and the variable-pay share of total pay, are recorded in Table 8.

[37]Some U.S. states have passed additional legislation governing mass layoffs to extend the notice requirement (e.g., to 90 days in New York), lessen the notice requirement (e.g., to 30 days in California), or reduce the threshold of firm size (e.g., to 50 employees in Wisconsin).

[38]We obtain these data from this WARN database. Each WARN announcement includes the announcing firm, the affected establishment (city and state), the number of workers to be laid off, the date of announcement, the date the layoffs would go into effect, and whether or not the layoffs reflected a plant closure.

[39]Since we match on firm name, measurement error between matched firms and within matched firms over time should be limited. Measurement error could arise for unmatched firms, since we cannot determine whether firms are unmatched because our fuzzymatching algorithms fall short in producing a match or because such firms have issued zero WARN notices. Reassuringly, if we incorporate the roughly 1,800 unmatched Compustat firms and assign them zero layoff intensity, we draw the same conclusion (Table F7).

Firms that use variable pay more intensively lay off a smaller fraction of their employees. With a sample standard deviation of 2.1 percent of employees laid off through WARN notices each year, one-standard-deviation greater variable-pay intensity is associated with 0.03–0.05 standard deviation lower layoff intensity. Given a mean firm size of 95,000 employees within our regression samples, this reduction translates into about 60 fewer workers laid off each year among firms one-standard-deviation more variable-pay intensive.

7 Conclusion

In this paper, we examine how variable pay acts as a transmission mechanism for passing on fluctuations in economic conditions to workers. Motivated by the ubiquity of variable pay in the U.S. labor market and the dispersion across firms, we construct a model in which a risk-averse firm shares risk with a risk-averse worker who is subject to limited commitment. We then extend the model to allow for multiple shareholders and workers to enrich our empirical predictions and highlight two novel risk-sharing externalities. Consistent with our model, we find using pay data from Glassdoor that firms increase base pay when local labor market conditions tighten and increase variable pay when they experience shocks to their borrowing constraints, financial health, or operational performance. While firms that rely more on variable pay enjoy less volatile sales and employment, workers employed in such firms experience greater pay variance. Variable pay thus plays a key role not only in transmitting shocks to workers, but also in mitigating the impact such shocks have on firms.

Our results suggest *how* workers are compensated, not just *how much*, has real implications for firms and their employees. Since firms set compensation, those that rely predominantly on base pay likely do so *voluntarily*. Why do many firms then choose to forego this risk sharing option? Further understanding the factors that contribute to differences in variable pay practices across firms represents a promising avenue for future work.

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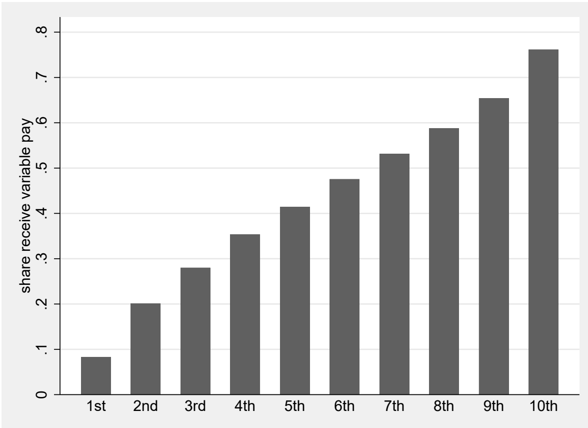
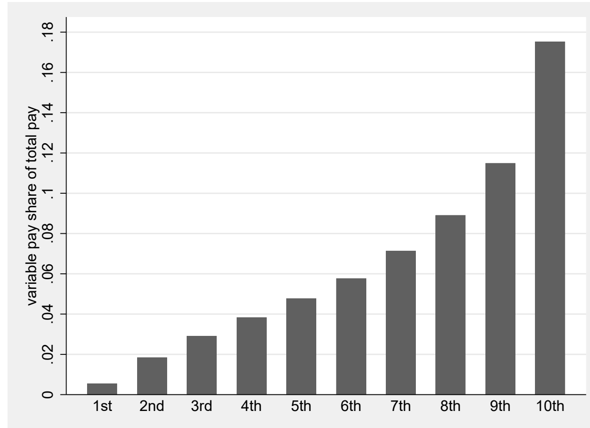
Figure 1: Incidence of Variable Pay Across Compustat Firms



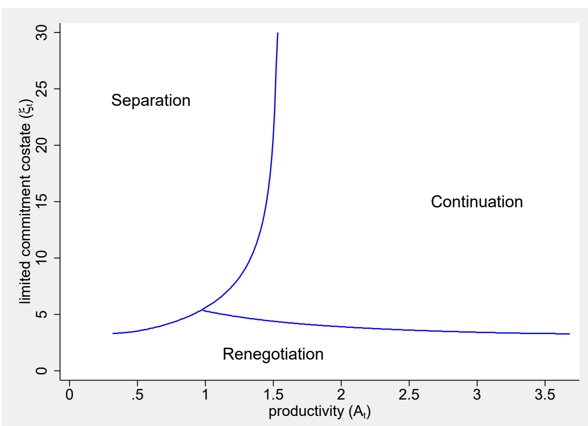
(a) Share receive VP



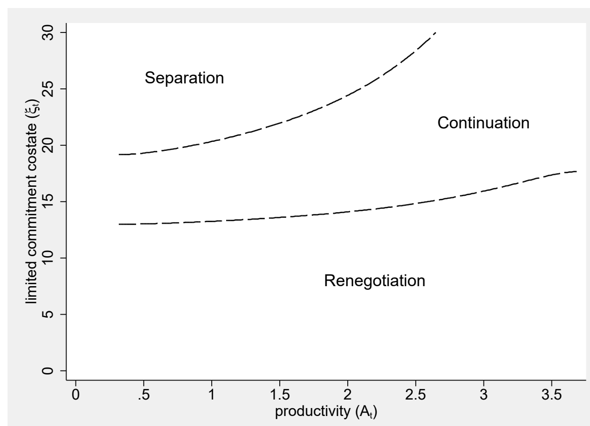
(b) VP share total pay

Notes: Figures report the intensity with which variable pay is used across Compustat firms in our sample. For each dimension of interest, the firm-specific average is calculated, and then firms are ranked in ascending order according to their averages. Firms are then partitioned into deciles. Within each decile, we calculate the equally-weighted average across firms. Deciles are numbered in ascending order, with the 10th decile representing firms with the greatest averages and the 1st decile the smallest averages.

Figure 2: Optimal Contracting Region for a Risk-Averse or Risk-Neutral Firm, Example



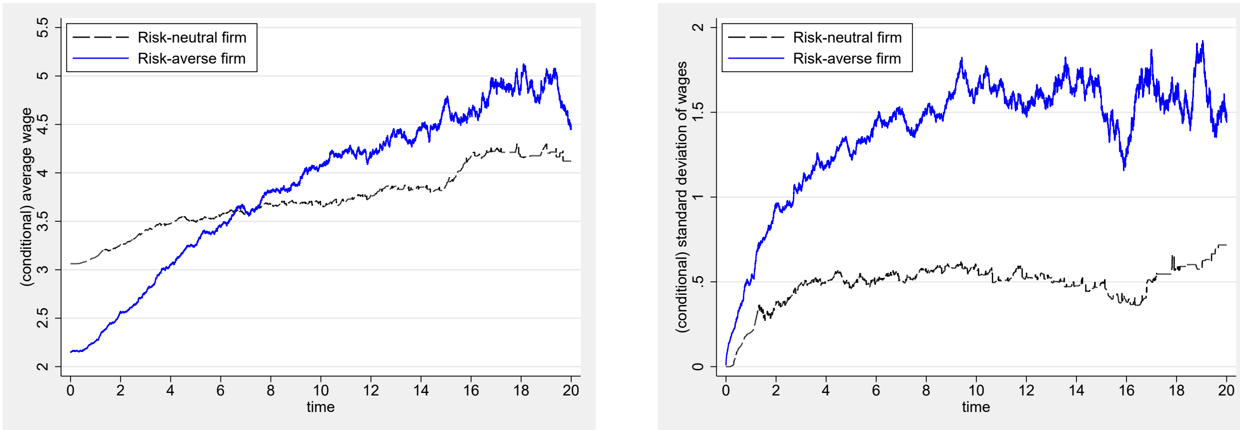
(a) Risk-averse firm



(b) Risk-neutral firm

Notes: These plots are simulations of the optimal contract model using the parameters and functional forms given in Internet Appendix A for $\theta = -.490$. The Continuation region is the open set of the $\{A_t, \xi_t\}$ plane on which the contract follows the dual HJB equation. The Separation region is the open set in which the firm retires the worker, and the Renegotiation region is the open set in which the worker renegotiates for a higher continuation value because of their outside option.

Figure 3: Sample Wage and Labor Supply Paths

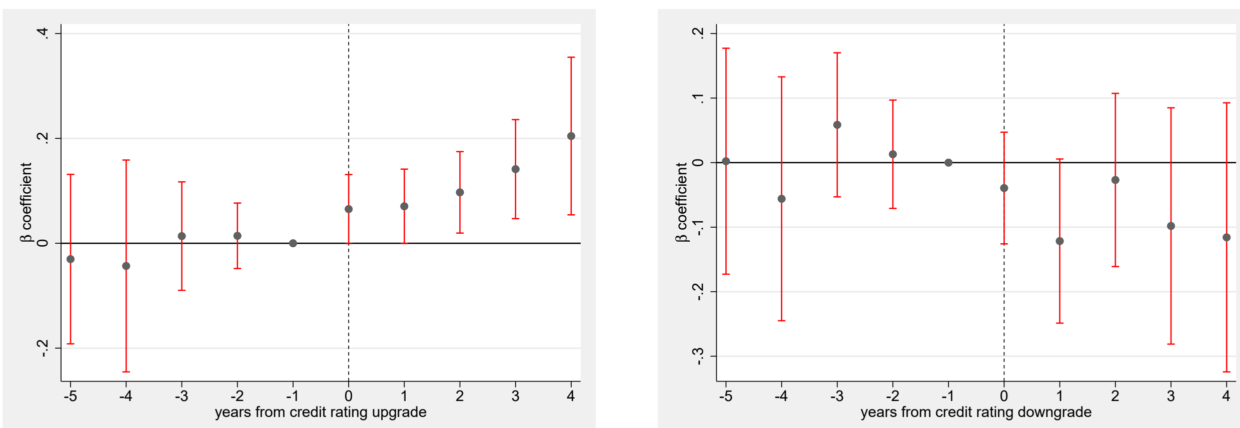


(a) Average wage

(b) Wage volatility

Notes: This figure plots, conditional on remaining employed, the average (panel a) and the standard deviation (panel b) of the optimal wage for 20 years over 250 simulations using the parameters and functional forms given in Internet Appendix A for $\theta = -.490$. Solid blue lines are for the baseline model while dashed black lines are for the case when the firm is risk-neutral.

Figure 4: Variable Pay Response to Credit Shock



(a) Upgraded to investment

(b) Downgraded to speculative

Notes: Figures display the coefficients on event-year dummies from a stacked regression of instances where a firm's bond credit rating switches from speculative to investment grade (panel a) or investment to speculative grade (panel b). Dummies after a switching event are shut off in years where the firm reverts back to speculative (panel a) or investment (panel b) grade. Firms that do not experience such a switching event over the sample period represent the control sample. Regressions include a quadratic in years of experience along with event-firm-job title, event-metro-year, event-industry-year and gender fixed effects. Standard errors are clustered by firm. Red vertical bars indicate 95% confidence intervals around each point estimate.

Table 1: Summary Statistics

	Log base pay	Log variable pay	1(Receives VP)	VP share total pay	Conditional VP share total pay
		Panel A: Full sample			
Observations	2,909,804	1,151,743	2,909,804	2,909,804	1,151,743
Mean	80,090	21,761	0.396	0.060	0.151
Median	70,000	10,000	0.000	0.000	0.100
Standard deviation	41,414	36,589	0.489	0.116	0.143
		Panel B: Compustat sub-sample			
Observations	748,004	383,283	748,004	748,004	383,283
Mean	89,158	25,253	0.512	0.083	0.162
Median	80,541	12,000	1.000	0.014	0.118
Standard deviation	42,579	39,169	0.500	0.128	0.138
		Panel C: Credit rating sub-sample			
Observations	688,784	357,333	688,784	688,784	357,333
Mean	90,773	25,483	0.519	0.082	0.158
Median	82,000	12,000	1.000	0.018	0.116
Standard deviation	43,742	40,145	0.500	0.124	0.132

Notes: Sample consists of pay reports submitted on Glassdoor for full-time, salaried workers at private sector firms from 2008–2020. Base and variable pay are inflation-adjusted to 2018 dollars using U.S. headline CPI. Variable pay is the sum of cash bonuses, stock bonuses, profit sharing, and sales commissions, and when reported in logarithms, is condtional on earning it. Compustat sub-sample reflects firms which could be successfully matched to a GVKEY identifier in Compustat. Credit rating sub-sample further refines the Compustat sub-sample to firms for which a Moody's credit rating is available.

Table 2: Compensation and Regional Labor Market Tightness

	Log base pay			Log total pay				
	Full sample	Does not earn VP	Earns VP	Full sample	Earns VP	1(Receives VP)	Log VP	VP share total pay
Metro UR	-0.185***	-0.159**	-0.220***	-0.223**	-0.311**	-0.010	-0.901**	-0.027
	(0.068)	(0.064)	(0.074)	(0.098)	(0.125)	(0.096)	(0.414)	(0.028)
Mean DV	1119.73	1108.95	1133.48	1128.01	1152.92	44.00	928.71	6.80
N	1792580	931126	713042	1792580	713042	1792580	713042	1792580
Adjusted R^2	0.84	0.82	0.87	0.82	0.83	0.31	0.69	0.48

Notes: The table displays the relation between metropolitan area unemployment rates and employee compensation. Each report is assigned the average of the unemployment rate at the time the pay report was submitted and that from 121“ months prior. Regressions include a quadratic in years of experience along with firm-job title, industry-year, metro, and gender fixed effects. Standard errors are clustered by firm. Significance levels: * 10%, ** 5%, *** 1%.

