# *Downsizing, trust, and worker morale**

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## Abstract

Downsizing can reduce the morale of remaining employees. We argue that the resulting lower motivation stems from a reduced effectiveness of gift-exchange incentives, in particular if layoffs cannot be readily justified. We provide empirical support for this claim using administrative data on workers that survive mass layoffs (MLs) in Austria. We find evidence that MLs increase shirking by up to 14 percent, but that this effect is less pronounced if a justification for layoffs seems easier to convey to workers. Moreover, we show that the higher shirking is driven by workers with low perceived job continuation probabilities, those in low-wage firms, in sectors other than manufacturing, and by workers on the tails of the age distribution. This is consistent with a theoretical model of a dynamic employment relationship, in which incentives to exert effort are provided by a combination of gift-exchange and relational contracts. There, the reduced effectiveness of gift-exchange incentives following layoffs yields stronger effort reductions if the expected future relationship surplus is small. Downsizing can reduce worker morale, especially if workers do not perceive layoffs as justified.

*JEL Classification*:
*Keywords:* Downsizing, worker morale

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# I. Introduction

Downsizing is supposed to reduce organizational slack, however often causes substantial turmoil in firms. In particular if survivors of layoffs are not convinced that the layoff was necessary, but instead suspect a mere cost-cutting activity at the expense of employees, their morale might be negatively affected. A huge amount of anecdotal evidence (mostly from the business press) has identified the potential for a significant detrimental impact of layoffs. Systematic or causal evidence is rare, though, that negative consequences for the morale and motivation of remaining employees indeed are a widespread phenomenon. [1]

In this paper, we causally identify an adverse effect of mass layoffs (MLs) on the motivation of survivors based on the universe of employees in an Austrian state. We argue that this result stems from a reduced effectiveness of gift-exchange incentives (Akerlof 1982), in particular if the justification for layoffs can be questioned. To derive a more specific idea about the consequences of layoffs on survivors, we develop a theoretical model of a dynamic employment relationship, in which incentives are provided by a combination of gift-exchange and informal "direct" (i.e., pay-for-performance) incentives. As predicted by this theoretical model, our empirical analysis confirms that the negative consequences of layoffs on the motivation of survivors are more pronounced in uncertain employment relationships, low-wage firms, sectors other than manufacturing, and for older and younger (compared to medium-aged) employees.

Our starting point is the gift-exchange paradigm of Akerlof (1982). It states that employees are incentivized to exert high effort if they are treated well (for example with a high wage or good working conditions; see DellaVigna 2009, or Camerer & Weber 2013, for surveys of evidence). The effectiveness of gift-exchange incentives is shaped by employees' social preferences. Those are not only determined by their personal characteristics, but also by the history of the employment relationship and the environment embedding it. Thereby, we follow recent evidence that norms and social preferences are endogenous and respond to circumstances (Kimbrough & Vostroknutov

[1] The experimental literature finds large productivity losses if a co-worker is dismissed in an experiment, e. g. Drzensky & Heinz (2016) or Heinz et al. (2017)

2016; Peysakhovich & Rand 2016; Krupka et al. 2017). More precisely, we assume that layoffs reduce survivors' willingness to engage in gift exchange with their employer. We do not take a stand on the underlying reason, but acknowledge that several causes might exist. For example, purely psychological reasons could result in a loss of trust in and less sentiment towards the employer; alternatively, the reduced responsiveness to gift-exchange incentives could serve as a commitment device for the employer (who has superior knowledge about the firm's future prospects) to only conduct layoffs when they are necessary (see Fahn & Klein 2019, for the optimality of such a mechanism).

As a consequence, we predict employees to reduce their effort if their employer conducts layoffs. This effect is permanent and might even become more pronounced over time, once the employer has accordingly adjusted the compensation scheme. Moreover, based on the aforementioned potential reasons for a reduction of an employee's responsiveness to gift-exchange considerations, we expect it to be less pronounced if layoffs seem justified, which, for example, might be the case for firms in industries with worse future prospects.

We test these predictions using administrative data from Austria. In particular, we consider sick leave takeup of workers that remain in firms that underwent a ML between 1998 and 2014. Because surviving a ML may be endogeneous we construct counterfactuals using workers who survive a ML themselves, but a few years in the future. This allows us to compare otherwise similar workers that differ only in the timing of the MLs they are exposed to. As a proxy for shirking, we use sick leaves taken on bridge days and days with good weather. Using flexible difference-in-difference regressions, we find that surviving a ML increases sickness days by up to 14 percent.

Having identified negative consequences of layoffs on survivors' motivation, we try to get a better idea of which kinds of employment relationships are more severly affected, and why. Thereby, we take the dynamic and incomplete nature of employment relationships into account and develop a theoretical model (based on Fahn 2021) in which a risk-neutral employer ("principal", "she") and a risk-neutral employee ("agent", "he") interact repeatedly over an infinite time horizon. They share a discount factor $\delta$, which not only captures time preferences, but also the perceived probability with which the relationship is continued. In every period, the agent's costly effort benefits the principal. As before, a generous wage payment lets the agent reciprocate by exerting higher effort. In addition, "direct" incentives are feasible by which the agent is rewarded with a bonus after exerting effort. Since effort is observable but not verifiable, though, a self-enforcing relational contract must be used for the latter. This implies that any promise to pay a bonus needs to be credible, which depends on the future profits she expects from the continued relationship.

Therefore, the principal has two means to provide incentives. She can pay a generous up-front wage (by generous we mean a wage extending payments the principal is supposed to make anyway), or promise a bonus after the agent has exerted effort. The former is called "reciprocity-based incentives", the latter "relational incentives". The optimal mix of incentives takes into account that reciprocity-based incentives pay the agent a rent but reduce his effective effort costs, whereas relational incentives allow the principal to keep the total surplus for herself. This optimal mix is feasible if the future is valuable enough for the principal to credibly promise her preferred bonus, for example if the discount factor $\delta$ is sufficiently high. Otherwise, i.e., if $\delta$ is so small that the use of relational incentives is restricted, effort is lower and a higher weight put on reciprocity-based incentives.

Now, layoffs reduce the agent's preferences for reciprocity. This decreases equilibrium effort, and the extent of this effort reduction depends on the size of $\delta$. If $\delta$ is sufficiently high for the principal to not be constrained when using relational incentives, the effect is moderate. Then, only reciprocity-based incentives become less effective. If $\delta$ is small, diminished (current and future) profits also constrain the effectiveness of relational incentives, and the resulting effort reduction is more pronounced.

This lets us predict stronger adverse reactions to layoffs in situations where the discount factor appears to be smaller or where other factors constrain the use of relational incentives.

First, we argue that workers whose observable characteristics indicate a higher propensity to leave the firm (or who are more similar to workers who actually left) generate less surplus in expectation, thus their effort reduction following layoffs should be particularly strong. To test this prediction, we estimate, for all Austrian workers, a propensity score that reflects the probability they quit their job in a given year, conditional on a flexible set of lagged worker and firm characteristics. When we match these scores to the survivors in our sample, we find that, indeed, those with above-median quitting propensities react particularly strong to the ML.

Second, firms paying higher wages than otherwise similar enterprises might indicate a more distinctive long-term orientation and thus be less constrained in providing relational incentives. Then, but also if the higher wages stem from a higher inherent productivity or a more reciprocal workforce, we would expect layoffs to have smaller consequences on effort. We provide empirical evidence in support of this prediction by estimating results separately for firms with below and above-median (Abowd et al. 1999, AKM) firm fixed effects, which measure wage premia paid by the firm holding worker characteristics constant. We find that the increase in shirking triggered by MLs is much stronger in low-wage firms where long-term orientation is less likely.

Third, the constraints on direct incentives are based on the inability to use formal, court-enforceable, contracts to motivate the agent. If, however, the agent's contribution to firm value can readily be measured objectively, the principal is not restricted in promising her preferred bonus. We argue that the use of formal incentives is rather possible in manufacturing, and thus expect the adverse effects of layoffs on effort to be less pronounced in this compared to other sectors. This is also what we find in our data. If we estimate our DD models by industry sectors, we find that MLs have sizable effects on shirking only in the service but not in the manufacturing sector.

Fifth, we take into account that the perceived future surplus generated in an employment relationship depends on its remaining tenure. This is limited for older workers who are close to retirement, but – in expectation – also for young workers whose match quality for their current job still has to be detected. Therefore, we predict the negative consequences of layoffs on effort to be smallest for workers of intermediate age, who have been revealed to be of sufficient match quality and whose retirement is still sufficiently far away. To test this, we separately estimate our models for four age groups. Here we find that effects are most pronounced at the tails of the age distribution, wheras middle-aged workers respond less to MLs in terms of effort.

