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Co-worker altruism and unemployment

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Abstract

It is well-known that social relationships and altruism among workers foster cooperation in the workplace and, therefore, may have beneficial effects for firms. Yet it is unclear how and to what extent co-worker altruism impacts labor market outcomes. In this paper, we find that, although co-worker altruism may be seamless in good times, it may impact the functioning of labor markets during bad times. Specifically, co-worker altruism may potentially lead to wage rigidity and involuntary unemployment in economic downturns. These results seem to be consistent with recent empirical findings.

Keywords:
affective empathy, emotional contagion, Interdependent utilities, non-paternalistic preferences

JEL Classification
D64, D91, J21

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1 Introduction

There is ample evidence that social relationships in the workplace are crucial for understanding managerial practices, workers' job satisfaction and employees' well-being.[1] In fact, recent field evidence indicates that financial incentives alone have a limited role in explaining what goes on inside profit-maximizing firms (Rotemberg, 2006). In particular, it has been found that worker-to-worker altruism fosters cooperation among workers, suggesting that it may be beneficial for firms to promote positive co-worker relationships.[2] These co-worker social relationships naturally induce altruism among workers. However, aside from these implications within organizations, it is unclear how and to what extent workers' social relationships, understood as worker-to-worker altruism, shape labor market outcomes.

Perhaps surprisingly, we find that worker-to-worker altruism could qualitatively impact labor market outcomes. Specifically, co-worker altruism could lead to wage rigidity and involuntary unemployment in an otherwise frictionless labor market. Thus, while incentivizing co-worker altruism may be seamless in economic expansions, it could have important effects in recessions. These results are consistent with empirical findings. Based on interviews with union leaders, job recruiters, and unemployment counselors on the early 1990s recession in the United States, Bewley (1999) found that firms prefer layoffs over pay cuts during a recession to prevent damaging workers' morale, which is understood as "[...] a sense of common purpose, happiness, or tolerance of unpleasantness" (p. 42). Bewley's evidence suggests that social relationships in the workplace impact workers' morale which, in turn, affects the functioning of labor markets. To better understand this channel, in this paper we model social relationships by assuming altruistic preferences among workers, as we explain next.

To examine the effects of co-worker altruism on labor market outcomes, we consider a labor market in which a representative profit-maximizing firm chooses how many workers to hire and their compensation scheme. We make the following simplifying assumptions. First, to isolate the effect of altruism, we omit performance-pay issues and instead assume a standard contract that involves a fixed wage rate and a non-binding amount of hours. Second, we model co-worker altruism in a *non-paternalistic* way (see, e.g., Pearce, 1983; Ray, 1987; Bergstrom, 1999; Bramoullé, 2001). Thus, workers' utility functions depend positively on the final welfare of co-workers, and their individual well-being is interdependent. Finally, workers have preferences over consumption, leisure, and the time spent at the workplace,

[1] See, e.g., Riordan and Griffeth (1995); Hodson (1997); Ducharme and Martin (2000); Morrison (2004); Wagner and Harter (2006); Krueger and Schkade (2008).

[2] Practitioners have already recognized this fact: according to Berman et al. (2002), more than 85% of managers in the United States actively promote friendship in the workplace by offering social events for employees; see Cohen and Prusak (2002) for a related discussion.

where the latter depends on the average level of the co-workers' well-being. Hired workers elect how much labor to supply and how many units of the final good to consume, taking the wage rate as given.

We first examine the game played among workers.[3] When wages are high or low enough, workers' well-being and labor supply are uniquely determined. However, for mid-wage levels, co-worker altruism could lead to multiple levels of workers' well-being, each being associated with a different labor supply decision. For instance, if workers' realized well-being is low, some workers will quit, and those who are employed will supply fewer hours. Consequently, a small pay cut can trigger a low labor supply outcome.

Finally, we study how firms respond to productivity shocks of varying intensity. When productivity is high, as in an economic expansion, the firm raises the wage and hires all available workforce. However, for moderate levels of productivity, the manager abstains from implementing a pay cut, as this may trigger a low morale outcome in the worker game. Instead, the firm insulates employees from adverse market conditions, giving rise to *wage rigidity*. If the economic downturn is more severe, as in a recession, then it is too costly for the firm to shield its workforce completely. The firm finds it optimal to adjust employment while keeping the wage unchanged; as a result, *involuntary unemployment* emerges.

Our paper relates to the literature on non-paternalistic preferences, according to which individuals derive happiness directly from the extent to which others are enjoying themselves and not from how they are doing so (Ray and Vohra, 2020). This type of utility interdependence has been used to capture altruism in a variety of settings (see, e.g., Dur and Sol, 2010; Genicot, 2016; Galperti and Strulovici, 2017; Bourlès et al., 2017). Contrary to this paper, this literature typically focuses on settings in which altruism induces *unique* levels of well-being among individuals.[4] To the best of our knowledge, this may be the first paper that examines how non-paternalistic co-worker altruism can impact labor markets.

There is an extensive literature that introduces behavioral concerns in organizations. These papers study incomplete contracts in which workers' effort (i.e., labor quality) is unobservable; see, e.g., Kőszegi (2014) for a survey. Of course, behavioral concerns can manifest in many ways, for example, as reciprocity and fairness between the firm and the worker; see Sobel (2005) and references therein.[5] Importantly, this would lead to a very different type of preference interdependence compared to the one we study in this paper.

[3]Technically, this is a strategic interaction with *payoff-based externalities* (Ray and Vohra, 2020), in which the worker's utility depends on her own action and the utilities of other workers (others' actions enter a worker's utility only via the utilities they generate for other players).

[4]See our recent work, Vásquez and Weretka (2020), for an exception.

[5]Fang and Moscarini (2005) study the role of worker confidence in the determination of wages. They consider a fixed pool of workers and find important implications for wage dispersion. By contrast, our focus is on the effects of co-worker altruism on both wage stickiness and involuntary unemployment.

More relatedly, the worker-to-worker altruism literature focuses on the conditions under which altruism would emerge in equilibrium and how this may affect cooperative behavior among workers (Rotemberg, 1994, 2006). The question of how co-worker altruism can distort labor market outcomes in recessions has gone unanswered.

Our paper also contributes to the literature on wage rigidity. There seems to be a consensus among economists that wages are relatively stable over the business cycles. This is particularly puzzling in light of the strong counter-cyclicality of the unemployment rate. Several influential theories offer mechanisms that explain why firms and unemployed workers may not exploit potential gains from trade during recessions. For instance, wages are sticky when used as a way to discipline workers (Shapiro and Stiglitz, 1984), because firms face menu costs (Sheshinski and Weiss, 1977), or due to implicit income insurance by firms (Baily, 1974; Azariadis, 1975). Yet these theories appear to be not in line with the practitioners' common perception that lowering wages could deteriorate workers' morale (Bewley, 1999).[6] Our paper provides a complementary theory to help understand the determinants of wage rigidity and unemployment. Central to our theory is the emotional friction that emerges at the workplace. A key distinction is that wage rigidity only arises in recessions, wherein emotional frictions are strong, as opposed to, for example, efficiency wage models in which wages are constantly above market clearing for all productivity levels.

Finally, recent behavioral studies have examined the implication of consumer loss aversion on price rigidity; see, e.g., Ahrens et al. (2017) and references therein. If workers are loss averse, then they are more severely harmed with wage reductions below their reference points; thus, firms are reluctant to cut wages below those reference levels after being hit by an adverse shock. By contrast, in our model workers' utility functions do not depend on reference wages, but rather on the average welfare level of co-workers. Yet, in equilibrium, workers are also severely harmed when wages are below certain thresholds; however, these wage thresholds are endogenous and a consequence of worker-to-worker altruism. We believe that this mechanism is novel and allows us to explain wage rigidity and involuntary unemployment without introducing reference points (or "kinks") on the utility function.

The rest of the paper is organized as follows. In §2, we develop a model that allows us to examine the effects of co-worker altruism on unemployment and wages. In §3, we explore the worker game and study the firm's problem. Finally, we demonstrate the robustness of the main result in §4 and conclude in §5. All omitted proofs are in the Appendix.

[6] See Bewley (1999) for a further discussion of standard wage rigidity theories and their empirical relevance.

2 Interdependent Preferences in the Workplace

The Model. We consider a representative firm (or manager) that faces a continuum of heterogeneous *potential workers* indexed by $i \in [0,1]$. We endow the set $[0,1]$ with the Borel $\sigma-$algebra $\mathcal{I}$ and a finite measure μ. Potential worker i has *reservation utility* $r(i) \equiv r_i \in \mathbb{R}$, where $r(\cdot)$ is a measurable function.[7] The firm chooses a set of workers $I \in \mathcal{I}$, with mass $\mu(I) \in [0,1]$, and a compensation scheme that specifies a uniform *wage rate* $w \geq 0$. Reservation utilities are distributed according to a cumulative distribution function $F(\cdot)$ with respect to μ. We assume that $F(\cdot)$ is strictly increasing with no atoms and has full support.

Given wage w, each employed worker $i \in I$ elects an *individual labor* supply $\ell_i \geq 0$. The firm then uses total labor $L \equiv \int_I \ell_i d\mu \geq 0$ to produce a consumption good using a technology $Ay(L)$ obeying $y' > 0 > y''$ for $L > 0$, $y(0) = 0$, $\lim_{L\to 0} y'(L) = \infty$ and $\lim_{L\to\infty} y'(L) = 0$. As usual, the parameter $A > 0$ is understood as the firm's *productivity.* The firm maximizes profits $Ay(L) - wL$, anticipating the labor choices of employed workers.

The available *labor force* μ^S is the mass of potential workers who are willing to work at the prevailing wage rate. The *employment rate* $\mu^D \equiv \mu(I)$ is the mass of employed workers and is bounded by the available labor force, namely, $\mu^D \leq \mu^S$. Naturally, the difference $\mu^S - \mu^D \geq 0$ represents the *level of involuntary unemployment.*

We offer predictions regarding wage, employment, and labor supply for any productivity level A. We say that *wages are rigid* if there exists a range of productivity values such that the equilibrium wage is constant. Also, *there is involuntary unemployment* if $\mu^S - \mu^D > 0$.

The Worker Game. Each hired worker $i \in I$ chooses how to allocate her endowed time of $T > 1$ hours between labor ℓ_i and *leisure* $T - \ell_i$ to finally consume $c_i \equiv w\ell_i$ units of the final good. The standard labor supply model supposes that workers derive utility from consumption and leisure (Lucas and Rapping, 1969), so their labor choices affect their utilities insofar as they crowd out leisure. However, there is ample evidence of social relationships in the workplace (e.g., Bewley, 1999; Rotemberg, 2006). In this paper, workers also care about the quality of their work environment, which is a byproduct of the work climate, social relationships with colleagues, etc. We depart from the standard labor supply framework by considering a utility function $\mathcal{U}_i(c_i, \ell_i, \upsilon)$. The non-standard variable $\upsilon \in \mathbb{R}$ denotes the workers' *morale* $\upsilon \equiv \int_I u_i d\mu/\mu(I) \in \mathbb{R}$, namely, the *average realized utility of others.* Indeed, the variable $u_i \in \mathbb{R}$ represents worker i's *realized utility* in the workplace, i.e., the utility level taken by $\mathcal{U}_i(c_i, \ell_i, \upsilon)$. More specifically, we discipline our analysis with the following

[7] The reservation utilities r_i may reflect foregone leisure (Lucas and Rapping, 1969), potential gains from job search (Diamond, 1981; Pissarides, 1985), or foregone household production (Hansen and Wright, 1998).

separable utility function:

$$\mathcal{U}_i(c_i, \ell_i, \upsilon) = U(c_i, \ell_i) + \alpha(\upsilon). \tag{1}$$

Notice from (1) that a worker's utility level at the workplace reflects two effects: one that emerges from the standard trade-off between consumption and leisure, which is captured by $U(c_i, \ell_i)$, and another one that is determined by the overall happiness level at the workplace, namely, $\alpha(\upsilon)$. Thus, $\alpha(\upsilon)$ can be seen as the work atmosphere level that arises when workers' morale is υ; so motivated, we call $\alpha(\cdot)$ the *atmosphere function*.

