Abstract

This paper uses a simple two-period model to study how firms make layoff decisions in the presence of adverse shocks. We analyze how the amount and sequencing of downsizing policies are determined when workers’ expectations about their job security affects their on-the-job performance. We find a fundamental tradeoff between laying off redundant workers and maintaining the ‘survivors’ commitment to their work. The tradeoff implies that when firms have private information about their future profits, conservative employment practices (such as zero or reduced layoffs) can allow them to signal that they have a bright future. This boosts workers confidence and induces them to be committed to their work. The tradeoff also provides strong insight into when waves of downsizing will occur as opposed to one-time massive cuts.

JEL Classifications: D21, D82, J23, J31, L14
Keywords: Reputation, downsizing, layoffs


1 Introduction

In 2002, companies in the United States announced layoffs of 1.96 million workers, with firms such as American Express, Lucent, Hewlett-Packard, and Dell Computer conducting multiple rounds in the same year\(^1\). The tragedy of 9/11 had reverberated throughout the economy, leaving businesses scrambling to adjust. When making downsizing decisions, firms take into account both the short run and long run economic environment, and the welfare impacts of these decisions can be very large. We attempt to provide insight into how downsizing is conducted, investigating the factors that affect both amount and sequencing of downsizing.

In an uncertain world, managing workers’ confidence about their employer’s future prospects is of vital importance since their beliefs have a direct impact on their performance. In particular, increased job insecurity due to the expectation of future downsizing can reduce workers’ commitment to their work and make them more likely to look for other positions. Job insecurity is a real phenomenon. Of the nearly 1,200 companies surveyed by the American Management Association in 1997, forty percent had job cuts in three or more calendar years since 1990. For the majority of companies surveyed, downsizing was said to have had adverse effects on the morale, workload, and commitment of the survivors. Moreover, downsizing did not necessarily result in productivity gains: In 34 percent of the cases productivity rose, while it fell in 30 percent of them.

We model perceived job insecurity as a worker’s expected probability of being let go in the future and analyze its effects on downsizing policies. We find that the amount and sequencing of downsizing should be governed by a fundamental tradeoff between laying off redundant workers and maintaining the ‘survivors’ commitment to their work.

First, we analyze the role that private information on the part of the firm about their future prospects can have in the amount of downsizing. Imagine that a strong negative demand shock occurs industry-wide, creating the need to lay off workers. In such a situation, firms may have private information about their prospects and how well they are prepared to deal with the shock while workers think that their firm’s future is facing great uncertainty. We find that conservative downsizing policies (i.e. zero or minimal layoffs) allow firms to signal that their future is bright and increase workers’ confidence

\(^1\)Taken from Cascio (2002).
in the firm and hence their commitment to working. Examples of minimal layoff employment practices abound. In the aftermath of the 9/11 disaster, airlines reduced their staff by 20% on average in response to dramatically reduced business. Southwest Airlines, on the other hand, did not lay off or furlough anyone. An even more interesting case is that of Airbus and Boeing in response to the same shock. Faced with much less demand for their airplanes, Boeing cut 20% of their workforce, while Airbus cut almost no one. Moreover, informal zero layoff policies are not infrequent (47 of the 100 companies that made Fortune’s 2002 list of the “100 Best Companies to work for” have them).

Second, we formalize the notion that the sequencing of downsizing can vary substantially. It is quite common to hear about massive layoffs and/or waves of downsizing. On average two-thirds of firms that lay off employees in a given year do so again the following year\(^2\). Specifically, we call a one time sweeping cut in the workforce a “big-bang” and waves of cuts “gradualism” and compare the two in terms of the fundamental trade-off. Baron and Kreps (1999), in their textbook on human resources discuss the basic costs and benefits of the approaches by saying, “by moving boldly and rapidly, companies may minimize the long-term psychological damage and also perhaps achieve a more pronounced and rapid increase in shareholder equity” while “a one-time massacre runs the risk of cutting too much”. Within the model we are able to be very precise about what determines which policy is used. We find that a big-bang is more likely when (i) workers’ future job prospects (conditional on being fired) are better since the firm would need to compensate them for insecurity and (ii) the firm’s marginal productivity is lower due to either its fundamental technology or demand shocks.

It should be noted that the major explanation for most of these stylized facts has been behavioral: layoff policies are dictated by the morale or the corporate culture within the firm. We do not exclude these possibilities and rather see our model as complementary in terms of explaining the data. Our model also gives us flexibility in assessing the effects of regulation and market structure on downsizing.

To be concrete, we look at a simple two period model in which firms face an unexpected negative demand shock (which is observed simultaneously by the firms and the workers) in period one. In period two, demand for a firm can either rebound or face a further negative shock; this information is known

\(^2\)U.S. Department of Labor
to firms ex-ante but unknown to workers. This second shock may reflect fluctuations specific to the industry (in market structure, shifting tastes of consumer, government regulations, etc.) and/or the firm’s preparation or sensitivity to downturns. The firm makes three choices in each period, the number of original workers to keep, the number of new workers to hire, and the wage to pay the workers. Workers observe these choices in each period and care about the possibility of being downsized in the future. Job insecurity will decrease their incentives to work on the job, and moral hazard will make the firms try to compensate for job insecurity.