## II. The Negative Effect of Dowsizing on Survivors' Motivation – Evidence

First, we causally identify a permanent negative effect of downsizing on the motivation of survivors. To do so, we study workers who remain in firms that underwent a mass layoff (ML) between 1998 and 2014 in Upper Austria. We use sick leave takeup as a proxy for motivation, focusing on leaves that cover bridge days or days with good weather.[2] We explore whether sick leave take up increases permanently after MLs, and whether any effect is short- or long-term. To construct valid counterfactuals, we use workers who survive a ML themselves, but a few years in the future, as a control group.[3] This allows us to compare otherwise similar workers that differ only in the timing of the MLs they are exposed to. We use this strategy because ML survivors may be selected, so we cannot compare them with workers who are not exposed to MLs. In this subsection, we first discuss the institutional setting and our data and summarize our difference-in-differences approach in section II.2. In section II.3, we present our baseline estimates.

### II.1. Institutional setting and data

Austria is an ideal setting to study worker morale effects of downsizing. The Austrian labor market is flexible, with relatively little protection against dismissal and high turnover rates for European standards (Böheim 2017). Labor contracts can be terminated unilaterally without cause, provided that a statutory notice period is observed. At the same time, however, workers have access to universal healthcare and paid sick leave, which makes it easier to shirk compared to settings where workers may incur income losses when taking leaves.

Sick employees are entitled to at least 6 to 12 weeks of full employer-provided wage continuation pay, where the maximum length increases with job tenure.[4] Sickness certificates are issued almost

[2] Bridge days are single working days between a public holiday (usually on a Thursday or Tuesday) and the weekend. Workers sometimes take these days off to save vacation days.

[3] This is in the spirit of Fadlon & Nielsen (2019) who compare families that experience health shocks at different times. Ahammer et al. (2020) previously employed this approach to mass layoffs.

[4] After this period of full reimbursement, workers receive half their salary for another 6 to 12 weeks, depending on job tenure, and one quarter of the full salary for another 4 weeks. The cost for longer sick leaves are typically shared

exclusively by general practitioners (GPs), who act as informal gatekeepers in the healthcare system. Most firms require such certificates even for 1-day sick leaves, but some firms allow employees to stay home for a maximum of 3 days without producing a certificate.[5] To ensure privacy, certificates must not reveal a medical diagnosis.

Our main data source is the *Austrian Social Security Database* (ASSD, Zweimüller et al. 2009), which is an employer-employee panel used to calculate pension benefits. The ASSD contains information on employment histories, wages, and a limited set of demographic information. We identify ML events based on thresholds mandated by the Austrian unemployment office's early reporting system for MLs.[6] In particular, we set up a quarterly panel with the number of employees in each firm. If a reduction in firm size between two quarters exceeds the early layoff reporting thresholds, we assume this constitutes a ML event. In line with other papers in the literature, we drop events where a larger number of employees moves to the same plant (this is likely a change in plant identifiers or a corporate spinoff and not a true ML) and we exclude seasonal industries, such as construction or hospitality.

Our final sample comprises all workers in Upper Austria, one of the nine Austrian federal states with 1.5 million residents. For Upper Austria, we can link the ASSD with medical claims data from the *Upper Austrian Health Insurance Fund* (UAHIF). This is the main health insurance provider with around 1 million members, including all private-sector employees apart from those in the mining and railway industry. The UAHIF database has individual-level data on sick leave spells for all employees. In our baseline model, the outcome is the aggregate number of days of sick leave in a quarter. We also use two other measures that presumably better reflect shirking: days of sick leave that cover bridge days per quarter (and sick days covering Mondays or Fridays) and days of sick leave on good weather days per quarter.[7]

between the employer and the social security provider.

[5]We discuss what this means for the interpretation of our estimates in detail below.

[6]Firms have to notify the unemployment office prior to larger layoffs. The law defines MLs as a layoff of 5 or more employees in firms with 10 to 99 employees, at least 5 percent of employees in firms with 100 to 599 employees, and at least 30 in firms with 600 or more employees.

[7]The Austrian climate is rather mild, hence it is unlikely that temperature increases will systematically lead to sick leaves due to medical reasons, as it has been shown for, e.g., India (Somanathan et al. 2021).

For the latter, we match daily data on temperature, snowfall, and sunshine duration on the zip code level from the *Austrian National Meterological Service* to our data. Good weather is defined, on a daily basis, as (i) temperatures exceeding 20 percent of the monthly mean, or 25 degrees for three consecutive days in quarters 2 and 3, (ii) the period of three days after at least 5 cm fresh snow in quarters 1 and 4, and (iii) sunshine hours exceeding 90 percent of the respective months maximum sunshine duration in any quarter. Sick leave days that coincide with good weather days as defined by (i) or (ii) are referred to as 'warm/snow'. We also include an alternative measure named 'warm/snow/sun' to refer to sick leave days that fall on any of the definitions (i), (ii), or (iii).

To illustrate how we construct our data, suppose there is a ML at time $t = 0$. Our control group consists of all MLs occurring between $t = 7$ and $t = 10$. However, we assume that the 'placebo' ML for the control group is also at $t = 0$, so we observe both treatment and control group workers in the same calendar quarters—that is, between $t = -6$ and $t = 6$. We note two things here. First, by construction, our control group workers have to be employed for at least 20 quarters in the same firm (e.g., for a control ML in $t = 7$; from $t = -6$ to $t = 13$, counting also $t = 0$). To maintain a consistent sample definition, we impose the same tenure requirement on the treatment group. Second, the pre-ML period of a control group ML overlaps with the post-ML period of the treatment group ML, and one ML can be both in the treatment and the control group, but not at the same time. Similar to Fadlon & Nielsen (2019), who compare families that experience the same health shock a few years apart, we adopt this sample definition to maximize the number of control group MLs to draw from. This would be a problem if workers were to reduce sick leave takeup prior to the ML, which would bias our estimates away from zero. However, we find no evidence for such behavior in our data (see Figure 7, where we plot sick leave takeup trends relative to the ML for both the treatment and the control group). Our final sample has 42,703 worker-ML pairs in the treatment group and 126,775 worker-ML pairs in the control group.

### II.2. Methodology

We estimate the effect of surviving a ML on sick leave takeup using difference-in-difference (DD) models,

$$S_{it} = \psi_i + \theta_t + \beta ML_{it} + X_{it}\gamma + \varepsilon_{it}, \tag{1}$$

where $S_{it}$ is days of sick leave in quarter $t$, $\psi_i$ are worker $\times$ ML fixed effects, $\theta_t$ are calendar quarter fixed effects, $ML_{it}$ is one for all workers who survive a ML in quarter $t$ and zero else, and $X_{it}$ is a set of time-variant controls including worker age and tenure. Our coefficient of interest is $\hat{\beta}$, which measures the average treatment effect of surviving a ML on sick leave takeup. Additionally, we estimate flexible DD that allow the ML effect to vary over time,

$$S_{it} = \psi_i + \theta_t + \sum_{k=-6 \,|\, k\neq 0}^{6} \beta_k(\tau_k \times ML_{it}) + X_{it}\gamma + \varepsilon_{it}, \tag{2}$$

where $\tau_k = \mathbf{1}\{t = k\}$, $k = -6, \ldots, -1, 1, \ldots, 6$ indicates quarters relative to the ML in $t = 0$, and $(\beta_{-6}, \ldots, \beta_{-1}, \beta_1, \ldots, \beta_6)$ are period-specific treatment effects. Our standard errors are clustered at the firm level.

For the DD models to be identified, we require the difference in sick leave takeup between the treatment and control group to remain constant absent the ML. We show evidence in support of this assumption below. Most importantly, we test the estimated pre-ML coefficients from equation (2), $(\beta_{-6}, \ldots, \beta_{-1})$, against zero for all our outcomes. If these tests are insignificant, we have reason to believe that workers do not systematically change sick leave takeup prior to the ML.

### II.3. Layoffs and Motivation

Table 1 shows our baseline results. We present both the average treatment effect from equation (1), which is the change in sick leave takeup between the post-ML and the pre-ML period, as well as dynamic effects from the model in equation (2). All coefficients are reported as percentage effects relative to the pre-ML sample mean. On average, we find that a downsizing episode increases sick leave takeup by 8 percent. This is a sizable effect, considering that this increase spans a 6-quarter period after the downsizing event. In the first quarter after the ML, sick leaves increase by 5.9 percent.

This effect clearly is permanent and even seems to become stronger over time. Six quarters after the ML, the increase in sick days is 20 percent. This speaks against simple psychological explanations, such as anger or fear, which would likely lead to an initial hike in sick leave takeup that fades out at some point. Instead, we think it is more likely that we see longterm effects damaging the worker-firm relationship, such as erosion of trust. In none of the specifications we find evidence for pre-trends, as indicated by the $F$-test which jointly tests the pre-ML coefficients $(\beta_{-6}, \ldots, \beta_{-1})$ against zero.

Since overall sick days do not necessarily point at shirking, in a next step we consider sick leave takeup on bridge days and around weekends. On such days, the benefit of a day off is particularly large, because workers can stay away from work for an extended period of time without taking holidays. This increases the incentives for shirking tremendously at the margin. Indeed, we find that sick days spanning bridge days increase by almost twice as much as overall sick leaves do, and the effect again becomes stronger over time. In quarter 6, our estimates suggest a 30 percent increase in shirking behavior.