Table 3: Worker Compensation and Credit Rating Changes

	Log BP	Log VP	1(Receives VP)	VP share total pay	Conditional VP share total pay
1(Investment grade)	0.015***	0.082***	0.024**	0.005***	0.006**
	(0.004)	(0.025)	(0.012)	(0.002)	(0.002)
N	59202436	30023192	59202436	59202436	30023192
Adjusted R^2	0.83	0.69	0.27	0.46	0.62

Notes: The table displays the coefficient on an indicator variable for a bond credit rating of investment grade from a stacked regression of instances where a firm switches between investment and speculative grade credit rating. Firms that do not experience such a switch over the sample period represent the control sample. For each switch, we consider a 10-year window: five years before, the year of, and four years after each switch. Sample restricted to firm-years for which a Moody's credit rating is available. Regressions include a quadratic in years of experience along with event-firm-job title, event-metro-year, event-industry-year and gender fixed effects. Standard errors are clustered by firm. Significance levels: * 10%, ** 5%, *** 1%.

Table 4: Firm Financial Performance and Compensation

Standardized z-score	Log BP	Log VP	1(Receives VP)	VP share total pay	Conditional VP share total pay
Stock return	0.052	1.018***	0.675***	0.128***	0.073**
	(0.056)	(0.315)	(0.135)	(0.023)	(0.031)
Log sales-to-employment ratio	0.636	11.341***	5.117***	1.078***	0.910**
	(0.528)	(3.491)	(1.415)	(0.233)	(0.367)
Log assets	0.884	14.269**	-2.659	0.493	1.774**
	(1.097)	(5.844)	(2.258)	(0.463)	(0.724)
Log leverage ratio	-0.459**	0.037	-0.590	-0.010	0.054
	(0.201)	(1.128)	(0.410)	(0.094)	(0.123)
Log employment	-0.053	10.782**	4.729*	0.702**	1.356**
	(1.027)	(5.031)	(2.680)	(0.356)	(0.628)
Log firm age	0.914	9.761	3.073*	0.502	0.338
	(0.964)	(6.515)	(1.814)	(0.400)	(0.520)
Log Tobin's Q	-0.193	7.349***	0.852**	0.425***	0.853***
	(0.278)	(1.134)	(0.428)	(0.079)	(0.125)
Mean DV	1128.67	944.44	51.24	8.31	16.55
N	748004	359471	748004	748004	359471
Adjusted R^2	0.84	0.69	0.29	0.48	0.64

Notes: The table displays regressions of annual firm financial performance on employee compensation. All Compustat measures are lagged one year, so pay reports in year t are assigned firm performance and characteristics in year $t-1$. All variables have been converted to standardized z-scores within each year, and have had the top and bottom 0.5% truncated to control for outliers (excluding log employment and firm age). Regressions include a quadratic in years of experience along with firm-job title, metro-year, industry-year and gender fixed effects. Standard errors are clustered by firm. Significance levels: * 10%, ** 5%, *** 1%.

Table 5: Worker Compensation After the Financial Crisis by Exposure to Lehman Brothers

	Log BP	Log VP	1(Receives VP)	VP share total pay	Conditional VP share total pay
Post-2008 x Lehman share of firm's portfolio	0.058	-5.834***	0.411	-0.700***	-0.934***
	(0.400)	(2.253)	(0.794)	(0.206)	(0.255)
Mean Lehman share	0.012	0.013	0.012	0.012	0.013
N	192505	105721	192505	192505	105721
Adjusted R^2	0.83	0.64	0.24	0.42	0.60

Notes: The table displays the coefficient on an indicator variable for the pay report occurs after 2008 interacted with a continuous measure for the fraction of a firm's portfolio overseen by Lehman Brothers. Bank health data are from Chodorow-Reich (2014). Sample is restricted to firms in finance. Regressions include a quadratic in years of experience along with firm-job title, metro, year and gender fixed effects. Standard errors are clustered by firm. Significance levels: * 10%, ** 5%, *** 1%.

Table 6: Variance of Workers' Total Pay and Firm-Level Variable Pay Intensity

	Full sample		Compustat sample	
Receives VP	0.043***		0.029**	
	(0.004)		(0.010)	
VP share total pay		0.545***		0.460***
		(0.027)		(0.035)
Mean DV	0.136	0.136	0.150	0.150
Std. dev. DV	0.125	0.125	0.060	0.060
N	64403	64403	3089	3089
Adjusted R^2	0.03	0.09	0.11	0.20

Notes: The table displays the association between residual variance in pay and the extent to which firms use variable pay. Log total pay and each variable-pay measure are first residualized at the worker level by: firm characteristics, a quadratic in years of experience and fixed effects for industry-year, metro-year, and gender. Firm characteristics for the full sample reflect the logarithm of firm age, whereas for the Compustat sample they reflect the logarithm of assets, leverage ratio, firm age, employment, and Tobin's Q. With the residuals for total pay, we take the firm-level variance. For each VP measure, we then take the firm-level average of the residuals. Each of the regressions in the table include the same firm characteristics as well as industry fixed effects. Regressions are weighted by the square root of each firms' sample size. Standard errors are clustered by industry. Significance levels: * 10%, ** 5%, *** 1%.

Table 7: Sales, Employment, and Productivity Volatility

	Sales volatility		Employment volatility		Productivity volatility	
Receives VP	-0.037**		-0.035***		-0.029	
	(0.017)		(0.012)		(0.023)	
VP share total pay		-0.217		-0.141**		-0.170
		(0.151)		(0.060)		(0.162)
Mean DV	0.126	0.126	0.114	0.114	0.123	0.123
Std. dev. DV	0.103	0.103	0.088	0.088	0.107	0.107
N	2328	2328	2300	2300	2296	2296
Adjusted R^2	0.20	0.21	0.15	0.15	0.19	0.19

Notes: The table relates a firm-level volatility and the extent to which the firm uses variable pay. Each VP-related covariate is first residualized across workers by a quadratic in years of experience, a vector of firm characteristics (the logarithm of assets, leverage ratio, firm age, employment, and Tobin's Q) at the beginning of the period and fixed effects for industry-year, metro-year, and gender, and then averaged by firm. Volatility regressions include industry fixed effects and the same vector of firm characteristics. For the firm characteristics, we use each firm's 2010 levels; if all characteristics are unavailable, we instead use, if available, the 2009, 2008, 2011, 2012, or 2013 characteristics in that order. We include a fixed effect for the year from which the characteristics are used. Sample is restricted to firms for which growth rates are available at least seven years. The top and bottom 0.5 percent of firms according to volatility are excluded. Regressions are weighted by the square root of each firm's sample size in residualizing the VP-measures. Standard errors are clustered by industry. Significance levels: * 10%, ** 5%, *** 1%.

Table 8: Layoff Intensity through WARN Notices

	Fraction of employees laid off	
Receives VP	-0.004***	
	(0.001)	
VP share total pay		-0.022***
		(0.005)
Mean DV	0.004	0.004
Std. dev. DV	0.021	0.021
N	6582	6582
Adjusted R^2	0.11	0.12

Notes: The table relates the fraction of a firm's employees laid off through WARN notices each year and the extent to which the firm uses variable pay. Receives VP and VP share total pay are first residualized across workers by a quadratic in years of experience, a vector of firm characteristics (the logarithm of assets, leverage ratio, firm age, employment, and Tobin's Q) at the beginning of the period and fixed effects for industry-year, metro-year, and gender, and then averaged by firm. For the firm characteristics, we use each firm's 2010 levels; if all characteristics are unavailable, we instead use, if available, the 2009, 2008, 2011, 2012, or 2013 characteristics in that order. We include a fixed effect for the year from which the characteristics are used. Regressions on WARN data include industry-year fixed effects and the same vector of firm characteristics, and are weighted by the square root of each firm's sample size in residualizing the VP-measures. Standard errors are clustered by firm. Significance levels: * 10%, ** 5%, *** 1%.

INTERNET APPENDIX

A Appendix for Optimal Contracting Model

A.1 Parametrization for Numerical Exercise

We estimate productivity A_t and outside option θ_t process parameters from Compustat and BLS data as follows. We fit an AR(1) process for log productivity (sales per worker) among Compustat firms. We restrict the sample to 1990–2019, exclude the top and bottom 1%, and estimate

$$log(\frac{sale_{k,t}}{emp_{k,t}}) = \beta_A log(\frac{sale_{k,t-1}}{emp_{k,t-1}}) + \lambda_k + \epsilon_{kt},$$

for each firm k in year t. The regression includes 2,243 unique firms, has an adjusted R^2 of 0.93, and yields $\beta_A = 0.718$. For state unemployment rates (UR), which we assume is θ_t, we estimate a separate AR(1) process. With a panel of state UR from 1990–2019, we estimate

$$UR_{s,t} = \beta_{UR} UR_{s,t-1} + \lambda_s + \epsilon_{st},$$

for each state s in year t. The adjusted R^2 is 0.77 and $\beta_{UR} = 0.847$.

We convert the annual AR(1) coefficient, β_A into a continuous-time counterpart according to $\kappa_A = -\log(\beta_A)$, and similarly with β_θ and κ_θ. We recover σ_A from its annual counterpart Σ_A according to $\sigma_A = \frac{2 * \kappa_A * \Sigma_A}{1 - e^{-2\kappa_A}}$, and similarly with σ_θ and Σ_θ, adjusting for $UR = \frac{\theta}{\rho}$. We recover $\bar{\theta}$ from the AR(1) estimation and set $\bar{A} = 2$ so output takes reasonable values.

We specify CRRA utility for both the worker and firm owner, $u(c) = \frac{c^{1-\gamma}}{1-\gamma}$, and set a common subjective discount rate, $\rho = 0.05$. We choose a standard value for the worker's risk aversion, $\gamma = 2$, and a more risk tolerant value for the owner ($\gamma_f = 0.6$ or 0.3). We choose a labor disutility function, $v(l) = \frac{l^{1+\psi}}{1+\psi}$, and set $\psi = 0.82$ following Chetty *et al.* (2011). Finally, we set $y = 2.5$ to match a 20-year job separation hazard rate of about 90 percent estimated from Glassdoor resume data.[40] We summarize our parameter choices below.

$\bar{A} =$	2	$\kappa_A =$	0.33	$\sigma_A =$	0.208	$\gamma =$	2
$\bar{\theta} =$	−0.257	$\kappa_\theta =$	0.16	$\sigma_\theta =$	0.142	$\gamma_f =$	0.6
$\rho =$	0.05	$\psi =$	0.82	$y =$	2.5		

[40] Estimation results are available upon request. We consider 555,000 workers' first jobs that began between 1975 and 2003, for which the potential tenure, based on the date the resume was posted, is at least 20 years.

A.2 Proofs of Propositions and Corollaries

A.2.1 Proof of Proposition 1

This is a standard result. From Proposition 2 , in the special case that the firm is risk-neutral (i.e., $\vartheta_t \equiv 1$), the optimal consumption of the worker then satisfies the first-order necessary condition

$$c_t = u'^{-1}\left(1/\xi_t\right).$$

Because the firm is risk-neutral while the worker is risk-averse, it is straightforward to see that it is optimal and cheaper for the firm to bear all output risk and raise consumption only when the limited commitment constraint binds.

A.2.2 Proof of Proposition 2

Step 1: The Convex Dual Problem of the Firm

As is standard, the continuation value of the worker W_t, when it satisfies the promise-keeping (PK) constraint has the law of motion

$$dW_t = \left(\rho W_t - \left(u\left(c_t\right) - v\left(l_t\right)\right)\right)dt + \vec{\beta}_t' d\vec{Z}_t, \tag{A1}$$

where $\vec{\beta}_t$ is a pre-visible L^2 process guaranteed to exist by the Martingale Representation Theorem when $W_t \in L^2$. We next express the primal problem of the firm as a Lagrangian for its dual cost minimization problem, which delivers a net cost to the firm of C_0

$$\begin{aligned} C_0 &= \min_{\{c,l\}} \mathbb{E}\left[\int_0^\tau e^{-\rho t}\vartheta_t\left(c_t - e^{A_t}l_t\right)dt + e^{-\rho\tau}\underline{C}_\tau\right] \\ &\quad - \mathbb{E}\left[\int_0^\tau e^{-\rho t}\gamma_t\left(dW_t - \left(\rho W_t - u\left(c_t\right) + v\left(l_t\right)\right)dt - \vec{\beta}_t' d\vec{Z}_t\right)\right] \\ &\quad - \mathbb{E}\left[\int_0^\tau e^{-\rho t}\lambda_t\left(E\left[\int_t^\tau e^{-\rho(s-t)}\left(u\left(c_s\right) - v\left(l_s\right)\right)ds \mid \mathcal{F}_t\right] + e^{-\rho(\tau-t)}U_\tau - \frac{\theta_t}{\rho}\right)dt\right], \end{aligned} \tag{A2}$$

where $\gamma_t \geq 0$ is the Lagrange multiplier on the promise-keeping (PK) constraint written as (A1), and λ_t is the multiplier on the worker's limited commitment constraint.