Theoretically, our paper is most similar to Holmstrom (1981) and Carmichael (1984). Both examine reputation in the labor market, but in a rational expectations framework. We include asymmetric information and thus reputation becomes defined by a signaling game à la Kreps-Wilson (1982) and Milgrom-Roberts (1982). Since we have two instruments for signaling, the wage and number of workers kept, the game resembles Milgrom and Roberts’ (1986) model, where price and amount spent on advertising are the signals. Another paper along these lines is Bagwell and Ramey (1988).

The relational contracting literature (Bull (1987), Baker, Gibbons and Murphy (1994), MacLeod and Malcomson (1989), and Levin (2003)) models to some extent a firm’s reputation in labor market, although the framework is not adapted to analyze how a firm should design its downsizing policy after an unexpected negative shock. François and Roberts (200x) get closer to this type of model with a relational contracting structure, but look at very different issues. Moral hazard indeed forms the basis of our analysis, but more along the lines of Shapiro and Stiglitz (1984).

Dewatripont and Roland (1992a, 1992b, 1995) were the first to study the relative merits of gradualism versus big-bang strategy in the context of reforms in transition economies. They focus either on adverse selection or on learning in the presence of aggregate uncertainty while, in our setting, neither of the two elements is present and the trade-off between both strategies is driven by job insecurity.

In section 2, we define the model. In section 3 we analyze the second stage of the game. Section 4 looks at the complete information game, while section 5 introduces the asymmetric information game. In section 6, we discuss social welfare and the results in relation to the stylized facts.
2 Model

2.1 Workers

There is a mass 1 of homogenous workers. We consider a very simple model of moral hazard. An employed worker has two possible choices of unobservable effort, high \((e = 1)\) or low \((e = \alpha)\) with \(0 < \alpha < 1\). There are two possible outputs, a high one equal to \(y_h\) and a low one equal to 0, where the probability of producing the output of \(y_h\) is equal to \(e\). We model two different benefits of shirking \((e = \alpha)\) that a worker may gain utility from. First, as usual, his disutility of working increases in the level of effort. More precisely, let the disutility of effort associated with \(e\) be given by \(e^2\). Second, he has more time available for searching for other jobs. Specifically, conditional on being laid off at the end of period \(t\), the worker has probability \((1 - \gamma_e e)_{\alpha + 1}\) at \(t + 1\), where \(\alpha + 1 \geq 0\) represents labor market slackness in period \(t + 1\). We assume that it is optimal for all firms to induce high effort.

To formalize the idea of job insecurity, let \(p_i^t\) be the expected probability for a worker employed at a type \(i\) firm (firm’s type will be defined later) at period \(t\) to remain employed at the same firm at period \(t + 1\). Given the total number \(n_i^t\) of workers employed by a type \(i\) firm at period \(t\), we define \(p_i^t = \min \left\{ \frac{E_{n_i^{t+1}}}{n_i^t}, 1 \right\} \) where \(E_{n_i^{t+1}}\) is workers’ expectation at \(t\) about firm \(i\)’s employment level at \(t + 1\). We assume that the firm cannot commit to long-term contracts. Let \(\bar{w}_i^t\) and \(w_i^t\) be firm \(i\)’s wages associated with high and low output respectively at period \(t\). We assume that workers are protected by limited liability such that the wages must be larger than \(w_0\): for example, \(w_0\) could represent unemployment benefits or a minimum wage.

A worker employed at firm \(i\) at period \(t\) thus has the following utility depending on his choice of effort:

\[
U_t(e) = e\bar{w}_i^t + (1 - e)w_i^t - e^2 + \delta(p_i^t + (1 - p_i^t)(1 - \gamma_e e)_{\alpha + 1})V_{t+1}^e + (1 - p_i^t)(1 - (1 - \gamma_e e)_{\alpha + 1})V_{t+1}^u
\]

where \(V_{t+1}^e (V_{t+1}^u)\) is the expected present discounted value at period \(t + 1\) of being employed (unemployed) and \(\delta\) is the discount rate common to firms.

\(^3\)We will assume that there are two types of workers, original and new, later in the text. Hence \(n_i^t = n_i^{oi} + n_i^{ni}\).
and workers.

Assuming the firm wants to implement high effort\(^4\), the incentive constraint takes the form of \(U_t(1) \geq U_t(\alpha)\), which reduces to:

\[
(\text{IC}_i^u) \quad \bar{w}_t^i - w_t^i \geq 1 + \alpha + \delta (1 - p_t^i) \gamma_e a_{t+1} (V_{t+1}^e - V_{t+1}^u)
\]

Since all that matters for giving incentives is the difference between the wages, and since wages are costly for the firm, this implies that the firm will set \(w_t^i\) as low as possible (i.e., \(w_t^i = w_0\)). Hence, we have:

\[
\bar{w}_t^i = w_0 + 1 + \alpha + \delta \max\left\{1 - \frac{E n_{t+1}^i}{n_t^i}, 0\right\} \gamma_e a_{t+1} (V_{t+1}^e - V_{t+1}^u) \equiv w^i(n_t^i)
\]