Observe that the right-hand side of (1) is common to all employed workers, so we henceforth drop the worker index i from the utility function $\mathcal{U}_i$. Consequently, the worker game for each wage level w is symmetric. We will examine symmetric equilibria wherein workers make the same decisions at the margin, conditional on being employed, which would allow us to drop the subindex i from consumption c_i and labor ℓ_i.

We next make assumptions on $U(\cdot)$ and $\alpha(\cdot)$, respectively. Let us start with the standard utility function $U(c, \ell)$. It is well-known that, in the standard labor supply model, an increase in wages has ambiguous effects on labor supply decisions unless strong assumptions are made (see, e.g., Keane, 2011). To avoid potential ambiguities, we consider a class of *standard utility functions* for which the induced labor supply function is monotone.

Assumption 1. *The utility function $U : \mathbb{R}^2 \to \mathbb{R}$ is continuously differentiable with partials $U_c > 0 > U_\ell$, and it induces an increasing labor supply function $\ell(w) \equiv \arg\max_{\ell \in [0,T]} U(w\ell, \ell)$.*

Assumption 1 is in line with many empirical studies showing a positive labor supply elasticity to wages (Chetty et al., 2011) and, thus, an increasing labor supply function. Next, we discipline the atmosphere function $\alpha(\upsilon)$ in expression (1).

Assumption 2. *The work atmosphere function $\alpha : \mathbb{R} \to (\underline{\alpha}, \overline{\alpha})$ is differentiable, bounded with $\underline{\alpha} < 0 < \overline{\alpha}$, and strictly increasing with vanishing marginal effects $\lim_{\upsilon \to \infty} \alpha'(\upsilon) = \lim_{\upsilon \to -\infty} \alpha'(\upsilon) = 0$. Also, $\alpha(\cdot)$ obeys $\alpha'(\upsilon) > 1$ for some morale level $\upsilon \in \mathbb{R}$.*

By Assumption 2, first as morale υ rises, the work atmosphere level rises too. Second, when workers' morale is low and negative, its effect on the work atmosphere is also negative, capturing the psychological phenomenon of *emotional contagion* among co-workers (e.g., Hatfield et al., 2014).[8] Finally, we assume that the atmosphere is not too sensitive to changes in co-workers' morale when morale is already high or low enough, capturing small contagion effects. However, this reverses for mild morale υ levels for which $\alpha'(\upsilon) > 1$. The logistic, S-shaped, function depicted in Figure 1 satisfies Assumption 2. There, the work atmosphere

[8] Vásquez and Weretka (2020) give a psychological foundation for this type of interdependent preferences.

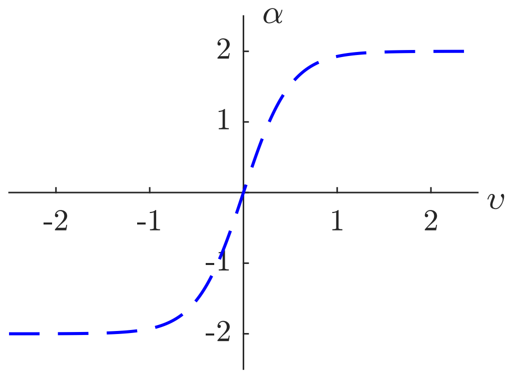

Figure 1: **The work atmosphere function** $\alpha(\upsilon)$**.** The figure plots $\alpha(\upsilon) = 4/(1 + e^{-4\upsilon}) - 2$ in Example 1, which satisfies Assumption 2.

rises at decreasing rates when morale is high and improving; conversely, the atmosphere deteriorates at diminishing rates when co-workers' morale is low and falling.[9]

Example 1 (Parametrization). We use the following functional forms to illustrate our analysis: $U(c_i, \ell_i) = \ln(c_i) + \ln(T - \ell_i)$ and $\alpha(\upsilon) = 4/(1 + e^{-4\upsilon}) - 2$. In addition, we set $T = 24$; $r_i \sim \mathcal{N}(2, 2)$; and $y(L) = \sqrt{L}$. Notice that $\overline{\alpha} = -\underline{\alpha} = 2$ and $\alpha'(0) = 4 > 1$; also, the labor supply function $\ell(w) = 12$. Altogether, Assumptions 1-2 are satisfied. ◊

Solution Concept. Our equilibrium notion for the worker game is inspired by recent developments in the literature on non-paternalistic altruism (see, e.g., Ray and Vohra, 2020; Vásquez and Weretka, 2020). First and crucially, we endow workers with *consistent beliefs* about workers' morale υ. Intuitively, this means that, for any labor profile $(\ell_i)_{i \in I}$, morale υ is correctly forecasted by workers. Hence, an equilibrium in the worker game is effectively a Nash equilibrium given consistent beliefs. Next, as we previously mentioned, we will focus on symmetric equilibria, in which all hired workers end up with the same realized utility level and choose the same labor intensity ℓ. Thus, workers' morale υ coincides with a worker's own realized utility, and ℓ represents the *average individual labor supply.* Consequently, an equilibrium in the worker game can be summarized by an *outcome* (υ, ℓ). Finally, because workers in a continuum have a negligible impact on aggregate variables, we further restrict workers' beliefs so that each worker operates under the natural premise that her behavior alone does not alter the realized utility of others.

Definition 1. Given workers I and a wage rate w, an outcome (υ, ℓ) is *implementable* iff:

i) *Optimality:* Labor supply ℓ solves $\max_{\ell' \geq 0} \mathcal{U}(w\ell', \ell', \upsilon)$;

[9]Although in a different context, Bramoullé (2001) shows how pure altruism can give rise multiple equilibria when the pure-altruism function is S-shaped.

ii) *Consistent Beliefs:* Morale v obeys $\mathcal{U}(w\ell, \ell, v) = v$; and

iii) *Individual rationality:* $v \geq r_i$ for all employed workers $i \in I$.

Definition 1 states that an outcome (v, ℓ) is implementable by the firm, if (v, ℓ) is an equilibrium outcome of the worker game (conditions *i*) and *ii*)) and, in addition, all employed workers get at least their reservation utility (condition *iii*)). Appendix B provides a game-theoretic foundation for the use of Definition 1 to analyze the worker game.

We solve the model using backward induction. There, the firm correctly anticipates the equilibrium responses of employed workers. If the firm's choices induce multiple implementable outcomes, the firm operates assuming its best-case scenario as in the traditional mechanism design literature. Namely, we examine *firm-preferred equilibrium*.

This approach is consistent with the traditional mechanism design literature, in which the designer chooses the game and the equilibrium. As a result, the designer optimizes assuming that the *best* equilibrium outcome will hold. In contrast, in the recent literature on robust mechanism design, the designer chooses the game but not the equilibrium. The designer may want to elect a game that performs well for all equilibrium outcomes. This concern naturally leads to an adversarial rule, in which the designer conjectures that the *worst* outcome will be realized; see Bergemann and Morris (2019) for a survey. Although our leading case considers the former criterion, this is purely expositional. In §4 we verify our results for *general* selection rules particularly the "worst-case scenario" selection rule.

3 Equilibrium Analysis

3.1 Standard Preferences

As a benchmark, we examine the case in which workers do not care about the co-workers' morale, i.e., $\alpha \equiv 0$. Suppose that the firm chooses wage w and hires a set of workers I. Then, by Definition 1-i), the individual labor supply $\ell(w)$ maximizes workers' utility $\mathcal{U}(w\ell, \ell, v) \equiv U(w\ell, \ell)$. Also, by Definition 1-ii), workers' morale obeys $v = U(w\ell(w), \ell(w)) \equiv V(w)$. That is, morale v is determined by the *indirect utility function*, given standard preferences:

$$V(w) = \max_{\ell' \in [0,T]} U(w\ell', \ell'). \tag{2}$$

Clearly, $V'(w) = \ell(w)U_c(w\ell(w), \ell(w)) \geq 0$, based on the Envelope theorem and $U_c > 0$ (Assumption 1). Thus, the available labor force $\mu^S = F(V(w))$ rises in w. Moreover, because $U(c, \ell)$ is continuous, both functions $V(w)$ and $\ell(w)$ are not only increasing but

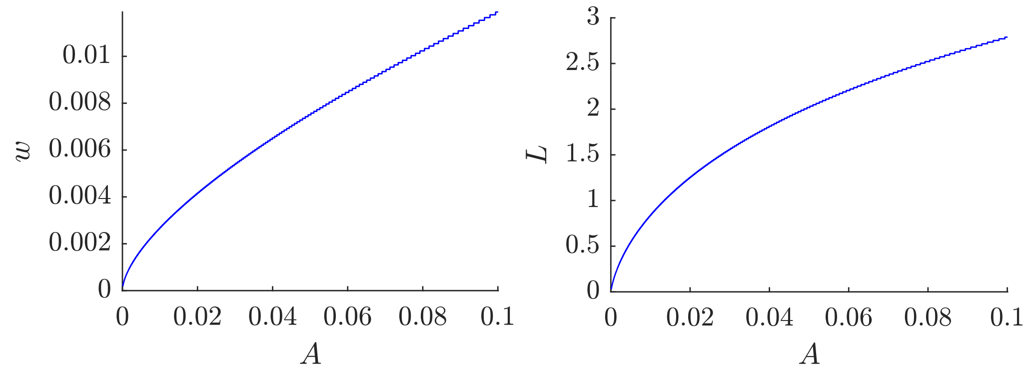

Figure 2: **Benchmark Case with Standard Preferences.** This figure considers the parametrization given in Example 1. Thus, the indirect utility function and labor supply function are $V(w) = \ln(wT/2) + \ln(T/2)$ and $\ell(w) = T/2$, respectively. When workers are neutral toward each other, the equilibrium wage rate $w^*(A)$ and labor $L^S(w^*(A))$ are both increasing in the productivity level A. There is neither wage rigidity nor involuntary unemployment.

also continuous in w, by the Maximum theorem. Consequently, the *aggregate labor supply function* $L^S(w) \equiv \ell(w)F(V(w))$ is both continuous and increasing in wage w.

Turning to the firm's problem, notice that the firm finds it optimal to hire every available worker, namely, $\mu^D = \mu^S$. Otherwise, the firm could raise its profits with a pay cut and then offset its effect by hiring more workers so that output remains unchanged. As a byproduct, the optimal wage w^* must maximize the following monopsony profits:

$$Ay(L^S(w)) - wL^S(w).$$

By standard results, the optimal wage rate w^* is strictly increasing in productivity A, as an increase in A raises the marginal productivity of labor. Thus, both labor supply $L^S(w^*(A))$ and employment rate $\mu^D = \mu^S$ are strictly increasing in productivity A, as seen in Figure 2.

All told, *there is no wage rigidity or involuntary unemployment when workers are unaffected by the welfare of others.* Wages covary with productivity, and workers are respectively hired or voluntarily quit when their utility outweighs or falls behind their reservation utility.