Similarly, we find strong effects of downsizing on sick leaves that span good weather days. The idea here is similar; on days with particularly good weather the opportunity cost of going to work are high and the incentive to shirk is larger than normal. Depending on our definition of good weather, we see that sick days increase by 11 to 13.5 percent. As before, these effects increases steadily to as much as 34 percent in quarter 6. We interpret these results as clear signs that motivation of the workers has suffered following the downsizing episode. One interpretation could be that motivational losses account for at least a 4 percent increase of sick leaves, which is the difference between the estimate on overall days and the estimate on either bridge days or nice weather days.

Table **??** and Figure **??** show results by sex. In general, females react stronger after downsizing with an average effect of around 11 percent. For males, the corresponding estimate is 6 percent.

This is particularly so for bridge days, with the being effect 26 percent for women and 8 percent for men. Nice weather, in contrast, seems to trigger absenteeism reactions to downsizing more for men. In all cases, effects increase over time.

### II.4. Layoffs and Reciprocity

So far, we have shown that layoffs can permanently lower the motivation of survivors. In particular the permanent effect is remarkable, because simple psychological theories, like anger or shock, would apparently not produce such long-term reactions of employees.

In the next step, we explore the prevailing hypothesis that workers' fairness concerns and changes in gift-exchange considerations cause such outcomes ("indirect reciprocity"; see...). Alternatively, one might argue that a lower motivation merely is the optimal response to a lower productivity of workers which caused the layoffs in the first place. The "indirect reciprocity" hypothesis would involve stronger reactions to layoffs that could be perceived as a means to cut short-run costs at the exponse of employees. Put differently, if layoffs seem justified given a firm's environment and salient characteristics, the effect on employees' motivation should be less pronounced. To the contrary, if layoffs and lower motivation both were the manifestion of a reduced worker productivity, we would not expect to observe any differences based on whether layoffs appear justified or not.

First, we argue that a firm's environment is important for the perception of layoffs, and the (market) conditions it faces. For example Charness & Levine (2000) find that layoffs are perceived as less unfair if product demand has gone down. Love & Kraatz (2009) quote executives with "*When you've just reported a $1.5 billion net loss, nobody wonders why you have to cut back.*" In contrast, "*the toughest thing to explain is why you need to trim your sails when your markets are booming*". Moreover, Brockner (1992), p. 10, states "*If other firms within the organization's reference groups also are downsizing, then survivors are more likely to believe that the layoff is justified.*" Taking this into account, we postulate that firms that are active in a declining market should experience less adverse reactions. If, to the contrary, a reduced productivity of employees is the cause of both, layoffs and a lower motivation, the latter might even be more pronounced in declining industries.

Second, observable characteristics could indicate that a firm is in serious trouble and might have to close down a plant. Then, layoffs are likely to perceived as an adequate response to at least save the remaining jobs. Therefore, we would argue that negative reactions of survivors to layoffs are less pronounced if their plant is in apparent danger to be closed down.

This yields

**Prediction 1:** The negative effect of layoffs on the motivation of survivors is smaller in declining industries, and if the perceived likelihood of plant closure is large.

Figure **??** replicates our empirical results from above for situations where it is likely that workers perceive layoffs to be more or less justified. First, we compare declining and non-declining regional industries, where an industry is defined as declining if the number of firms shrank during the two years prior to the ML. If we run our DD regressions separately for both subsamples, we find that our downsizing effects are driven by non-declining sectors, where justification for the layoff is less obvious. For none of our outcomes the effect for declining sectors is statistically significant. We also consider effects by firm size and ML size, but here the results are inconclusive.

FURTHER PREDICTION: If firms first fires some employees but then hires new workers who might even be cheaper, the negative effect on motivation should be more pronounced.

## III. Incentives in Dynamic Employment Relationships

So far, we have shown that layoffs have a permanent negative effect on the motivation of survivors. Moreover, our results on "justified layoffs" (which confirm earlier results derived in previous literature) indicate that this is caused by a transformed relationship of a firm with its employees, with social ties having weakened. Then a reduced sentiment for their employer would decrease employees' responsiveness to gift-exchange incentives (Akerlof 1982).

In the following, we explore further implications of the reduced effectiveness of gift-exchange incentives, incorporating that incentives in which performance is directly rewarded are also commonly used to motivate workers. We further take into acount that important aspects of an employee's performance often are not verifiable and therefore subject to informal, "subjective," incentive systems. Those must be self-enforcing, thus are more effective if the value of future rents generated in an employment relationship is large. We first derive a theoretical model based on these presumptions and demonstrate that both means to provide incentives – gift exchange and direct incentives – complement each other. Moreover, the extent of the adverse effect layoffs (which cause a reduced capability of gift-exchange incentives) on a worker's motivation depends on the perceived future value of the relationship. Second, we derive a number of empirical predictions based on this theoretical mechanism, and, third, test these predictions.

### III.1. Model Setup

*Environment* Our model consists of one risk-neutral principal/firm ("she") who employs one risk-neutral agent ("he"), we consider an infinite time horizon. In every period $t = 1, 2, ...$, the principal makes an employment offer to the agent which specifies an upfront wage $w_t \geq 0$ (paid at the beginning of a period) and a discretionary bonus $b_t \geq 0$ (to be paid at the end of a period). Upon acceptance (a rejection lets both players consume their outside options of zero), the agent receives $w_t$ and chooses an effort level $e_t \in \mathbb{R}_+$ which is associated with effort costs $c(e_t) = e_t^3/3$. Effort generates a deterministic output $e_t$ which is subsequently consumed by the principal.

Effort in our setting relates to the agent's motivation (other, easily measurable, aspects are already taken care of by not-further-modelled incentive contracts). Moreover, although we use the term "wage" when referring to the agent's compensation, this does not need to only describe a monetary payment. In particular if salaries are constrained by collective bargaining agreements or contractual obligations, firms might be restricted in setting them. Therefore, the wage in our setup reflects everything that is costly to the principal and valued by the agent. For example, it might include good working conditions, flexibility in working times, or perks.

Future payoffs are discounted with a common factor $\delta \in (0, 1]$; $\delta$ not only captures time preferences, but also reflects the probability with which the relationship is continued. Continuation probabilities can be driven by industry- or firm-wide, but also by personal characteristics.

*Contractibility* We assume that no formal incentive contract is possible, for example because the agent's motivation cannot be verified by a third party (however relax this assumption below, in Section IV.1). Nevertheless, a self-enforcing *relational contract* can (potentially) be formed.

*Preferences* To incorporate gift-exchange incentives in our model, we assume that the agent not only cares about his compensation, but also has preferences for reciprocity. His per-period utility in a period $t$ equals

$$u_t = w_t - c(e_t) + \eta w e_t. \tag{3}$$

The term $\eta \geq 0$ captures the agent's inherent preferences for positive reciprocity and lets the output enter the agent's utility whenever he is paid a positive wage. This formalizes the idea of gift exchange because the agent's outside option is zero (strictly positive outside reference wages in response to positive outside options could easily be incorporated). Importantly, we do not assume $\eta$ to be an invariable personality trait. Instead, it relies on the match-specific relationship between the principal and the agent and can be affected by events in- and outside the relationship.

First, (mass) layoffs let $\eta$ fall to a smaller level $\hat{\eta} \in [0, \eta]$, unless layoffs seem justified. This incorporates the previously discussed evidence that layoffs appear to reduce a worker's sentiment for the principal.

Second, following the assumptions and discussion of history-dependent social preferences in Fahn (2021), we assume that the agent's preferences for reciprocity in the second period remain at $\eta$ (or $\hat{\eta}$ in case layoffs have occurred) *if and only if the principal has kept a promise of paying* $b$. Otherwise, it drops to zero. Moreover, the agent only reciprocates to *non-discretionary* payments, i.e., not to payments that the agent is supposed to be paid as a reward for previously exerted effort. Therefore, it is without loss of generality to only use $b$ for direct performance pay. Moreover, $\eta$ does not drop to zero after a deviation by the agent (and if no bonus is paid in response), capturing the idea that the agent's general "goodwill" towards the principal depends on the latter's behavior, not on his own. These assumptions substantially simplify the analysis because they allow for a separation of direct and gift-exchange incentives, as well as for a recursive structure of the optimization problem.

However, they are not material for the results we will derive below.[8]

The principal has no preferences for reciprocity and only cares about her (monetary) payoffs. In the following, our objective is to find a *subgame perfect equilibrium* (given the restrictions laid out above) that maximizes the principal's profits at the beginning of the game,

$$\Pi_1 = \sum_{t=1}^{\infty} \pi_t = \frac{e - b - w}{1 - \delta}. \tag{4}$$

*Optimal Spot Contract* As a benchmark, we first derive the properties of a profit-maximizing spot contract. Because effort is not verifiable, such a spot contract cannot involve a performance-based bonus because the principal has no incentive to pay it. This implies that only gift exchange can used to provide incentives: Given he is paid a wage $w$, the agent chooses effort to maximize his utility $u = w - c(e) + \eta w e$, thus

$$e^* = \sqrt{\eta w}. \tag{5}$$

Taking this into account, the principal sets $w$ to maximize her expected per-period profits $\pi = e^* - w$. This yields $w = \eta/4$ and $e^* = \eta/2$. Therefore, $\pi = \eta/4$ and $u = \eta/4 + \eta^3/12$. Intuitively, a positive wage lets the agent partially internalize the principal's payoff, therefore he reciprocates and selects a positive effort level. Because this interaction is stronger for a more reciprocal agent, a higher $\eta$ induces larger values of $w$, $e^*$, $\pi$, and $u$.