Recognizing that γ_t (assuming it is square integrable) by the Martingale Representation Theorem has the law of motion

$$d\gamma_t = \mu_{\gamma t}dt + \vec{\sigma}_{\gamma t}dZ_t,$$

Further, define

$$\Lambda_t = \int_0^t \lambda_s ds \geq 0,$$

to be the locally deterministic costate of finite total variation with $\Lambda_0 = \lambda_0$. By stochastic integration by parts, we can then express this Lagrangian (A2) as a saddle-point problem

$$\begin{aligned} C_0 &= \min_{\{c,l,W\}} \max_{\{\gamma,\Lambda\}} \mathbb{E}\left[\int_0^\tau e^{-\rho t}\vartheta_t\left(c_t - e^{A_t}l_t\right)dt + e^{-\rho\tau}\left(\underline{C}_\tau - \left(\gamma_\tau + \Lambda_\tau\right)U_\tau\right)\right] \\ &+\mathbb{E}\left[\int_0^\tau e^{-\rho t}\left(\mu_{\gamma t}W_t + \vec{\sigma}'_{\gamma t}\vec{\beta}_t\right)dt\right] + \left(\gamma_0 + \lambda_0\right)U_0 \\ &-\mathbb{E}\left[\int_0^\tau e^{-\rho t}\left(\left(\gamma_t + \Lambda_t\right)\left(u\left(c_t\right) - v\left(l_t\right)\right) - \lambda_t\frac{\theta_t}{\rho}\right)dt\right]. \end{aligned} \tag{A3}$$

Complimentary slackness for the state variable W_t and control $\vec{\beta}_t$ implies that

$$\begin{aligned} W_t &: \mu_{\gamma t} = 0, \\ \vec{\beta}_t &: \vec{\sigma}_{\gamma t} = \vec{0}, \end{aligned}$$

otherwise one could minimize C_0 by making W_t or $\vec{\beta}_t$ arbitrarily large or small depending on the sign of $\mu_{\gamma t}$ and $\vec{\sigma}_{\gamma t}$. This implies that $\gamma_t = \gamma_0$ is a constant. Now define $\xi_t = \gamma_0 + \Lambda_t \geq 0$ with $\xi_0 = \gamma_0$, which has law of motion

$$d\xi_t = d\Lambda_t = \lambda_t dt.$$

Our cost minimization problem (A3) then simplifies to

$$\begin{aligned} C_0 &= \min_{\{c,l\}} \max_{\xi} \mathbb{E}\left[\int_0^\tau e^{-\rho t}\left(\vartheta_t\left(c_t - e^{A_t}l_t\right) - \xi_t\left(u\left(c_t\right) - v\left(l_t\right)\right)\right)dt - e^{-\rho t}d\xi_t\frac{\theta_t}{\rho}\right] \\ &+\mathbb{E}\left[e^{-\rho\tau}\left(\underline{C}_\tau - \xi_\tau U_\tau\right)\right] + \xi_0 U_0. \end{aligned} \tag{A4}$$

Step 2: Optimal Consumption, Labor, and Co-state λ_t

Define the Fechel-Legendre transforms

$$f\left(\vartheta,\xi\right) = \inf_c\left[\vartheta c - \xi u\left(c\right)\right], \tag{A5}$$

$$g\left(\vartheta,\xi,e^A\right) = \inf_l\left[\xi v\left(l\right) - \vartheta e^A l\right], \tag{A6}$$

which are strictly convex functions in c and l, respectively. Under additional regularity conditions, we can invoke the Minimax Theorem to switch the max and min in the cost minimization program (A4) to construct its convex dual using (A5) and (A6)

$$C_0 = \max_{\xi} \mathbb{E}\left[\int_0^{\tau} e^{-\rho t}\left(f\left(\vartheta_t, \xi_t\right) + g\left(\vartheta_t, \xi_t, e^{A_t}\right)\right) dt + e^{-\rho t} d\xi_t \frac{\theta_t}{\rho} + e^{-\rho\tau}\left(\underline{C}_{\tau} - \xi_{\tau} U_{\tau}\right)\right] + \xi_0 U_0, \tag{A7}$$

where c_t and l_t from first-order necessary conditions satisfy

$$c_t = u'^{-1}\left(\vartheta_t / \xi_t\right), \tag{A8}$$

$$l_t = v'^{-1}\left(e^{A_t} u'\left(c_t\right)\right). \tag{A9}$$

where we recognize that because u and v are strictly concave and convex, respectively, that their derivatives are invertible. In addition, because $u(\cdot)$ satisfies the Inada condition, $v(0) = v'(0) = 0$, and $v'^{-1}\left(e^{A_t}\vartheta_t/\xi_t\right) \geq 0$, it follows $c_t, l_t > 0$.

Finally, we recognize that λ_t pinned down by complementary slackness

$$\lambda_t \left(W_t - \theta_t/\rho\right) = 0,$$

Step 3: Dual-HJB Variational Inequality

Notice because after separation, $\underline{C}_{\tau} = \mathbb{E}\left[\int_{\tau}^{\infty} e^{-\rho t}\vartheta_t \left(c_t - y\right) dt\right]$, we can represent the continuation dual value function as $e^{-\rho t}K_t = e^{-\rho t}\left(C_t - \xi_t U_t\right)$ for a $\mathcal{C}^2$ dual value function K_t with separation value $\underline{K}_{\tau} = \underline{C}_{\tau} - \xi_{\tau} U_{\tau}$. Next, notice by the Envelope Theorem we can recover W_t from K_t by

$$\partial_{\xi} K_t = -W_t,$$

and W_t is increasing in the two natural states (A_t, θ_t) (more surplus and better outside option), and consequently

$$\vec{\beta} = \left[\begin{array}{cc} \partial_A W \sigma_A & \partial_{\theta} W \sigma_{\theta} \end{array}\right]' = \left[\begin{array}{cc} \partial_{\xi A} K \sigma_A & \partial_{\xi\theta} K \sigma_{\theta} \end{array}\right]'.$$

In addition, because $C_t = -\Pi_t$ and $W_t = -\partial_{\xi} K$, we can recover Π_t

$$K_t = \xi_t W_t - \Pi_t,$$

Finally, after separation, the firm receives a net profit of $y - c_t$ from paying the worker a wage after separation. Since the worker and firm are risk-averse, optimal risk sharing is achieved by offering a constant flow payment to the worker

$$c = \arg\inf_{c} \left[\underline{\vartheta} c - \xi u\left(c\right) \right],$$

from which follows that $c = c\left(\xi\right)$ where c solves the first-order necessary condition

$$u'\left(c\right) = \underline{\vartheta}/\xi.$$

It then follows that the dual value function is given by $\underline{K}\left(A, \theta, \xi\right) = \underline{K}\left(\xi\right)$

$$\underline{K}\left(\xi\right) = \int_{s}^{\infty} e^{-\rho(s-t)} \left(\underline{\vartheta}\left(c\left(\xi\right) - y\right) - \xi u\left(c\right)\right) ds = \frac{\underline{\vartheta}\left(c\left(\xi\right) - y\right) - \xi u\left(c\left(\xi\right)\right)}{\rho}. \tag{A10}$$

The firm will retire the worker when the cumulative cost of employing the worker, K_t, exceeds that under separation, $\underline{K}_t$. As such, the optimality of the optional stopping time for retiring the worker implies a stopping region $\mathcal{S}$ whose boundary satisfies value-matching

$$K\left(\xi, A, \theta\right) = \underline{K}\left(\xi\right). \tag{A11}$$

Because the firm's total cost follows a diffusion, it will hit this bound continuously.

Since we have a Markovian system in $\left(\xi_t, A_t, \theta_t\right)$, it follows we can represent K_t by the convex dual HJB variational inequality

$$0 = \min\left\{ f\left(\vartheta, \xi\right) + g\left(\vartheta, \xi, e^{A}\right) - \rho K + \mathcal{A}K, -\partial_{\xi}K - \theta/\rho, K - \underline{K} \right\}, \tag{A12}$$

where $\mathcal{A}$ is the infinitesimal generator

$$\mathcal{A}K = -\partial_A K \kappa_A \left(A - \bar{A}\right) - \partial_\theta K \kappa_\theta \left(\theta - \bar{\theta}\right) + \frac{1}{2}\partial_{AA} K \sigma_A^2 + \frac{1}{2}\partial_{\theta\theta} K \sigma_\theta^2.$$

The variational inequality specifies that, in the continuation region of the contract $\mathcal{C}$, the HJB equation $f\left(\vartheta, \xi\right) + g\left(e^{A}, \xi\right) - \rho K + \mathcal{A}K$ holds with equality while $W = -\partial_\xi K > \theta/\rho$ and $K < \underline{K}$. In the region $\mathcal{O}$ where the limited commitment constraint binds, it instead satisfies $-\partial_\xi K = \theta/\rho$. In the stopping region $\mathcal{S}$ where the firm retires the worker, it follows on the boundary that $K = \underline{K}$ and on the interior $K > \underline{K}$.

Finally, the initial choice of ξ_t, ξ_0, is set to satisfy the worker's participation constraint

$$W_0 = U_0.$$

A.2.3 Proof of Corollary 1

Recognizing that $\vartheta_t = \left(e^{A_t} l_t - c_t\right)^{-\gamma_f}$ and $l_t = v'^{-1}\left(e^{A_t} u'(c_t)\right)$ from Proposition 1, it follows we can express consumption c_t implicitly as

$$u'(c_t) = \left(e^{A_t} v'^{-1}\left(e^{A_t} u'(c_t)\right) - c_t\right)^{-\gamma_f} / \xi_t. \tag{A13}$$

Note there is no direct dependence on θ_t. Applying the Implicit Function Theorem to (A13),

$$\partial_A c_t = \frac{-\gamma_f e^{A_t}\left(e^{A_t} v'^{-1}\left(e^{A_t} u'(c_t)\right) - c_t\right)^{-\gamma_f - 1}\left(v'^{-1}\left(e^{A_t} u'(c_t)\right) + \frac{e^{A_t} u'(c_t)}{v''\left(v'^{-1}\left(e^{A_t} u'(c_t)\right)\right)}\right)/\xi_t}{u''(c_t) + \gamma_f\left(e^{A_t} v'^{-1}\left(e^{A_t} u'(c_t)\right) - c_t\right)^{-\gamma_f - 1}\left(\frac{e^{2A_t} u''(c_t)}{v''\left(v'^{-1}\left(e^{A_t} u'(c_t)\right)\right)} - 1\right)/\xi_t}, \tag{A14}$$

$$\partial_\xi c_t = \frac{-\left(e^{A_t} v'^{-1}\left(e^{A_t} u'(c_t)\right) - c_t\right)^{-\gamma_f} / \xi_t^2}{u''(c_t) + \gamma_f\left(e^{A_t} v'^{-1}\left(e^{A_t} u'(c_t)\right) - c_t\right)^{-\gamma_f - 1}\left(\frac{e^{2A_t} u''(c_t)}{v''\left(v'^{-1}\left(e^{A_t} u'(c_t)\right)\right)} - 1\right)/\xi_t}. \tag{A15}$$

Since $u''(c_t), -\gamma_f\left(e^{A_t} v'^{-1}\left(e^{A_t} u'(c_t)\right) - c_t\right)^{-\gamma_f - 1} < 0$, $v'^{-1}\left(e^{A_t} u'(c_t)\right), v''\left(v'^{-1}\left(e^{A_t} u'(c_t)\right)\right) > 0$, and $\xi_t \geq 0$, it follows that the denominators of $\partial_A c_t$ and $\partial_\xi c_t$ are negative. Furthermore, the numerators of $\partial_A c_t$ and $\partial_\xi c_t$ are both negative, and consequently from equations (A14) and (A15) $\partial_A c_t,\ \partial_\xi c_t > 0$. It is also immediate c_t is continuously differentiable in A_t and ξ_t (i.e., $\mathcal{C}^{1,1}$).

For the second derivative with respect to A_t, we recognize that output, $y_t = e^{A_t} v'^{-1}\left(e^{A_t} u'(c_t)\right)$, is decreasing in consumption ($v'^{-1}(\cdot)$ is an increasing function for convex $v(\cdot)$). Since output is quasi-convex in A_t, it is increasingly cheaper to provide more consumption to the worker at higher levels of output. As such, $\partial_{AA} c_t > 0$ where it exists.

Assuming c_t is twice differentiable in A_t, it follows by Itô's Lemma

$$dc_t = \partial_A c_t dA_t + \partial_\xi c_t d\xi_t + \frac{1}{2}\partial_{AA} c_t \sigma_A^2 dt$$

which we can expand as

$$dc_t = \left(\partial_\xi c_t \lambda_t - \partial_A c_t \kappa_A\left(A_t - \bar{A}\right) + \frac{1}{2}\partial_{AA} c_t \sigma_A^2\right) dt + \partial_A c_t \sigma_A dZ_t^A.$$

A.2.4 Proof of Corollary 2

When the firm offers a piecewise constant wage, then the worker's wage is completely insulated from productivity shocks, and only adjusts when the worker's limited commitment constraint binds (Proposition 1). As a result, the variance of worker compensation is higher under the optimal contract.

Next, notice with a piecewise constant wage, the firm implements a suboptimal contract. As such, its continuation value at each point is lower than under the optimal contract. As such, separation occurs sooner and there is higher employment volatility.

In addition, under the optimal contract, the worker's compensation c_t is an increasing function of output productivity A_t (Corollary 1). In contrast, optimal labor l_t is decreasing in c_t because

$$\partial_c l_t = \frac{e^{A_t} u''(c_t)}{v''(l_t))} \leq 0,$$

because $u(\cdot)$ is a strictly concave function and $v(\cdot)$ is strictly convex. Consequently, output $e^{A_t} l_t$ rises less with A_t under the optimal contract because

$$\partial_A \left(e^{A_t} l_t\right) = e^{A_t} l_t + e^{A_t} \frac{v'(l_t)}{v''(l_t)} + e^{A_t} \partial_c l_t \partial_A c_t,$$

and the last term (which is negative because $\partial_A c_t > 0$ from Corollary 2) is absent with a piecewise constant wage. Consequently, output fluctuates less with A_t for the same level of output $e^{A_t} l_t$, and output volatility is therefore lower.

