

The Layoff Rat Race*

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Abstract

We investigate how discretionary investments in general and specific human capital are affected by the possibility of layoffs. After investments are made, firms may have to lay off workers, and will do so in inverse order of the profit that each worker generates. Greater skill investments, especially in specific human capital, contribute more to a firm's bottom line, so that workers who make those investments will be laid off last. We show that as long as workers' bargaining positions are not too weak, workers invest in specific human capital in order to reduce layoff probabilities. Indeed, workers *over-invest* in skill acquisition from a social perspective whenever their bargaining power is strong enough, even though they only receive a share of any investment. More generally, we characterize how equilibrium skill investments are affected by the distribution of worker abilities within firms, the probability that a firm will downsize, and the distribution of employment opportunities in the economy.

I. Introduction

How does a firm convince its workforce to invest enough in human capital, and specific human capital in particular? This question has received attention since the seminal work of Becker (1962). The conundrum is that workers incur all of the investment costs, but they capture only a fraction of the returns on the investment. Several theoretical papers detail contract forms or informational settings that induce workers to invest in specific skills. For example, Kahn and Huberman (1988) and Waldman (1990) investigate “up-or-out” contracts; Zabojnik (1998) considers sales-based compensation;

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and Lazear and Rosen (1981), Carmichael (1983), Prendergast (1993), Scoones and Bernhardt (1998), Gibbons and Waldman (1999, 2006), and Zabojnik and Bernhardt (2001) investigate promotion ladders and the wage consequences of information revealed through placement.

In this paper, we identify a new factor that enters the calculus driving a worker's human capital investments. When firms receive adverse shocks that cause them to lay off workers, they will lay off those workers who add the least to the bottom line, and will retain workers who generate greater profits.¹ While transferable skills strengthen a worker's outside options and are more valued by a fired worker, workers must also internalize how the types and magnitudes of human capital investments affect the profits their employer derives from them, and hence their layoff probabilities. A worker must further determine how investments by other workers affect layoff probabilities, as human capital investments by one worker affect not only that worker's wages and chances for continued employment, but also the employment opportunities of other workers.

We derive how equilibrium skill investments depend on the distribution of worker abilities in the firm, and the probability that workers are laid off. To emphasize how the rat race to avoid being fired affects human capital investments, we assume skills are either fully specific or fully general, and we also assume that both forms of human capital are *perfect* substitutes in production if a worker remains with his employer. More generally, our analysis extends to skill types that are less or more transferable to other firms. Because workers may be laid off, therefore, it is never socially optimal to invest in specific capital (or in skills that are less transferable). Nonetheless, workers may do precisely that.

We consider an economy where wages are determined through worker-firm bargaining. Workers make specific and general human capital investments, taking into account how these investments affect both their probability of being retained by an employer and the possible outcomes from wage bargaining. In classical bargaining frameworks, workers under-invest in human capital in general, and specific human capital in particular, because they share the return with the firm but incur all of the costs; see Grout (1984), Chang and Wang (1996), Stole and Zweibel (1996), or Zabojnik (1998). That these bargaining incentives should induce workers to under-invest seems compelling. Nonetheless, we find that as long as workers' bargaining positions are not too weak, workers acquire *more* human capital than is socially optimal. The under-investment incentive associated with sharing the returns on human capital is still present in our environment, but the

¹ We focus on a setting in which workers bear the costs of human capital investments. For analyses in which firms bear the costs, see Acemoglu and Pischke (1998, 1999), Kessler and Lülfsmann (2006), or Katsimi (2008).

rat race to reduce layoff probabilities provides workers with overwhelming countervailing incentives to make excessive human capital investments. Workers understand that firms will lay off employees in inverse order of profitability, and that greater investments in human capital (especially in skills that are less transferable to other firms), contribute to the firm's bottom line via wage-bargaining. We derive the following results:

- If human capital investments are quite costly so that a worker's total human capital investment is small, then workers distort investments towards *less transferable* skills and *over-invest* in total skill acquisition. This is because the benefit of keeping a job dominates the cost of a weaker bargaining position on a slight human capital investment—the rat race incentives dominate the standard bargaining incentive in determining investments.
- If human capital investments are less costly so that workers invest more, workers over-invest, but they allocate a greater share of their investments towards transferable, general skills.
- As human capital investments become sufficiently cheap, workers cease to invest in specific skills (dominated by assumption) but still over-invest in general skills.
- Only when human capital investment is inexpensive does the standard bargaining incentive effect dominate so that workers under-invest in skill development.

These human capital investment patterns are generated by the rat race incentives *within* a firm. We also characterize how *economy-wide* market conditions affect worker investments. For example, if economy-wide conditions are such that the expected general skill investments of workers searching for jobs is higher, then the outside option at a given firm is improved which reduces compensation for skill investments. Because the benefit of being retained by a firm is reduced, workers shift investments from specific to general human capital.

Thus, our paper challenges the conventional wisdom that workers under-invest in human capital in general, and specific/imperfectly transferable skills in particular. Investment in human capital is not easily observable, but direct and indirect evidence suggests that workers invest in imperfectly transferable skills. Firm-specific skills are central to many white-collar jobs. For example, managers must learn the attributes of workers with whom they interact, and to whom they must assign tasks, and this knowledge of personnel has no value at other firms. Topel (1991) and others suggested that one way to measure investment in specific (less transferable) human capital was to look at wage reductions faced by displaced workers. Using PSID data, he found that a U.S. male worker with 10 years of seniority would suffer a

wage reduction of up to 25% upon separation. This is also a feature of our model—workers who lose their jobs receive reduced wages due, in part, to their loss of specific human capital. More recently, researchers have focused on industry or occupation-specific skill acquisition—see, e.g., Neal (1995), Parent (2000), Lazear (2003), and Kambourov and Manovskii (2009). What is crucial for our analysis is that workers extract a smaller share of the investment in less transferable skills (e.g., because laid-off workers switch industries or occupations). Indeed, Neal (1995) (using CPS data) and Parent (2000) (using NLSY data) both find that more than 60% of displaced workers switch one-digit industries, numbers that rise to 80% at the three-digit industry level; Kambourov and Manovskii (2009) find similar levels of occupation switching at one-digit and three-digit levels.

Indirect evidence of the human capital investment patterns suggested by our paper includes the fact that in regions with high employment rates, workers are often highly specialized and have low levels of general education. For example, the correlation between regional unemployment rates and regional high-school graduation rates in Canada is -0.39 and drops to -0.58 for the Atlantic provinces (Canadian Census Data, 1991). So, too, in Europe, where unemployment rates are higher and a search takes longer, workers make greater firm-specific skill investments and greater occupation-specific skill investments (e.g., apprenticeships). Other research emphasizing excessive investments by workers includes Landers *et al.* (1996), who argue that young lawyers work (inefficiently) long hours to signal a willingness to work hard in the future. Our paper identifies an important, distinct countervailing force to under-investment sources, a force that researchers should account for.