**Relational Contract**

In the following, we focus on *stationary outcomes*, i.e., payments and equilibrium effort are the same in every period (note that this assumption is without loss of generality), which allows us to omit time subscripts. Now, the principal is also able to pay a performance-based bonus $b$ at the end of a period. Informally speaking, the principal could "ask" the agent to exert more effort than the agent would exert anyway given $w$. As a reward, the principal promises to pay $b$.T The promise to pay $b$ must be credible, which is captured by a dynamic enforcement (DE) constraint stating that

[8] These depend on the size of future payoffs, which are increasing in discount factor and reciprocity parameter, two features that would continue to hold with other specifications.

the principal's profits when paying the bonus must be larger than her profits when reneging. The (DE) constraint equals

$$-b + \delta\Pi \geq 0. \tag{DE}$$

It takes into account that any observable deviation should be punished as harshly as possible (Abreu 1988), which here manifests in a termination of the relationship (note that, if $\eta$ did not drop to zero after a deviation by the principal but remained constant, the spot contract would constitute players' off-path payoffs).

The agent's first-period incentives to exert effort now are determined by the wage $w$ and the bonus $b$ (since effort is public information, it is without loss to only pay a positive bonus $b \geq 0$ if the agent has exerted equilibrium effort and no bonus otherwise). To specify his so-called incentive compatibility (IC) constraint, note that the agent's continuation utility is unaffected by his current effort (see Fahn 2021; a firing threat, for example, would not be credible), thus his (IC) constraint – which determines whether it is optimal for him to exert equilibrium effort $e^*$ – equals

$$-\frac{(e^*)^3}{3} + \eta w e^* + b \geq -\frac{(\tilde{e})^3}{3} + \eta w \tilde{e}, \tag{IC}$$

with $\tilde{e} = \operatorname{argmax}\left(-e^3/3 + \eta w e\right)$, i.e., $\tilde{e} = \sqrt{\eta w}$.

Finally, note that individual rationality constraints which ensure participation of players are not needed because payments are non-negative.

To further simplify the problem, it can be shown that the equilibrium is sequentially optimal (hence, on the equilibrium path, maximizing $\Pi$ is equivalent to maximizing per-period profits) and that (IC) holds as an equality.[9] The latter yields $b = e^3/3 - \eta w e + 2/3\left(\sqrt{\eta w}\right)^3$.

Taking these implications into account, the optimization problem becomes to maximize

$$\pi = e - \left(\frac{e^3}{3} - \eta w e + \frac{2}{3}\left(\sqrt{\eta w}\right)^3\right) - w, \tag{6}$$

[9] If it did not bind, the bonus $b$ could be slightly reduced, which would increase profits and relax the (DE) constraint without violating the (IC) constraint.

subject to $\frac{e^3}{3} - \eta we \leq \delta\Pi - \frac{2}{3}\left(\sqrt{\eta w}\right)^3$ which can be simplified to

$$\frac{e^3}{3} + \frac{2}{3}\left(\sqrt{\eta w}\right)^3 - \eta we \leq \delta\left(e - w\right). \tag{DE}$$

Generally, the principal faces the following trade-off. Direct incentives provided by the bonus allow her to extract the full surplus; reciprocity-based incentives grant the agent a rent but reduce his effective effort costs. The optimal relational contract balances the costs and benefits of both means to provide incentives, taking into account that the (DE) constraint restricts the use of relational incentives.

Whether it is optimal to pay a positive wage depends on the size of the reciprocity parameter $\eta$, but also on whether the (DE) constraint binds or not.

**Lemma 1** *Assume the (DE) constraint does not bind. Then, setting a strictly positive wage is optimal for* $\eta > 1$*, whereas the optimal wage is zero for* $\eta \leq 1$.

*Assume the (DE) constraint binds. Then, equilibrium effort is smaller than with a non-binding (DE) constraint. Moreover, there exists a* $\tilde{\eta} < 1$ *such that setting a strictly positive wage is optimal for* $\eta > \tilde{\eta}$*, whereas the optimal wage equals zero for* $\eta \leq \tilde{\eta}$.

The proof can be found in Appendix B.

Besides reducing effective effort costs, an upfront wage also relaxes the principal's (DE) constraint by decreasing the bonus that must be paid for implementing a given effort level. Therefore, if the (DE) constraint binds, the wage is generally larger than when it does not bind.

The following Lemma states that a non-binding (DE) is more likely for larger values of $\delta$.

**Lemma 2** *Fix* $\eta \geq 0$. *Then, there exists a* $\bar{\delta} > 0$ *such that (DE) binds for* $\delta \leq \bar{\delta}$ *but does not bind for* $\delta > \bar{\delta}$.

The proof can be found in Appendix B.

The principal's commitment in a relational contract is determined by what she has to lose given she deviates, i.e., the future relationship profits. If the discount factor (or reciprocity parameter) is large, future relationship profits (from today's perspective) are larger and consequently increase the principal's commitment when promising a bonus today.

Now, we state the main theoretical result of the section, namely that the consequences of a reduction of $\eta$ on equilibrium effort depend on whether the (DE) binds or not.

**Proposition 1** *Equilibrium effort decreases if $\eta$ is reduced. This effect is more pronounced if $\delta < \bar{\delta}$, i.e., if the (DE) constraint binds.*

The proof can be found in Appendix B.

A smaller $\eta$ directly reduces $e$ (and consequently profits) for a given $w > 0$ because of the increase in effective effort costs. This theoretical result is in line with the empirical observations described in Section II.3, that mass layoffs permantly reduce the motivation of remaining employees (unless layoffs seem justified). There also is an indirect effect. Because future profits increase in $\eta$, a lower $\eta$ tightens the (DE) constraint which further leads to lower effort and profits. This indirect effect kicks in if the (DE) constraint binds, therefore the effect of $\eta$ on effort is stronger in this case.[10]

In the following, we focus on the different consequences of a reduction in $\eta$ on effort depending on the size of $\delta$. There, we identify aspects which we argue rather indicate a binding or a non-binding (DE) constraint, either on the level of the firm as a whole or of an individual employment relationship.

### III.2. Predictions

Recall that $\delta$ not only captures time preferences, but all aspects that affect the perceived continuation probability of a relationship. Thus, if the probability of leaving the firm soon is regarded as high,

[10]Evidence for this interaction is provided by Fahn et al. (2017).

the effective $\delta$ is small and (DE) more likely to bind.

**Prediction 2:** The negative effect of layoffs on the motivation of survivors is more pronounced in relationships that have a low perceived continuation probability.

Moreover, although we are not able to observe reciprocity parameter or discount factor, we can indirectly assess whether the (DE) constraint binds or not by looking at an agent's total compensation.

**Lemma 3** *Holding $\eta$ fixed, the agent's total compensation $w + b$ is higher with a non-binding than with a binding (DE) constraint.*

Lemma 3 states that, if the discount factor is large enough for (DE) to be slack, the agent is paid more in total. We argue that "residual wages" might reflect higher discount factors. This could also provide a microfoundation for the results found by Card et al. (2018), who state that such residual wage differentials might indicate productivity differences. In our setting, the latter can emerge endogenously and be the consequence of a higher discount factor – which then results in a higher commitment of firms to keep their promises in informal relationships. Gibbons & Henderson (2012), for example, justify such a view by arguing that observed persistent productivity differences among seemingly similar enterprises might be driven by variations in the effectiveness of relational contracts.

**Prediction 3:** The negative effect of layoffs on the motivation of survivors is less pronounced in high-wage firms.

Note that, even if higher wages were caused by other factors than the discount factor, our prediction would continue to hold. For example, if high-wage firms were more productive for exogenous reasons, their (DE) constraint would still be less likely to bind and a decrease in $\eta$ result in a smaller effort reduction.

### III.3. Empirical evidence

The left bars in Figure **??** show effect heterogeneity by similarity in characteristics of the survivors and quitters. In order to build a proximity measure, we first run a logit regression of being laid off on a set of covariates, such as age, gender, tenure, experience, and migration status, as well as a set of industry and firm covariates for all layoff firms in our sample. The estimated average scores for the leavers at the firm level are then compared to the individual survivors' scores. The sample split is at an absolute deviation of 0.2. For estimating the quitting propensity we use the universe of all Upper Austrian firms that are at least one year old. We find no significant effect heterogeneity by similarity of survivors and quitters.