This simple benchmark shares many predictions with real business cycle models (e.g., Lucas and Rapping, 1969) as well as labor-search models (Diamond, 1981; Pissarides, 1985). These models, with their focus on the supply side, have difficulties reproducing some of the empirical patterns observed over the business cycle. For instance, these theories predict that low productivity must be accompanied by a significant drop in the real wage rate, yet in practice, salaries vary very little during business cycles.[10] Job departures are also not accounted

[10] Although search models are capable of explaining, respectively, more and less volatility in employment and wages than the real business cycle framework can do, they can account for only a small fraction of the unemployment volatility observed in the data; see Shimer (2005).

for by these theories. Reductions in salaries should trigger a surge in workers voluntarily quitting less attractive jobs. However, quitting for unemployment sharply falls, as does the chance of finding another job, during a recession (Bewley, 1999, p. 398). Finally, supply-side theories assume that agents choose unemployment to take advantage of their more attractive alternatives. However, the broad psychological literature shows that job loss is often a traumatic experience (Argyle, 2013; Clark et al., 2001), and it is one of the main events to have a long-lasting adverse impact on life satisfaction (Lucas et al., 2004; Kahneman and Krueger, 2006).[11] These arguments highlight the involuntary nature of unemployment.

3.2 The Effects of Co-Worker Altruism

We now consider the more general case in which workers' are affected by the co-workers' realized utilities. As in §3.1, for any wage w, the average individual labor ℓ maximizes utility $\mathcal{U}(w\ell, \ell, \upsilon)$ in (1). Given the separability of $\mathcal{U}(w\ell, \ell, \upsilon)$, the optimal labor supply $\ell(\cdot)$ coincides with the one found in §3.1. Thus, the workers' indirect utility function obeys:

$$\mathcal{V}(w, \upsilon) \equiv V(w) + \alpha(\upsilon), \tag{3}$$

where $V(w)$ is given by expression (2). Notice that the indirect utility function (3) now depends on workers' morale υ. Furthermore, given Assumptions 1-2, for any wage $w > 0$ the indirect utility function $\mathcal{V}(w, \cdot)$ is differentiable, with $\mathcal{V}_\upsilon(w, \upsilon) > 1$ for some υ, strictly increasing, additively separable in (w, υ), and uniformly bounded.

Next, by Definition 1-ii), in equilibrium, workers' morale υ must be consistent — namely, it must solve $\upsilon = \mathcal{V}(w, \upsilon)$. The next lemma characterizes the fixed-point correspondence $\Upsilon(w) \equiv \{\upsilon \in \mathbb{R} : \mathcal{V}(w, \upsilon) = \upsilon\}$, which determines workers' consistent morale levels, given w.

Lemma 1.

(a) For any wage $w > 0$, $\Upsilon(w)$ is non-empty and contains a smallest and a largest element; both are strictly increasing in w.

(b) There exist wages $w_2 > w_1 > 0$ such that, for all $w \in (0, w_1) \cup (w_2, \infty)$, the fixed-point correspondence $\Upsilon(w)$ is single-valued.

(c) There exists a non-empty interval $[w_3, w_4]$ wherein $\Upsilon(w)$ contains multiple fixed-points.

Figure 3 illustrates these findings, using Example 1. The indirect utility function parallely shifts up when wage w rises; thus, for either low enough or high enough wages, consistency

[11] These findings are in line with the observations of the advisers to the unemployed during a recession, as "their clients are desperate for work and miserable being jobless" (Bewley, 1999, p. 400).

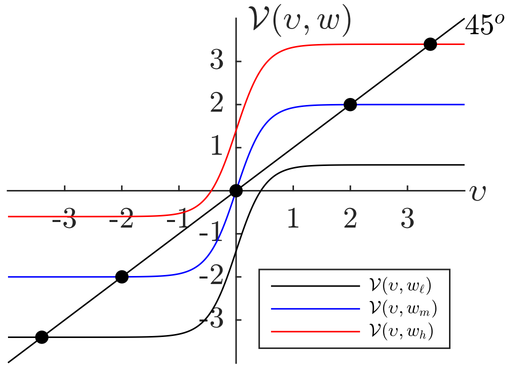

Figure 3: **Indirect Utility Function and Belief Consistency.** This figure fixes the wage at three different levels, $w_\ell < w_m < w_h$, and depicts the indirect utility function $\mathcal{V}$ with altruistic worker preferences. For a fixed wage, the function $\mathcal{V}$ is strictly increasing in υ and bounded. Also, an increase in wage shifts the indirect utility function $\mathcal{V}$ up without affecting its slope (parallel shift). In equilibrium, workers' morale υ is a fixed point of $\mathcal{V}$ by consistency of workers' beliefs. For wage w_ℓ and w_h, there is a unique consistent morale level. However, for mid wage w_m, the function $\mathcal{V}(\cdot, w_m)$ has multiple fixed points.

of beliefs uniquely pins down the workers' morale. However, when wages are in a mid range, there are naturally multiple consistent morale levels.

We now turn to characterize the aggregate supply of labor. The aggregate labor supply reflects both the intensive and extensive margin, and it is given by $\ell(w)F(\upsilon)$ for consistent morale υ (i.e., for $\upsilon \in \Upsilon(w)$). Notice that, for either low enough or high enough wages, the aggregate labor supply slopes up in the (w, ℓ)-space, because workers' (consistent) morale level is unique and increasing in wage w (Lemma 1). Nonetheless, for mid wages, the labor characterization is more subtle because of the emergence of multiple consistent morale levels. Technically, the aggregate labor supplies take multiple values for intermediate wages; that is, the supply of labor is a *correspondence* at the aggregate level, as depicted in Figure 4. However, when the focus is on firm-preferred equilibrium (i.e., the firm optimizes assuming its best-case scenario), the relevant labor supply is an increasing and right-continuous function (see Appendix A.4 for a proof). Moreover, as seen in Figure 4, when wage rate w falls slightly below the wage threshold, the aggregate labor supply drastically falls because of a discontinuous drop in workers' morale υ. Thus, an arbitrarily small downward wage adjustment can substantially discourage workers' participation, thereby impacting labor market outcomes. For the purpose of our result, it is enough to focus on the lowest wage that yields multiple consistent morale levels, which we henceforth refer it as *morale wage* w^m.[12]

[12] Appendix A.2 shows that $w^m \in (0, \infty)$ and that $\Upsilon(w^m)$ contains multiple fixed points.

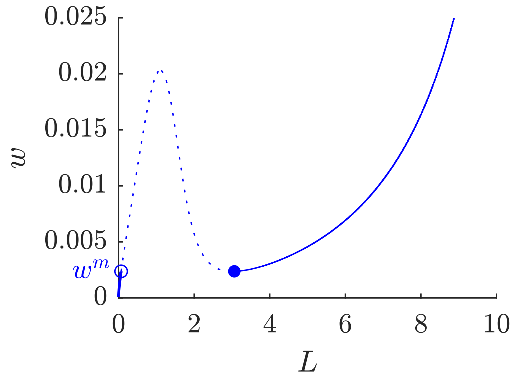

Figure 4: **The Aggregate Labor Supply.** When workers care about their co-workers' welfare, the aggregate labor supplies L^S is an increasing and right-continuous function. When wage w equals w^m, the labor supply function jumps right as wage w^m induces multiple consistent morale levels.

3.3 The Firm's Responses to Productivity Shocks

Consider the firm's problem. It is apparent that the firm's problem can be reduced to:

$$\max_{\substack{w\in[0,\infty) \\ L\in[0,L^S(w)]}} Ay(L) - wL,$$

where the labor supply function $L^S(w)$ is reflected by the right panel of Figure 4. We now examine the implications for labor market outcomes. We show that wage rigidity and involuntary unemployment emerge for mid levels of productivity under mild assumptions.

Theorem 1 (Wage Rigidity and Unemployment). *There are reservation utilities $\bar{r} > \underline{r} > 0$ and a critical level $\bar{\epsilon} \in (0, 1)$, such that for any distribution $F(\cdot)$ for which the mass of potential workers with reservation utility in $[\underline{r}, \bar{r}]$ is above $\bar{\epsilon}$, namely, $F(\bar{r}) - F(\underline{r}) \geq \bar{\epsilon}$, wage rigidity and involuntary unemployment emerge in equilibrium for mid productivity levels A.*

The intuition behind Theorem 1 is best understood by examining Figure 5 (the formal proof is delegated to Appendix A.3). Figure 5 depicts productivity thresholds $A_3 > A_2 > A_1$ such that, in equilibrium: (1) wages are rigid and there is involuntary unemployment when $A \in (A_1, A_2)$; and (2) wages are rigid and there is no involuntary unemployment when $A \in [A_2, A_3]$. To see this, let us first classify productivity shocks according to their intensity level and then explain how these shape the equilibrium wage and unemployment level.

Expansions. When the firm's productivity is high, or $A > A_3$, the firm finds it optimal to hire all available workers based on the same logic given in §3.1. Thus, the firm behaves as a monopsony facing an upward-sloping and continuous labor supply function $L^S(w)$. By our previous analysis in §3.1, both the wage and employment rates are strictly increasing in

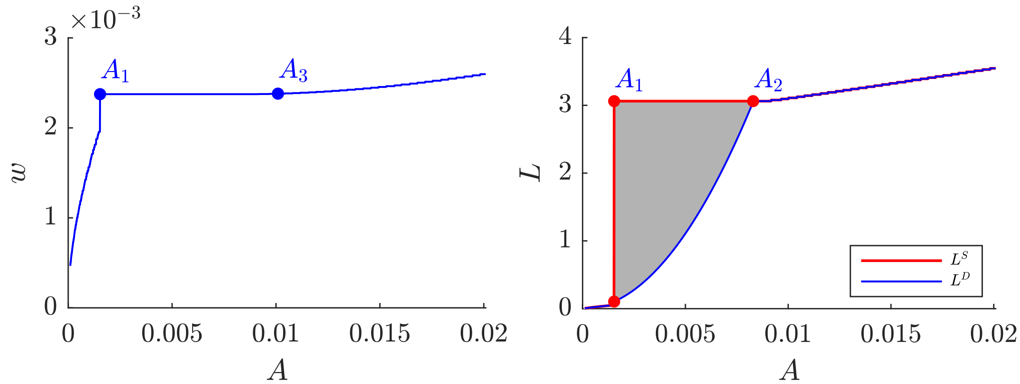

Figure 5: **Implications on Wages and Unemployment.** The respective left and right panel represent the firm's optimal choices of wage and employment for different productivity shocks. Left: In an economic expansion, $A > A_3$, wages vary continuously, so there is no wage rigidity. However, in mild and severe recessions, $A \in (A_1, A_3]$, the firm keeps the wage fixed at w^m, giving rise to wage rigidity. Right: In expansions and mild recessions, the firm hires all available workers, and there is no involuntary unemployment. However, in severe recessions $A \in (A_1, A_2)$, the firm fires workers, giving rise to involuntary unemployment, as depicted by the shaded area.

productivity A. Hence, the wage smoothly falls to morale wage w^m as productivity falls to A_3. Likewise, the firm gradually adjusts employment downward as the economy decelerates.

Mild Recessions. When the economy starts to slow down or when the firm's productivity $A \in [A_2, A_3]$, it is never optimal to choose wage $w > w^m$, as $w = w^m$ is optimal for productivity $A = A_3$. Thus, the firm restricts wages to $w \leq w^m$. However, wages $w < w^m$ trigger a low morale outcome, leading to a sizable drop in labor supply. Thus, a profit-maximizing firm chooses to *insulate* its employees from these adverse productivity shocks, meaning that for all productivity $A \in [A_2, A_3]$, the optimal wage equals w^m and employment satisfies $\mu^D = \mu^S$. Thus, there is wage rigidity but no involuntary unemployment.