There is a large body of literature—e.g., Becker (1962), Scoones and Bernhardt (1998), Gibbons and Waldman (1999), or Bai and Wang (2003)—on human capital investment by workers when there are constant returns to scale in the firm; that is, a worker's productivity does not depend on the number of other employees or on their abilities. A common feature of these models is that when human capital acquisition is not verifiable by third parties and hence cannot be contracted on, then individuals may not invest in specific human capital. In particular, post-investment competitive wages only reflect a worker's value at a competing firm. Scoones and Bernhardt (1998) show that if worker ability varies and competing firms observe a worker's job placement but not his skill, then workers may willingly invest in specific skills if it raises the probability that they are promoted, because promotion communicates to competing firms that the worker is able. Bai and Wang (2003) show that a worker may invest in specific human capital in a setting in which a firm and worker first strike a wage agreement, then the worker invests, and finally the worker's productivity is realized, with the firm terminating the agreement if and only if its profit would be negative.

In our paper, we characterize the human capital investment game between workers as a rat race, as workers alter their human capital investments in the hope of not being laid off. Akerlof (1976) was the first to formalize the idea of rat races. Since then, rat races have been explored in contexts ranging from labor market decisions to patent races. Moen (1999) considers a related labor market setting in which job candidates may over-invest in general training prior to going on the job market in order to increase their likelihood of being hired. Moen derives this result in a labor search setting in which multiple candidates compete for a single vacancy—the resulting interpersonal comparisons determine which worker is hired, and they induce workers to over-invest in general skills. By way of comparison, in our layoff setting, rat race incentives affect both the magnitude and composition of skill investments, and we distinguish how this multi-dimensional rat race is affected by *both within-firm* conditions and *economy-wide* market conditions.

Finally, there is a large body of literature on internal labor market tournaments, where compensation also depends on relative performance—see, e.g., Lazear and Rosen (1981), Carmichael (1983), Prendergast (1993), Gibbons and Waldman (1999), and Zabojnik and Bernhardt (2001).² Our environment can be interpreted as a tournament whose equilibrium structure is endogenously determined in a decentralized fashion by the actions of the entire workforce. The probability a worker is retained by a firm depends on both the worker's actions and those of his cohort. The equilibrium need not have desirable welfare properties. For example, if specific and general skills are perfect substitutes within a firm, industry output is always lower when workers acquire specific skills, because some workers will be laid off and their productivity elsewhere will be reduced. Another way in which this endogenous tournament differs qualitatively from standard promotion tournaments is that selection is from the bottom, where there are few workers to fire, rather than from the top, where there are few workers to promote.

We next present and analyze the model in Sections II and III, characterizing how human capital investments depend on the economic environment. Section IV discusses extensions and policy implications. For example, if the layoff rat race would significantly distort human capital investments, then union-negotiated seniority-based layoff rules that reduce a firm's discretion over whom to lay off can dominate the equilibrium outcomes that we analyze. Section V concludes.

² We can modify our model so that a worker can take actions that make her “indispensable” by reducing the productivity of co-workers *if* she is not there. Such investments are not sabotage, but are socially unproductive, because workers will be laid off. The literature on influence activities is also related; see Milgrom (1988), Schaefer (1998), and Repping (2000).

II. The Economy

We consider a two-period economy without discounting; it is an environment rich enough to capture key features. The economy has many *ex ante* identical, risk-neutral firms, as well as a continuum of risk-neutral workers. Each worker has one unit of labor that she can costlessly supply to the firm of her choice. Each firm initially has one measure of job slots in which it can productively employ workers, and for simplicity we assume that the first period is characterized by full employment.

A worker's productivity depends on her human capital, her ability and her employer. Workers start period one with a common level of transferable general capital of G . During period one, workers can make costly discretionary investments in specific and general human capital that affect their second-period productivities. The productivity of a human capital investment depends on a worker's ability. A worker with ability a who invests g in general skills develops second-period transferable general human capital of $G + ag$. Similarly, a specific capital investment of s gives rise to specific human capital of as . Hence, the second-period productivity of a worker with ability a at her period-one employer is $G + a(s + g)$, while her productivity at another firm is only $G + ag$.

To highlight the strategic effects of layoffs on human capital investments, we assume that the total cost to a worker of investments (g, s) is $\beta c(g + s)$, where $\beta > 0$ is a scaling parameter. Hence, it is Pareto optimal to invest solely in general capital: specific skill investments of workers who leave their employers are wasted. The cost function has the standard properties $c(0) = 0$, $c'(0) = 0$, $c''(\cdot) > 0$, and $\lim_{g+s \rightarrow \infty} c'(g + s) = \infty$.

Workers' abilities are distributed according to a common probability density function $f(a)$ with support $[\underline{a}, \bar{a}]$, where $\underline{a} > 0$. We assume that there is "enough" dispersion in worker abilities, a notion that we will make precise. There is no aggregate uncertainty so that the realized distribution of worker abilities at each firm is $f(a)$. For simplicity, we assume that workers do not know their abilities when making investment decisions; this lets us characterize the actions of a representative worker at a firm. At the end of the first period, a worker's investment and ability are observed by firms.³ However, investments are not verifiable by a third party such as a court, making it impossible for workers and firms to write contracts contingent on skill realizations or investments. We discuss the importance of this incompleteness further when we solve for equilibrium outcomes.

At the beginning of date 2, some firms are hit with positive employment shocks and are forced to lay off workers, while other firms (or new firms)

³ What is important is that potential employers can discern a worker's relevant attributes. An outside firm that meets a searching worker only has to be able to distinguish her ability and transferable general skills when they meet.

develop job openings. A firm hit with employment shock $\lambda > 0$ must lay off a fraction λ of its workers.⁴ We assume that the distribution over employment shocks, $H(\lambda)$, is the same at all firms. With no aggregate uncertainty, a measure $L = E[\lambda]$ of workers are laid off in the economy. Laid-off workers can potentially find jobs at firms that have new openings. There is a measure N of new job openings, either at the fraction $H(0)$ of firms that do not lay off workers or at new firms. Hence, there are N/L new job openings per laid-off worker. Laid-off workers must search to find jobs, and the presence of search friction means that only a fraction of the job openings are filled. The probability a searching worker finds a firm with an open slot is $P = p(N/L)$, where $p'(\cdot) > 0$ and $p(\cdot) \in [0, 1]$. Conversely, a firm with an open position finds a candidate with probability $Q = q(N/L)$, where $q'(\cdot) < 0$ and $q(\cdot) \in [0, 1]$. Market clearing in this search market implies that $(N/L) = (P/Q)$. A worker who does not find a new job receives a payoff of u . This benefit u can be interpreted as a combination of home production plus unemployment insurance.