Note that \(w^i(n_t^i) - w_0 \geq 1 + \alpha\) for any \(\delta\) and any \(n_t^i\). By plugging in the optimal wage, the utility conditional on being employed in firm \(i\) at time \(t\) (given \(p_t^i\)) is given by:

\[
V_t^e(p_t^i) \equiv w_0 + \alpha + \delta \left\{ [p_t^i (1 - p_t^i) a_{t+1}] V_{t+1}^e + (1 - p_t^i)(1 - a_{t+1}) V_{t+1}^u \right\}.
\]

Assuming that if a worker is unemployed for a period, she receives \(w_0\) and her probability of finding a job in the next period is \((1 - \gamma_u) a_{t+1}\), with \(\gamma_u \in (0, 1)\), the utility of an unemployed person at period \(t\) is equal to \(V_t^u \equiv w_0 + \delta [(1 - \gamma_u) a_{t+1} V_{t+1}^e + V_{t+1}^u]\). Therefore, the participation constraint is satisfied if the following holds:

\[
(\text{PC}) \quad V_t^e(p_t^i) \geq V_t^u
\]

It is obvious that the participation constraint strictly holds for any \(p_t^i\). Hence, employed workers earn rents from the moral hazard.

\(^4\)Here we don’t allow for the firm to fire the worker for low output (as in Shapiro and Stiglitz (1984)). This can easily be done, but at the expense of simplicity. With firing as the punishment, after a lot of algebra the incentive constraint boils down to

\[
\bar{w} - w \geq 1 + \alpha + \delta (\gamma_e a - \frac{p_t}{1 - \alpha} (1 - (1 - \gamma_e) a))(V_{t+1}^e - V_{t+1}^u)
\]

There are a few things to notice here. First, more job security (higher \(p_t^i\)) reduces the amount need to compensate the worker (as in the text). Second, firing reduces the moral hazard problem. Indeed it may possibly eliminate it, depending on whether the right hand side is negative or not. Thus assuming that a moral hazard problem exists is saying that that expression is positive, which is similar to our incentive constraint in the text.
2.2 Firms

There is a mass $M$ of firms in the industry we consider. The firms have two possible sources of labor supply, their workers from the previous period (who we will call original workers) and workers from the general labor market (who we will call new workers). In line with empirical findings, we assume that original workers are more productive for the firm than new workers, i.e. there exists firm specific human capital. Specifically, original workers produce $y^o_h = 1$ and new workers produce $y^n_h = \phi < 1$. Define the total output of the workers to be $N^i_t = n^o_t + \phi n^n_t$. In our formulation, wages are not connected to $y^h$; hence firms strictly prefer re-hiring original workers to replacing them with new workers.

We consider a two-period model. In period one, the industry has an adverse shock and all the firms have the same profit function $f(N^i_1, \theta_1)$ gross of the wage payment where $\theta_1$ is a parameter which represents the shock that is common to all the firms. Therefore, all the firms downsize their labor force at period one (we will formalize this in an assumption later). However, firms are heterogeneous in terms of how well they adapt to the adverse shock. More precisely, firm $i$ either adapts well to the shock and has the profit function $f(N^G_2, \theta^G_2)$ at period 2 or does not adapt well and has the profit function $f(N^B_2, \theta^B_2)$ at period 2. We call a firm with $\theta_2 = \theta^G_2$ a good type and a firm with $\theta_2 = \theta^B_2$ a bad type$^5$. It is common knowledge that a proportion $\nu$ of the firms have type $\theta_2 = \theta^G_2$. Formally, the index $i \in \{G, B\}$ denotes a firm’s type.

Assumption 1:

\[
\begin{align*}
  f(N, \theta^G_2) &> f(N, \theta_1) > f(N, \theta^B_2) \\
  f_1(N, \theta^G_2) &> f_1(N, \theta_1) > f_1(N, \theta^B_2), \\
  f_{11}(N, \theta) &< 0 \text{ for all } \theta \in \{\theta_1, \theta^G_2, \theta^B_2\}.
\end{align*}
\]

We assume that firm $i$ has better knowledge about how well it can adapt to the adverse shock than workers. This is formalized by assuming that at period 1 firm $i$ has private information about $\theta_2$. After its realization, $\theta_2$ is

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$^5$This is the simplest possible specification for type. A more realistic specification would be to have the shocks be stochastic, e.g. a high or low shock in period two, where the good firm has a higher probability of the high shock occurring. In this case the results are qualitatively the same, but more notationally involved.
known to everybody. We note that the profit function introduced above is conditional on inducing high effort.

Lastly, we assume that there is involuntary unemployment at each period because of the moral hazard: when wage is equal to \( w_0 \), the total labor demand is larger than one while when wage is equal to \( w_0 + 1 + \alpha \), the total labor demand is smaller than one.

### 2.3 Timing

Since we consider a two-period model, in period two there is no possibility of future production and therefore workers face no job insecurity. This is captured by setting \( p^i_2 = 1 \) for \( i = G, B \).

The timing within a period \( t \) is given by:

1. \( \theta_t \) is publicly known.
2. Each firm decides the amount of original workers to retain and their wage.
3. Original workers decide whether to accept or reject the firm’s offer.
4. Each firm decides the amount of new workers to hire and their wage.
5. New workers decide whether to accept or reject the firm’s offer.
6. Workers exert effort, production occurs, and profits are realized.