A.2.5 Proof of Proposition 3

Step 1: The Problem of Shareholders

Suppose a shareholder of the firm has preferences over their consumption $u_f(c)$ and invests a fraction $x^j_{m,t}$ of their wealth w^j_t in a market index at time t, $x^j_{f,t}$ in the firm's equity at time t, and the remaining in a risk-free asset that pays instantaneous return r. The market index has an instantaneous excess return

$$dr^{mkt}_t = \left(\mu^{mkt} - r\right) dt + \sigma^{mkt} dZ^{mkt}_t,$$

while firm equity has price Π_t and instantaneous excess return

$$dr^f_t = D_t dt + \mathbb{E}\left[d\Pi_t\right] - r\Pi_t dt + \sigma^\Pi_t d\hat{Z}_t,$$

where $d\hat{Z}_t$ is given by equation (6) in the main text and

$$\sigma^\Pi_t = \sqrt{\left(\partial_A \Pi \sigma_A\right)^2 + \left(\partial_\theta \Pi \sigma_\theta\right)^2} \tag{A16}$$

by an appropriate application of Itô's Lemma to Π_t as a function of A_t and θ_t. By a change of measure such that $\hat{Z}_t$ is a standard Wiener process, markets are effectively complete with two risky assets with respect to the Wiener processes $\{Z_t^{mkt}, \hat{Z}_t\}$.

Shareholder j solves the optimization program

$$\begin{aligned} V_0^j &= \min_{\left\{c^j, x_m^j, x_f^j\right\}} \mathbb{E}\left[\int_0^\infty e^{-\rho t} u_f\left(c_t^j\right) dt\right] \\ &\quad -\mathbb{E}\left[\int_0^\infty e^{-\rho t} \vartheta_t \left(dw_t^j - \left(\left(r w_t^j - c_t^j\right) dt + x_{m,t}^j w_t^j dr_t^{mkt} + x_{f,t}^j w_t^j dr_t^f\right)\right)\right], \quad \text{(A17)} \end{aligned}$$

where $e^{-\rho t}\vartheta_t$ is the nonnegative Lagrange multiplier on the law of motion of the shareholder's wealth with its own law of motion

$$d\vartheta_t / \vartheta_t = \mu_{\vartheta t} dt - \sigma_{mkt} dZ_t^{mkt} - \sigma_{\vartheta t} d\hat{Z}_t.$$

Because ϑ_t will be adapted to the shareholder's filtration, it necessarily has this functional form. Performing integration-by-parts on the program (A17)

$$\begin{aligned} V_0^j &= \min_{\left\{c^j, x_m^j, x_f^j\right\}} \mathbb{E}\left[\int_0^\infty e^{-\rho t} \left(u_f\left(c_t^j\right) - \vartheta_t c_t^j\right) dt\right] - \lim_{t\to\inf} \mathbb{E}\left[e^{-\rho T} \vartheta_T w_T^j\right] + \vartheta_0 w_0^j \\ &\quad + \mathbb{E}\left[\int_0^\infty e^{-\rho t} \vartheta_t w_t^j \left(r + x_{m,t}^j \left(\mu^{mkt} - r\right) + x_{f,t}^j \left(D_t + \frac{1}{dt}\mathbb{E}\left[d\Pi_t\right] - r\Pi_t\right)\right) dt\right] \\ &\quad + \mathbb{E}\left[\int_0^\infty e^{-\rho t} \vartheta_t w_t^j \left(\left(\mu_{\vartheta t} - \rho\right) + \sigma_{mkt}\sigma^{mkt} + \sigma_{\vartheta t}\sigma_t^\Pi\right) dt\right]. \end{aligned}$$

It then follows by complementary slackness for w_T^j that

$$\lim_{t\to\inf} \mathbb{E}\left[e^{-\rho T} \vartheta_T w_T^j\right] = 0,$$

and for $x_{m,t}^j$ and $x_{f,t}^j$

$$\sigma_{mkt} = \frac{\mu^{mkt} - r}{\sigma_{mkt}}, \quad \text{(A18)}$$

$$\sigma_{\vartheta t} = \frac{D_t + \frac{1}{dt}\mathbb{E}\left[d\Pi_t\right] - r\Pi_t}{\sqrt{\left(\partial_A \Pi \sigma_A\right)^2 + \left(\partial_\theta \Pi \sigma_\theta\right)^2}}, \quad \text{(A19)}$$

where we have substituted for σ_t^Π with equation (A16).

Further, one can recover the optimal consumption policy as

$$c_t^j = u_f'^{-1}\left(\vartheta_t\right).$$

It is immediate that ϑ_t is the marginal value of wealth of shareholder j, and consequently their state price deflator (SPD). As all shareholders share the same SPD, this is necessarily the SPD the firm uses to value its dividends.

Step 2: Optimal Contract for Workers

Let ω_t be the cash holdings of the firm and $e^{-\rho t}X_t$ be the Lagrange multiplier on the law of motion of ω_t with law of motion

$$dX_t/X_t = \mu_{xt}dt + \vec{\sigma}_{xt}dZ_t, \tag{A20}$$

Let $\phi_t(A_i, \xi_i)$ be the (time-varying) distribution of A_i and ξ_i among active workers, and $\delta_t(A_i, \xi_i)$ the measure of workers with characteristics $\{A_i, \xi_i\}$ retiring at time t. The t subscript captures the dependence of these distributions on ϑ_t. The law of motion of $\phi_t(A_i, \xi_i)$ follows a Kolmogorov Forward Equation (KFE) with mass shifts of new workers replacing retiring ones that we characterize in the sequel. We can derive an analogous Lagrangian for the dual cost minimization problem that delivers a net cost to the firm of C_0

$$\begin{aligned} C_0 \;=\; & \min_{\{D,c_i,l_i\}} \mathbb{E}\left[\int_0^\infty e^{-\rho t}\vartheta_t D_t dt\right] \\ & - \mathbb{E}\left[\int_{\mathcal{A}\times\Xi}\int_0^\infty e^{-\rho t}\gamma_{i,t}\left(dW_{i,t} - \left(\rho W_{i,t} - u\left(c_{i,t}\right) + v\left(l_{i,t}\right)\right)dt - \vec{\beta}'_{i,t}d\vec{Z}_{i,t}\right)\phi_t\left(A_i,\xi_i\right)di\right] \\ & - \mathbb{E}\left[\int_0^\infty e^{-\rho t}X_t\left(d\omega_t - \left(r\omega_t + \int_{\mathcal{A}\times\Xi}\left(e^{A_{i,t}}l_{i,t} - c_{i,t}\right)\phi_t\left(A_i,\xi_i\right)di - \int_{\mathcal{A}\times\Xi}\bar{c}_i\delta_t\left(A_i,\xi_i\right)di - D_t\right)dt\right)\right] \\ & - \mathbb{E}\left[\int_{\mathcal{A}\times\Xi}\int_0^\infty e^{-\rho t}\lambda_{i,t}\left(E\left[\int_t^{\tau_i} e^{-\rho(s-t)}\left(u\left(c_{i,s}\right) - v\left(l_{i,s}\right)\right)ds \mid \mathcal{F}_t\right] + e^{-\rho(\tau_i - t)}U_{i,\tau} - \frac{\theta_t}{\rho}\right)\phi_t\left(A_i,\xi_i\right)didt\right], \end{aligned}$$

where $d\vec{Z}_{i,t}$ includes both the aggregate and individual productivity shocks.

Notice the separation utility for a worker is now $u\left(\rho\bar{c}_i\right)/\rho$ from amortizing $\bar{c}_i$ over their lifetime. Analogous arguments to those in the proof of Proposition 2 allow us to derive the saddle-point problem

$$\begin{aligned} C_0 \;=\; & \min_{\{D,c_i,l_i\}}\max_{\{\xi_i,X\}} \mathbb{E}\left[\int_0^\infty e^{-\rho t}\vartheta_t D_t dt - e^{-\rho\tau}\int_0^1 \xi_{i,t}\frac{u\left(\rho\bar{c}_i\right)}{\rho}\delta_t\left(A_i,\xi_i\right)di\right] + \int_{\mathcal{A}\times\Xi}\xi_{i,0}U_{i,0}\phi_0\left(A_i,\xi_i\right)di \\ & + \mathbb{E}\left[\int_0^\infty e^{-\rho t}\left(\omega_t X_t\mu_{xt}dt + X_t\left(\left(r-\rho\right)\omega_t + \int_{\mathcal{A}\times\Xi}\left(e^{A_{i,t}}l_{i,t} - c_{i,t}\right)\phi_t\left(A_i,\xi_i\right)di - \int_{\mathcal{A}\times\Xi}\bar{c}_i\delta_t\left(A_i,\xi_i\right)di - D_t\right)dt\right)\right] \\ & - \mathbb{E}\left[\int_{\mathcal{A}\times\Xi}\int_0^\infty e^{-\rho t}\left(\xi_{i,t}\left(u\left(c_{i,t}\right) - v\left(l_{i,t}\right)\right) - \lambda_{i,t}\frac{\theta_t}{\rho}\right)dt\phi_t\left(A_i,\xi_i\right)di\right], \end{aligned} \tag{A21}$$

where $\xi_{i,t}$ is defined as in Proposition 2 now at the individual worker-level.

It is immediate from applying complementary slackness to the cost minimization problem (A21) for D_t that $X_t = \vartheta_t$ and $\mu_{xt} = -(r-\rho)$. We can then rewrite (A21) as

$$\begin{aligned} C_0 &= \min_{\{c_i,l_i\}} \max_{\{\xi_i\}} \mathbb{E}\left[\int_{\mathcal{A}\times\Xi}\left(\int_0^\infty e^{-\rho t}\left(\vartheta_t\left(e^{A_{i,t}}l_{i,t}-c_{i,t}\right)-\xi_{i,t}\left(u\left(c_{i,t}\right)-v\left(l_{i,t}\right)\right)\right)dt-e^{-\rho t}d\xi_{i,t}\frac{\theta_t}{\rho}\right)\phi_t\left(A_i,\xi_i\right)di\right] \\ &+\mathbb{E}\left[\int_0^\infty\int_{\mathcal{A}\times\Xi}\left(\vartheta_t\bar{c}_i-\xi_{i,t}\frac{u\left(\rho\bar{c}_i\right)}{\rho}\right)\delta_t\left(A_i,\xi_i\right)di\right]+\int_{\mathcal{A}\times\Xi}\xi_{i,0}U_{i,0}\phi_0\left(A_i,\xi_i\right)di. \end{aligned} \tag{A22}$$

Given the firm takes ϑ_t as given, it is immediate from the linearity of the cost objective in i and the linearity of the derivatives operator that we can separate this problem into a cost functional agent-by-agent. Define the cost $C_{i,t}$ to be the cost to the firm of worker i. Then we can express $C_{i,0}$ from the linearity of (A22) as

$$\begin{aligned} C_{i,0} &= \min_{\{c_i,l_i\}} \max_{\{\xi_i\}} \mathbb{E}\left[\int_0^{\tau_i} e^{-\rho t}\left(\vartheta_t\left(e^{A_{i,t}}l_{i,t}-c_{i,t}\right)-\xi_{i,t}\left(u\left(c_{i,t}\right)-v\left(l_{i,t}\right)\right)\right)dt-e^{-\rho t}d\xi_{i,t}\frac{\theta_t}{\rho}\right] \\ &+\mathbb{E}\left[e^{-\rho\tau_i}\left(\vartheta_\tau\bar{c}_i-\xi_{i,\tau}\frac{u\left(\rho\bar{c}_i\right)}{\rho}\right)\right]+\xi_{i,0}U_{i,0}. \end{aligned} \tag{A23}$$

It is immediate that (A23) is identical to (A4) except ϑ_t is a state variable and the optimal separation condition is now $u'\left(\rho\bar{c}_i\right) = \vartheta_\tau/\xi_{i,\tau}$. Consequently, the cost minimization problem solves the convex dual HJB variational inequality for $k_{i,t}$

$$0 = \min\left\{f\left(\vartheta,\xi_i\right)+g\left(\vartheta,\xi_i,e^{A_i}\right)-\rho k_i+\mathcal{G}k_i, -\partial_{\xi_i}k_i-\frac{\theta}{\rho}, k_i+\bar{c}_i-\int_{\mathcal{A}\times\Xi}kp\left(A_j,\xi_j\right)dj\right\}, \tag{A24}$$

where $\int_{\mathcal{A}\times\Xi}kp\left(A_j,\xi_j\right)dj-\bar{c}_i$ is the firm's outside option and $\mathcal{G}$ the infinitesimal generator

$$\begin{aligned} \mathcal{G}k &= -\partial_A k_i\kappa_A\left(A_i-\bar{A}\right)-\partial_\vartheta k_i\left(r-\rho\right)\vartheta-\partial_\theta k_i\kappa_\theta\left(\theta-\bar{\theta}\right)+\frac{1}{2}\partial_{AA}k_i\left(\sigma_A^2+\sigma_e^2\right) \\ &+\frac{1}{2}\partial_{\theta\theta}k_i\sigma_\theta^2+\frac{1}{2}\partial_{\vartheta\vartheta}k_i\left(\sigma_{mkt}^2+\sigma_\vartheta^2\right)+\sigma_\vartheta\frac{\partial_{A\vartheta}k_i\partial_A\Pi\sigma_A^2+\partial_{\theta\vartheta}k_i\partial_\theta\Pi\sigma_\theta^2}{\sqrt{\left(\partial_A\Pi\sigma_A\right)^2+\left(\partial_\theta\Pi\sigma_\theta\right)^2}}. \end{aligned}$$

The optimality of the optional separation time for each worker is embedded in the minimization in the dual-HJB variational inequality.