Second-period wages are determined through simultaneous negotiation; each worker's second-period wage is determined in a one-on-one bargaining session with an employer. A worker's alternative is to quit and search for a new job, and a firm's alternative is to cease bargaining and search to fill its vacancy with another worker. Workers receive a share $\alpha \in (0, 1)$ of the surplus created. Because wage negotiations are held simultaneously on an individual worker–firm basis, a firm cannot use wage offers for one worker to extract surplus from other workers. As a result, after firms realize employment shocks and observe their employees' human capital investments and abilities, a firm with a layoff shock λ lays off the measure λ of workers who contribute least to its bottom line; or equivalently, a firm offers low wages that induce these workers to quit. We let $w_2(a, g, s)$ be the yet-to-be-determined equilibrium wage of a retained worker with ability a who invests g in general skills and s in specific human capital.

Workers who are laid off or who fail to reach an agreement on wages search for new jobs. Firms with job openings seek workers. If a searching worker and firm meet, they bargain over wages, with workers again receiving share α of the surplus. If a worker and firm fail to reach an agreement, the worker remains unemployed and receives unemployment benefit u , and the firm has an open job slot that generates no income. We assume that $u < G$, so that the unemployment benefit is less than the productivity of a worker who does not invest in general skills. As a result, there is always surplus over which a laid-off worker and a firm can bargain. We let $\hat{w}_2(a, g)$

⁴ The implicit technology underlying this environment is a Leontief production technology in which fraction λ of a firm's machines are destroyed or become obsolete. We revisit broader interpretations of these shocks in Section IV.

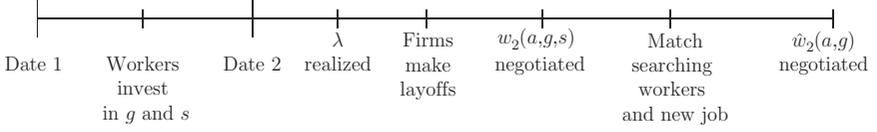


Fig. 1. Timing of the model

be the yet-to-be-determined equilibrium wage of a *searching* worker with ability a who invested g in general human capital. Figure 1 summarizes the timing of the game.

Efficient Investment

To maintain comparisons with the symmetric investment equilibrium, we determine the investment choice by a social planner who must choose a common investment for all workers in a firm. It is socially efficient to invest solely in general skills. Given λ , a firm will lay off all workers with ability levels $a < a(\lambda)$, where $a(\lambda) = F^{-1}(\lambda)$. The surplus generated by an investment g in general human capital is

$$S = \int_{\lambda} \left[\int_{\underline{a}}^{a(\lambda)} P a g f(a) da + \int_{a(\lambda)}^{\bar{a}} a g f(a) da \right] H(d\lambda) - \beta c(g). \quad (1)$$

The first-order condition characterizing the socially optimal investment is

$$\beta c'(g) = E[a] - \int_{\lambda} \lambda (1 - P) [E[a | a < a(\lambda)]] H(d\lambda). \quad (2)$$

The first-order condition equates the marginal benefit of investing in general human capital—the expected marginal return on the investment $E[a]$ minus the loss associated with being laid off and not finding a job—with the marginal cost of the investment.

Before solving for equilibrium investments, we emphasize the basic fact that inefficient investments must reflect frictions that give rise to incomplete contracting. Here, the friction is that investments are non-verifiable, so that contracts with investment-contingent compensation are not possible. Clearly, such contingent contracts could help both workers and firms, as efficient investments in general skills could be elicited, raising surplus; and with the appropriate contingent first-period wages, this surplus could be split. But just as clearly, such contracts are not feasible in practice.

Second-period Wages

We solve recursively for equilibrium outcomes. Consider first the bargain struck between a searching worker and a firm that meet. The surplus over

which a worker and a firm bargain depends on the worker's general human capital investment. A worker with ability a who developed general skills g generates output $G + ag$. The threat point of a worker is his unemployment alternative, u , and the threat point of the firm is the zero profit generated by an open slot. Hence, bargaining provides a searching worker with a wage of

$$\hat{w}_2(a, g) = \alpha[G + ag - u] + u \quad (3)$$

and leaves the firm with a profit of

$$\hat{\pi}_2(a, g) = (1 - \alpha)[G + ag - u]. \quad (4)$$

The wages and profits generated by a successful search determine the threat points for workers and employers in their initial second-period bargaining session. The threat points are determined by integrating over the possible employment outcomes. The threat point of a worker with ability a who invested g in general human capital is

$$\begin{aligned} Z^w(a, g) &= P\hat{w}_2(a, g) + (1 - P)u \\ &= P\alpha[G + ag - u] + u \\ &\equiv z_0 + \alpha P ag, \end{aligned} \quad (5)$$

where $z_0 = P\alpha(G - u) + u$.

If a firm does not reach agreement with a worker, then it has a job vacancy that may be filled by a searching worker. A firm's threat point corresponds to the expected profit it derives from the open slot that it would have if the firm and worker fail to reach agreement. The value of the open slot depends on the equilibrium mix of skill investments and ability levels of searching workers. A firm finds a potential hire with probability Q , and $G + E[ag|\text{laidoff}] \equiv G + \nu$ is the expected productivity of a laid-off worker. It follows that a firm's threat point is

$$Z^f = (1 - \alpha)Q[G + \nu - u]. \quad (6)$$

A worker's threat point increases with her general skill investment, the unemployment alternative u , her bargaining power α , and the probability P of successful search. Conversely, a firm's threat point decreases with u , but increases with the general human capital investments made throughout the economy by workers. These threat points determine equilibrium wages. The wage outcome of bargaining between a firm and a worker with ability a who made a general human capital investment g and specific skill investment s is

$$\begin{aligned} w_2(a, g, s) &= \alpha[G + ag + as - Z^f - Z^w(a, g)] + Z^w(a, g) \\ &\equiv w_0(Z^f, u) + \alpha[1 + (1 - \alpha)P]ag + \alpha as, \end{aligned} \quad (7)$$

where $w_0(Z^f, u)$ is a constant, $\alpha[1 + (1 - \alpha)P]$ is the contribution of general skills to wages, and α is the contribution of specific skills. We index w_0 by Z^f and u to emphasize that it is decreasing in Z^f —specifically, in the general human capital investments made outside the firm—and is increasing in u . In particular, workers internalize how their human capital investments affect their *own* threat points, but they do not internalize the consequences for the threat points of *other* agents. A worker's wage rises with her bargaining power and with factors that improve her bargaining position relative to the firm's.