We then calculate a propensity score that measures the conditional probability of workers quitting their job based on a set of worker and firm observables. We estimate this for the universe of Austrian workers. Indeed, we find that workers with characteristics that make them more likely to quit their job react stronger to the ML, which suggests that our effects are stronger for worker-firm relationships with a low continuation probability.

Finally, to test Prediction 3, we identify high-wage firms estimating (Abowd et al. 1999, AKM) models on a sample containing the universe of Upper Austrian firms. We define high-wage firms are as having an above-median AKM fixed effect. As predicted, Figure **??** shows that a downsizing episode has larger effects on shirking in low-wage firms. This difference is even stronger for sick leaves including a bridge day.

## IV. Further Aspects

### IV.1. Formal vs. Informal Contracts

So far, we have assumed that no formal, court-enforceable, contracts can be used to motivate the agent to exert effort. Informal, "subjective" dimensions of performance are relevant in many occupations where individual contribution to firm value cannot be measured objectively.[11] However, the importance of informal incentives probably varies and depends on an employee's occupation. There, we would argue that the performance in jobs in manufacturing can easier be measured objectively than jobs in, for example, the service industry.

Being able to use formal contracts to incentivize effort in our setting would allow us to omit the (DE) constraint (because the principal could formally commit to pay a bonus for satisfactory effort). Therefore, results for formal contracts would be equivalent to those with a non-binding (DE) constraint, which yields the following prediction.

**Prediction 4:** The negative effect of layoffs on their motivation is smaller in manufacturing than in other sectors.

*Empirical evidence*

Figure **??**, Panel A , indeed, shows smaller results for the manufacturing sector, the results for bridge days and nice weather days are not significant for the manufacturing sector, but relatively high for the sector sales, retailing, transport and energy.

### IV.2. Age Differences

Our theoretical setup is stationarity. Whereas this assumption greatly simplifies the analysis, in reality many aspects that affect employment relationships do so differently at various stages of a career. This particularly relates to one of our major variables, the expected time horizon and thus the perceived future surplus of an employment relationship. Towards the end of one's career, the remaining time horizon and thus future relationship surplus is smaller. But also in early stages, when the match quality is highly uncertain, the extent of turnover and thus the probability of a termination arguably are relatively large. Therefore, we would argue that the expected future relationship surplus

[11] See Prendergast (1999), Gibbons & Henderson (2012), Malcomson (2012), Kampkötter & Sliwka (2016), or Frederiksen et al. (2017) for arguments on the importance of incentive schemes based on informal assessments of performance.

is largest for those at intermediate stages, when a good match has been found but the remaining time horizon still is sufficiently large. We incorporate these aspects by allowing for different discount factors while maintaining a potentially infinite time horizon. Therefore, we would expect discount factors to be highest at intermediate career stages, and lower at early and late stages.

Since an individual's career level is highly correlated with their age, and since a non-binding (DE) constraint is more likely with a higher discount factor, we make the following prediction.

**Prediction 5:** The negative effect of layoffs on their motivation is less pronounced for middle-aged employees, compared to relatively young and old individuals.

*Empirical evidence*

Panel A of Figure **??** shows results by age groups. We do not find sizeable differences for overall sick leaves. Results concentrating only on sick leave periods including bridge days or days with nice weather do show a significant U-shape: motivation effects are largest for workers in their twenties, smaller for workers between 30 and 49 years of age and increase again for workers above age 50.

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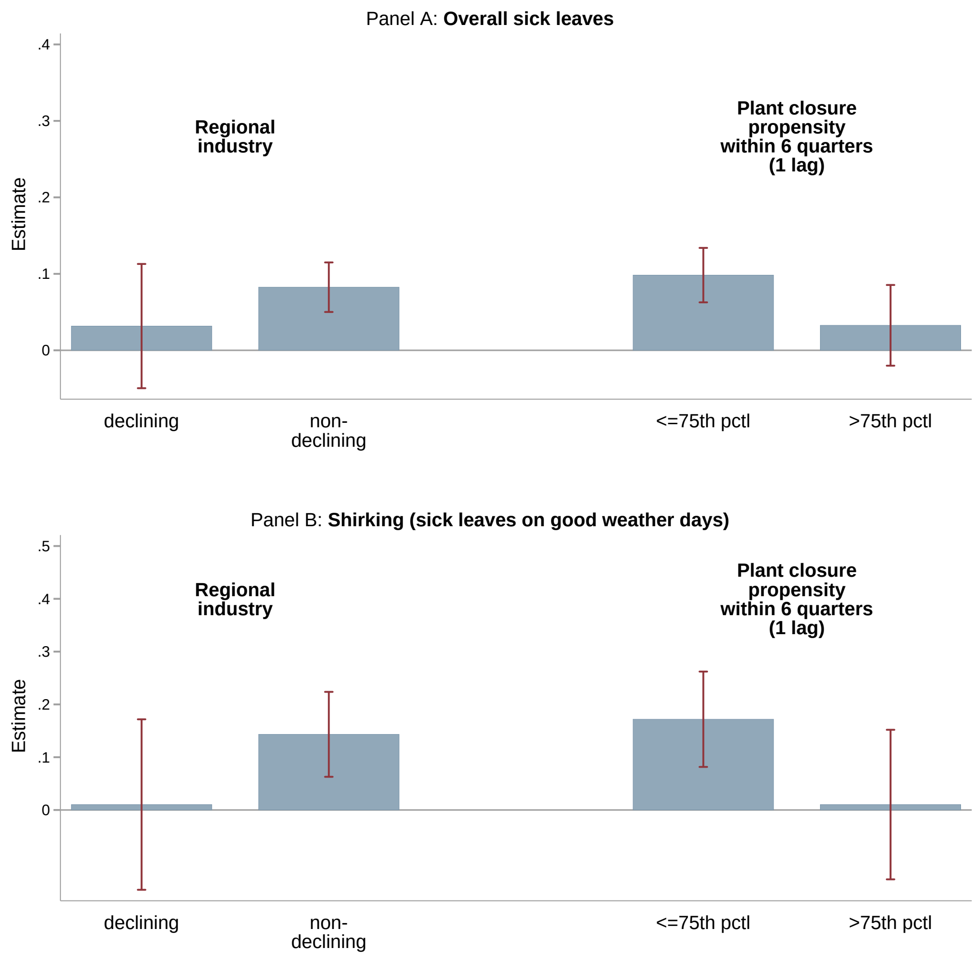
# A. Tables and figures

Table 1 — Full sample

| | Overall | Including special weekdays | | | | | Nice weather | |
|---|---|---|---|---|---|---|---|---|
| | days | Mondays | Fridays | Bridgedays | Mon/Fri | Mon/Fri/Brdg | warm/snow | warm/snow/sun |
| **Average Effect** | | | | | | | | |
| Average effect | 0.0792*** | 0.0862*** | 0.0773*** | 0.1387*** | 0.0815*** | 0.0836*** | 0.1353*** | 0.1101** |
| | (0.0159) | (0.0166) | (0.0154) | (0.0364) | (0.0158) | (0.0159) | (0.0390) | (0.0340) |
| **Dynamic Effects** | | | | | | | | |
| t = 1 | 0.0587** | 0.0672** | 0.0528** | 0.0308 | 0.0596** | 0.0590** | 0.0700 | 0.1028 |
| | (0.0197) | (0.0209) | (0.0201) | (0.0852) | (0.0200) | (0.0201) | (0.0616) | (0.0524) |
| t = 2 | 0.0918*** | 0.0919*** | 0.0909*** | 0.1622* | 0.0914*** | 0.0941*** | 0.1331* | 0.1148* |
| | (0.0238) | (0.0252) | (0.0239) | (0.0675) | (0.0240) | (0.0243) | (0.0664) | (0.0575) |
| t = 3 | 0.0750** | 0.0760** | 0.0740** | 0.0785 | 0.0749** | 0.0757** | 0.1948** | 0.1646** |
| | (0.0246) | (0.0252) | (0.0251) | (0.0877) | (0.0247) | (0.0255) | (0.0659) | (0.0562) |
| t = 4 | 0.0749** | 0.0753** | 0.0777*** | 0.0789 | 0.0766** | 0.0766** | 0.1163 | 0.0782 |
| | (0.0233) | (0.0242) | (0.0233) | (0.0623) | (0.0233) | (0.0234) | (0.0647) | (0.0476) |
| t = 5 | 0.1266*** | 0.1373*** | 0.1160*** | 0.2030* | 0.1260*** | 0.1296*** | 0.1769** | 0.1520** |
| | (0.0251) | (0.0276) | (0.0246) | (0.0963) | (0.0255) | (0.0260) | (0.0659) | (0.0564) |
| t = 6 | 0.1976*** | 0.2077*** | 0.1882*** | 0.3109*** | 0.1974*** | 0.2014*** | 0.3389** | 0.2373* |
| | (0.0282) | (0.0300) | (0.0281) | (0.0757) | (0.0286) | (0.0291) | (0.1063) | (0.0920) |
| Pre-ML mean (days) | 2.2115 | .2984 | .336 | .0253 | .6344 | .6597 | .1642 | .2413 |
| Prob>F [-6,-1] | .4015 | .4147 | .4628 | .9354 | .4217 | .4413 | .5838 | .2325 |
| Observations (treated) | 2,145,611 ( 497,536) | | | | | | | |