There are two things to notice in this timing. First of all, the firm demand parameter \( \theta_2 \) is known by the firm at least one period ahead. In our complete information analysis, the workers will know at period one what type of demand the firm faces in period 2. Secondly, in the first period, by assumption, the firms are downsizing. Hence there will be no hiring of new workers in period 1, although new workers may be hired in period 2.

We begin by examining the second period solution. We will then analyze the first period solution under both complete and asymmetric information.
3 The Second Period

Since the second period is the last period and \( p^i_2 = 1 \) for \( i = G, B \), the wage for both types of firm is equal to \( w_2 = w_0 + 1 + \alpha \). This implies that the value of being employed at period 2, \( V^e_2 = w_0 + \alpha \), is greater than the value of being unemployed, \( V^u_2 = w_0 \). Firm \( i \)'s maximization problem at period two is defined as follows:

\[
\max_{n^i_2, n^{ni}_2} f(n^{oi}_2 + \phi n^{ni}_2, \theta^i_2) - w_2(n^{oi}_2 + n^{ni}_2)
\]

\[\text{s.t. } n^{oi}_2 \leq n^i_1, \quad n^{ni}_2 \geq 0\]

Associating the multipliers \( \lambda \) with the first constraint on \( n^{oi}_2 \) and \( \psi \) with the second constraint on \( n^{ni}_2 \), we get the following two first order conditions:

\[
f_1(n^{oi}_2 + \phi n^{ni}_2, \theta^i_2) - w_2 - \lambda = 0
\]

\[
\phi f_1(n^{oi}_2 + \phi n^{ni}_2, \theta^i_2) - w_2 + \psi = 0
\]

By subtracting the second condition from the first and using the facts that the marginal product of labor is positive and \( \phi < 1 \), it is clear that at least one of the constraints binds. The solution depends on how many original workers are left from the previous period. When there are a large number of original workers (\( n^i_1 \) large), the firm lays off original workers and does not hire any new workers. The optimal amount of original workers to retain in this case is given by \( n^{*oi}_2 \), where:

\[
f_1(n^{*oi}_2, \theta^i_2) = w_2
\]

(1)

Therefore, for any \( n^i_1 > n^{*oi}_2 \), \( n^{oi}_2 = n^{*oi}_2 \) and profits are constant.

For \( n^i_1 < n^{*oi}_2 \), all original workers are kept (\( n^{*oi}_2 = n^i_2 \)). The firm decides to hire new workers if the amount of original workers is very low. We define \( n^{ni}_2 \) as the number of new workers hired and \( \tilde{N}^i_2 \) as the total effective labor output from new and original workers, which both follow from the equation:

\[
f_1(\tilde{N}^i_2, \theta^i_2) = \frac{w_2}{\phi}
\]

(2)
Therefore the number of new workers hired is \( n_2^{si} = \frac{\tilde{N}_2 - n_1^i}{\phi} \), and new workers are hired when \( n_1^i < \tilde{N}_2^i \).

Lastly, for the range \( \tilde{N}_2^i < n_1^i < n_2^{sai} \), no new workers are hired and all the original workers are retained. To summarize, we define the profits in period two as:

\[
\pi_2^i(n_1^i) = \begin{cases} 
  f(\tilde{N}_2^i, \theta_2^i) - w_2\frac{\tilde{N}_2^i - (1-\phi)n_1^i}{\phi} & \text{if } n_1^i < \tilde{N}_2^i \\
  f(n_1^i, \theta_2^i) - w_2n_1^i & \text{if } \tilde{N}_2^i < n_1^i < n_2^{sai} \\
  f(n_2^{sai}, \theta_2^i) - w_2n_2^{sai} & \text{if } n_1^i > n_2^{sai}
\end{cases}
\]

4 Complete information

Suppose that all the firms’ types are common knowledge at period one. Workers are concerned about their probability of being retained in period 2. From the previous section, we saw that all original workers are retained when \( n_1^i < n_2^{sai} \), so \( p_i^t = \min\left\{\frac{n^{si}_1}{n_1^i}, 1\right\} \). Since we assume the firm is downsizing in period 1, no new workers will be hired.

4.1 The firm’s optimal employment decision

Firm \( i \)'s maximization problem at period one is defined as follows:

\[
\max f(n_1^i, \theta_1) - w^i(n_1^i)n_1^i + \delta \pi_2^i(n_1^i)
\]

The first order condition is given as follows:

\[
\begin{align*}
  f_1(n_1^i, \theta_1) &= (w_0 + 1 + \alpha)(1 - \delta \frac{1-\phi}{\phi}) & \text{if } n_1^i < \tilde{N}_2^i \\
  f_1(n_1^i, \theta_1) &= (w_0 + 1 + \alpha)(1 + \delta) - \delta f_1(n_1^i, \theta_2^i) & \text{if } \tilde{N}_2^i < n_1^i < n_2^{sai} \\
  f_1(n_1^i, \theta_1) &= (w_0 + 1 + \alpha) + \delta \gamma_e \alpha a & \text{if } n_1^i > n_2^{sai}
\end{align*}
\]

Let \( n_1^* \) denote the optimal static level of employment: it represents the optimal level of employment at \( t=1 \) when \( \delta = 0 \) and hence \( f_1(n_1^*, \theta_1) = w_0 + 1 + \alpha \).