Having solved for second-period wages as a function of ability and human capital investments, we can solve for firm profits:

$$\pi(a, g, s) = (1 - \alpha)[G + ag + as - Z^f - Z^w(a, g)] + Z^f. \quad (8)$$

From the perspective of a worker with skill a , the profits of her employer from a human capital investment (g, s) equal $(1 - \alpha)a[g + s - P\alpha g]$ plus a constant. In particular, fixing the total investment in human capital, $g + s$, a firm earns more from a worker who acquired more specific human capital. Also, the more likely a worker is to find a new job, the more the worker extracts in bargaining from an investment in general skills. This implies a greater difference in firm profits from investing in specific rather than general skills. That is, while both wages and profits rise with a, g , and s , the firm extracts a greater share of the investment in specific skills than in general skills, as competing firms only value transferable skill investments.

The key feature of the environment that drives our analysis is that even workers who invest only in general skills incur costs from being laid off. In our setting, these costs are driven by the possibility that laid-off workers will not find jobs and by the weakened bargaining positions of searching workers.⁵ However, our results extend if the costs take a different form, for example, psychological costs from being laid off, or if laid-off workers find jobs in a secondary sector at lower wages. Our bargaining/search setting endogenizes these costs and the solutions for outside wages, and lends itself to a tractable analysis of how conditions both inside and outside the firm influence investments. Owing to these costs, workers have incentives

⁵ In our model, this weaker bargaining position reflects the finite (two-period) horizon, and would not appear in a stationary model with risk-neutral workers. But, in the real world, this weakened bargaining position emerges when searching workers have strictly concave utility and face borrowing constraints—as savings fall, they accept worse terms in lieu of continued search. Evidence of this includes (i) workers grow less particular when unemployment insurance runs out (job take-up rises), and (ii) as savings fall, workers are more likely to switch occupations or sectors. This suggests that the weaker bargaining position of searching workers is relevant, in practice.

to make skill investments that raise their relative profitability to their employers, thereby lowering the probability that they are laid off.

Equilibrium Human Capital Investments

After layoff shocks are revealed, each firm chooses which workers to fire, laying off those workers who generate the least profits. A worker's ability and skill development affects a firm's profits according to $(1 - \alpha)a[g + s - P\alpha g]$. At a firm that must lay off a proportion λ of its workforce, let $x(\lambda)$ be the minimum level of $a(1 - \alpha)[(1 - \alpha P)g + s]$ such that the firm retains the worker; a worker with ability a and skill investments (g, s) is retained if and only if $a(1 - \alpha)[(1 - \alpha P)g + s] \geq x(\lambda)$. That is, the standard $x(\lambda)$ is such that the measure of workers who fail to meet the standard is λ .

We first characterize equilibria within a firm, given the mix of skill investments throughout the economy that determines the threat point Z^f for the firm.⁶ A worker's expected payoff from human capital investment (g, s) is

$$\begin{aligned} V(g, s) &= \int_{\lambda} \left[\int_{\underline{a}}^{a(\lambda)} Z^w(a, g) f(a) da + \int_{a(\lambda)}^{\bar{a}} w_2(a, g) f(a) da \right] H(d\lambda) - \beta c(g + s) \\ &= \int_{\lambda} \left[\int_{\underline{a}}^{\frac{x(\lambda)}{(1-\alpha)[(1-\alpha P)g+s]}} [z_0 + \alpha P a g] f(a) da \right. \\ &\quad \left. + \int_{\frac{x(\lambda)}{(1-\alpha)[(1-\alpha P)g+s]}^{\bar{a}}} [w_0 + \alpha[1 + (1 - \alpha)P] a g + \alpha a s] f(a) da \right] H(d\lambda) - \beta c(g + s). \end{aligned} \tag{9}$$

In a symmetric equilibrium in which all workers in a firm make the same human capital investments, the only differences in the profits generated by workers within a firm are due to their different abilities. As a result, a firm that lays off a fraction λ of its workforce, lays off all workers with abilities $a \leq a(\lambda)$, where $a(\lambda) = F^{-1}(\lambda)$.

Only General Human Capital

To highlight how layoff rat race incentives affect human capital investments, we first suppose that specific human capital is completely unproductive. This allows us to focus on the total human capital investment, and permits

⁶ Taking Z^f as a parameter, we will characterize asymmetric settings as those in which firms differ in their likelihoods of laying off workers. These, in turn, give rise to heterogeneity in human capital investments across firms.

clean comparisons with the socially optimal investment. Then, a worker's general capital investment solves

$$\begin{aligned}
\beta c'(g) &= \int_{\lambda} \left[\int_{\underline{a}}^{a(\lambda)} \alpha P a f(a) da + \int_{a(\lambda)}^{\bar{a}} \alpha [1 + (1 - \alpha)P] a f(a) da \right. \\
&\quad \left. + \frac{a(\lambda) f(a(\lambda))}{g} [w_2(a(\lambda), g) - Z^w(a(\lambda), g)] \right] H(d\lambda) \\
&= \alpha E[a] + \int_{\lambda} \left[(1 - \lambda) \alpha (1 - \alpha) P E[a | a \geq a(\lambda)] - \lambda \alpha (1 - P) E[a | a < a(\lambda)] \right. \\
&\quad \left. + \alpha \frac{a(\lambda) f(a(\lambda))}{g} [G + a(\lambda)g - Z^f - Z^w(a(\lambda), g)] \right] H(d\lambda). \tag{10}
\end{aligned}$$

The left-hand side of the first-order condition (10) is the marginal cost of the investment; the right-hand side is the marginal benefit. The first line on the right-hand side is the fraction of the marginal investment that the worker expects to receive, integrating over the possibilities that he is fired or retained. The second line is the rat race effect—the marginal increase in the probability of being retained (due to the greater investment) times the expected wage difference from being retained versus being fired. Inspection reveals that the symmetric equilibrium is unique when it exists. To see this, multiply both sides of (10) by g : the left-hand side is a convex function of g and the right-hand side is linear in g , implying a unique solution.

When abilities are uniformly distributed, the symmetric equilibrium exists if and only if there is sufficient dispersion in worker abilities; that is, if and only if the density $f(a)$ is small enough. In particular, when ability is uniformly distributed, there does not exist asymmetric equilibria with multiple positive investments, because the marginal benefit from a higher investment simplifies to the right-hand side of (10) (because $f(a(\lambda))$ is a constant). Hence, the only form that asymmetric equilibria can take has some workers making a common positive investment, and all other workers investing nothing. The right-hand side is increasing in $f(a)$: with less dispersion, a marginally higher investment allows a worker to “pass” more ability types; and for all $f(a)$ sufficiently high, some workers prefer not to invest and to accept that they will be the first to be fired in the event of layoffs.⁷ For such high $f(a)$, the fraction of workers that does not invest leaves workers indifferent between the positive and zero skill investments. Asymmetric equilibria otherwise share the properties of symmetric equilibria, and in what follows we assume that there is sufficient dispersion in worker abilities that the symmetric equilibrium exists.