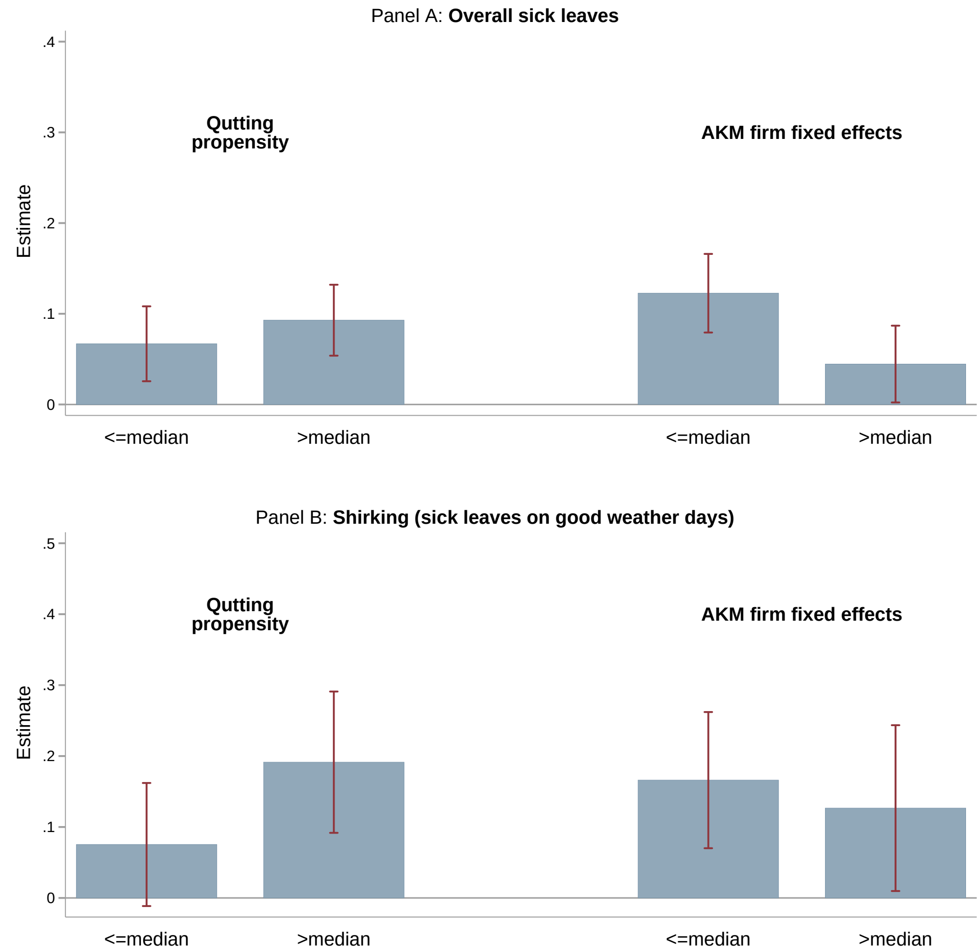
*Notes:* Variables are divided by their pre-ML sample mean and can be interpreted as percentage changes. Standard errors are clustered at the firm level, stars indicate significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Figure 1 — Credible justification of layoffs



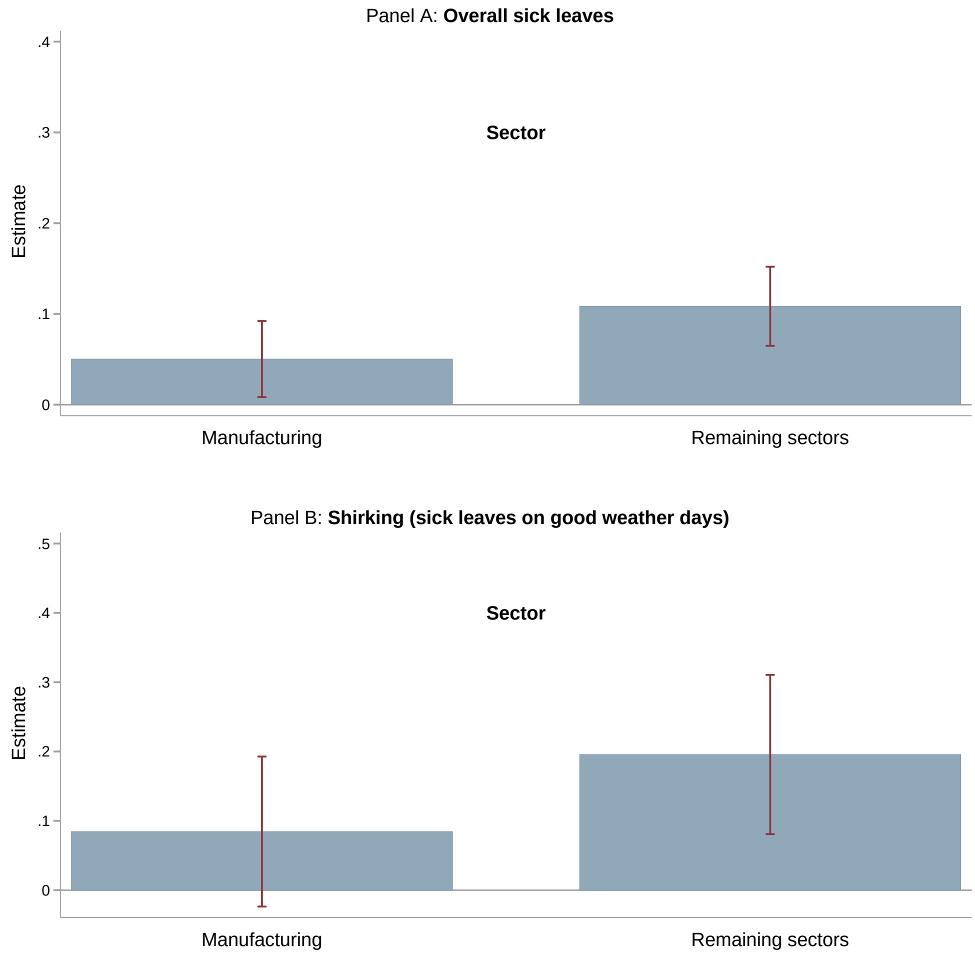

*Notes:* This figure plots average treatment effects for sample splits by whether a regional industry was declining for two consecutive years prior to the layoff and by plant closure propensity within the next 6 quarters, estimated with one lag of firm covariates. Panel A reports estimates for all sick leave days per quarter and panel B reports estimates for sick leave days on nice weather days.

FIGURE 2 — Relational contract



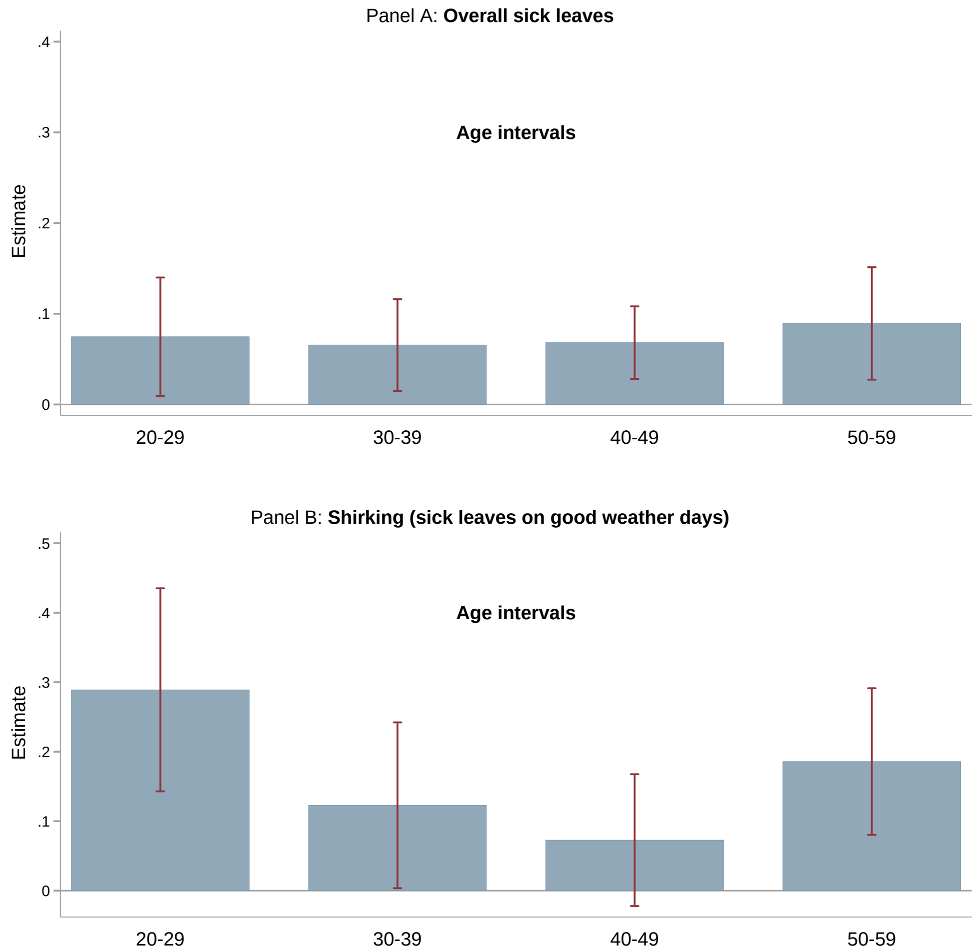

*Notes:* This figure plots average treatment effects for sample splits by the estimated conditional quitting propensity of the survivors, and the relative wage conditional on firm fixed effects. Panel A reports estimates for all sick leave days per quarter and panel B reports estimates for sick leave days on nice weather days.