Severe Recessions. In an economic recession, or when productivity $A \in (A_1, A_2)$, the firm still faces the event of having workers with low morale should it decide to lower their wages. As productivity A falls from A_2 to A_1, the firm no longer finds it optimal to keep the firm's employment level full. In particular, the firm chooses to fire some of its employees (see Figure 5, right panel). Thus, the employment level is strictly less than the available labor force, $\mu^D < \mu^S$, and *involuntary unemployment emerges.* As seen in Figure 5, *there is also wage rigidity* as the firm keeps the wage at w^m so as not to harm the workers' morale.

Contrary to the implicit insurance literature (Baily, 1974; Azariadis, 1975), the firm here is not motivated by the potential long-term benefits of providing income insurance to its workers. Instead, what happens during severe recessions is that the firm's market power vanishes due to "morale concerns." As seen in Figure 5, the firm behaves as a competitive firm that takes the wage w^m as given and chooses labor to maximize profits. In mild recessions, the firm hires all available workers (binding case), whereas in severe recessions it hires strictly fewer workers than those available (non-binding case). This economic mechanism also yields different implications compared to efficiency wage models (Shapiro and Stiglitz, 1984), because in those models involuntary unemployment emerges for all productivity levels.

Depressions. For productivity $A \leq A_1$, it becomes too costly for the firm to keep workers' morale high by fixing the wage at w^m. As productivity falls from A_1, the firm chooses to discontinuously lower wages. The employment and labor supply drop significantly.

4 Robustness

A. Stability. So far we have considered a firm that chooses wages and demands labor, assuming *all* equilibria (in the worker game) are equally plausible. However, some equilibrium outcomes may be more plausible than others. After a small perturbation, would a natural tatonnement process lead the firm to consider another equilibrium?

The social psychology literature allows us to motivate a natural tatonnement process for beliefs. According to this literature, emotional contagion is a process that is "...relatively *automatic, unintentional, uncontrollable*, and largely inaccessible to conversant awareness..." (Hatfield et al., 2014). This process induces individuals to quickly synchronize their own emotions with those of others and, thus, *converge* emotionally (Iacoboni, 2009; Hatfield et al., 1993; Singer et al., 2004). So motivated, we posit that workers initially start with some beliefs about a morale level and then adjust their beliefs accordingly after observing the workers' morale at the workplace. Precisely, we consider the following tatonnement process:

$$\dot{\upsilon}_t = \eta(\mathcal{V}(w, \upsilon_t) - \upsilon_t), \tag{4}$$

where $\eta \in (0, 1)$ determines the speed of adjustment. Given wage w, consistent morale υ^* is *stable* if it is asymptotically stable for the adjustment process (4), in other words, every dynamic converges to the equilibrium υ^*. By standard arguments, for almost all wage rates w, the largest and smallest consistent morale levels are stable. Also, even if for some wages w the largest consistent morale level is unstable, it can be arbitrarily approximated to a stable one; Appendix A.4 provides a formal proof. Thus, the firm's optimal behavior is unaffected by this stability criterion. Hence, our implications regarding wage rigidity and unemployment remain unchanged, even if the focus is on stable equilibria.

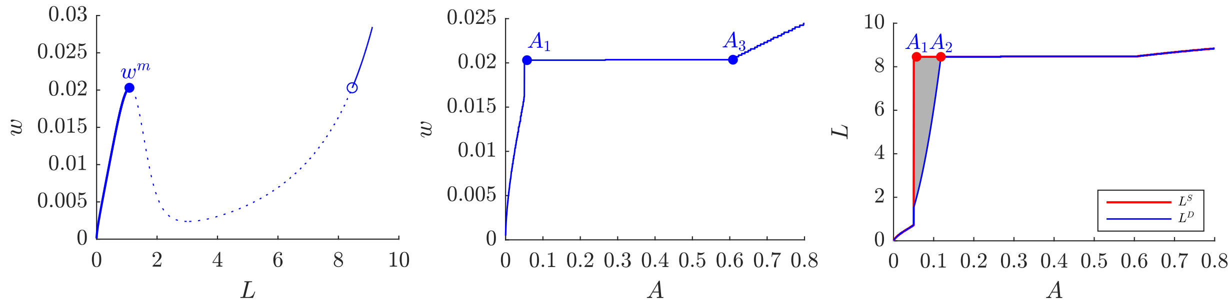

Figure 6: **Implications on Wages and Unemployment with Pessimistic Firm Beliefs.** LEFT: The aggregate labor supply function is increasing and left-continuous, and it jumps right when wage w is slightly greater than the morale wage w^m, which is now the highest wage that yields multiple equilibria. MIDDLE AND RIGHT: Wage rigidity and involuntary unemployment emerge for mid levels of productivity.

B. Equilibrium Selection Rules. Another premise of our framework is that the firm optimizes with respect to its *best* implementable outcome. Next, we show that our results do not depend on this specific equilibrium selection, but rather on the fact that the *labor supply function is discontinuous for any selection rule.*

To gain some intuition, consider the polar case in which the firm optimizes assuming the "worst-case" scenario. This case resembles a cautious or *pessimistic* firm that assumes that the lowest labor supply will prevail. Figure 6 depicts the aggregate labor supply faced by a pessimistic firm. For the range of wages with multiple implementable outcomes, the one with the lowest aggregate labor supply is relevant. Compared to our leading case, the aggregate labor supply $L^S(w)$ is discontinuous at a higher morale wage w^m. Intuitively, a cautious firm is more reluctant to cut wages to prevent a low morale outcome, giving rise to rigidities at higher wage levels. Therefore, wage rigidity and involuntary unemployment also emerge for mid productivity levels, as seen in the middle and right panels of Figure 6. Thus, our qualitative results extend to this case.

In general, our results extend to any piecewise continuous *selection rule.* Appendix A.5 shows that $L^S(w)$ is necessarily discontinuous and, therefore, our qualitative predictions hold for arbitrary selection rules.

C. Intensive Margin. So far we have considered a separable utility function (1), for which morale υ solely affects the workers' extensive margin: whether to enter the labor force or not. However, it is plausible that a positive work atmosphere amplifies the incentives to supply hours of labor or encourages workers to work harder, given a compensation scheme.

So motivated, we now verify that our insights extend to environments in which morale υ impacts not only the extensive marginal but also the intensive one, namely, how much labor to supply conditional on being hired. To this end, we consider the following, non-separable, utility function:

$$\mathcal{U}(c, \ell, \upsilon) \equiv \ln(c) + \ln(T - \ell) + \gamma(\upsilon)\ln(\ell), \tag{5}$$

where $\gamma(\upsilon) = 1/(1 + e^{-4\upsilon}) - 1/2$ is S-shape as $\alpha(\upsilon)$ in Example 1.[13]

Unlike §3.2, an increase in morale now raises the marginal utility from working, i.e., $\mathcal{U}_{\upsilon\ell} = \gamma'/\ell > 0$, and so the optimal individual labor supply rises in morale υ, capturing the effect of morale on workers' intensive margin. Nonetheless, the resulting indirect utility function $\mathcal{V}(w, \upsilon) \equiv \max_{\ell' \in [0,T]} \mathcal{U}(w\ell', \ell', \upsilon)$ has identical properties compared to the one described in §3.2. Indeed, Appendix A.6 shows that, given wage $w > 0$, the indirect utility function $\mathcal{V}(w, \cdot)$ is differentiable, with $\mathcal{V}_\upsilon(w, \upsilon) > 1$ for some υ, strictly increasing, additively separable in (w, υ), and uniformly bounded. Thus, the set of consistent morale levels $\Upsilon(w) \equiv \{\upsilon \in \mathbb{R} : \mathcal{V}(w, \upsilon) = \upsilon\}$ satisfies all properties stated in Lemma 1.

Therefore, as in §3.2, for sufficiently low and high wages, morale is uniquely determined, as is the aggregate labor supply. However, for mid wages, there are multiple consistent morale levels, so both the individual and aggregate labor supplies are correspondences. The precise shape of the labor supplies depend on the equilibrium selection criterion, as discussed in 4-B. Indeed, unlike in §3.2, now in a firm-preferred equilibrium both the individual and aggregate labor supply functions are increasing, right-continuous, and discontinuous at w^m, as seen in the top panel of Figure 7. Because Theorem 1 exploits the properties of the aggregate labor supply function, our results in §3.3 regarding wage rigidity and involuntary unemployment naturally extend to this setting with non-separable preferences, as shown in the bottom panel of Figure 7.

This exercise shows that our results extend to more general environments, provided $\mathcal{U}(c, \ell, \upsilon)$ induces a correspondence $\Upsilon(w)$ that satisfies the properties described in Lemma 1.

D. Sympathy for the Unemployed. We can also extend our model to include settings in which workers' morale is harmed by both wage cuts and layoffs. This would require an alternative way to determine morale at the workplace. To this end, suppose that morale υ depends on the the average utility level of workers in the labor force, and recall that I denotes the set of employed workers. Next, call LF the *labor force*, namely, the set of workers willing to work, $LF = \{i \in [0, 1] : r_i \leq \mathcal{V}(w, \upsilon)\}$. Then, by Definition 1-ii), morale υ must solve:

$$\upsilon = \frac{\mu(I)}{\mu(LF)}\mathcal{V}(w, \upsilon) + \frac{\mu(LF \setminus I)}{\mu(LF)} \int_{LF \setminus I} \frac{r_i}{\mu(LF \setminus I)} d\mu. \tag{6}$$

[13] Appendix A.6 shows that our results hold for more general non-separable preferences.

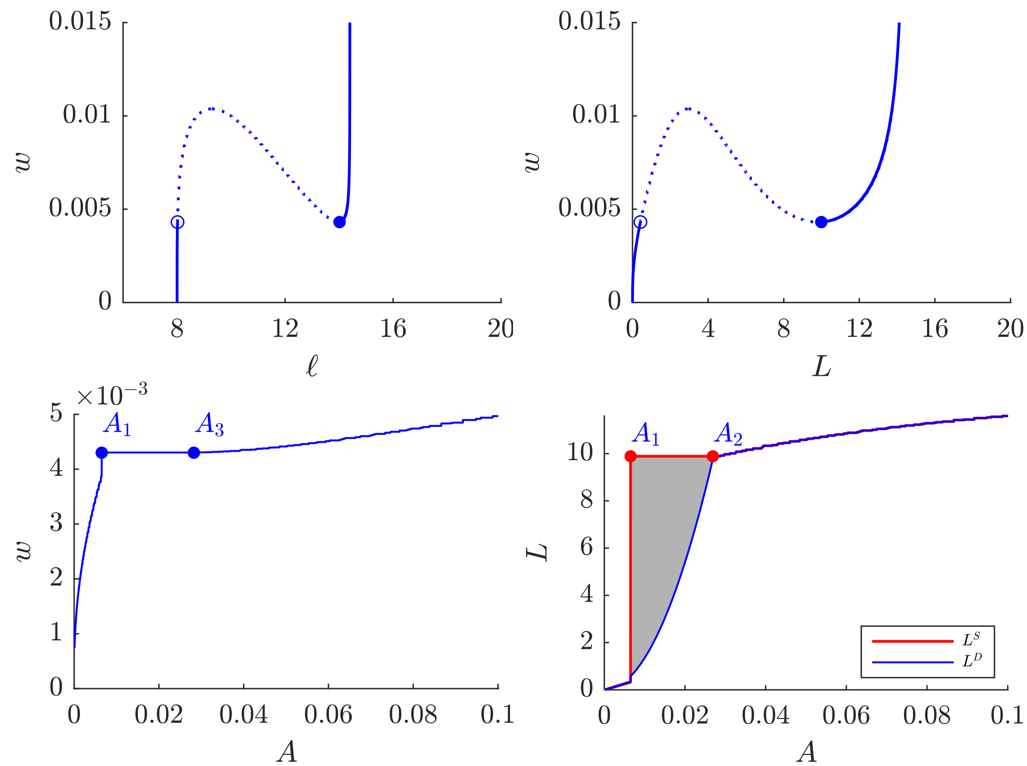

Figure 7: **The Effect of Morale on the Intensive Margin.** Both panels assume $r_i \sim \mathcal{N}(0,1)$, $T = 24$, and $y(L) = \sqrt{L}$. Top: The labor supply functions are increasing, right-continuous, and discountinuous at wage $w = w^m$. Bottom: Wage rigidity and involuntary unemployment emerge for mid levels of productivity.