Step 3: Optimal Consumption

The optimal choice of consumption satisfies (A8). Applying Itô's Lemma to $u'\left(c_{i,t}\right)$

$$du'\left(c_{i,t}\right)/u'\left(c_{i,t}\right) = d\vartheta_t/\vartheta_t - d\xi_t/\xi_t = -\left(r+\lambda_t/\xi_t-\rho\right)dt-\sigma_{mkt}dZ_t^{mkt}-\sigma_{\vartheta t}d\hat{Z}_t. \tag{A25}$$

Given by Itô's Lemma, one also has that

$$\frac{du'(c_{i,t})}{u'(c_{i,t})} = \frac{u''(c_{i,t})}{u'(c_{i,t})}dc_{i,t} + \frac{1}{2}\frac{u'''(c_{i,t})}{u'(c_{i,t})}d\langle c_i\rangle_t = -\gamma(c_{i,t})\frac{dc_{i,t}}{c_{i,t}} + \frac{\gamma(c_{i,t})}{2}\varphi(c_{i,t})\frac{d\langle c_i\rangle_t}{c_{i,t}^2}, \qquad \text{(A26)}$$

where $\gamma(c_t)$ and $\varphi(c_t)$ are the worker's coefficient of relative risk aversion and relative prudence, respectively. We can substitute equation (A26) and quadratic variation $d\langle c_i\rangle_t / c_{i,t}^2 = \frac{\sigma_{mkt}^2+\sigma_{\vartheta t}^2}{\gamma(c_{i,t})^2}dt$ into equation (A25) to find

$$d\log c_{i,t} = \left(\frac{r-\rho+\lambda_{i,t}/\xi_{i,t}}{\gamma(c_{i,t})} + \frac{\varphi(c_{i,t})-1}{2}\frac{\sigma_{mkt}^2+\sigma_{\vartheta t}^2}{\gamma(c_{i,t})^2}\right)dt + \frac{\sigma_{mkt}}{\gamma(c_{i,t})}dZ_t^{mkt} + \frac{\sigma_{\vartheta t}}{\gamma(c_{i,t})}d\hat{Z}_t, \qquad \text{(A27)}$$

recognizing that $\frac{dc_{i,t}}{c_{i,t}} = d\log c_{i,t} + \frac{1}{2}\frac{d\langle c_i\rangle_t}{c_{i,t}^2}$.

Step 4: Law of Motion of Worker Population

Finally, we can write the law of motion of the distribution of workers, $\phi_t(A_i,\xi_i)$

$$\begin{aligned} d\phi_t(A_i,\xi_i) \;=\;& \mathcal{G}'\phi_t(A_i,\xi_i)\mathbf{1}_{\{\{A_i,\xi_i\}\in\mathcal{C}\}} - \phi_t(A_i,\xi_i)\mathbf{1}_{\{\{A_i,\xi_i\}\in\mathcal{S}\}} + \int_{\mathcal{A}\times\Xi} p(A_i,\xi_i)\,d\delta_t(A_i,\xi_i) \\ &+\partial_\xi\phi_t(A_i,\xi_i)\lambda_i\mathbf{1}_{\{\{A_i,\xi_i\}\in\mathcal{R}\}} - \partial_A\phi_t(A_i,\xi_i)\sigma_A dZ_t^A \\ &+\partial_\vartheta(\phi_t(A_i,\xi_i)\vartheta_t\sigma_{mkt})dZ_t^{mkt} + \partial_\vartheta(\phi_t(A_i,\xi_i)\vartheta_t\sigma_{\vartheta,t})d\hat{Z}_t, \end{aligned} \qquad \text{(A28)}$$

where $p(A_i,\xi_i)$ is the distribution from which new workers are drawn. As there is a direct mapping between ξ_i and reservation values given A_i, drawing a reservation value is equivalent to drawing a ξ_i. The first piece is the law of motion in the continuation region. The second is if workers of that type retire. The third is the influx of new workers. The fourth is the law of motion if the limited commitment constraint binds. The final terms reflect that $\phi_t(A_i,\xi_i)$ is stochastic because of movements in ϑ_t and A_t. Since the diffusions of $\phi_t(A_i,\xi_i)$ depend on $\phi_t(A_i,\xi_i)$ itself, $\phi_t(A_i,\xi_i)$ solves a McKean-Vlasov stochastic differential equation.

A.2.6 Proof of Corollary 3

Consider the second-variation process η_t with law of motion

$$d\eta_t = -\eta_t\left(rdt + \sigma_{mkt}dZ_t^{mkt} + (\sigma_{\vartheta,t} + \vartheta_t\partial_\vartheta\sigma_{\vartheta,t})d\hat{Z}_t\right) - \tilde{\sigma}_i d\hat{Z}_t,$$

which represents the law of motion of the perturbed process ϑ_t to a variation $\epsilon\tilde{\sigma}_i$ as $\epsilon\to 0$.

Define $EBIT_t = \int_{\mathcal{A}}\left(\left(e^{A_i}l_i - c_i\right)\phi_t(A_i) - \bar{c}_i\delta_t(A_i)\right)di$ to be the net income of the firm at time t. Without limited commitment, we do not need to keep track of the limited commitment costate $\xi_{i,t}$. We then have the perturbed risk-neutral value of future net income

$$\partial_{\tilde{\sigma}_i} R_t = \partial_{\tilde{\sigma}_i} \mathbb{E}\left[\int_t^\infty e^{-r(s-t)} EBIT_s ds\right] = \mathbb{E}\left[\int_t^\infty e^{-r(s-t)} \partial_\vartheta EBIT_s \eta_s ds\right],$$

where

$$\partial_\vartheta EBIT_s = \int_{\mathcal{A}} \left(\left(\frac{e^{2A_i}}{v''(l_i)} - \frac{1}{u''(c_i)} \right) \phi_s(A_i) - \frac{1}{\rho u''(\rho \bar{c}_i)} \delta_s(A_i) - \bar{c}_i \partial_{\vartheta_s} \delta_s(A_i) \right) di, \quad \text{(A29)}$$

where $\delta_s(A_i)$, the separation distribution, depends on ϑ_s. The first two terms on the right-hand side of equation (A29) are positive because labor disutility is convex ($v''(l_i) > 0$) and consumption utility is concave ($u''(c_i) < 0$). Notice if $EBIT$ per workers increases with ϑ_t (the first two terms), the firm has less incentive to fire workers, consequently $\partial_{\vartheta_s} \delta_s(A_i) < 0$. Therefore, $\partial_\vartheta EBIT_s > 0$.

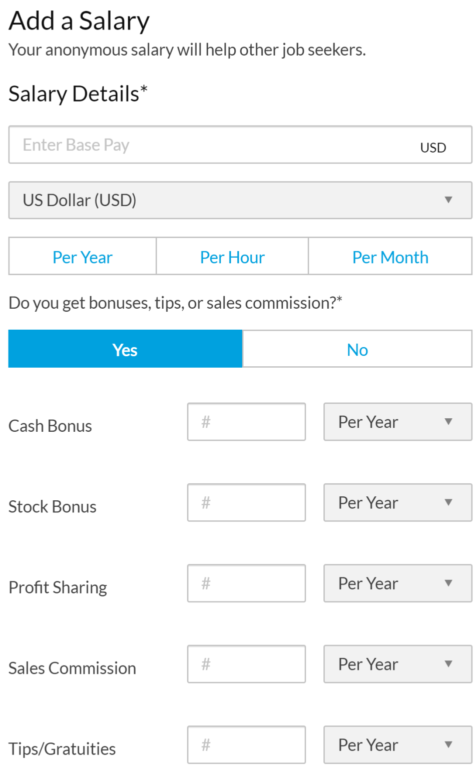
B Additional Summary Information

This appendix provides background summary information for our full sample as well as our Compustat and Moody's credit rating sub-samples.

To provide context for the data generating process of our pay reports, we include in Figure B1 a screenshot of the submission form for providing a pay report. This screenshot was taken after clicking on the "Yes" button, and the drop-down menu for each type of variable pay was displayed. Figure B2 validates the Glassdoor sample against the ADP sample from Grigsby *et al.* (2021) by comparing the share of total pay derived through variable pay across the distribution of workers ordered by their percentile in the base pay distribution.

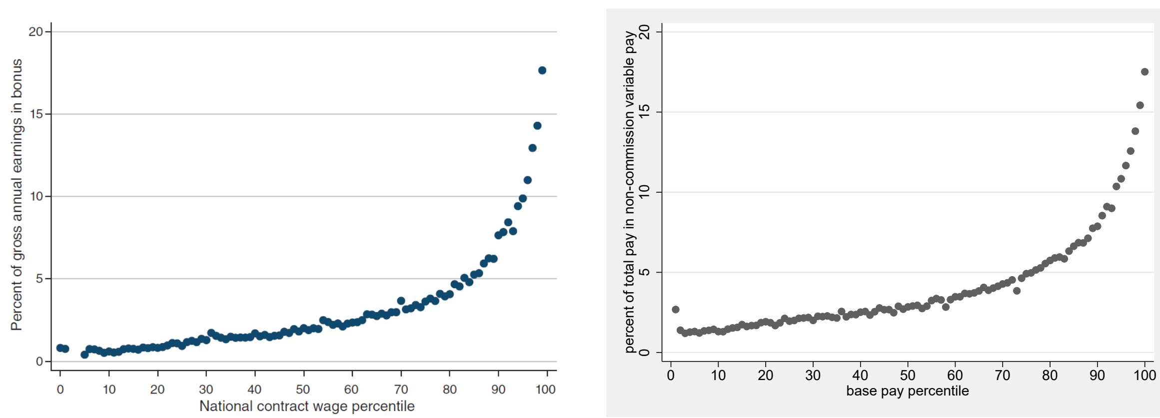
Table B1 offers summary statistics for worker observables, firm observables, and variable pay types in the full sample. Table B2 offers summary pay measures for investment-grade compared with speculative-grade employers. Table B3 provides the list of firms from the Chodorow-Reich (2014) dataset on bank health that could be matched with Glassdoor. For each lender, included is the number of pay reports in the Glassdoor sample and the key measure of bank health, i.e., the fraction of a bank's syndicate portfolio in which Lehman Brother held a lead role. Table B4 details the distributions and Table B5 the correlations of the measures of firm performance and financial characteristics from Compustat. Table B6 provides the standard deviations of the firm-level variable-pay intensity measures for each of the main analyses in which they are incorporated: the variance of total pay and the volatility of growth.

Figure B1: Sample Pay Report


Add a Salary
Your anonymous salary will help other job seekers.
Salary Details*
Enter Base Pay USD
US Dollar (USD)
Per Year | Per Hour | Per Month
Do you get bonuses, tips, or sales commission?*
Yes | No
Cash Bonus # Per Year
Stock Bonus # Per Year
Profit Sharing # Per Year
Sales Commission # Per Year
Tips/Gratuities # Per Year

Notes: The figure provides a screenshot of the submission form for providing a pay report on Glassdoor.

Figure B2: Sample Validation Comparing Bonus Intensity with Grigsby *et al.* (2021)



(a) ADP (Figure 1A of Grigsby *et al.* (2021))

(b) Glassdoor

Notes: This figure offers a comparison between bonus data in two samples, Glassdoor and ADP. Panel (a) displays the share of annual pay attributable to non-commission bonuses by workers' percentiles in the distribution of base wages for hourly and salaried job-stayers in ADP. Panel (b) calculates the same distribution of non-commission variable pay for the Glassdoor sample of salaried workers' pay reports.

Table B1: Summary Statistics for Worker and Firm Observables

Observable	Observations	Mean	Median	Standard deviation	5th percentile	95th percentile
Panel A: Worker and firm characteristics						
Years of experience	2,909,804	7.0	5.0	6.9	0.0	20.0
Job title's average years of experience	2,909,804	5.5	4.0	4.2	1.0	14.0
1(Male employee)	2,909,804	0.41	0.00	0.49	0.00	1.00
1(Female employee)	2,909,804	0.28	0.00	0.45	0.00	1.00
Firm size	2,909,804	48,792	6,600	109,068	27	268,000
Firm age (years)	2,614,084	57.6	39.0	50.9	6.0	164.0
1(Firm publicly traded)	2,435,712	0.54	1.00	0.50	0.00	1.00
Unemployment rate	2,909,804	5.11	4.65	1.90	2.85	9.05
Job vacancy to unemployment rate ratio	1,521,659	0.78	0.76	0.36	0.24	1.43
Panel B: Variable pay type						
Cash bonus	923,243	13,677	8,000	21,849	1,000	45,000
Stock bonus	153,370	26,087	12,000	41,352	1,000	100,000
Profit sharing	95,533	8,085	5,000	14,657	800	25,000
Sales commission	185,638	37,044	25,000	42,570	2,000	120,000
1(Receives cash bonus)	2,909,804	0.32	0.00	0.47	0.00	1.00
1(Receives stock bonus)	2,909,804	0.05	0.00	0.23	0.00	1.00
1(Receives profit sharing)	2,909,804	0.03	0.00	0.18	0.00	0.00
1(Receives sales commission)	2,909,804	0.06	0.00	0.24	0.00	1.00

Notes: Table provides summary statistics (mean, median, standard deviation, fifth percentile, and ninety-fifth percentile) for each of the worker and firm characteristics used as regression controls or to partition the sample, along with the magnitude and incidence of each variable pay type.

Table B2: Worker Compensation at Firms with Investment or Speculative Credit Ratings

	Investment grade (Baa3–Aaa)		Speculative grade (Ca—Ba1)	
Measure of interest	N	Measure	N	Measure
Base pay: mean	612,196	91,628	76,588	83,936
Base pay: median	612,196	83,429	76,588	74,164
1(Receives VP)	612,196	0.532	76,588	0.417
VP share total pay	612,196	0.085	76,588	0.060
Variable pay: mean	325,399	25,961	31,934	20,620
Variable pay: median	325,399	12,293	31,934	10,000
Conditional VP share total pay	325,399	0.159	31,934	0.144

Notes: Sample consists of pay reports that can be matched successfully to Bloomberg credit ratings data. Base and variable pay are inflation-adjusted to 2018 dollars using U.S. headline CPI. Investment grade reflects the ten rungs between Baa3 and Aaa, inclusively. Speculative grade reflects the ten rungs between Ca and Ba1, inclusively.