⁷ Most starkly, the symmetric equilibrium does not exist if workers have identical abilities, as a worker could then ensure retention by investing marginally more than other workers.

When workers have almost all the bargaining power (i.e., $\alpha \rightarrow 1$) the first-order condition characterizing equilibrium investments given by equation (10) becomes

$$\beta c'(g) = E[a] - \int_{\lambda} [\lambda(1-P)E[a|a < a(\lambda)]]H(d\lambda) + \int_{\lambda} \left[\frac{a(\lambda)}{g}(1-P)(G + a(\lambda)g - u)f(a(\lambda)) \right] H(d\lambda). \quad (11)$$

Comparing the equilibrium investment with the social optimum, given by equation (2), reveals the following proposition.

Proposition 1. *As $\alpha \rightarrow 1$, the equilibrium human capital investment exceeds the socially optimal investment.*

Proof: Immediate. The first two terms on the left-hand sides of equations (2) and (11) are equal, but the last term in (11) is positive and has no analogue in (2). ■

This last term in (11) reflects the internal rat race between workers that arises when there is positive unemployment. A fraction $E[\lambda](1-P)$ of workers will be unable to find jobs, no matter what human capital investments are made. Socially, it is not optimal for workers to increase their own skill investments in order to raise the probability that other workers are laid off. Privately, however, workers internalize the fact that if they invest more, they are less likely to be unemployed and only receiving benefit u . A marginally greater investment in general skills marginally reduces by $a(\lambda)/g$ the layoff probability at a firm that must lay off a fraction λ of its labor force, and $(G + a(\lambda)g - u)$ is the gain from escaping the layoff. As a result of this rat race, if workers have sufficient bargaining power, they invest more than is socially optimal.

More generally, workers over-invest in skill development if and only if they have sufficient bargaining power. This follows immediately from the observation that investment is increasing in a worker's bargaining power: each of the three terms on the right-hand side of equation (10) is increasing in α . Intuitively, as we reduce α , workers reduce investments because they receive a smaller share of any investment but still incur all of the cost. Most sharply, when workers have no bargaining power (i.e., $\alpha = 0$) they do not invest at all. It follows that there is a unique sharing rule α^* that induces efficient investment in general skills.⁸

Differentiation yields several other interesting comparative statics results on worker investments.

⁸ The existence of such an optimal sharing rule relies on the premise that specific skills are unproductive.

- $H(\lambda)$: As long as the density of worker abilities does not decline too quickly—i.e., provided that $f'(\cdot)$ is not *too* negative⁹—then taking market conditions outside the firm as given, when layoffs within a firm are more likely, workers invest more effort to avoid being laid off.
- Z^f : Investment is decreasing in the strength of the firm's bargaining position. Most concretely, if workers outside the firm invest more, workers inside the firm invest less.
- u : The greater u is, the less workers invest in human capital. Increasing unemployment compensation, u , reduces the cost of being laid off, and hence induces workers to invest less. In particular, if workers over-invest in general capital, it may be optimal for the government to increase unemployment compensation, to reduce rat race incentives within firms.
- $\bar{a} - \underline{a}$: If ability is uniformly distributed, then workers invest less in the symmetric equilibrium when they are more heterogeneous (i.e., when the support $\bar{a} - \underline{a}$ is greater). Intuitively, as $\bar{a} - \underline{a}$ rises, ability rather than investment becomes the primary determinant of which workers are laid off.

Productive-specific Human Capital

When both general and specific human capital are productive, the first-order conditions describing a worker's skill investments become the following:

$$\begin{aligned}
 g: \beta c'(g+s) &\geq \int_{\lambda} \left[\int_{\underline{a}}^{a(\lambda)} \alpha P a f(a) da + \int_{a(\lambda)}^{\bar{a}} \alpha [1 + (1-\alpha)P] a f(a) da \right. \\
 &\quad \left. + \frac{(1-\alpha P) a(\lambda) f(a(\lambda))}{(1-\alpha P)g+s} [w_2(a(\lambda), g) - Z^w(a(\lambda), g)] \right] H(d\lambda) \\
 &= \int_{\lambda} \left[\alpha P \lambda E[a|a < a(\lambda)] + \alpha [1 + (1-\alpha)P] (1-\lambda) E[a|a \geq a(\lambda)] \right. \\
 &\quad \left. + \frac{(1-\alpha P) a(\lambda) f(a(\lambda))}{(1-\alpha P)g+s} [w_2(a(\lambda), g) - Z^w(a(\lambda), g)] \right] H(d\lambda),
 \end{aligned} \tag{12}$$

⁹ In particular,

$$\begin{aligned}
 \frac{d}{da(\lambda)} \left\{ \left[\int_{\underline{a}}^{a(\lambda)} \alpha P a f(a) da + \int_{a(\lambda)}^{\bar{a}} \alpha [1 + (1-\alpha)P] a f(a) da + \frac{a(\lambda)}{g} [w_2(a(\lambda), g) \right. \right. \\
 \left. \left. - Z^w(a(\lambda), g)] f(a(\lambda)) \right] \right\} = \frac{1}{g} [w_2(a(\lambda), g) - Z^w(a(\lambda), g)] [f(a(\lambda)) + a(\lambda) f'(a(\lambda))]
 \end{aligned}$$

is positive as long as $f'(\cdot)$ is not too negative.

$$\begin{aligned}
s: \beta c'(g+s) &\geq \int_{\lambda} \left[\int_{a(\lambda)}^{\bar{a}} \alpha a f(a) da + \frac{a(\lambda) f(a(\lambda))}{(1-\alpha P)g+s} [w_2(a(\lambda), g) \right. \\
&\quad \left. - Z^w(a(\lambda), g)] \right] H(d\lambda) \\
&= \int_{\lambda} \left[\alpha(1-\lambda) E[a|a \geq a(\lambda)] + \frac{a(\lambda) f(a(\lambda))}{(1-\alpha P)g+s} [w_2(a(\lambda), g) \right. \\
&\quad \left. - Z^w(a(\lambda), g)] \right] H(d\lambda), \tag{13}
\end{aligned}$$

where the inequalities hold as equalities if the associated investments are strictly positive, and it is always the case that at least one human capital investment is positive. To understand the content of the first-order conditions, suppose that workers invest in both specific and general skills. Then equating the right-hand sides of (12) and (13) yields

$$\begin{aligned}
&\int_{\lambda} \frac{\alpha P a(\lambda) f(a(\lambda))}{(1-\alpha P)g+s} \left[w_2(a(\lambda), g, s) - Z^w(a(\lambda), g) \right] H(d\lambda) \\
&= \int_{\lambda} \left[\int_{\underline{a}}^{a(\lambda)} \alpha P a f(a) da + \int_{a(\lambda)}^{\bar{a}} \alpha [(1-\alpha)P] a f(a) da \right] H(d\lambda). \tag{14}
\end{aligned}$$

The left-hand side is the marginal gain from a marginal investment in specific rather than general skills. It is the greater marginal impact on the probability the worker is retained by the firm due to a specific human capital investment times the “relative prize” from being retained rather than laid off. The right-hand side is the marginal cost of a specific rather than the general skill investment. A specific investment weakens a worker’s bargaining position with her current employer, and the worker is less productive when laid off—the right-hand side is the corresponding marginal reduction in wages.