Notice that $LF \setminus I$ denotes the set of involuntary unemployed workers. Thus, workers' morale is given by the weighted average of the utility level of employed and involuntary unemployed workers. These weights naturally reflect the employment and unemployment rate, respectively. Indeed, if there is no involuntary unemployment, i.e., $I = LF$, then the second component of equation (6) vanishes, and morale is simply determined by the average realized utility at the workplace, as in our baseline model.

Our numerical simulation, depicted in Figure 8, shows that wage rigidity still arises for mid levels of productivity. Nonetheless, because layoffs now have a direct impact on workers' morale, the simulations suggest that employers prefer to insulate their workforce from adverse technological shocks to prevent damaging the morale of workers. As a result, involuntary unemployment might not be observed.

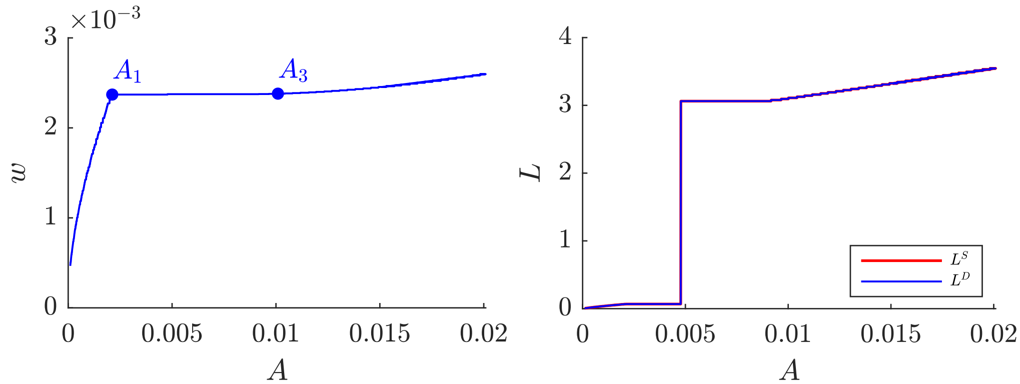

Figure 8: **Sympathy for the Unemployed.** This figure simulates the model using equation (6). In the left panel, wage rigidity emerges for mid levels of productivity. However, there is no involuntary unemployment, as layoffs can also trigger a low morale outcome.

5 Concluding Remarks

In this paper, we show that, when workers are affected by the welfare of others, the firm's responses to adverse productivity shocks involve rigid wages and involuntary transitions to unemployment. This novel finding is robust to different model variations and in line with the empirical patterns and transmission mechanisms explained by practitioners (Bewley, 1999). It highlights that, although social relationships may be seamless in good times, they may impact the functioning of labor markets in bad times. Thus, promoting co-worker altruism may have unexpected effects on the overall economy, especially during times of economic hardship.

Central to our mechanism is workers' interdependent utilities, which give rise to natural discontinuities in the labor supply that manifest via endogenous wage floors. For the sake of transparency, we have considered a stylized labor market with a representative firm. It would be interesting to examine the effects of our main mechanism on team and contract design. A principal, for example, could incentivize workers with a combination of material incentives (via bonuses) and non-material ones (via emotional contagion). In addition, our insights can be straightforwardly embedded into a dynamic labor supply model with free entry and matching frictions. Finally, we believe that our main mechanism may be fruitfully applied to other contexts beyond labor markets in which morale management is important, such as in sport economics and family economics. All these avenues are left for future research.

A Omitted Proofs

A.1 The Fixed-Point Correspondence: Proof of Lemma 1

Proof (a)**.** We want to show that, for any wage $w > 0$, $\Upsilon(w)$ is non-empty and contains a smallest and a largest element, namely, $\underline{\upsilon}(w)$ and $\bar{\upsilon}(w)$, respectively. Moreover, both elements $\underline{\upsilon}(w), \bar{\upsilon}(w) \in \Upsilon(w)$ are strictly increasing in w. We prove part (a) in two steps.

Step 1: Existence. Fix $w > 0$ and restrict the domain of $\mathcal{V}(w, \cdot)$ to the interval $[V(w)+\underline{\alpha}, V(w)+\bar{\alpha}]$. Clearly, the restricted value function is monotone and maps into itself, by Assumption 2. Thus, by Tarski's Fixed Point Theorem, the restricted function has a fixed point and so does the unrestricted one, namely, $\Upsilon(w) \neq \emptyset$. Also, since $[V(w)+\underline{\alpha}, V(w)+\bar{\alpha}]$ is a complete lattice, $\Upsilon(w)$ is also complete lattice, by Tarski's Theorem, and so both the greatest lower bound and least upper bound belong to $\Upsilon(w)$.

Step 2: Monotonicity. By Step 1, $\underline{\upsilon}(w) = \inf\{\upsilon : \mathcal{V}(w, \upsilon) \leq \upsilon\}$. Now consider $w' < w$. Because $\mathcal{V}(w, \upsilon)$ is strictly increasing in w, we have $\mathcal{V}(w', \underline{\upsilon}(w)) < \underline{\upsilon}(w)$. In other words, $\underline{\upsilon}(w) \in \{\upsilon : \mathcal{V}(w', \upsilon) \leq \upsilon\}$, and thus $\underline{\upsilon}(w') < \underline{\upsilon}(w)$. It follows that $\underline{\upsilon}(\cdot)$ is strictly increasing. The proof for the monotonicity of the largest element $\bar{\upsilon}(w)$ is analogous. □

Proof (b)**.** First, by Assumption 2 one has $\lim_{\upsilon \to -\infty} \alpha'(\upsilon) = 0$, and so there exist υ_1 such that,

$$\frac{\partial \mathcal{V}(w, \upsilon)}{\partial \upsilon} = \alpha'(\upsilon) < 1.$$

for all $\upsilon \in (-\infty, \upsilon_1)$. Next, define $w_1 > 0$ so that $V(w_1) \equiv \upsilon_1 - \bar{\alpha}$. Thus, $V(w_1) + \bar{\alpha} = \upsilon_1$, and so for all wages $w \in (0, w_1)$, we have $V(w) + \bar{\alpha} < \upsilon_1$, since $V(w)$ is strictly increasing. This implies that for all $w \in (0, w_1)$, the fixed-point correspondence

$$\Upsilon(w) \subset [V(w) + \underline{\alpha}, V(w) + \bar{\alpha}] \subset (-\infty, \upsilon_1).$$

Therefore, for all $w \in (0, w_1)$, the function $\mathcal{V}(w, \upsilon) - \upsilon$ is strictly decreasing for all $\upsilon \in [V(w) + \underline{\alpha}, V(w) + \bar{\alpha}]$, and thus it vanishes only once. In other words, $\Upsilon(w)$ must have a unique fixed-point. The argument for the upper interval (w_2, ∞) is analogous. □

Proof (c)**.** First, by Assumption 2), there exists $\upsilon^\dagger$ so that $\alpha'(\upsilon^\dagger) > 1$. This implies that at $\upsilon = \upsilon^\dagger$ the slope of value function is strictly greater than one,

$$\frac{\partial \mathcal{V}(w, \upsilon^\dagger)}{\partial \upsilon} = \alpha'(\upsilon^\dagger) > 1.$$

Thus, by continuity, there exists $\varepsilon > 0$ such that $\alpha'(\upsilon^\dagger) > 1$ for all $\upsilon \in [\upsilon^\dagger - \varepsilon, \upsilon^\dagger + \varepsilon]$. Next, for each υ, define $W(\upsilon)$ as the wage that makes υ a fixed-point, or $V(W(\upsilon)) \equiv \upsilon - \alpha(\upsilon)$. Now, let $w_3 \equiv W(\upsilon^\dagger - \varepsilon)$ and $w_4 \equiv W(\upsilon^\dagger + \varepsilon)$. By construction, any $\upsilon \in [\upsilon^\dagger - \varepsilon, \upsilon^\dagger + \varepsilon]$ solves $\mathcal{V}(W(\upsilon), \upsilon) = \upsilon$ and $\partial\mathcal{V}(W(\upsilon), \upsilon)/\partial\upsilon > 1$. Hence, $\mathcal{V}(W(\upsilon), \upsilon + \Delta) > \upsilon + \Delta$ for small enough $\Delta > 0$. But since $\mathcal{V}(W(\upsilon), \cdot)$ is uniformly bounded, we have that $\mathcal{V}(W(\upsilon), \upsilon_h) < \upsilon_h$ for high enough υ_h. Thus, by continuity of $\mathcal{V}(W(\upsilon), \cdot)$, there exists $\bar{\upsilon} \in (\upsilon + \Delta, \upsilon_h)$ with $\mathcal{V}(W(\upsilon), \bar{\upsilon}) = \bar{\upsilon}$. Altogether, $\underline{\upsilon}(w) < \bar{\upsilon}(w)$ for all $w \in [w_3, w_4]$. □

A.2 The Morale Wage w^m

Let the *morale wage* be the lowest wage that yields multiple consistent morale levels, namely, $w^m \equiv \inf\{w > 0 : \underline{\upsilon}(w) < \bar{\upsilon}(w)\}$. The next lemma proves that morale wage is well-defined.

Lemma A.2.1. *The morale wage $w^m \in (0, \infty)$ and entails $\underline{\upsilon}(w^m) < \bar{\upsilon}(w^m)$.*

Proof: First, by Lemma 1-(b), $w^m > 0$. Also, by Lemma 1-(c), the set $\{w > 0 : \underline{\upsilon}(w) < \bar{\upsilon}(w)\} \neq \emptyset$ and so $w^m < \infty$. Next, we show that $\underline{\upsilon}(w^m) < \bar{\upsilon}(w^m)$.

By contradiction, assume that $\Upsilon(w^m) = \{\upsilon^m\}$ and define $g(w, \upsilon) \equiv \mathcal{V}(w, \upsilon) - \upsilon$. Then $g(w^m, \upsilon) \neq 0$ for all $\upsilon \neq \upsilon^m$. Also, since $\lim_{\upsilon\to-\infty} g(w^m, \upsilon) = \infty$ and $\lim_{\upsilon\to\infty} g(w^m, \upsilon) = -\infty$, the function $g(w^m, \upsilon)$ must be strictly decreasing to ensure a single-crossing, and so

$$\frac{\partial g(w^m, \upsilon^m)}{\partial \upsilon} < 0.$$

But then, by the Implicit Function Theorem, there exist open neighborhoods $\mathcal{M}$ and $\mathcal{W}$ about υ^m and w^m, respectively, and a bijective function $\phi : \mathcal{W} \to \mathcal{M}$ obeying $g(w, \phi(w)) = 0$.