Table B3: Bank Health Sample

Firm	Sample size	Fraction of a bank's syndicate portfolio in which Lehman Brothers held a lead role
Regions Financial Corporation	1280	0.0000
Silicon Valley Bank	368	0.0000
M&T Bank Corporation	960	0.0000
The Bank of New York Mellon Corporation	3595	0.0035
Fifth Third Bancorp	1525	0.0036
The Toronto-Dominion Bank	1386	0.0041
Comerica Incorporated	655	0.0042
KeyCorp	1269	0.0043
U.S. Bancorp	3933	0.0045
The PNC Financial Services Group, Inc.	5129	0.0055
Bank of America Corporation	15194	0.0056
HSBC Holdings plc	1728	0.0057
Mitsubishi UFJ Financial Group, Inc.	519	0.0059
The Bank of Nova Scotia	103	0.0059
SunTrust Banks Inc.	1862	0.0064
UBS AG	2480	0.0066
BNP Paribas S.A.	561	0.0066
Canadian Imperial Bank of Commerce	92	0.0066
CoBank, ACB	75	0.0070
RBS Citizens, N.A.	87	0.0074
Wells Fargo & Company	14048	0.0078
JPMorgan Chase & Co.	15238	0.0082
Citigroup Inc.	9028	0.0089
National City Corporation	91	0.0090
Société Générale	455	0.0093
Branch Banking and Trust Company	1327	0.0097
UnionBanCal Corporation	772	0.0100
Wachovia Corporation	677	0.0108
Barclays PLC	2113	0.0132
Banco Santander S.A.	1080	0.0171
General Electric Capital Corporation	870	0.0178
Deutsche Bank AG	2230	0.0178
Merrill Lynch & Co., Inc.	2631	0.0183
Credit Suisse Group AG	1979	0.0186
CIT Group Inc.	439	0.0191
Royal Bank of Canada	647	0.0330
The Bear Stearns Companies Inc.	47	0.0463
Morgan Stanley	5265	0.0475
The Goldman Sachs Group, Inc.	4813	0.0500

Notes: The table lists the sample of banks in ascending order according to the measure of health from Chodorow-Reich (2014). Also listed is the number of pay reports for each bank in the Glassdoor sample.

Table B4: Summary of Firm Financial Performance Measures

Measure of interest	Non-standardized: Mean	Non-standardized: Standard deviation	Standardized z-scores: Mean	Standardized z-scores: Standard deviation	p1	p99
Stock return	16.21	34.53	0.00	1.00	-2.27	3.36
Log sales to employment ratio	5.926	0.794	0.00	1.00	-2.57	2.46
Log assets	10.50	2.091	0.00	1.00	-2.32	2.03
Log leverage ratio	-0.476	0.412	0.00	1.00	-3.35	1.47
Log employment	3.988	1.568	0.00	1.00	-2.61	2.31
Log firm age	3.973	0.865	0.00	1.00	-2.96	1.70
Log Tobins's Q	0.639	0.515	0.00	1.00	-1.41	2.41

Notes: The table displays summary statistics for annual firm performance and characteristics. Standardized measures correspond to z-scores within each year. The top and bottom 0.1 percent of each measure (excluding log employment and firm age) have been truncated to control for outliers. The last two columns, p1 and p99, refer to the 1st and 99th percentiles, respectively. Sample size is 748,000 pay reports.

Table B5: Correlation of Firm Financial Performance Measures

Standardized z-scores	Stock return	Log sales to employment ratio	Log assets	Log leverage ratio	Log employment	Log firm age	Log Tobin's Q
Stock return	1.00	-	-	-	-	-	-
Log sales to employment ratio	0.05	1.00	-	-	-	-	-
Log assets	0.02	0.41	1.00	-	-	-	-
Log leverage ratio	-0.03	0.13	0.38	1.00	-	-	-
Log employment	0.02	-0.14	0.67	0.24	1.00	-	-
Log firm age	-0.08	0.06	0.39	0.35	0.27	1.00	-
Log Tobins's Q	0.24	-0.20	-0.40	-0.37	-0.06	-0.36	1.00

Notes: The table displays the correlation across the standardized annual firm performance and characteristics. Standardized measures correspond to z-scores within each year. The top and bottom 0.1 percent of each measure (excluding log employment and firm age) have been truncated to control for outliers.

Table B6: Standard Deviations of Firm-Level Residuals for Variable Pay Intensity

		Standard deviation of residuals					
Analysis	Firms	Receives VP	Receives cash bonus	Receives stock bonus	Receives profit sharing	Receives sales commission	VP share total pay
Volatility of growth	2,349	0.183	0.180	0.107	0.077	0.098	0.047
Variance of total pay	64,306	0.182	0.176	0.090	0.067	0.095	0.046
WARN notices	786	0.144	0.148	0.095	0.071	0.074	0.034

Notes: Table provides the number of firms represented along with the standard deviation for each varable pay intensity measure used when relating variable pay intensity with the variance of workers' total pay (Table 6) and the volatility of firm growth through Compustat measures (Table 7) and WARN notices (Table 8).

C Decomposition into Variable Pay Types

This appendix decomposes our empirical analyses into the four types of variable pay. See Table C1 for local labor market tightness, Table C2 for borrowing conditions, Table C3 for the 2008 Financial Crisis, Tables C4 and C5 for annual firm performance, Table C6 for pay variance, and Table C7 for firm-level volatility.

Table C1: Variable Pay Responsiveness to Tightness by Sub-Components

	Any VP	Cash bonus	Stock bonus	Profit sharing	Sales commission
	Panel A: Incidence of variable pay				
Metro UR	-0.010	-0.008	-0.041	0.014	-0.009
	(0.096)	(0.096)	(0.071)	(0.030)	(0.022)
N	1792580	1792580	1792580	1792580	1792580
Adjusted R^2	0.31	0.30	0.35	0.18	0.50
	Panel B: Magnitude of variable pay				
Metro UR	-0.901**	-0.581**	-2.216**	-0.585	-0.198
	(0.414)	(0.278)	(0.872)	(0.581)	(0.320)
N	713042	556133	98204	42519	109716
Adjusted R^2	0.69	0.66	0.59	0.62	0.60

Notes: The table displays the relation between labor market tightness—as measured through metropolian area unemployment rates—and employee variable pay overall and decomposed by type. Panel A investigates the relation with the incidence of each variable pay type, panel B the magnitude. Standard errors are clustered by firm. Significance levels: * 10%, ** 5%, *** 1%.

Table C2: Variable Pay and Credit Rating Changes by Sub-Components

	Any VP	Cash bonus	Stock bonus	Profit sharing	Sales commission
	Panel A: Incidence of variable pay				
1(Investment grade)	0.024**	0.026**	0.013*	0.002	-0.005
	(0.012)	(0.011)	(0.007)	(0.004)	(0.004)
Mean DV	0.54	0.44	0.13	0.04	0.07
N	59202436	59202436	59202436	59202436	59202436
Adjusted R^2	0.27	0.28	0.39	0.18	0.50
	Panel B: Magnitude of variable pay				
1(Investment grade)	0.082***	0.079***	0.364***	0.024	0.048
	(0.025)	(0.028)	(0.059)	(0.084)	(0.064)
Mean DV	9.48	9.21	9.61	8.44	9.97
N	30023192	24173993	6877026	1831350	3484991
Adjusted R^2	0.69	0.65	0.58	0.59	0.64

Notes: The table displays the relation between a bond credit rating of investment grade from a stacked regression around firm switches between investment and non-investment grade for variable pay overall and decomposed by type. Panel A investigates the relation with the incidence of each variable pay type, panel B the magnitude. Standard errors are clustered by firm. Significance levels: * 10%, ** 5%, *** 1%.

Table C3: Exposure to Lehman Brothers and Variable Pay by Sub-Components

	Any VP	Cash bonus	Stock bonus	Profit sharing	Sales commission
Post-2008 x Lehman share of firm's portfolio	-5.834***	-5.486**	9.867*	4.188	8.847
	(2.253)	(2.183)	(5.010)	(5.091)	(12.260)
Mean Lehman share	0.013	0.013	0.016	0.012	0.008
N	105721	90350	6889	5827	14558
Adjusted R^2	0.64	0.64	0.60	0.66	0.63

Notes: The table displays the coefficient on an indicator variable for the pay report occurs after 2008 interacted with a continuous measure for the fraction of a firm's portfolio overseen by Lehman Brothers for the magnitude of variable pay overall and decomposed by type. Bank health data are from Chodorow-Reich (2014). Sample is restricted to firms in finance. Standard errors are clustered by firm. Significance levels: * 10%, ** 5%, *** 1%.

Table C4: Firm Performance and Variable Pay by Sub-Components

Standardized z-score	Any VP	Cash bonus	Stock bonus	Profit sharing	Sales commission
Stock return	1.018***	1.213***	0.999	1.976*	0.771
	(0.315)	(0.296)	(0.648)	(1.163)	(0.559)
Log sales-to-employment ratio	11.341***	6.927*	6.065	21.056*	2.959
	(3.491)	(3.551)	(6.126)	(12.287)	(5.734)
Mean DV	940.05	909.97	952.38	843.55	999.19
N	359471	285584	79155	19677	46730
Adjusted R^2	0.69	0.65	0.59	0.58	0.64

Notes: The table regresses annual firm financial performance on the magnitude of each variable pay type. Compustat measures are lagged one year, so pay reports in year t are assigned firm performance and characteristics from year $t-1$, have been converted to standardized z-scores within each year, and have had the top and bottom 0.5% truncated to control for outliers (excluding log employment and firm age). Regressions include a quadratic in years of experience along with firm-job title, metro-year, industry-year and gender fixed effects. Standard errors are clustered by firm. Significance levels: * 10%, ** 5%, *** 1%.

Table C5: Firm Performance and Variable Pay Incidence by Sub-Components

Standardized z-score	1(Any VP)	1(Cash bonus)	1(Stock bonus)	1(Profit sharing)	1(Sales commission)
Stock return	0.675***	0.591***	0.081	0.073*	0.052
	(0.135)	(0.146)	(0.077)	(0.044)	(0.037)
Log sales-to-employment ratio	5.117***	4.341***	2.235***	1.639***	-0.013
	(1.415)	(1.256)	(0.864)	(0.606)	(0.319)
Mean DV	51.24	41.70	12.36	3.97	7.09
N	748004	748004	748004	748004	748004
Adjusted R^2	0.29	0.29	0.38	0.17	0.51

Notes: The table regresses annual firm financial performance on the incidence of each variable pay type. Compustat measures are lagged one year, so pay reports in year t are assigned firm performance and characteristics from year $t-1$, have been converted to standardized z-scores within each year, and have had the top and bottom 0.5% truncated to control for outliers (excluding log employment and firm age). Regressions include a quadratic in years of experience along with firm-job title, metro-year, industry-year and gender fixed effects. Standard errors are clustered by firm. Significance levels: * 10%, ** 5%, *** 1%.

Table C6: Wage Variance and Variable Pay Intensity by Variable Pay Type

	Variance of log total pay	
	Full sample	Compustat
Receives cash bonus	0.005	0.013
	(0.007)	(0.016)
Receives stock bonus	0.101***	0.080***
	(0.012)	(0.016)
Receives profit sharing	-0.006	-0.031
	(0.009)	(0.030)
Receives sales commission	0.147***	0.143***
	(0.012)	(0.014)
Mean DV	0.134	0.151
Std. dev. DV	0.141	0.058
N (firms)	102759	3723
Adjusted R^2	0.04	0.14

Notes: The table relates residual variance in wages with the extent to which firms use each variable pay type. For all specifications, log total pay and each VP-related covariate are first residualized at the worker level by: a quadratic in years of experience and fixed effects for industry-year, metro-year, and gender. For VP-related measures, we calculate firm-level averages of the residuals. For the residuals of total pay, we calculate the firm-level variance. Regressions are weighted by the square root of each firms' sample size. Standard errors are clustered by industry. Significance levels: * 10%, ** 5%, *** 1%.

Table C7: Sales, Employment, and Productivity Volatility, 2011–2020

	Sales volatility	Employment volatility	Productivity volatility
Receives cash bonus	-0.020	-0.023**	-0.006
	(0.014)	(0.011)	(0.015)
Receives stock bonus	-0.000	0.028	0.001
	(0.032)	(0.019)	(0.026)
Receives profit sharing	-0.063**	-0.115***	-0.086***
	(0.027)	(0.014)	(0.029)
Receives sales commission	-0.133***	-0.070**	-0.138***
	(0.038)	(0.026)	(0.048)
Mean DV	0.126	0.114	0.123
Std. dev. DV	0.103	0.088	0.107
N	2328	2300	2296
Adjusted R^2	0.21	0.16	0.20

Notes: The table displays the association between a firms' volatility of sales, employment, and labor productivity and the extent to which the firm uses each type of variable pay. Each VP-related covariate is first residualized across workers — by a quadratic in years of experience, a vector of firm characteristics (the logarithm of assets, leverage ratio, firm age, employment, and Tobin's Q) at the beginning of the period and fixed effects for industry-year, metro-year, and gender — and then averaged by firm. Volatility regressions include industry fixed effects and the vector of firm characteristics. For the firm characteristics, we use each firm's 2010 levels; if all characteristics are unavailable, we instead use, if available, the 2009, 2008, 2011, 2012, or 2013 characteristics in that order. Sample is restricted to firms for which growth rates are available at least seven years. The top and bottom 0.5 percent of firms according to volatility are excluded. Regressions are weighted by the square root of each firm's sample size in residualizing the VP-measures. Standard errors are clustered by industry. Significance levels: * 10%, ** 5%, *** 1%.

D Worker Heterogeneity in Response to Shocks

This appendix investigates worker heterogeneity in responses to each shock. We consider two salient characteristics for partitioning workers. The first is one's own human capital, defining high (low) experience as years of experience above (at or below) the sample median. The second is one's position in the job ladder, where high (low) seniority reflects average years of experience among workers with the same industry-job title of at least (at most) six years. Table D1 explores local labor market movements, Table D2 a change in borrowing conditions, Table D3 exposure to the Financial Crisis, and Table D4 to annual firm performance. For each exercise, the coefficients reported are those obtained from estimating the regressions separately for each sub-sample.