FIGURE 3 — Sector of industry



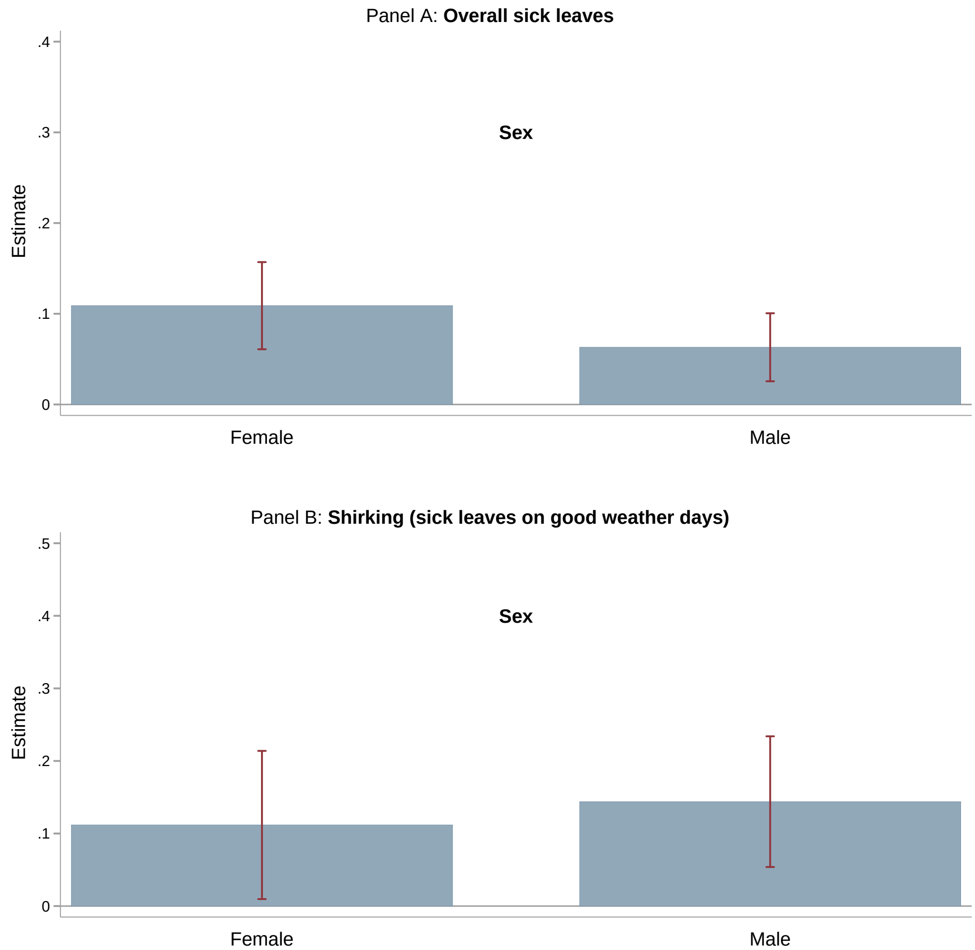

*Notes:* This figure plots average treatment effects for the manufacturing sector and the remaining sectors of the industry. Panel A reports estimates for all sick leave days per quarter and panel B reports estimates for sick leave days on nice weather days.

Figure 4 — Age intervals



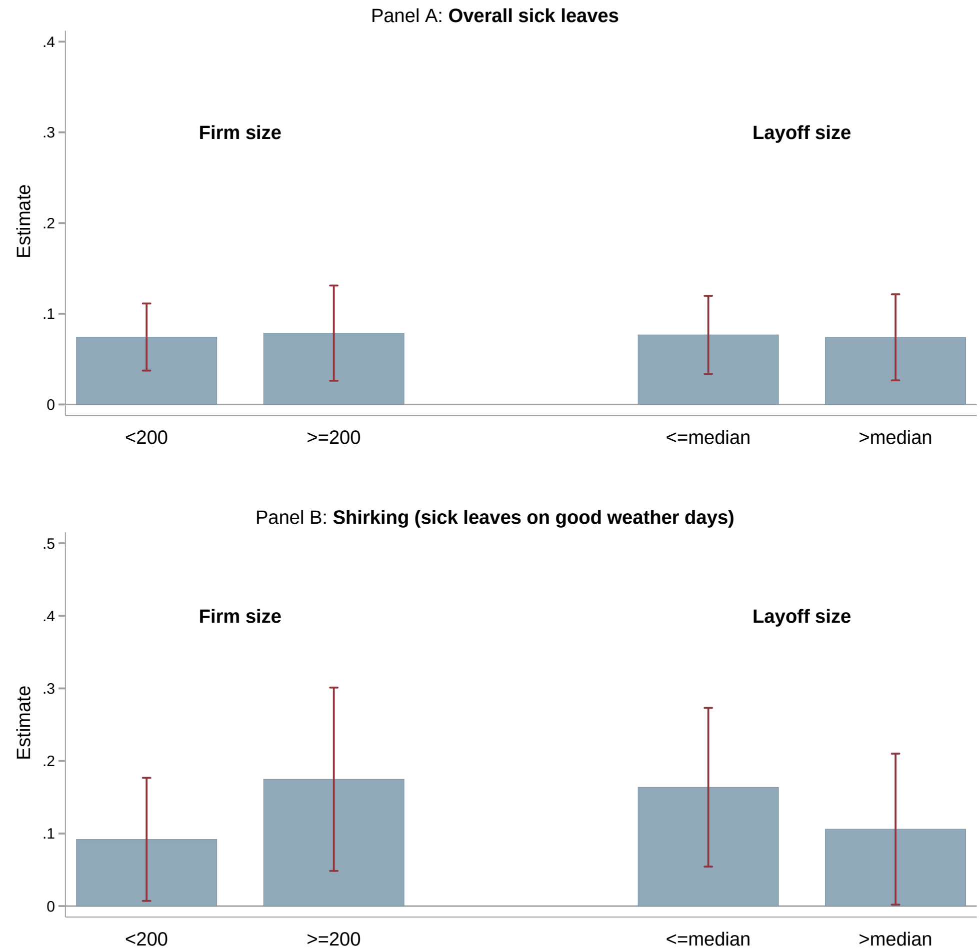

*Notes:* This figure plots average treatment effects for sample splits by age of the employee. Panel A reports estimates for all sick leave days per quarter and panel B reports estimates for sick leave days on nice weather days.

Figure 5 — Female and male employees




*Notes:* This figure plots average treatment effects for sample splits by sex of the employee. Panel A reports estimates for all sick leave days per quarter and panel B reports estimates for sick leave days on nice weather days.

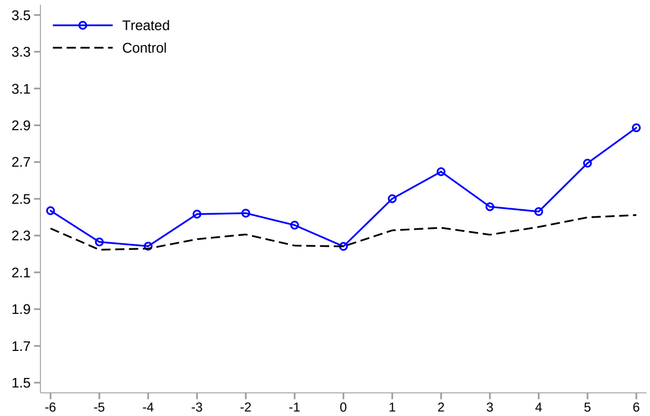
FIGURE 6 — Dimensions of the layoff



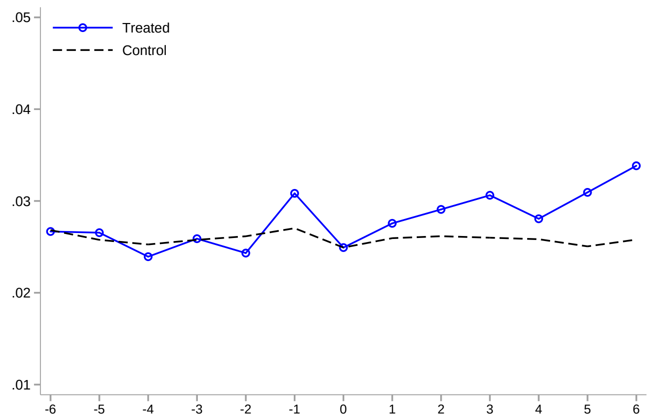

*Notes:* This figure plots average treatment effects for a firm size split at 200 employees and a layoff size split at the median of all layoff sizes in the sample. Panel A reports estimates for all sick leave days per quarter and panel B reports estimates for sick leave days on nice weather days.