Next, consider a minimizing sequence of $\{w_n\}_n \to w^m$ such that $\{w_n\}_n \subset \mathcal{W}$ and $w_n > w^m$, with $\underline{\upsilon}(w_n) < \bar{\upsilon}(w_n)$ for all n. As previously argued, for any $w_n \in \mathcal{W}$ there is a unique fixed-point $\phi(w_n) \in \mathcal{M}$; therefore, there must exist another one, say, $\hat{\phi}(w_n)$ in the complement $\mathcal{M}^c$. Because $\Upsilon(w_n)$ is bounded and $\mathcal{M}^c$ is closed, we can extract a subsequence $\{w_{n_k}, \hat{\phi}(w_{n_k})\}_k \to \{w^m, \hat{\phi}^m\}$ with $\hat{\phi}^m \in \mathcal{M}^c$. Finally, since $g(w, \upsilon)$ is jointly continuous, $g(w^m, \hat{\phi}^m) = 0$, which contradicts that $\Upsilon(w^m)$ is single-valued. □

A.3 Wage Rigidity and Unemployment: Proof of Theorem 1

In a firm-preferred equilibrium, the aggregate labor supply can be written as:

$$L^S(w) = \begin{cases} \ell(w)F(\underline{\upsilon}(w)), & \text{if } 0 \leq w < w^m \\ \ell(w)F(\bar{\upsilon}(w)), & \text{if } w \geq w^m \end{cases} \tag{7}$$

Since $\ell(\cdot)$ and $F(\cdot)$ are strictly increasing, $L^S(w)$ exhibits a discontinuous right jump at wage $w = w^m$. Call $\underline{r} \equiv \underline{v}(w^m)$ and $\bar{r} \equiv \bar{v}(w^m)$ the minimal and maximal realized utility that can arise when the wage is w^m (Lemma A.2.1). Also, let $\epsilon > 0$ so that $F(\underline{r}) \leq \epsilon$ and $F(\bar{r}) \geq 1-\epsilon$. Finally, define $\bar{A} \equiv w^m/y'(\ell(w^m))$.

Proof of Theorem 1. As a first step, we'll show that there exists a productivity range wherein profits are uniformly bounded from above for all wages $w < w^m$. First, since $y(L)$ is strictly concave with $y(0) = 0$, we have that profits $\bar{A}y(\ell(w^m)) - \ell(w^m)w^m > 0$. Next, since profits are continuous in productivity A, there exists a productivity level $\underline{A} \in (0, \bar{A})$ such that $\underline{A}y(\ell(w^m)) - \ell(w^m)w^m > 0$. Also, for any wage w below w^m, monotonicity of $\underline{v}(\cdot)$ (Lemma 1-*a*)) implies that $\underline{v}(w) \leq \underline{v}(w^m) = \underline{r}$. Thus, the labor supply is bounded: $L^S(w) \leq \ell(w^m)\epsilon$. This implies that, for any wage $w \in (0, w^m)$ and productivity $A \in [\underline{A}, \bar{A}]$ the firm's profit is uniformly bounded from above by $\bar{\pi}(\epsilon) \equiv \bar{A}y(\ell(w^m)\epsilon)$.

Next, we show that for any productivity $A \in [\underline{A}, \bar{A}]$, fixing the wage at $w = w^m$ is strictly better than choosing any other wage $w < w^m$. To see this, consider a firm that sets wage $w = w^m$, and optimally chooses the amount of labor $L^D \leq L^S(w^m)$. Observe that for all productivity $A \in [\underline{A}, \bar{A}]$, the maximal profit — namely, $\max_{L^D \leq L^S(w^m)} Ay(L^D) - w^m L^D$ — is uniformly bounded from below by $\underline{\pi}(\epsilon) \equiv \underline{A}y(\ell(w^m)(1-\epsilon)) - \ell(w^m)(1-\epsilon)w^m$. Also, these bounds $\bar{\pi}(\epsilon)$ and $\underline{\pi}(\epsilon)$ are continuous and obey $\lim_{\epsilon\to 0} \bar{\pi}(\epsilon) = 0$ and $\lim_{\epsilon\to 0} \bar{\pi}(\epsilon) = \underline{A}y(\ell(w^m)) - \ell(w^m)w^m > 0$. Consequently, there exists $\epsilon^1 > 0$ such that for all $\epsilon \leq \epsilon^1$, we have $\bar{\pi}(\epsilon^1) < \underline{\pi}(\epsilon^1)$. Altogether, for all productivity $A \in [\underline{A}, \bar{A}]$, keeping the wage fixed at $w = w^m$ strictly dominates any choice involving $w < w^m$.

Finally, we conclude by showing that for a range of productivity levels A, fixing $w = w^m$ along with involuntary unemployment are globally optimal for the firm. Let $\epsilon^2 \in (0, \epsilon^1)$ for which $\bar{\bar{A}} \equiv w^m/y'(\ell(w^m)(1-\epsilon^2)) \in (\underline{A}, \bar{A})$. (Notice that this value is well defined.) Next, for any distribution $F(\cdot)$ that satisfies $F(\bar{r}) \geq 1 - \epsilon^2$, labor supply $L^S(w^m) = \ell(w^m)F(\bar{r}) \geq \ell(w^m)(1-\epsilon^2)$. The profit maximizing labor demand of a *wage taking* firm facing wage w^m is implicitly determined by the FOC: $Ay'(L^D) = w^m$. So by construction, for all productivity $A \in (\underline{A}, \bar{\bar{A}})$, this choice satisfies $L^D < L^S(w^m)$, and hence it involves involuntary unemployment. Finally, the choice of a wage-taking firm gives strictly higher profit than any other choice $L > L^D$ given w^m. Because such pair (L^D, w^m) is available to the firm, these choices dominate any other alternative involving $L > L^D$ and $w \geq w^m$. Altogether, (L^D, w^m) is globally optimal. To conclude the argument, define $\bar{\epsilon} = 1 - \epsilon^2$. □

A.4 Stability of Implementable Outcomes

We'll show that the solution to the firm's problem is robust.

Step 1: $\partial g(\bar{\upsilon}, w)/\partial\upsilon \leq 0$ for $\bar{\upsilon} \in \Upsilon(w)$. Indeed, consider the largest morale level $\bar{\upsilon}(w)$. By Lemma 1-(c), we must have $\partial g(\bar{\upsilon}, w)/\partial\upsilon = \partial\mathcal{V}(\bar{\upsilon}, w)/\partial\upsilon - 1 \leq 0$; otherwise, $\bar{\upsilon}(w)$ would not be the largest fixed-point, which is a contradiction.

Step 2: for almost all $w > 0$, we have $\partial g(\bar{\upsilon}, w)/\partial\upsilon < 0$. To see this, recall that for any $w > 0$ the function $g(\upsilon, w) \equiv \mathcal{V}(w, \upsilon) - \upsilon$ is separable in (υ, w), since $\mathcal{V}(w, \upsilon)$ is separable by Lemma A.6.1, and also strictly increasing in w as $\partial g(\upsilon, w)/\partial w = \partial\mathcal{V}(w, \upsilon)/\partial w = \alpha/w > 0$. Thus, g is transverse to zero, or $g(\cdot, \cdot) \pitchfork 0$. Consequently, by the Transversality Theorem, $g(\cdot, w) \pitchfork 0$ for almost all $w > 0$ (Milnor, 1997). In other words, for almost all wage $w > 0$ and $\tilde{\upsilon} \in \Upsilon(w)$, $\partial g(\tilde{\upsilon}, w)/\partial\upsilon \neq 0$.

Step 3: for almost all $w > 0$, the largest morale level $\bar{\upsilon}$ is stable. By Steps 1–2, we conclude that for almost all wages $w > 0$, the largest morale level $\bar{\upsilon}$ satisfies $\partial g(\bar{\upsilon}, w)/\partial\upsilon < 0$. Thus, for almost all $w > 0$, the tâtonnement (4) asymptotically converges to $\bar{\upsilon}$, by standard results.[14]

Next, consider a wage $w^\dagger > 0$ for which $\bar{\upsilon}(w^\dagger)$ is unstable according to (4), and take a converging sequence $\{w_n\}_n \downarrow w^\dagger$ such that $\bar{\upsilon}_n \equiv \bar{\upsilon}(w_n)$ is stable for all n. Such sequence must exist, as the set of wages for which $\bar{\upsilon}$ is unstable has zero Lebesgue measure. Also, because $\bar{\upsilon}(\cdot)$ is increasing, by Lemma 1-(a), and bounded from below by $\bar{\upsilon}(w^\dagger)$, the image sequence $\{\bar{\upsilon}_n\}_n$ must converge to some limit $\bar{\upsilon}^\dagger$, obeying $\bar{\upsilon}^\dagger \geq \bar{\upsilon}(w^\dagger)$.

Step 4: $\bar{\upsilon}^\dagger = \bar{\upsilon}(w^\dagger)$. To see this, notice that *under optimistic beliefs, the largest morale level* $\bar{\upsilon}(w)$ *is right-continuous*. Indeed, by definition, $g(\bar{\upsilon}_n, w_n) = 0$ for all n. Thus, $g(\bar{\upsilon}^\dagger, w^\dagger) = 0$ because g is jointly continuous. That is, $\bar{\upsilon}^\dagger \in \Upsilon(w^\dagger)$ and so $\bar{\upsilon}^\dagger \leq \bar{\upsilon}(w^\dagger)$. But, $\bar{\upsilon}^\dagger \geq \bar{\upsilon}(w^\dagger)$, and so $\bar{\upsilon}^\dagger = \bar{\upsilon}(w^\dagger)$.

For the sake of clarity, we slightly abuse and introduce some notation that is just needed here. The firm's optimization can be written as $(\mathcal{P}) : \sup_{w>0} \Pi(w|\Upsilon)$, where $\Pi(w|\Upsilon) \equiv \sup_{\upsilon\in\Upsilon(w)} \pi(\upsilon, w)$ and

$$\pi(\upsilon, w) \equiv \sup_{L\in[0,\ell(\upsilon)F(\upsilon)]} Ay(L) - wL.$$

Observe that $\pi(\upsilon, w)$ is jointly continuous, by the Maximum Theorem. Moreover, $\pi(\cdot, w)$ is increasing in υ, and so $\Pi(w|\Upsilon) = \pi(\bar{\upsilon}(w), w)$ since $\bar{\upsilon}(w) \in \Upsilon(w)$. Also, since $\bar{\upsilon}(w)$ is right-continuous (Step 4), it follows that $\Pi(w|\Upsilon)$ *is right-continuous* as well.

Analogously, given $w > 0$, call $\Upsilon^*(w)$ the *set of stable morale levels*. Under optimistic and stable beliefs, the firm solves $(\mathcal{P}^*) : \sup_{w>0} \Pi(w|\Upsilon^*)$. We say that w^* *solves* $(\mathcal{P}^*)$ if there exists sequence $(w_n) \to w^*$ such that $\Pi(w_n) \to \sup_{w>0} \Pi(w|\Upsilon^*)$.

Let $\Pi^* \equiv \sup_w \Pi(w|\Upsilon)$ and suppose that $w^* > 0$ solves $(\mathcal{P})$, namely, $\Pi(w^*|\Upsilon) = \Pi^*$.[15]

[14] The lowest morale level $\underline{\upsilon}(w) \in \Upsilon(w)$ is also stable for almost all wages $w > 0$, following the same logic.

[15] Such wage w^* must exist. First, the labor supply is bounded, $\ell(\cdot)F(\cdot) < \hat{L}$ for some $\hat{L} > 0$. Thus,

Step 5: If w^* solves $(\mathcal{P})$ then it also solves $(\mathcal{P}^*)$. To see this, first notice that $\sup_{w>0} \Pi(w|\Upsilon^*) \leq \Pi^*$ as $\Upsilon^*(w) \subseteq \Upsilon(w)$. Now, let $\mathcal{W} \equiv \{w : \bar{\upsilon}(w) \in \Upsilon^*(w)\}$ be the (full Lebesgue measure) set of wages w for which $\bar{\upsilon}(w)$ is stable. Next, we separate in cases.