Table D1: Pay Responsiveness to Labor Market Tightness, Worker Heterogeneity

	Log BP	Log VP	1(Receives VP)	VP share total pay	Conditional VP share total pay
Low experience	-0.214***	-0.945***	-0.005	-0.033	-0.072**
	(0.060)	(0.296)	(0.113)	(0.020)	(0.030)
High experience	-0.189**	-0.971	-0.086	-0.020	-0.068
	(0.091)	(0.602)	(0.140)	(0.050)	(0.072)
Low seniority	-0.168***	-0.772***	-0.013	-0.025	-0.055*
	(0.064)	(0.286)	(0.098)	(0.018)	(0.029)
High seniority	-0.252***	-1.219*	-0.005	-0.028	-0.091
	(0.092)	(0.706)	(0.168)	(0.066)	(0.080)

Notes: The table displays the relation between metropolitan area unemployment rates and employee compensation by characteristics of the worker. Regressions include a quadratic in years of experience along with firm-job title, metro, industry-year, and gender fixed effects. Standard errors are clustered by firm. Significance levels: * 10%, ** 5%, *** 1%.

Table D2: Pay Responsiveness to Credit Rating Changes, Worker Heterogeneity

	Log BP	Log VP	1(Receives VP)	VP share total pay	Conditional VP share total pay
Low experience	0.027***	0.072**	0.015	0.003	0.002
	(0.005)	(0.029)	(0.014)	(0.002)	(0.003)
High experience	0.009	0.091**	0.040***	0.007***	0.008**
	(0.006)	(0.040)	(0.015)	(0.002)	(0.004)
Low seniority	0.017***	0.060**	0.023*	0.003	0.003
	(0.005)	(0.028)	(0.014)	(0.002)	(0.003)
High seniority	0.011*	0.117***	0.025	0.010***	0.012***
	(0.006)	(0.039)	(0.017)	(0.003)	(0.004)

Notes: The table displays the relation between a credit rating of investment grade and employee compensation by characteristics of the worker. Stacked regressions include a quadratic in years of experience along with event-firm-job title, event-metro-year, event-industry-year and gender fixed effects. Standard errors are clustered by firm. Significance levels: * 10%, ** 5%, *** 1%.

Table D3: Worker Compensation and Exposure to Lehman Brothers, Worker Heterogeneity

	Log BP	Log VP	1(Receives VP)	VP share total pay	Conditional VP share total pay
Low experience	0.133	-3.513	0.469	-0.474**	-0.627**
	(0.431)	(2.585)	(1.305)	(0.226)	(0.274)
High experience	0.308	-8.033***	0.604	-1.081***	-1.276***
	(0.459)	(1.878)	(0.809)	(0.321)	(0.286)
Low seniority	0.266	-3.162	0.611	-0.449*	-0.604**
	(0.593)	(2.384)	(1.250)	(0.234)	(0.272)
High seniority	-0.359	-10.797***	0.179	-1.319***	-1.589***
	(0.679)	(2.740)	(0.964)	(0.379)	(0.387)

Notes: The table displays the coefficient on an indicator variable for the pay report occurs after 2008 interacted with a continuous measure for the fraction of a firm's portfolio overseen by Lehman Brothers by characteristics of the worker. Bank health data are from Chodorow-Reich (2014). Sample is restricted to firms in finance. Regressions include a quadratic in years of experience along with firm-job title, metro, year and gender fixed effects. Standard errors are clustered by firm. Significance levels: * 10%, ** 5%, *** 1%.

Table D4: Firm Financial Performance and Compensation, Worker Heterogeneity

	Log base pay				Log variable pay			
	Low		High		Low		High	
Standardized z-score	experience	seniority	experience	seniority	experience	seniority	experience	seniority
Stock return	0.059	0.067	0.091	0.044	0.981**	0.905***	1.232***	1.131***
	(0.065)	(0.067)	(0.071)	(0.067)	(0.384)	(0.312)	(0.403)	(0.430)
Log sales-to-employment ratio	0.054	0.419	0.947*	1.221**	10.132***	9.811***	11.143**	13.511***
	(0.599)	(0.604)	(0.548)	(0.572)	(3.238)	(2.938)	(4.493)	(5.074)
Mean DV	1109.66	1111.41	1151.15	1165.31	913.60	915.33	974.82	989.10
N	374771	507754	323976	239442	158468	216764	175357	141786
Adjusted R^2	0.81	0.78	0.82	0.75	0.67	0.66	0.68	0.66

Notes: The table displays regressions of annual firm financial performance on employee compensation by characteristics of the worker. All Compustat measures are lagged one year, so pay reports in year t are assigned firm performance and characteristics in year $t-1$. All variables have been converted to standardized z-scores within each year, and have had the top and bottom 0.5% truncated to control for outliers (excluding log employment and firm age). Regressions include a quadratic in years of experience along with firm-job title, metro-year, industry-year and gender fixed effects. Standard errors are clustered by firm. Significance levels: * 10%, ** 5%, *** 1%.

E Response to Shocks with Match Fixed Effects

This appendix re-estimates the effect of shocks on base and variable pay when incorporating worker-firm fixed effects in lieu of firm-job title fixed effects. See Table E1 for local labor market tightness, Table E2 for borrowing conditions, Table E3 for the 2008 Financial Crisis, and Table E4 for annual firm performance.

Table E1: Variable Pay Responsiveness to Tightness within the Match

	Log base pay			Log total pay				
	Full sample	Does not earn VP	Earns VP	Full sample	Earns VP	1(Receives VP)	Log VP	VP share total pay
Metro UR ratio	-0.523***	-0.493**	-0.446**	-0.585***	-0.527**	0.166	-0.774	-0.056
	(0.146)	(0.211)	(0.208)	(0.212)	(0.253)	(0.259)	(0.671)	(0.101)
Mean DV	1134.13	1116.88	1147.77	1144.21	1167.07	56.79	949.01	8.42
N	131918	40597	58915	131918	58915	131918	58915	131918
Adjusted R^2	0.90	0.88	0.91	0.89	0.90	0.49	0.80	0.69

Notes: The table displays the relation between metropolitan area unemployment rates and employee compensation. Regressions include a quadratic in years of experience along with worker-firm, metro, and industry-year fixed effects. Standard errors are clustered by firm. Significance levels: * 10%, ** 5%, *** 1%.

Table E2: Credit Rating Changes and Variable Pay within the Match

	Log BP	Log VP	1(Receives VP)	VP share total pay	Conditional VP share total pay
1(Investment grade)	0.002	0.089*	0.043*	0.014***	0.008
	(0.012)	(0.050)	(0.023)	(0.005)	(0.005)
N	4109341	2240216	4109341	4109341	2240216
Adjusted R^2	0.91	0.81	0.44	0.67	0.74

Notes: The table displays the coefficient on an indicator variable for a credit rating of investment grade from a stacked regression of instances where a firm switches between investment and speculative grade credit rating. This control sample is restricted to non-switching firms that, at some point over the sample period, had a credit rating on the boundary rungs of a switch, i.e., Ba1 or Baa3. For each switch, we consider a 10-year window: five years before, the year of, and four years after each switch. Regressions include a quadratic in years of experience along with event-worker-firm, event-metro-year, and event-industry-year fixed effects. Standard errors are clustered by firm. Significance levels: * 10%, ** 5%, *** 1%.

Table E3: Worker Compensation by Exposure to Lehman Brothers within the Match

	Log BP	Log VP	1(Receives VP)	VP share total pay	Conditional VP share total pay
Post-2008 x Lehman share of firm's portfolio	0.998	-8.785	-4.164**	-1.484*	-1.127
	(1.609)	(8.607)	(1.866)	(0.770)	(0.843)
Mean Lehman share	0.012	0.012	0.012	0.012	0.012
N	14036	8244	14036	14036	8244
Adjusted R^2	0.91	0.79	0.39	0.65	0.72

Notes: The table displays the coefficient on an indicator variable for the pay report occurs after 2008 interacted with a continuous measure for the fraction of a firm's portfolio overseen by Lehman Brothers. Bank health data are from Chodorow-Reich (2014). Sample is restricted to firms in finance. Regressions include a quadratic in years of experience, along with log assets, leverage ratio, firm employment, firm age, and Tobin's Q, and worker-firm, metro, and year fixed effects. Standard errors are clustered by firm. Significance levels: * 10%, ** 5%, *** 1%.

Table E4: Firm Financial Performance and Compensation within the Match

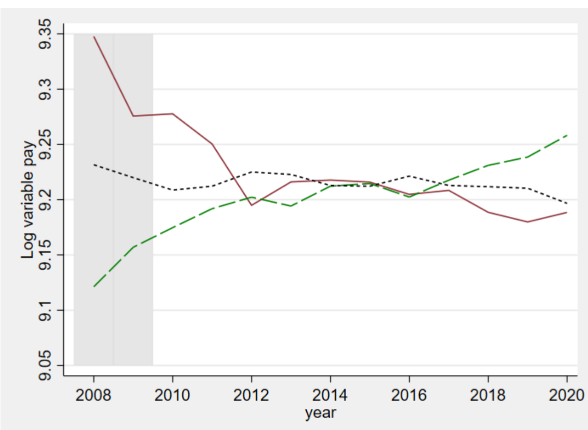
Standardized z-score	Log BP	Log VP	1(Receives VP)	VP share total pay	Conditional VP share total pay
Stock return	-0.017	0.761	-0.009	0.035	0.050
	(0.137)	(0.688)	(0.321)	(0.067)	(0.079)
Log sales-to-employment ratio	0.783	14.463**	11.201***	2.217***	1.839**
	(1.310)	(6.095)	(2.295)	(0.680)	(0.833)
Mean DV	1144.73	971.34	66.85	10.99	17.41
N	39262	21169	39262	39262	21169
Adjusted R^2	0.91	0.80	0.46	0.68	0.75

Notes: The table displays regressions of annual firm financial performance on employee compensation. All Compustat measures are lagged one year, so pay reports in year t are assigned firm performance and characteristics in year $t-1$. All variables have been converted to standardized z-scores within each year, and have had the top and bottom 0.5% truncated to control for outliers (excluding log employment and firm age). Regressions include a quadratic in years of experience along with worker-firm, metro-year, and industry-year fixed effects. Standard errors are clustered by firm. Significance levels: * 10%, ** 5%, *** 1%.

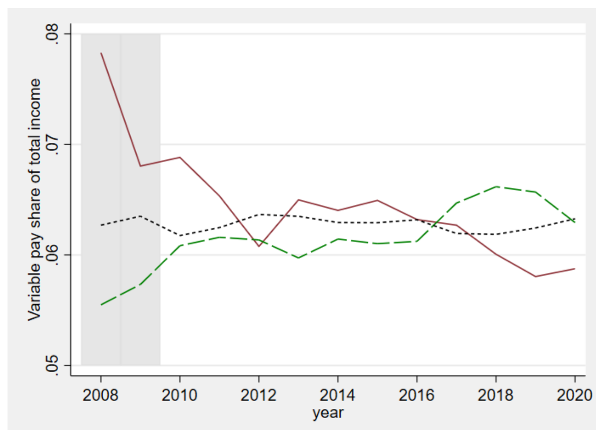
F Additional Results and Robustness

This appendix offers robustness for our findings. Figure F1 emphasizes the importance of including industry-time controls and motivates examining bank health after the 2008 Financial Crisis. Table F1 considers an alternative measure for proxying for workers' outside options, the ratio of the metropolitan area job vacancy rate to the metropolitan area unemployment rate, and alternative timing for assigning unemployment and job-vacancy-rate-to-unemployment-rate ratios. Table F2 offers causal estimates from shocks to borrowing conditions under an alternative control sample. Figure F2 plots the dynamic effect of bank health on base and variable pay, while Table F4 considers the effect of bank health on pay using an alternative control sample. Figure F3 presents the results from from a leave-out approach whereby 80 percent of the sample is used to predict firm-level variable-pay intensity for the remaining 20 percent. Table F5 considers the relation between variable-pay intensity and pay variance when variation between job titles is residualized out. Table F6 examines firm-level volatility under alternative specifications.

Figure F1: Industry-Specific Compensation and the Great Recession



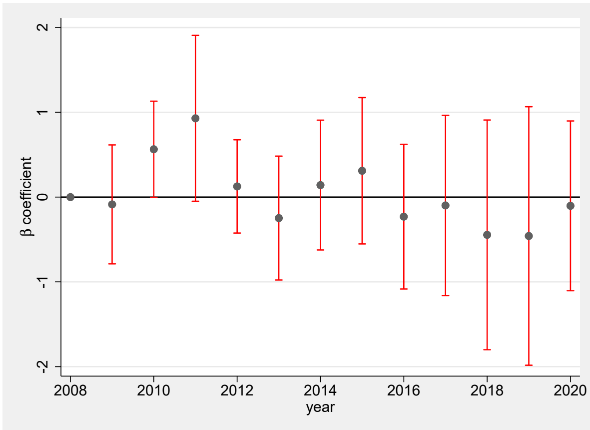
(a) Log variable pay



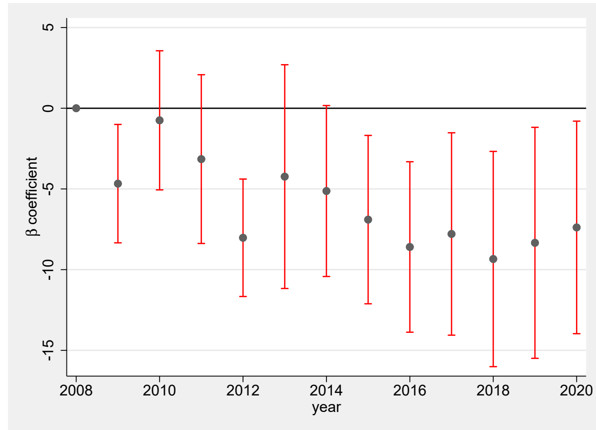
(b) VP share total pay

Notes: The figures reflect the evolution of pay for finance and information technology compared with other industries after the Financial Crisis. To account for aggregate trends and sample composition over time, each measure is first residualized by a quadratic in years of experience along with firm-job title, MSA, year, and gender fixed effects. Sample averages are added back to the residuals. Sample of other industries includes Accounting and Legal, Business Services, Health Care, Insurance, Manufacturing, Media, Retail, and Telecommunications.