FIGURE 7

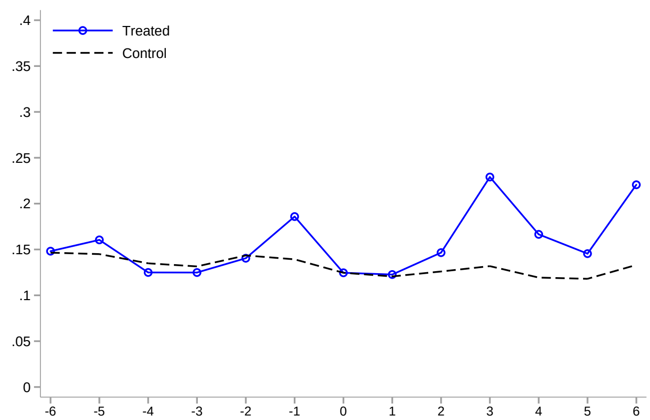
Panel A - **All sick leaves**




Panel B - **Sick leaves including bridge-days**




Panel C - **Sick leaves on nice weather days**




*Notes:* This figures plots raw data means for all sick leaves in panel A, sick leave days in periods that include bridge-days in panel B, and sick leave days on nice weather days in panel C, relative to the ML quarter in both the treatment group and the control group. For the treatment group, $t = 0$ is the period of the actual ML, for the control group, $t = 0$ is when a 'placebo' shock occurs, with their actual shock occurring between $t = 7$ and $t = 10$. Similar to Fadlon & Nielsen (2019), we normalize the level of the control group's outcome to the treatment group's level at $t = 0$.

## B. Omitted Proofs

**Proof of Lemma 1.**

In every period, the principal maximizes profits $\pi = e - \left(e^3/3 - \eta we + 2/3\left(\sqrt{\eta w}\right)^3\right) - w$, subject to $w \geq 0$ and the (DE) constraint, $\frac{e^3}{3} + \frac{2}{3}\left(\sqrt{\eta w}\right)^3 - \eta we \leq \delta\left(e - w\right)$

The Lagrange function equals

$$L = e - e^3/3 + \eta we - 2/3\left(\sqrt{\eta w}\right)^3 - w$$
$$+ \lambda_{DE}\left[\delta\left(e - w\right) - \frac{2}{3}\left(\sqrt{\eta w}\right)^3 - e^3/3 + \eta we\right] + w\lambda_w,$$

where $\lambda_w \geq 0$ represents the Lagrange parameter for the agent's limited liability constraint and $\lambda_{DE} \geq 0$ represents the Lagrange parameter for the principal's dynamic enforcement constraint. First order conditions are

$$\frac{\partial L}{\partial e} = 1 - e^2 + \eta w + \lambda_{DE}\left[\delta - e^2 + \eta w\right] = 0$$
$$\frac{\partial L}{\partial w} = \eta e - \eta\sqrt{\eta w} - 1 + \lambda_{DE}\left[-\delta - \eta\sqrt{\eta w} + \eta e\right] + \lambda_w = 0.$$

First, assume $\lambda_{DE} = 0$. Then, if $\lambda_w = 0$, the first order conditions yield $w = \left(\eta^2 - 1\right)^2/(4\eta^3)$ and $e = \left(1 + \eta^2\right)/(2\eta)$. If $\lambda_w > 0$ and hence $w = 0$, $e = 1$ and $\pi = \frac{2}{3}$. To establish the existence of $\tilde{\eta}$, note that $d\pi/dw\mid_{w=0}= \sqrt{\eta^2 - 1}$. This is positive for $\eta > 1$, hence a strictly positive wage is optimal in this case and not otherwise.

Second, assume $\lambda_{DE} > 0$. Then, if $\lambda_w = 0$, the first order conditions yield $w = \frac{\left[\eta^2(1+\lambda_{DE})-(1+\delta\lambda_{DE})\right]^2}{4\eta^3(1+\lambda_{DE})^2}$ and $e = \frac{1+\delta\lambda_{DE}+\eta^2(1+\lambda_{DE})}{2\eta(1+\lambda_{DE})}$. It follows that, given $\lambda_{DE} > 0$ and $\eta > 1$, $\frac{\left[\eta^2(1+\lambda_{DE})-(1+\delta\lambda_{DE})\right]^2}{4\eta^3(1+\lambda_{DE})^2} > \frac{\left(\eta^2-1\right)^2}{4\eta^3}$ and $\frac{1+\delta\lambda_{DE}+\eta^2(1+\lambda_{DE})}{2\eta(1+\lambda_{DE})} < \frac{1+\eta^2}{2\eta}$.

If $\lambda_w > 0$ and hence $w = 0$, $e = \sqrt{\left(1 + \delta\lambda_{DE}\right)/\left(1 + \lambda_{DE}\right)}$. To establish the existence of $\tilde{\eta} < 1$, note that $\partial L/\partial w\mid_{w=0}= \frac{\eta^2-1+\lambda_{DE}\left(\eta^2-\delta\right)}{2}$.

This is positive for $\eta > \sqrt{\left(1 + \delta\lambda_{DE}\right)/\left(1 + \lambda_{DE}\right)}$, thus a strictly positive wage is optimal in this case and not otherwise. For $\lambda_{DE} > 0$, $\tilde{\eta} = \sqrt{1/(1 + \lambda_{DE})} < 1$. ∎

**Proof of Lemma 2.**

Assume $\eta > 1$ and a non-binding (DE) constraint. Then, $w = \frac{\left(\eta^2-1\right)^2}{4\eta^3} > 0$ and $e = \frac{1+\eta^2}{2\eta}$, and the (DE) constraint becomes

$$6\eta^2 - 2 \leq 3\delta\left(4\eta^2 + \eta^4 - 1\right)$$

Both sides are strictly positive for $\eta > 1$, and the right-hand side is strictly increasing in $\delta$. For $\delta \to 1$, the condition approaches $6\eta^2 + 2\eta^4 - 1 \geq 0$ and is satisfied. For $\delta \to 0$, the condition is violated. This confirms the existence of $\bar{\delta}$ for $\eta > 1$.

Assume $\eta \leq 1$ and a non-binding (DE) constraint. Then, $w = 0$, $e = 1$, and (DE) constraint becomes

$$\delta \geq \frac{1}{3}.$$

This confirms the existence of $\bar{\delta}$ for $\eta \leq 1$. ■

**Proof of Proposition 1.**

Take two values of the discount factor, $\delta_1$ and $\delta_2$, with $\delta_1 < \bar{\delta} < \delta_2$. The following cases are possible.

- $w = 0$ at $\delta_1$ and $\delta_2$; then, the reduction in $\eta$ has no effect on effort.
- $w > 0$ at $\delta_1$ (thus $\eta > \sqrt{(1 + \delta\lambda_{DE}) / (1 + \lambda_{DE})}$), $w = 0$ at $\delta_2$; then, the reduction in $\eta$ has no effect on effort at $\delta_2$; at $\delta_1$, effort is $e = \frac{1+\delta\lambda_{DE}+\eta^2(1+\lambda_{DE})}{2\eta(1+\lambda_{DE})}$, with

  $$\frac{\partial e}{\partial \eta} = \frac{\eta^2 (1 + \lambda_{DE}) - (1 + \delta\lambda_{DE})}{2\eta^2 (1 + \lambda_{DE})} - \frac{1 - \delta}{2\eta (1 + \lambda_{DE})^2} \frac{\partial \lambda_{DE}}{\partial \eta}.$$

  It can be shown that $\Pi$ is increasing in $\eta$, which also implies that $\partial\lambda_{DE}/\partial\eta < 0$. Moreover, since $\eta > \sqrt{(1 + \delta\lambda_{DE}) / (1 + \lambda_{DE})}$, $\partial e/\partial\eta > 0$.
- $w > 0$ at $\delta_1$ and $\delta_2$, thus $\eta > 1$; again,

  $$\frac{\partial e}{\partial \eta} = \frac{\eta^2 (1 + \lambda_{DE}) - (1 + \delta\lambda_{DE})}{2\eta^2 (1 + \lambda_{DE})} - \frac{1 - \delta}{2\eta (1 + \lambda_{DE})^2} \frac{\partial \lambda_{DE}}{\partial \eta} > 0$$

  at $\delta_1$; at $\delta_2$, $\partial e/\partial\eta = (\eta^2 - 1)/2\eta^2$, which is also positive but smaller. ■