The right-hand side of (14) does not vary with the human capital investments. Hence, we can characterize investments in each skill as a function of the *total* investment, $s + g$.¹⁰ Next observe that total human capital

¹⁰ While we focus on specific and general skill development, our analysis extends directly to investments in “intermediate” skills s_1 and s_2 , where fraction x of skill s_1 is transferable to other firms, and fraction $y > x$ of skill s_2 is transferable. In particular, as long as in equilibrium, workers invest strictly positive amounts in s_1 and s_2 , then the total investment $s_1 + s_2$ still solves (14), and investment in transferable skills is also unchanged, as

$$s_1 = \frac{yf - (1-y)g}{y-x} \quad \text{and} \quad s_2 = \frac{(1-x)g - xf}{y-x}.$$

Our decomposition into specific and general skills eases presentation and characterization, but save for consideration of boundary conditions is without loss of generality.

investment is a decreasing function of the cost parameter β , and that $s + g \rightarrow 0$ as $\beta \rightarrow \infty$. With this monotonic relationship in hand, we can characterize the composition of human capital investments as a function of β . Inspection of the right-hand sides of equations (12) and (13), or equivalently of each side of equation (14), reveals that there is a critical value of β , which we call $\bar{\beta}$, such that equation (14) holds as an equality at $g = 0$. We have the following result.

Proposition 2. *For all $\beta \geq \bar{\beta}$, human capital investments are small and workers invest only in specific human capital.*

Proof: The result follows directly from the fact that the left-hand side of (14) rises monotonically and continuously as β is increased so that $s + g$ falls, going to infinity as $s + g \rightarrow 0$, while the right-hand side is constant. ■

Workers can raise the likelihood of retention both by increasing total investment in human capital and by tilting the mix of investment towards specific skills. That is, since firms receive a greater share of the surplus from specific skill investments than from general skill investments, investing in specific skills has a greater impact on the probability of retention than a comparable investment in general skills. However, all specific skill investments are wasted if, at the end of the day, a worker is laid off. Therefore, the cost of tilting investments towards specific skills rises with the size of the investment. When human capital investments are sufficiently small, the costs associated with a weaker bargaining position and with foregone skills upon layoff are sufficiently slight; but there is a positive prize, $(1 - P)(G - u)$, from being employed rather than unemployed that is unrelated to the scale of investment. As a result, investments in specific skills have small costs relative to the benefits when skill investments are small, and in this instance the intra-firm rat race to avoid layoffs drives workers to direct all human capital investments inefficiently towards firm-specific skills.

Investments are small precisely when β is high; that is, when significant skill investments are costly. A reduction in β raises total optimal human capital investments and hence raises the cost associated with losing these investments if the worker is laid off. At $\beta = \bar{\beta}$, the expected cost of foregone specific skills when laid off is just equal to the positive prize from being employed rather than unemployed. Reducing β below $\bar{\beta}$, human capital investments become even more attractive, and we have the following result.

Proposition 3. *Reducing β below $\bar{\beta}$ both raises total human capital investments and causes workers to shift investments towards general skills and away from specific skills.*

Proof: For $\beta < \bar{\beta}$, if there are non-trivial investments in specific and general skills, equation (14) must hold as an equality: to maintain the equality as $s + g$ rises, investments must shift towards general skills. ■

Intuition says that as human capital investments grow, their contributions grow relative to the non-discretionary component of the prize associated with being employed $(1 - P)(G - u)$. That is, there is more foregone compensation to discretionary specific human capital when the investment is large relative to the non-discretionary prize. As a result, it becomes more attractive to switch the investment mix towards general skills.

Proposition 4 presents the important result that when workers invest in general and specific skills, they distort their human capital investments towards specific skills *and* they over-invest.

Proposition 4. *If workers invest in both specific and general skills in equilibrium, a worker's total investment in human capital $s + g$ is given by $\beta c'(s + g) = E[a]$. Hence, the worker's total human capital investment exceeds the social optimum.*

Proof: Using equation (14), substitute

$$\int_{\lambda} \frac{a(\lambda)}{(1 - \alpha P)g + s} [w_2(a(\lambda), g, s) - Z^w(a(\lambda), g, s)] f(\cdot) H(d\lambda)$$

into equation (13) to obtain

$$\begin{aligned} \beta c'(s + g) &= \int_{\lambda} \left[\int_{\underline{a}}^{a(\lambda)} af(a) da + \int_{a(\lambda)}^{\bar{a}} [(1 - \alpha)] af(a) da + \int_{a(\lambda)}^{\bar{a}} \alpha af(a) da \right] H(d\lambda) \\ &= \int_{\lambda} \left[\int_{\underline{a}}^{\bar{a}} af(a) da \right] H(d\lambda). \end{aligned} \quad (15)$$

■

Finally, as β is reduced further, the marginal costs of human capital investments will eventually fall by so much that workers invest solely in general human capital. In particular, there is a critical value of β , which we call $\underline{\beta}$, such that the left-hand side of (14) just equals the right-hand side at $s = 0$. Proposition 5 is then immediate.

Proposition 5. *For all $\beta < \underline{\beta}$, workers invest only in general skills.*

In summary, in economies where workers make limited human capital investments, they invest primarily in specific skills and over-invest in total skill development. In economies where human capital investments are higher, an ever greater share of investment is allocated towards general skills. Only when human capital investment costs are slight do workers

invest solely in general skills, and this is the point where investments may be too low from a social perspective.¹¹

Economy-wide Market Conditions

None of our findings hinge on the assumed symmetry across firms (i.e., that the distribution $H(\lambda)$ is the same for all firms). The symmetry is only used to simplify the calculation of the measure L of laid-off workers who are searching, as well as the threat point Z^f of firms (via the investments in general skills by workers laid off by other firms). It follows that by fixing conditions at one firm, we can characterize how human capital investments at that firm are affected by economy-wide market conditions. For simplicity, we focus on parametrizations in which workers in that firm invest in both firm-specific and general human capital. Now suppose that, for whatever reason, the average general human capital investments outside the firm are increased.¹² This raises the threat point of the employer, Z^f , because it increases the value of an open slot—the laid-off searching workers from outside firms are expected to be more productive. In turn, this reduces

$$w_2(a, g, s) - Z^w(a, g) = \alpha[G + ag + as - Z^f - Z^w(a, g)].$$

Proposition 3 reveals that this change in Z^f does not affect a worker's total human capital investment. However, to maintain equation (14) as an equality, workers within the firm must also shift their human capital investments towards general skills. Proposition 6 follows immediately.