**Assumption 2:** There exists an \( n_1^{G} \) such that \( n_1^{G} < \tilde{N}_2^G \) and
\[ f_1(n^G_1, \theta_1) = (w_0 + 1 + \alpha) \left( 1 - \frac{1 - \phi}{\phi} \right) \]

Therefore, under complete information, a good type keeps \( n^G_1 \) of original workers both periods and hires \( \frac{N_2 - n^G_1}{\phi} \) of new workers at period two. Basically, we assume that good types find it optimal to hire some workers at period two. We draw this in Figure 1 as points A1 or A2. Assumption 2 implies \( n^G_1 > n_1^* \).

A bad firm, on the other hand, will never hire new workers in period two. We prove this in the following lemma:

**Lemma 1** A type B firm will never hire in period two. Moreover, it will never choose \( n^*_B < n^*_{oB} \).

**Proof.** Suppose that a type B firm chose \( n^*_B < n^*_{oB} \). This implies that \( f_1(n^*_B, \theta_1) < w_0 + 1 + \alpha = f_1(n^*_{oB}, \theta^B_2) \). However, by assumption A1, \( f_1(n^*_{oB}, \theta^B_2) < f_1(n^*_{oB}, \theta_1) \) and by concavity, \( n^*_B < n^*_{oB} \) also implies that \( f_1(n^*_{oB}, \theta_1) < f_1(n^*_B, \theta_1) \), which gives us a clear contradiction.

Lemma 1 and assumption 2 imply that \( n^*_B \leq n^*_1 \leq n^G_1 \).

We now have two possible cases, one where \( n^*_B = n^*_{oB} \) and one where \( n^*_B > n^*_{oB} \). In the first case, the bad firm, which faces adverse shocks at both period one and period two, lays off workers only once - in period one. At period two the firm makes no further labor force adjustments. We call this strategy “big bang”, since the firm drops the axe on its employees in one blow. This is depicted in Figure 1 as point B. When the firm lays off workers in both periods (i.e. when \( n^*_B > n^*_{oB} \)), we say that the firm resorts to a policy of “gradualism”, where the firm adjusts its labor supply every time there is an adverse shock. Gradualism can be seen in Figure 1 as point C. It is clear from the figure that the discontinuity in the marginal wage due to job insecurity creates the two possible solutions.

We have the following proposition:

**Proposition 1** Under complete information on \( \theta_2 \) and assumptions 1-2, given the degree of slackness of the labor market \( \alpha \),

(i) The good type chooses \( n^*_1 (> n^*_1) \) and hires a positive amount of new workers at period two.
(ii) The bad type either chooses a big-bang strategy \((n_{1}^{*B} = n_{2}^{*B})\) or a gradual downsizing strategy \((n_{1}^{*B} \in (n_{2}^{*B}, n_{1}^{*})\)). In the first case, there is no further downsizing at period two while in the second case, downsizing occurs at both periods and it lays off \(n_{1}^{*B} - n_{2}^{*B}\) amount of workers at period two.

It is important to point out that in either big-bang or gradualism, the amount of workers retained by a bad type at the end of period two is the same. If job insecurity didn’t affect the survivors’ effort levels, a bad type would keep \(n_{1}^{*}\) amount of workers at period one and lay off \(n_{1}^{*} - n_{2}^{*B}\) of them at period two. However, job insecurity reduces survivors commitment to their job and this in turn makes firms pay higher wages to induce them to exert effort \(e = 1\). Therefore, when choosing \(n_{1}^{*B}\), a bad type faces a tradeoff between increasing the amount of workers retained at period one and reducing their job insecurity. This tradeoff can make it optimal to completely remove job insecurity of the survivors by choosing a big-bang strategy \((n_{1}^{*B} = n_{2}^{*B})\).

We can now analyze what determines whether a firm engages in a big-bang or gradual downsizing strategy\(^6\).

\(^6\)It is possible to argue that our specification of deterministic shocks reduces the ro-
Corollary 1  Big-bang is more likely if

1. Workers’ future job prospects (conditional on being fired) are better, i.e. if
   (i) job search is effective ($\gamma_e$ high)
   (ii) the labor market is very slack ($a$ high)
   (iii) the value of finding employment in the following period is large ($V_2^e - V_2^u$ high)

2. The firm’s marginal productivity is low
   (i) in absolute terms: due to technology
   (ii) relative to wages: when the second period shock is not as bad ($\theta^B$ larger) or the first period shock is worse ($\theta_1$ smaller)

In general, given a level of job insecurity, the larger the expected outside option, the higher a premium the workers command, making the big-bang more likely. The value of the outside option in turn depends on employment opportunities, job search, and labor market tightness. In addition, lower marginal productivity for the firm can make it more likely to make sweeping cuts. This may be due to its fundamental production process, or the shocks which hit the firm. A smaller negative shock in period two implies that the total number of people to be downsized is smaller. With more workers, the marginal productivity of the last worker is lower, making it too costly to pay a high wage and big-bang more likely. A larger negative shock in period one reduces the marginal productivity of all workers, making a high wage more costly and big-bang more likely.