Case 1: $w^* \in \mathcal{W}$. Then $\bar{\upsilon}(w^*) \in \Upsilon^*(w^*)$, and so $\Pi(w^*|\Upsilon^*) = \Pi(w^*|\Upsilon) = \Pi^*$.

Case 2: $w^* \notin \mathcal{W}$. Here, $\bar{\upsilon}(w^*)$ is unstable, and so $\bar{\upsilon}(w^*) > \sup(\Upsilon^*(w))$. Thus, $\pi(\bar{\upsilon}(w^*), w^*) \geq \pi(\upsilon, w^*)$ for all $\upsilon \in \Upsilon^*(w^*)$, as $\pi(\cdot, w^*)$ is increasing. Consequently, $\Pi^* \geq \Pi(w^*|\Upsilon^*)$. Now if $\Pi(w^*|\Upsilon) = \Pi(w^*|\Upsilon^*)$ then w^* solves $(\mathcal{P}^*)$. Otherwise, $\Pi^* > \Pi(w^*|\Upsilon^*)$. In such case, we consider a convergent sequence $\{w_n\} \to w^*$ and extract a monotone decreasing subsequence $\{w_{n_k}\} \downarrow w^*$. WLOG we can pick a subsequence with $w_{n_k} \in \mathcal{W}$ for all k, as $\mathcal{W}$ has full measure. But, as previously argued, $\Pi(\cdot|\Upsilon)$ is right-continuous, and so $\Pi^* = \Pi(w^*|\Upsilon) = \lim_{w_{n_k} \downarrow w^*} \Pi(w_{n_k}|\Upsilon) = \lim_{w_{n_k} \downarrow w^*} \Pi(w_{n_k}|\Upsilon^*)$. That is, w^* solves $\mathcal{P}^*$. □

A.5 General Selection Rules

We now show that for any piecewise continuous selection $w \mapsto \sigma(w) \in \Upsilon(w)$, the induced labor supply $L^S(w) \equiv \ell(w)F(\sigma(w))$ is discontinuous. Thus, wage rigidity and involuntary emerge, under mild conditions, by paralleling the logic given in the proof of Theorem 1.

Let $\upsilon_o \equiv \inf\{\upsilon \in \mathbb{R} : \exists \varepsilon > 0 \text{ such that } g(\cdot, w) \text{ is increasing on } (\upsilon, \upsilon+\varepsilon)\}$.

Step 1: $\upsilon_o \in (-\infty, \infty)$. Because the value function $\mathcal{V}(w, \upsilon)$ is additively separable, the derivative of $g(\upsilon, w) \equiv \mathcal{V}(w, \upsilon) - \upsilon$ in υ is unaffected by w. Also, because $\lim_{\upsilon \to -\infty} \alpha'(\upsilon) = 0$ by Assumption 2, we have that $\lim_{\upsilon \to -\infty} g_\upsilon(\upsilon, w) = -1$, and so $g(\upsilon, w)$ strictly decreasing on the "left tail." Thus, $\upsilon_o > -\infty$. Also, by Assumption 2, there exists υ with $g_\upsilon(\upsilon, w) > 0$; thus, $\upsilon_o < \infty$.

Step 2: $g(\cdot, w)$ is strictly decreasing on $(-\infty, \upsilon_o)$. Suppose not. Then, there exist $\upsilon_1, \upsilon_2 \in (-\infty, \upsilon_o)$ with $\upsilon_2 > \upsilon_1$ and $g(\upsilon_2, w) \geq g(\upsilon_1, w)$. Because $g(\cdot, w)$ is continuous, there exists $\upsilon^\star \in [\upsilon_2, \upsilon_1]$ such that $g(\upsilon^\star, w) = \max_{\upsilon \in [\upsilon_1, \upsilon_2]} g(\upsilon, w)$. If $\upsilon^\star > \upsilon_1$, then there exists $\upsilon' \in (\upsilon_1, \upsilon^\star)$ such that $g(\cdot, w)$ increases on $(\upsilon', \upsilon^\star)$. But then $\upsilon_o \leq \upsilon'$, which is a contradiction. Alternatively, if $\upsilon^\star = \upsilon_1$, then $g(\upsilon_2, w) = g(\upsilon^\star, w)$, and so there exists $\upsilon'' \in (\upsilon_1, \upsilon_2)$ such that $g(\cdot, w)$ increases on (υ'', υ^2). But then, again, $\upsilon_o \leq \upsilon''$, which is a contradiction

Let $w_o \equiv W(\upsilon_o)$, where $W(\cdot)$ is defined in the proof of Lemma 1-(c). By construction, $g(\upsilon, w)$ is strictly decreasing in υ and strictly increasing in w for all $(\upsilon, w) \in (-\infty, \upsilon_o) \times (0, w_o)$. Thus, $W : (-\infty, \upsilon_o) \mapsto (0, w_o)$ is strictly increasing and differentiable, with derivative $W'(\upsilon) = -g_\upsilon(\upsilon, W(\upsilon))/g_w(\upsilon, W(\upsilon)) > 0$. Finally, $W(\cdot)$ is surjective, and so its inverse

$\Pi(w|\Upsilon) \leq \bar{\Pi}(w) \equiv \max_{L \in [0,\hat{L}]} Ay(L) - wL$. Second, since $Ay'(0) - w = \infty$, $\bar{\Pi}(w)$ is strictly decreasing and continuous, by standard results. Finally, $\bar{\Pi}(0) > 0 > \bar{\Pi}(\infty) = -\infty$; thus, there exists $\hat{w} \in (0, \infty)$ such that $\bar{\Pi}(w) < 0$ for all $w > \hat{w}$. Altogether, $\sup_{w>0} \Pi(w|\Upsilon) = \max_{w \in [0,\hat{w}]} \Pi(w|\Upsilon)$, as $\Pi(\cdot|\Upsilon)$ is right-continuous.

$W^{-1}(\cdot)$ is well-defined, namely, $g(W^{-1}(w), w) = 0$ for all $w \in (0, w_o)$.

Step 3: Any continuous selection $\sigma : (0,\infty) \mapsto \mathbb{R}$ must coincide with $W^{-1}(\cdot)$ on $(0, w_o)$. Suppose not, and let $w_\sigma = \inf\{w \in (0, w_o) : W^{-1}(w) \neq \sigma(w)\}$. First, $w_\sigma > 0$, as for low w the correspondence $\Upsilon(w)$ is single-valued (Lemma 1-(b)). Next, consider two cases.

Case 1: $\sigma(w_\sigma) = W^{-1}(w_\sigma)$. Then by definition of w_σ, there exists sequence $\{w_n\}_n \to w_\sigma$ such that $\sigma(w_n) \neq W^{-1}(w_n)$. Since for each w_n the selection $\sigma(w_n) \in \Upsilon(w_n)$, we must have $\sigma(w_n) \geq \upsilon_o$. But then, $\sigma(w_\sigma) = \lim_{n\to\infty} \sigma(w_n) \geq \upsilon_o$. This is a contradiction, since $\sigma(w_\sigma) = W^{-1}(w_\sigma) \in (-\infty, \upsilon_o)$.

Case 2: $\sigma(w_\sigma) \neq W^{-1}(w_\sigma)$. Then, $\sigma(w_\sigma) \geq \upsilon_o$. Next, consider any sequence $\{w_n\} \to w_\sigma$ with $w_n < w_\sigma$. By definition of w_σ, $\sigma(w_n) = W^{-1}(w_n)$ for all n. Thus,

$$\lim_{w_n \to w_\sigma} \sigma(w_n) = \lim_{w_n \to w_\sigma} W^{-1}(w_n) = W^{-1}\left(\lim_{w_n \to w_\sigma}\right) = W^{-1}(w_\sigma) < \upsilon_o \leq \sigma(w_\sigma).$$

Therefore, the selection $\sigma(\cdot)$ is discontinuous at w_σ, which is a contradiction.

Step 4: There is no continuous selection $\sigma(w)$ on $(0,\infty)$. By contradiction, suppose $\sigma(\cdot)$ is continuous. Then, by the previous step, $\sigma(\cdot)$ must coincide with $W^{-1}(\cdot)$ on $(0, w_o)$. Also, there exists $\varepsilon > 0$ such that $g(\upsilon, w_o)$ is increasing for all $\upsilon \in (\upsilon_o, \upsilon_o + \varepsilon)$. Thus, because $g(\cdot, \upsilon)$ is strictly increasing, $g(w, \upsilon) > 0 = g(w_o, \upsilon_o)$ for all $w > w_o$ and $\upsilon \in (\upsilon_o, \upsilon_o + \varepsilon)$. This implies that for all $w > w_o$, any selection $\sigma(w) \geq \upsilon_o + \varepsilon$. Finally, consider sequences $\{w_n'\} \uparrow w_o$ and $\{w_n''\} \downarrow w_o$. Then,

$$\lim_{w_n' \uparrow w_o} \sigma(w_n) = \sigma(w_o) = \upsilon_o < \upsilon_o + \varepsilon \leq \lim_{w_n'' \downarrow w_o} \sigma(w_n).$$

Therefore, $\sigma(\cdot)$ is discontinuous at w_o, which is a contradiction. □

A.6 The Effect of Morale on Workers' Intensive Margin

In this section, we generalize the class of non-separable preferences examined in §4-C. We now consider the following utility function:

$$\mathcal{U}(c, \ell, \upsilon) \equiv \beta_1 \ln(c) + \beta_2 \ln(T - \ell) + \gamma(\upsilon) \ln(\ell), \tag{8}$$

where $\beta_1, \beta_2 > 0$. The first two terms in (1) capture the usual trade-off between consumption and leisure, whereas the last one reflects the enjoyment level derived at the workplace. Notice that enjoyment at the workplace is determined by the workers' morale $\upsilon \in \mathbb{R}$. We impose the following restrictions on $\gamma(\cdot)$, which parallel those given for $\alpha(\cdot)$ in Assumption 2.

Assumption 3. *The function* $\gamma : \mathbb{R} \to (\underline{\gamma}, \bar{\gamma})$ *is differentiable, bounded with* $\underline{\gamma} < 0 < \bar{\gamma}$*, and strictly increasing with vanishing marginal effects* $\lim_{\upsilon\to\infty} \gamma'(\upsilon) = \lim_{\upsilon\to-\infty} \gamma'(\upsilon) = 0$*. Also,*

a) the lowest enjoyment satisfies $\underline{\gamma} > -\beta_1 + \beta_2/(T-1)$*; and*

b) the marginal enjoyment $\gamma'(\cdot)$ *obeys* $\gamma'(\upsilon^\dagger) > 1/\ln(T\beta_1/(\beta_1+\beta_2))$ *for some* $\upsilon^\dagger \in \mathbb{R}$.