Proposition 6. *Economy-wide shifts towards general skill investments **outside** the firm induce shifts towards general investments **within** the firm.*

Intuitively, if workers elsewhere in the economy make greater general skill investments, a worker has a smaller incentive to invest in specific skills because the worker's employer extracts a greater share of the surplus associated with specific skill investments. It follows that the skill-investment

¹¹ A referee questioned whether a firm might profit from raising β (i.e., from raising the marginal cost of investment) thereby raising the share of total investment in specific skills. In fact, the firm never benefits from raising β . To see this, observe from (8) that the firm's profits depend on skill investments according to $C[(1 - \alpha P)g + s]$, where C is a constant. Profits become unboundedly large as $\beta \rightarrow 0$ so that $g \rightarrow \infty$; increasing β when such β lies below $\underline{\beta}$ or above $\bar{\beta}$ is obviously dominated. The question becomes whether profits monotonically fall in β for $\beta \in [\underline{\beta}, \bar{\beta}]$, where increases in β reduce total investment but raise the share of investment in specific skills. Equation (13), however, reveals that increasing β raises s only if $(1 - \alpha P)g$ decreases by more than s increases, which implies that profits must fall.

¹² That is, perturb parameters at outside firms along the lines of our comparative static results, in such a way that P is unchanged, but investments in general skills by workers at outside firms are increased.

externalities that operate at the firm level also operate at the economy-wide level. Phrased differently, if the conditions that we identify within a firm that lead to increased general skill investment hold economy-wide, then there is an additional general equilibrium feedback effect at the economy-wide level that serves to reinforce this increase in general skill investments.

III. *Ex Ante* Heterogeneity in Ability

We now explore how *ex ante* heterogeneity in workers' ability affects human capital investments. Workers understand that more able workers are less likely to be fired, and when workers receive signals about their abilities prior to investment, they update their probability of being fired, and invest accordingly. To glean insights, we integrate *ex ante* heterogeneity into a simple parametrized version of our model. We assume that prior to investing, a fraction γ of workers receive a signal \bar{a}_l that they have low ability, and the remaining workers receive high signals, \bar{a}_h . The ability of a type i worker is uniformly distributed on $[\underline{a}_i, \bar{a}_i]$, where $\bar{a}_i - \underline{a}_i = 1$, where obviously $\bar{a}_h > \bar{a}_l$ so $E[a_h] > E[a_l]$. Investment costs are quadratic, $c(g+s) = (\beta/2)(g+s)^2$, and a fraction μ of firms must lay off $\lambda > 0$ of their employees, while fraction $1 - \mu$ of firms need not lay off anyone.

There are two easy scenarios to examine when *ex ante* expected differences in ability are sufficiently large: (i) when λ is sufficiently smaller than γ , there are "enough" workers with low *ex ante* signals so that workers with high signals understand they are sheltered from layoffs, and (ii) when λ is sufficiently larger than γ , workers with low *ex ante* signals give up and reconcile themselves to being laid off if the firm is hit with a layoff shock. These scenarios *exclude* the scenario where some (but not all) of both types of workers are vulnerable to layoffs, which occurs when λ is close to γ and *ex ante* differences in ability are small enough.

In the first scenario, workers with high *ex ante* signals have secure jobs and therefore invest only in general skills. Workers who receive a low *ex ante* signal face almost the same problem as before, except that the ability cut-off is now $a(\lambda) = F^{-1}(\lambda/\gamma)$ to account for the fact that the density of low-ability individuals is less than one. They all make symmetric investment choices, and the *ex post* randomness in ability determines which of these workers get laid off. For example, when only general skills are productive, g_l solves a slightly modified version of equation (10):

$$\begin{aligned} \beta g_l = & (1 - \mu)\alpha[1 + (1 - \alpha)P]E[a_l] + \mu[\alpha P[a(\lambda) - \underline{a}_l] \\ & + \alpha[1 + (1 - \alpha)P][\bar{a}_l - a(\lambda)]] + \mu\alpha\frac{a(\lambda)}{g_l} [G + a(\lambda)g_l - Z^f - Z^w]. \end{aligned} \quad (16)$$

Investment g_l satisfies the same properties as in the previous section, including over-investment when α is sufficiently large. Two considerations affect investments by high-ability individuals. Given that they are never laid off, their desired level of general capital,

$$g_h = \alpha \frac{1 + (1 - \alpha)P}{\beta} E[a_h],$$

simply equates the marginal wage increase with the marginal cost of the investment. The requisite ability difference that ensures high-ability workers who make this investment are not laid off is then $\underline{a}_h \geq (g_l/g_h)\bar{a}_l$. For sufficiently big differences in *ex ante* heterogeneity, high-ability individuals acquire the efficient level of general skill, and this will be enough. For intermediate differences, high-ability individuals also over-invest, because they must make sufficient investments to guarantee retention.

The other easy scenario to analyze is where $\lambda > \gamma$ and all low-ability individuals at an unlucky firm are laid off. Then investments by individuals with high *ex ante* signals mirror those in the first scenario by low-ability workers—that is, when only general skills are productive, replace g_l by g_h in (16), where now

$$a(\lambda) = F^{-1} \left(\frac{\lambda - \gamma}{1 - \gamma} \right).$$

In contrast, low-ability individuals simply give up and make their investment decisions knowing they will be laid off if the firm is unlucky, so that

$$g_l = \alpha \frac{1 + (1 - \mu)(1 - \alpha)P}{\beta} E[a_l]$$

(and they will not invest in specific skills even if specific skills are productive). Again, for this equilibrium to exist, the *ex ante* difference in abilities must be sufficiently great.