It is natural to wonder about how gradualism takes place - does the majority of downsizing take place in period one or period two? That answer is also given to us by the corollary. Conditional on being in a regime of gradualism, the factors which made the big-bang more likely also make the amount of downsizing larger in period one relative to period two.

Wages may be different between firms in period 1 if the bad firm has a policy of gradualism. The bad firm must pay higher wages to compensate for job insecurity. In some sense, this is a compensating differential, although the bustness of our claims. If the second period consisted of a possible continuous range of shocks and types were to be defined as probability distributions over these shocks, a bad firm may have to downsize for especially low realizations of demand in period 2 no matter what policy it tried to follow. We contend that a big-bang policy in this context would be where the firm downsizes enough to completely eliminate expected job insecurity in period one.
worker is not directly choosing between jobs at a good and a bad firm. One might argue, on the other hand, that general job insecurity should decrease wages since it decreases the outside opportunities and bargaining power (this thesis was originally put forth by Alan Greenspan (1998)). This does not conflict with our model. Firstly, if outside options are worse, $V_{t+1}$ should decrease, reducing the wage demanded by workers. Secondly, we assume that some firms rebound from the initial negative shock. If the economy is in a persisting recession, then this may not be true and a wage differential between firms may disappear. At this point we have little to say about wage dynamics, since the wages in the second period are essentially fixed.

Note that since we assume a continuum of firms, each firm regards $a$ as given.

5 Asymmetric information

We now assume that the firm has private information about $\theta_2$. Workers at the firm have an ex-ante belief that with probability $\nu$, $\theta_2 = \theta^G$ and with probability $1 - \nu$, $\theta_2 = \theta^B$. The private information may reflect the firm’s superior knowledge of how well prepared it is for demand shocks and overall market conditions and trends. As we have seen in the section on complete information, the second period demand has a serious effect on the firm’s decisions in both periods. The difference creates a possible role for adverse selection when types become private information. It should be obvious that the good type has no incentives to masquerade as the bad type (i.e. choosing the bad type’s wage and employment levels). The reason is that it could easily have chosen them in complete information, but found it optimal not to do so. The bad type, on the other hand, was restricted in its choices. It could not choose the wage-employment level pair that the good type chose, because it had to offer higher wages to compensate workers for the probability of being laid off in the second period. The minimum wage that the bad firm could offer was $w^B(n_1) = w_0 + 1 + \alpha + \delta \max\{(1 - \frac{n_2\pi}{n_1}), 0\} \gamma_e \alpha a$.

The bad firm has incentives to pretend it is the good firm when:

$$f(n_1^*G, \theta_1) - (w_0 + 1 + \alpha)n_1^*G + \delta \pi_2^B(n_1^*G) > f(n_1^*B, \theta_1) - w^B(n_1^*B)n_1^*B + \delta \pi_2^B(n_1^*B)$$

Since $n_1^*G > n_1^*B > n_2^{*oB}$ and the bad firm always downsizes to $n_2^{*oB}$ in
period 2, it must be that \( \pi_2^B(n_1^G) = \pi_2^B(n_1^B) \). Hence the following assumption is sufficient for establishing the existence of an adverse selection problem when there is asymmetric information.

**Assumption 3:**

\[
f(n_1^G, \theta_1) - (w_0 + 1 + \alpha)n_1^G > f(n_1^B, \theta_1) - w_1(n_1^B)n_1^B
\]

We first study the fully separating equilibrium and then the pooling equilibrium\(^7\). The equilibrium concept employed is Perfect Bayesian Equilibrium and we refine the set of equilibria using the Cho-Kreps intuitive criterion (1987). The model presents a two-dimensional signaling problem: firms may use both the period 1 employment level and wages of original workers to signal. This problem is similar to that of Milgrom and Roberts (1986) in two ways. First, Milgrom and Roberts also have two dimensions of signaling, prices and advertising. Second, advertising is dissipative, meaning that it does not affect demand and hence does not interact with the type of the firm. Wages in our model function in a similar way. Under complete information, any choice beyond \( w^i(n_1) \) (with \( i = G, B \)) involves extra cost for a firm at no gain. Nevertheless, we will see that excess wages may be used in equilibrium.

### 5.1 The fully separating equilibrium

In the separating equilibrium, the good firm chooses in period 1 an employment level \( n_S \) and a wage \( w_S \) for workers such that the bad firm does not have any incentives to masquerade as the good firm. Specifically, we define the belief structure of workers, \( \mu(n_1, w_1) \), as the probability that the firm is good given its first period employment and wage decisions. This then implies that in the separating equilibrium \( \mu(n_S, w_S) = 1 \). Moreover, if the separating equilibrium exists, the bad firm is recognized as bad. It will then choose its employment and wage optimally, yielding the solution to the complete information case \( (n_1^B, w^B(n_1^B)) \) and the consequent belief \( \mu(n_1^B, w^B(n_1^B)) = 0 \).

For now, we delay a discussion of beliefs off the equilibrium path, only noting that \( (n_S, w_S) \) may be more than a singleton.