Figure F2: Pay in Finance after the Financial Crisis by Exposure to Lehman Brothers



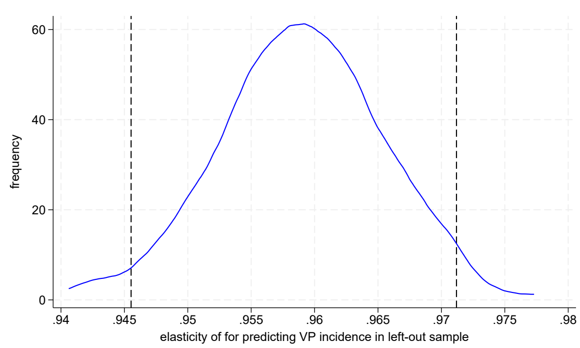
(a) Log base pay



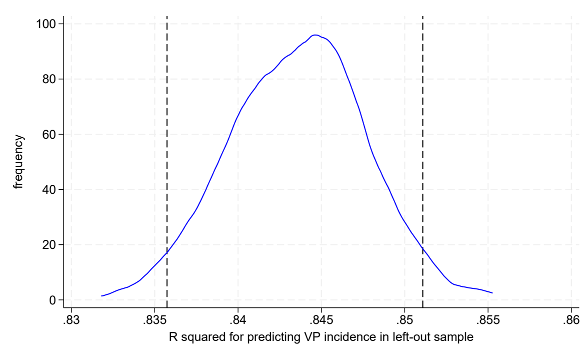
(b) Log variable pay

Notes: The Figure displays the coefficients on year dummies interacted with the fraction of the bank's portfolio exposed to Lehman Brothers. Bank health data are from Chodorow-Reich (2014). Sample is restricted to firms in finance. Regressions include a quadratic in years of experience along with firm-job title, metro, year and gender fixed effects. Standard errors are clustered by firm. Red vertical bars indicate 95% confidence intervals around each point estimate.

Figure F3: Predicting Firm-Specific Variable Pay Intensity, Repeated 80-20 Sample Splits



(a) Distribution of prediction coefficient



(b) Distribution of adjusted R^2

Notes: The figures reflect the distribution of the regression coefficient and the adjusted R^2 from our repeated exercise for testing the stability of our estimates for variable-pay intensity. Our procedure is the following: (i) randomly partition our sample into two sets, one with 80 percent of the sample, the other with the remaining 20 percent, (ii) within each sub-sample, obtain an estimate for each firm's variable-pay intensity, and (iii) regress the estimates from the 20 percent sample on those from the 80 percent sample. We repeat this procedure 500 times. Vertical blue bars represent 95% confidence intervals.

Table F1: Robustness in Choice of Timing for Labor Market Tightness Measure

	Log base pay			Log total pay				
	Full sample	Does not receive VP	Receives VP	Full sample	Receives VP	1(Receives VP)	Log VP	VP share total pay
	Panel A: Arithmetic mean of lagged and contemporaneous UR							
Metro UR	-0.185***	-0.159**	-0.220***	-0.223**	-0.311**	-0.010	-0.901**	-0.027
	(0.068)	(0.064)	(0.074)	(0.098)	(0.125)	(0.096)	(0.414)	(0.028)
	Panel B: Contemporaneous UR							
Metro UR	-0.026	-0.003	-0.053	-0.047	-0.100*	0.001	-0.430**	-0.015
	(0.030)	(0.029)	(0.036)	(0.042)	(0.057)	(0.049)	(0.195)	(0.013)
	Panel C: Lagged UR							
Metro UR	-0.443***	-0.480***	-0.419***	-0.478***	-0.514***	-0.032	-1.049*	-0.024
	(0.098)	(0.099)	(0.094)	(0.140)	(0.170)	(0.113)	(0.553)	(0.038)
	Panel D: Arithmetic mean of lagged and contemporaneous VR-UR ratio							
Metro VR-UR ratio	3.342***	3.738***	3.046***	3.424***	2.880***	0.763	4.042	0.099
	(0.817)	(0.974)	(0.744)	(0.942)	(0.992)	(0.632)	(3.222)	(0.150)
	Panel E: Contemporaneous VR-UR ratio							
Metro VR-UR ratio	2.668***	2.931***	2.383***	2.706***	2.356***	0.246	3.483	0.047
	(0.633)	(0.791)	(0.567)	(0.729)	(0.760)	(0.465)	(2.300)	(0.114)
	Panel F: Lagged VR-UR ratio							
Metro VR-UR ratio	2.731***	3.134***	2.538***	2.817***	2.270**	0.970	2.848	0.103
	(0.810)	(0.921)	(0.759)	(0.933)	(0.970)	(0.626)	(3.185)	(0.144)

Notes: The table displays the relation between labor market tightness and employee compensation, comparing results among six separate choices for the labor market conditions an employee faces. They are: i) the prevailing unemployment rate the month the pay report is submitted (panel B), ii) the unemployment rate 12 months prior (panel C), iii) the average of the two (panel A), iv) the prevailing ratio of the vacancy rate to the unemployment rate the month the pay report is submitted (panel E), v) the ratio of the vacancy rate to the unemployment rate 12 months prior (panel F), and vi) the average of the two (panel D). Regressions include a quadratic in years of experience along with firm-job title, industry-year, metro, and gender fixed effects. Standard errors are clustered by firm. Significance levels: * 10%, ** 5%, *** 1%.

Table F2: Credit Rating Changes, Alternative Control Sample

	Log BP	Log VP	1(Receives VP)	VP share total pay	Conditional VP share total pay
1(Investment grade)	0.009*	0.066**	0.028**	0.005**	0.006*
	(0.005)	(0.033)	(0.012)	(0.002)	(0.003)
N	5450611	2330413	5450611	5450611	2330413
Adjusted R^2	0.84	0.67	0.28	0.47	0.60

Notes: The table displays the coefficient on an indicator variable for a credit rating of investment grade from a stacked regression of instances where a firm switches between investment and speculative grade credit rating. This control sample is restricted to non-switching firms that, at some point over the sample period, had a credit rating on the boundary rungs of a switch, i.e., Ba1 or Baa3. For each switch, we consider a 10-year window: five years before, the year of, and four years after each switch. Regressions include a quadratic in years of experience along with event-firm-job title, event-metro-year, event-industry-year and gender fixed effects. Standard errors are clustered by firm. Significance levels: * 10%, ** 5%, *** 1%.

Table F3: Credit Rating Changes, Looser Fixed Effects

	Log BP	Log VP	1(Receives VP)	VP share total pay	Conditional VP share total pay
1(Investment grade)	0.000	0.059***	0.018*	0.006***	0.007***
	(0.007)	(0.021)	(0.010)	(0.002)	(0.002)
N	75444053	39181592	75444053	75444053	39181592
Adjusted R^2	0.48	0.34	0.15	0.17	0.21

Notes: The table relates an investment grade credit rating to pay without controlling for job title.Regressions include a quadratic in years of experience along with event-firm, event-metro-year, event-industry-year and gender fixed effects. Standard errors are clustered by firm. Significance levels: * 10%, ** 5%, *** 1%.

Table F4: Exposure to Lehman Brothers, Alternative Control Sample

	Log BP	Log VP	1(Receives VP)	VP share total pay	Conditional VP share total pay
Post-2008 x Lehman share of firm's portfolio	0.048	-4.168**	0.104	-0.657***	-0.702***
	(0.404)	(1.891)	(0.860)	(0.216)	(0.211)
Mean Lehman share	0.012	0.013	0.012	0.012	0.013
N	153801	85911	153801	153801	85911
Adjusted R^2	0.84	0.63	0.23	0.41	0.57

Notes: The table displays the coefficient on an indicator variable for the pay report occurs after 2008 interacted with a continuous measure for the fraction of a firm's portfolio overseen by Lehman Brothers. Data on bank health are from Chodorow-Reich (2014). Sample is restricted to only public firms and subsidiaries in finance, which we observe from a Glassdoor lookup table that contains such information on each employer. Regressions include a quadratic in years of experience along with firm-job title, metro, year and gender fixed effects. Standard errors are clustered by firm. Significance levels: * 10%, ** 5%, *** 1%.

Table F5: Variance of Total Pay and Variable Pay Intensity, Looking Within Job Titles

	Full sample		Compustat sample	
Receives VP	0.011***		0.015*	
	(0.003)		(0.008)	
VP share total pay		0.383***		0.367***
		(0.019)		(0.033)
Mean DV	0.081	0.081	0.077	0.077
Std. dev. DV	0.094	0.094	0.037	0.037
N (firms)	62508	62508	3076	3076
Adjusted R^2	0.02	0.05	0.08	0.16

Notes: The table relates residual variance in total pay and firms' use of variable pay. Log total pay and each variable-pay measure are first residualized at the worker level by: firm characteristics, a quadratic in years of experience and fixed effects for job title, industry-year, metro-year, and gender. Firm characteristics are log firm age (Full sample) and log assets, leverage ratio, firm age, employment, and Tobin's Q (Compustat sample). Regressions are weighted by the square root of each firms' sample size. Standard errors are clustered by industry. Significance levels: * 10%, ** 5%, *** 1%.

Table F6: Sales, Employment, and Productivity Volatility, Alternative Specifications

	Sales volatility		Employment volatility		Productivity volatility	
Panel A: Accounting for differences betwen job titles, 2011–2020						
Receives VP	-0.035		-0.049***		-0.033	
	(0.021)		(0.013)		(0.026)	
VP share total pay		-0.197		-0.214**		-0.128
		(0.216)		(0.081)		(0.221)
Std. dev. DV	0.103	0.103	0.088	0.088	0.107	0.107
N	2327	2327	2300	2300	2296	2296
Panel B: Annual growth rates, 2008–2020						
Receives VP	-0.026		-0.035***		-0.025	
	(0.020)		(0.010)		(0.022)	
VP share total pay		-0.153		-0.072		-0.107
		(0.138)		(0.065)		(0.165)
Std. dev. DV	0.100	0.100	0.084	0.084	0.112	0.112
N	2167	2167	2143	2143	2140	2140
Panel C: Three-year growth rates, 2008–2020						
Receives VP	-0.066**		-0.061**		-0.059*	
	(0.027)		(0.025)		(0.032)	
VP share total pay		-0.279*		-0.202		-0.229
		(0.157)		(0.132)		(0.139)
Std. dev. DV	0.169	0.169	0.157	0.157	0.154	0.154
N	2164	2164	2133	2133	2126	2126

Notes: The table displays the association between a firm's volatility in sales, employment, and labor productivity (annually in Panels A and B and over three-year periods in Panel C) and the extent to which the firm uses variable pay. Each VP-related covariate is first residualized across workers — by a quadratic in years of experience, a vector of firm characteristics at the beginning of the period (the logarithm of assets, leverage ratio, firm age, employment, and Tobin's Q) and fixed effects for industry-year, metro-year, and gender — and then averaged by firm. Panel A additionally includes job title fixed effects when residualizing. Regressions include industry fixed effects and the vector of firm characteristics at the beginning of the period. For the firm characteristics, we use each firm's 2010 levels in Panel A and 2007 levels in Panels B and C; if all characteristics are unavailable, we instead use, if available, the 2009, 2008, 2011, 2012, or 2013 characteristics in that order for Panel A, and the 2006, 2005, 2008, 2009, or 2010 characteristics in that order for Panels B and C. We include a fixed effect for the year from which the characteristics are used. Sample is restricted to firms for which growth rates are available for at least seven years. The top and bottom 0.5 percent of firms according to growth or volatility are excluded. Regressions are weighted by the square root of each firm's sample size in residualizing the VP-measures. Standard errors are clustered by industry. Significance levels: * 10%, ** 5%, *** 1%.

Table F7: Layoff Intensity through WARN Notices, Sensitivity Check Assigning Zero WARN Notices to Unmatched Firms

	Fraction of employees laid off	
Receives VP	-0.001**	
	(0.001)	
VP share total pay		-0.005***
		(0.002)
Mean DV	0.002	0.002
Std. dev. DV	0.016	0.016
N	18744	18744
Adjusted R^2	0.09	0.09

Notes: The table relates the fraction of a firm's employees laid off through WARN notices each year and the extent to which the firm uses variable pay, incorporating unmatched Compustat firms and assuming they produce zero WARN notices each year. Receives VP and VP share total pay are first residualized across workers by a quadratic in years of experience, a vector of firm characteristics (the logarithm of assets, leverage ratio, firm age, employment, and Tobin's Q) at the beginning of the period and fixed effects for industry-year, metro-year, and gender, and then averaged by firm. For the firm characteristics, we use each firm's 2010 levels; if all characteristics are unavailable, we instead use, if available, the 2009, 2008, 2011, 2012, or 2013 characteristics in that order. We include a fixed effect for the year from which the characteristics are used. Regressions on WARN data include industry-year fixed effects and the same vector of firm characteristics, and are weighted by the square root of each firm's sample size in residualizing the VP-measures. Standard errors are clustered by firm. Significance levels: * 10%, ** 5%, *** 1%.

Table F8: Layoff Intensity through WARN Notices and Employment Growth

	Annual growth in employment		
Number of WARN notices	-0.004***		
	(0.001)		
Number of workers laid off		-0.000***	
		(0.000)	
Ln(Number of workers laid off + 1)			-0.012***
			(0.001)
Mean DV	0.024	0.024	0.024
Std. dev. DV	0.232	0.232	0.232
Mean WARN measure	1.065	120.495	1.293
Std. dev. WARN measure	6.352	943.922	2.325
N	7454	7454	7454

Notes: The table displays the association between three different measures of layoff intensity through WARN notices in year t and growth in firm employment between years $t-1$ and t. Standard errors are clustered by firm. Significance levels: * 10%, ** 5%, *** 1%.

Internet Appendix References

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