Next, we show that our results from Theorem 1 extend to environments wherein preferences are governed by (1). As usual, define the workers' indirect utility function as $\mathcal{V}(w,\upsilon) \equiv \max_{\ell'} \mathcal{U}(w\ell', \ell', \upsilon)$. Then,

Lemma A.6.1. *For any* $w > 0$*, the indirect utility function* $\mathcal{V}(w,\cdot)$ *is differentiable, with* $\mathcal{V}_\upsilon(w,\upsilon) > 1$ *for some* υ*, strictly increasing, additively separable in* (w,υ)*, and uniformly bounded.*

Proof: First, consider the workers' optimization problem. The average individual labor ℓ that maximizes $\mathcal{U}(w\ell, \ell, \upsilon)$ in (1) is given by the first-order condition:

$$\ell(\upsilon) = T\left(\frac{\beta_1 + \gamma(\upsilon)}{\beta_1 + \beta_2 + \gamma(\upsilon)}\right). \tag{9}$$

Clearly, the optimal labor supply $\ell(\upsilon)$ is strictly increasing and bounded, since $\gamma(\upsilon)$ is increasing and bounded, given Assumption 3. Also, by Assumption 3-a), ℓ is uniformly bounded from below: $\ell(\cdot) > T\left(\frac{\beta_1+\underline{\gamma}}{\beta_1+\beta_2+\underline{\gamma}}\right) > 1$; and from above: $\ell(\cdot) < T\left(\frac{\beta_1+\bar{\gamma}}{\beta_1+\beta_2+\bar{\gamma}}\right)$. Thus, the value function $\mathcal{V}(w,\upsilon) = \mathcal{U}(w\ell(\upsilon), \ell(\upsilon), \upsilon)$ is differentiable in υ and, by the Envelope Theorem, its derivative $\partial\mathcal{V}(w,\upsilon)/\partial\upsilon$ obeys:

$$\frac{\partial\mathcal{V}(w,\upsilon)}{\partial\upsilon} = \frac{\partial\mathcal{U}(w\ell,\ell,\upsilon)}{\partial\upsilon}\Big|_{\ell=\ell(\upsilon)} = \gamma'(\upsilon)\ln(\ell(\upsilon)). \tag{10}$$

Hence, $\mathcal{V}(w,\cdot)$ is strictly increasing, as $\gamma' > 0$ and $\ell(\upsilon) > 1$ and so $\gamma'(\upsilon)\ln(\ell(\upsilon)) > 0$.

Next, we show that $\mathcal{V}(w,\cdot)$ is additively separable. Plugging (9) into the utility function (1), we see that there exists functions $V_1(w)$ and $V_2(\gamma(\upsilon))$ such that,

$$\mathcal{V}(w,\upsilon) = V_1(w) + V_2(\gamma(\upsilon)).$$

In particular, $V_1(w) \equiv \alpha\ln(w)$ which is strictly increasing, continuous, and its inverse is well-defined. On the other hand, $V_2(\gamma(\upsilon))$ is given by:

$$V_2(\gamma(\upsilon)) \equiv (\beta_1+\beta_2+\gamma(\upsilon))\ln T + (\beta_1+\gamma(\upsilon))\ln(\beta_1+\gamma(\upsilon)) - (\beta_1+\beta_2+\gamma(\upsilon))\ln(\beta_1+\beta_2+\gamma(\upsilon)),$$

which is strictly increasing, continuous, and uniformly bounded from below and above by $\underline{V} \equiv V_2(\underline{\gamma})$ and $\bar{V} \equiv V_2(\bar{\gamma})$, respectively. Thus, the value function $\mathcal{V}(w, \upsilon)$ is also uniformly bounded from below and above by $V_1(w) + \underline{V}$ and $V_1(w) + \bar{V}$, respectively.

Finally, notice that $\mathcal{V}_\upsilon(w, \upsilon^\dagger) > 1$ follows from Assumption 3-b). □

By Lemma A.6.1, the set of consistent morale levels $\Upsilon(w) \equiv \{\upsilon \in \mathbb{R} : \mathcal{V}(w, \upsilon) = \upsilon\}$ satisfies all properties stated in Lemma 1. Moreover, in a firm-preferred equilibrium, the aggregate labor supply function is increasing and right-continuous and takes the following form:

$$L^S(w) = \begin{cases} \ell(\underline{\upsilon}(w))F(\underline{\upsilon}(w)), & \text{if } 0 \le w < w^m \\ \ell(\bar{\upsilon}(w))F(\bar{\upsilon}(w)), & \text{if } w \ge w^m \end{cases} \tag{11}$$

Thus, Theorem 1 can be established using the same arguments given in Appendix A.1-A.2.

B A Game-Theoretic Foundation

In this section, we develop a conceptual principal-agent framework with many agents who have interdependent preferences among each other. Specifically, the principal chooses a simultaneous move game with complete information, wherein players *care* about the realized utility of others (Ray and Vohra, 2020; Vásquez and Weretka, 2020).

A *game* Γ consists of a set of agents I and a strategy set for each agent S_i, with $\mathbf{S} \equiv \times_{i\in I} S_i$ and generic element $s = (s_i)_{i\in I}$. We assume that agents' realized utilities depend upon not only the strategy profile being played, but also the realized utilities of others. Formally, a *utility function* of agent i is a map $\mathcal{U}_i : \mathbf{S} \times \mathbb{R}^I \to \mathbb{R}$, defined over available strategy profiles $s \in \mathbf{S}$ and realized agents' payoffs $u \in \mathbb{R}^I$. Thus, for any profile s, an interdependent *utility system* $\mathbf{U} \equiv (\mathcal{U}_i)_{i\in I}$ maps the agents' payoffs into itself: $\mathbf{U}(s, \cdot) : \mathbb{R}^I \to \mathbb{R}^I$. Altogether, a game is described by $\Gamma \equiv \langle I, \mathbf{S}, \mathbf{U} \rangle$. The set of games available to the principal is $\mathcal{G}$.

A key challenge when analyzing this class of games is that, because of the feedback effects among agents' final or *realized utilities* $u \equiv (u_i)_{i\in I}$, for some strategy profile s there may be multiple solutions to the utility system $\mathbf{U}(s, u) = u$. If so, the utility system fails to induce uniquely a normal-form game, and standard solution concepts, such as the Nash equilibrium, are inapplicable.[16] We bypass this issue by endowing agents with *consistent beliefs* about the others' realized utilities. This allows agents to assess unilateral deviations, which is a key step toward the determination of the strategies that arise in equilibrium.

Individual beliefs about the realized utilities of others are *consistent at s* if they can be justified by a solution to the system $\mathbf{U}(s, u) = u$. Precisely, fix a utility system $\mathbf{U}$ and strategy

[16]For example, in a two-agent game there are, respectively, infinite and none reduced-form payoffs when $\mathcal{U}_i(s, u_{-i}) = u_{-i}$ and $\mathcal{U}_i(s, u_{-i}) = u_{-i} + 1$ for both agents.

profile s. The set of unilateral deviations for agent i given s is $\mathbf{S}_{i|s} \equiv \{s' \in \mathbf{S} : s'_{-i} = s_{-i}\}$ and the union of such deviation sets is $\mathbf{S}_s \equiv \bigcup_{i \in I} \mathbf{S}_{i|s}$. Next, the *set of reduced-form payoffs* is $\mathbf{U}_s \equiv \{u \in \mathbb{R}^{I \times \mathbf{S}_s} : u(s') = \mathbf{U}(s', u(s')), \forall s' \in \mathbf{S}_s\}$ with generic element $u(s) \equiv (u_i(s))_{i \in I}$, $s \in \mathbf{S}_s$. In words, for any potential deviation s', consistency of beliefs demands that players' realized utilities $u(s')$ solve the utility system $\mathbf{U}(s', u(s')) = u(s')$.

Definition 2. A strategy profile s is an *equilibrium given consistent beliefs* $u(\cdot) \in \mathbf{U}_s$ if for each player $i \in I$, $u_i(s) \geq u_i((s'_i, s_{-i}))$ for all $s'_i \in S_i$.

Because a strategy profile may be associated with multiple realized utilities u, we focus on the game's outcomes. Given Γ, an *outcome* is a tuple $o \equiv (s, u(s)) \in \mathbf{S} \times \mathbb{R}^I$. We call the *set of feasible outcomes* $\mathbf{O}_\Gamma$ and assume that agents have heterogeneous *reservation utilities* $r_i \in \mathbb{R}$, $i \in I$. A feasible outcome $o \equiv (s, u(s)) \in \mathbf{O}_\Gamma$ is *implementable with beliefs* $u \in \mathbf{U}_s$ if the profile s is an equilibrium given beliefs u and individual rationality holds, i.e., $u_i(s) \geq r_i$ for all i. In other words, an outcome is implementable when the strategy chosen by each agent is optimal, given consistent beliefs, and all agents have incentives to participate.

Now let us turn to the principal's incentives. In general, the principal may care about not only agents' actions, but also their well-being. Thus, we define her payoff function $\pi(\cdot)$ over the set of feasible outcomes $\mathbf{O}_\Gamma$. As in a sub-game Perfect Equilibrium, the principal forecasts the equilibrium response to variations in the environment, which translates into the principal restricting her attention to the *set of implementable outcomes* $\mathbf{O}^*_\Gamma$. Next, we endowed the principal with an equilibrium *selection rule* $\sigma : \Gamma \mapsto \mathbf{S} \times \mathbb{R}^I$, where $\sigma(\Gamma) \in \mathbf{O}^*_\Gamma$ for all $\Gamma \in \mathcal{G}$. Altogether, the principal solves:

$$\sup_{\Gamma \in \mathcal{G}} \pi(\sigma(\Gamma)).$$

For instance, if the principal cares about the best-case scenario, as in the traditional mechanism design literature, then $\pi(\sigma(\Gamma)) \equiv \sup_{o \in \mathbf{O}^*_\Gamma} \pi(o)$. Conversely, if the principal cares about the worst-case scenario, $\pi(\sigma(\Gamma)) \equiv \inf_{o \in \mathbf{O}^*_\Gamma} \pi(o)$, as in the robust design literature.

Finally, we can further restrict the agents' beliefs in settings in which there is a large population (or continuum) of agents, wherein each agent "cares" about the average realized welfare of the population. Because individual agents in a continuum have negligible impact on aggregate variables, we restrict the agents' beliefs and thus refine the implementable outcome set. For beliefs $u \in \mathbf{U}_s$, agents are *negligible* if for any agent i and deviation $s' = (s'_i, s_{-i})$ their beliefs u obey $u_{-i}(s') = u_{-i}(s)$. Thus, each agent operates under the premise that her behavior alone does not alter the realized welfare of others. This framework justifies the use of Definition 1 in the worker subgame. Indeed, it easily follows that,

Claim B.0.1. *Given a set of workers I and a wage rate w, a symmetric outcome (υ, ℓ) is implementable among negligible workers if and only if (υ, ℓ) satisfies Definition 1.*

Proof: STEP 1: SUFFICIENCY. Suppose the outcome (υ, ℓ) is implementable among negligible workers. Since beliefs at the equilibrium strategy are consistent, they satisfy $\mathcal{U}_i(w\ell, \ell, \upsilon) = \upsilon$ for all $i \in I$, or condition ii). Next, since we consider negligible workers, their beliefs regarding utilities of others are fixed, implying that morale is fixed at υ for all off equilibrium deviations ℓ'. Given such beliefs, the equilibrium condition in Definition 1 implies the optimality condition i). Finally iii) is implied by the individual rationality condition.

STEP 2: NECESSITY. Assume (υ, ℓ) satisfy conditions i)–iii). Fix a worker i, and consider an arbitrary unilateral deviation $\ell_i \in (0, T)$ from $\ell_j = \ell$ for all $j \neq i$. Notice that the wage is fixed, and the choice of ℓ_i affects utilities of others only indirectly through worker i's utility. However, since worker i is negligible in a continuum, we have that others' utilities are unchanged and workers' morale is thus fixed at υ. Given this constant beliefs for all off equilibrium deviation, worker i's utility after deviating is $\mathcal{U}_i(w\ell, \ell, \upsilon)$, which is maximized when $\ell_i = \ell$, by condition i). This logic holds for all workers, and thus the best response condition in Definition 1 is met. Finally, iii) obviously implies individual rationality. □

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