Two incentive constraints define the set \( (n_S, w_S) \). First, the bad firm must prefer being recognized to masquerading:

\[
f(n_1^B, \theta_1) - w^B(n_1^B)n_1^B + \delta\pi_2^B(n_1^B) \geq f(n_s, \theta_1) - w_sn_s + \delta\pi_2^B(n_s) \quad (IC_B)
\]

\(^7\)We ignore semi-separating equilibria, where a firm may have mixed strategies.
Second, the good firm must prefer separating to pretending to being perceived as the bad firm. When the good firm is perceived to be the bad firm, any hiring level above \( n^*_2 \) in the first period will make it necessary to compensate workers with higher wages, as workers will believe the layoff probability in the second period will be positive. The wage level necessary to prevent quits is the same that the bad firm must use to prevent quits: \( w^B(n_1) \). Since beliefs are not pinned down off the equilibrium path\(^8\), we assume that the beliefs of workers are such that any feasible choice of the bad firm (i.e. an \( n_1 \) and \( w_1 \geq w^B(n_1) \)), is believed to have come from the bad firm, or \( \mu(n_1, w_1) = 0 \). We denote \((n_G, w^B(n_G))\) as the optimal choice of the good type when workers believe that it is the bad type. The incentive constraint for the good firm is thus:

\[
\begin{align*}
    f(n, \theta_1) - w_n + \delta \pi^G(n) &\geq f(n_G, \theta_1) - w^B(n_G)n_G + \delta \pi^G_G(n_G) \\
    \text{(IC}_G\text{)}
\end{align*}
\]

We will establish the result using a graphical argument. The curves and solution are depicted in Figures 2 and 3. For now, we assume that the optimal full information choice for the bad firm was that of gradualism, where the solution was \( n^*_B \) and \( w^B(n^*_B) \). The results for a big-bang solution are qualitatively the same.

We begin the analysis by defining isoprofit curves in \((n_S, w_S)\) space. The curve \( ISO_B \) represents all of the employment-wage pairs for firm B which yield the same profits as B’s full information choice. The curve \( ISO_G \) depicts the employment-wage pairs for firm G which yield the same profits as G’s choice when it is believed to be the bad firm, \((n_G, w^B(n_G))\). By the definition of the incentive constraints, these curves are the minimum level of profits that the firms can achieve in a separating equilibrium \((n^*_S, w^*_S)\). The curves are both tangent to the \( w^B(n_1) \) curve at points \((n^*_B, w^B(n^*_B))\) and \((n_G, w^B(n_G))\). These are depicted in Figure 1 as points B and C, respectively. From the isoprofit curve of B, we see that, 1) Gradualism is preferred to big-bang (point B is preferred to point A) and 2) the bad firm prefers the good firm’s full information choice to its own (point D is preferred to point B). The isoprofit curves intersect only once since they satisfy a weak single crossing property:

\[
(\frac{dw}{dn}_S)_{\theta_2=\theta^G} - (\frac{dw}{dn}_G)_{\theta_2=\theta^G} \geq 0.
\]

\(^8\)Cho-Kreps is not of any use here, since both firms’ equilibrium choices will dominate the payoffs of choices where \( w > w^B(n_1) \).
to show, and the inequality is strict everywhere except when $n_S < \tilde{N}_2^B$ and $n_S \geq n_{2*G}$. The former inequality will never be relevant, since a B firm must always get at least as large profits as in the full information solution, and the region indicated by the former inequality gives less profits than in full information. In the case of the latter inequality, both firms lay off workers in period two and their second period profits do not change with $n_S$, implying that the slope of their isoprofit line does not change with their type. This will be relevant for both the separating and the pooling equilibrium. We assume that the isoprofits curves are concave to simplify the analysis.

Notice that some choices $(n_S, w_S)$ in Figure 2 are not feasible due to the need to provide incentives, namely any $w_S < w_0 + 1 + \alpha + \delta \max\{(1 - \frac{n_{G}^{*G}}{n_1}), 0\} \gamma_c \alpha a$. The area below the isoprofit curve for the good firm and above the isoprofit curve for the bad firm satisfies both incentive constraints. All choices in this area are equilibrium dominated for the bad firm, hence Cho-Kreps assigns $\mu(n_S, w_S) = 1$ to these choices. The signaling problem then amounts to the good firm maximizing its profits subject to $IC_B$ holding with equality. The solution $(n_S^*, w_S^*)$ is characterized by:

**Proposition 2** With asymmetric information and assumptions 1-3, one of
two possible separating equilibria exist:

1. The good firm chooses \( n^*_S \in (n^{*G}_1, n^{*G}_2) \) and \( w^*_S = w_0 + 1 + \alpha \) in period 1 and retains all workers (possibly hiring new ones) and pays the same wage in period 2.

2. The good firm chooses \( n^*_S > n^{*G}_2 \) and \( w^*_S > w_0 + 1 + \alpha \) in period 1 and in period 2 chooses \( n^{*G}_2 \) and \( w_0 + 1 + \alpha \).

In both solutions, the bad firm chooses its symmetric information levels.

The result of the proposition is depicted in figures 2 and 3. There are two possible cases. The first is where the asymmetric information problem is ‘small’ in the sense that point D (type G’s symmetric information solution) would increase the bad firm’s profits only a small amount. In this case, the good firm can use only increased hiring to signal, holding the wage fixed at \( w_0 + 1 + \alpha \). This is evident in Figure 2, since the good firm’s isoprofit curve always has greater slope than the bad firm’s, the tangency can only occur at the kinked part (denoted as point S1 in the graph). In the second case, depicted in Figure 3, the asymmetric information problem is ‘large’; the bad firm has large incentives to masquerade as the good one. In this case, there are a range of tangencies, since both firms’ isoprofit lines have the same slope in the area where \( n_S \geq n^{*G}_2 \). This is represented by a hollow oval in Figure 3. All of these solutions involve the good firm increasing its level of hiring above \( n^{*G}_1 \) and its wage strictly above \( w_0 + 1 + \alpha \). Hence, when the asymmetric information problem is more difficult, the good firm must resort to using both hiring and wages to signal its type.

Under asymmetric information, a good type can reduce job insecurity of survivors only by retaining more workers than necessary at period one. Therefore, he faces the tradeoff between reducing personnel and decreasing the job insecurity of the survivors. The effectiveness of signaling comes from the fact that it is less costly for the good firm to reduce its downsizing in period 1. An increase in hiring makes the second period profits decline more for the bad firm than the good firm, since the good firm has better prospects in period 2 and is closer to its optimum. A wage increase will be a part of the signal when the hiring increases so much that the good firm creates some job insecurity in period 2.

When we compare this to the full information solution, we see how a conservative employment policy works and its associated costs. Good firms will reduce their downsizing in the first period to signal, reducing their profits and potentially forcing them to not hire and maybe even fire people in the
second period.

5.2 Pooling Equilibria

In a pooling equilibrium, both types of firm choose the same hiring and wage levels \((n^*_P, w^*_P)\). When a worker observes these, she is unable to update her information set and believes that the firm is good with probability \(\nu\). In order to prevent quits, the firm must offer a wage high enough to compensate workers for the probability of being laid off; taking into account the uncertainty of the firm’s type, \(w_P\) must then be greater than or equal to:

\[
w^P(n_1) = w_0 + 1 + \alpha + (1 - \nu) \delta \max\{ (1 - \frac{n^*_2B}{n_1}), 0 \} \gamma_e \alpha a + \nu \delta \max\{ (1 - \frac{n^*G}{n_1}), 0 \} \gamma_e \alpha a \]

Despite this restriction on the choice of wage, isoprofit curves take the same shape as in the previous section. They are determined by incentive constraints for type \(i\) (\(i=B,G\)) where type \(i\) prefers \((n_P, w_P)\) to the optimal deviation of type \(i\). We assume that off the equilibrium path a deviation is
believed to come from the bad type, or equivalently, $\mu(n_1, w_1) = 0$. Therefore the best deviations are $(n_1^*, w^B(n_1^*))$ for type B and $(n_{GB}, w^B(n_{GB}))$ for type G.

A pooling equilibrium can only occur in the area where the single crossing property does not hold, i.e. where both the good and the bad would be in a firing regime at period two and their second period profits are fixed with respect to first period hiring. When the single crossing property does hold, it is always possible to find a $(n_1, w_1)$ between the isoprofit curves that the bad firm would never choose and that the good firm prefers. Since the bad firm would never choose this point irrespective of being recognized as the good or bad firm, the intuitive criterion assigns $\mu(n_1^o, w_1) = 1$ to the beliefs at this point, leaving the good firm able to select it and be recognized as the good firm.

In figure 3, we depict pooling equilibria as the shaded region. Any point in the region satisfies the criteria that the single crossing property does not hold, both firms earn at least as much as they would if recognized as the bad firm (points B and C are the respective points of maximum profits when type B and G, respectively, are recognized as bad firms), and there are no other
profitable deviations. Notice that since the slope of the isoprofit curve of the
good firm is always larger than that of the bad firm outside of this region,
the good firm’s isoprofit curve lies below that of the bad firm. Thus both
the good firm and the bad firm are making profits in the pooling equilibrium
that are not feasible (and at least as large as) when recognized as a bad firm.
Feasibility for a bad firm, of course, is defined as the wage being above the
line $w^B(\cdot)$.

If the pooling equilibria exist, there are a continuum of them. Existence
depends on whether the isoprofit curve for B, defined by B’s incentive con-
straint, extends into the area where the single crossing property doesn’t hold,
i.e. $n_P \geq n^{*\text{PG}}$.

The following proposition characterizes the equilibria.

**Proposition 3** Assuming existence, any pooling equilibria $(n^*_P, w^*_P)$ has $n^*_P \geq n^{*\text{PG}}$ and $w^*_P \geq w^P(n_1)$. In a pooling equilibrium, a bad type firm never adopts the big-bang strategy.

In the pooling equilibria, both firms raise their hiring levels above their
full information levels. They both pay a wage above $w_0 + 1 + \alpha$ in the first
period. This wage may actually be dissipative in the sense that it is not
the minimum wage demanded by workers to compensate them for expected
job insecurity. Both firms downsize in the second period as well, due to the
overhiring in the first period. Once again, asymmetric information can make
it more likely to observe waves of downsizing.

6 Social welfare

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