Finally, consider the scenario where, in equilibrium, some but not all low-signal workers are laid off, and some but not all high-signal workers are laid off; this requires that *ex ante* skill differences are small enough and γ is sufficiently close to λ . If specific skills are unproductive, this case is still relatively easy to analyze. The general skill investment by an agent receiving a type i signal solves

$$\begin{aligned} \max_{g_i} (1 - \mu)[w_0 + \alpha[1 + (1 - \alpha)P]]E[a_i]g_i + \mu \left[\int_{\underline{a}_i}^{\frac{x(\lambda)}{(1-\alpha)(1-\alpha P)g_i}} [z_0 + \alpha P a g_i] da \right. \\ \left. + \int_{\frac{x(\lambda)}{(1-\alpha)(1-\alpha P)g_i}}^{\bar{a}_i} [w_0 + \alpha[1 + (1 - \alpha)P] a g_i] da \right] - \frac{\beta}{2} g_i^2, \end{aligned}$$

where a worker is retained if and only if $a(1 - \alpha)(1 - \alpha P)g_i \geq x(\lambda)$, and the cut-off standard $x(\lambda)$ results in layoffs of measure λ of workers. Without stating the first-order conditions, inspection reveals that two factors affect the relative investments of workers who receive high and low *ex ante* signals. First, individuals receiving high signals have higher expected marginal rates of return to investment due to the complementarities between skill and investment, which leads them to invest more than individuals with lower *ex ante* signals. Second, there is a positive rat race component for type i of

$$\frac{x(\lambda)}{(1 - \alpha)(1 - \alpha P)g_i^2} C,$$

where C is a constant common to the two types. We see immediately that this term is the same when both types make the same investment, implying that while rat race incentives can induce those with low signals to raise their investments in general skills, they will not raise investment to the level made by agents with high signals (as the marginal product difference remains). As a result, workers who received a high-ability signal will invest more than those who received a low signal.

When specific skills are productive, then the case where both types may be laid off in equilibrium is much more difficult to analyze. We make two observations: first, due to surplus sharing, high-ability individuals face a greater cost if they invest more heavily in specific human capital rather than in general skills. Individuals with high *ex ante* signals of ability consequently shift the composition of their investments towards general skills. In turn, this difference in skill investments means that workers with high *ex ante* signals do not mind being fired as much as those with low *ex ante* signals. We conjecture that in some scenarios, the different composition of skill investments can result in workers with high *ex ante* signals being *more* likely to be laid off than workers with low *ex ante* signals. That is, workers with high signals may shift investment towards general skills sufficiently that they are more likely to be fired, but they prefer the heavier general skill investment because it leads to higher wages conditional on being retained and conditional on being fired (even though expected compensation is higher when retained than when fired). Intuitively, individuals with high *ex ante* signals of ability gamble on their ability by tilting investment towards general skills, because the prize for being retained is higher, and they also expect to have a softer fall if laid off.

IV. Other Extensions and Policy Implications

Alternative Production Technologies

The implicit production technology in our economy is a Leontief technology with a fixed number of workers per identical machine. The technology

exhibits constant returns to scale. This technology allows us to analyze the problem on a worker-by-worker basis, greatly simplifying matters. In addition, it allows us to take the “size” of firms as exogenous, because a firm’s size does not affect the strategic calculus of workers or firms. In particular, all firms will set the same first-period wage, no matter how we close the model; and the way we close the model does not affect equilibrium investments. With this assumption, the cleanest way to interpret the random employment shock in our economy is that a fraction λ of a firm’s Leontief machines are destroyed or become obsolete. Still, it seems clear that the essence of our analysis extends more broadly to alternative settings in which firms instead face demand/price shocks and choose to retire some machines, thereby laying off workers. However, to model this formally, one needs decreasing returns to scale, so that the marginal productivity of (possibly identical) machines are higher when a firm operates fewer machines. But then, the date 1 scale of the firm also becomes a choice variable, and we would have to solve for how that scale affects equilibrium variables because now one would want to endogenize workers’ choices of employers at date 1. Such choices do not affect the qualitative features of the rat race incentives that we model, taking as *given* the date 2 distribution over scales of operation chosen by firms; however, explicitly characterizing how date 1 and date 2 choices by firms of operating scale (internalizing the consequences for wage determination) compare with the social optima appears highly non-trivial.

What *would* alter our qualitative findings is if we modeled decreasing returns to scale by assuming that some of a firm’s machines are more productive than others. In such a case, a firm hit by a negative shock shuts down its less productive machines. In essence, we assume an extreme form in which machines are either productive or not. But were there heterogeneity in the productivity of machines that operate, then assignment of heterogeneous machines to heterogeneous workers would occur. That assignment would be positively assortive—more able workers would be assigned to more productive machines. Assuming symmetric human capital investments are made, in the subgame following investment, assignment complicates the bargaining game between a given worker and a firm, albeit in a manageable way; see, for example, Li (2008). However, it complicates investment choices more significantly, enhancing the rat race incentives for workers, because workers want to be ranked more highly even if they stay at the firm, simply because more highly ranked workers are assigned to more productive machines, and therefore extract more surplus.

Investment by Employers

If firms rather than workers invest in worker skill development, then the standard under-investment result is obtained. This follows immediately from

the observation that investment choices by firms are unaffected by rat race incentives. Each worker cares about which workers turn out to be most profitable for the firm—because that determines which employees are retained—but the firm does not. When specific and general skills are perfect substitutes in production, firms invest solely in specific skills (assuming that investments are made *after* date 1 wages are determined) because they extract a greater share of the returns from these investments in bargaining.

Schooling

It would also be useful to consider the choice by individuals of whether to stay in school and develop general skills, or to drop out and develop specific skills through on-the-job training. Results consistent with the ones obtained in Gibbons and Waldman (2006) would obtain, but for different reasons. In particular, schooling would be correlated with wages because it is chosen by workers who specialize in general human capital, and workers who choose to drop out of school early specialize in specific human capital.

Layoffs According to Seniority

Seniority rules can have subtle effects. If workers are laid off not according to the relative profits that they generate their employer but rather by other arbitrary rules, this would reduce the incentives of workers to distort human capital investments to avoid layoffs. Plausibly, seniority layoff rules could raise social surplus above the competitive outcome by reducing discretion in the layoff process, thereby reducing the incentive to manipulate such processes. Clearly, the distortion introduced by an arbitrary layoff rule would have to be small for such a policy to be optimal. Importantly, such distortions would be small precisely where variations in ability between workers are small, and it is precisely in such environments that the rat race greatly skews worker skill investments. In such contexts, union-negotiated seniority layoff rules may be optimal.

Selection by Firms among Searching Workers

In our model, workers who quit or who are laid off search, and may or may not find a new employer. However, each firm meets at most one searching worker, so there is no competition between laid-off workers for a job at a given firm. If a hiring firm meets multiple workers, then bargaining will extract positive profits from both ability and general skills. The firm will then hire from the top, hiring workers with the highest ability plus transferable human capital. Firms tend to hire from multiple searching workers.

This provides currently employed workers with incentives to shift the mix of their investments towards transferable general skills and to increase total investment in human capital.

Unemployment Insurance

Government intervention may induce workers to make more efficient investment choices. For example, higher unemployment insurance reduces the cost of being fired, and it may encourage workers to shift investments efficiently towards general skills and away from specific skills, or to reduce excessive human capital investments. The lower the probability of finding a new job, the more generous the unemployment insurance (UI) program would have to be. This provides an argument in favor of higher UI in regions where unemployment is high and finding a job is hard, or when economy-wide unemployment rates are higher.

Our bargaining environment, in which some laid-off workers fail to find jobs, can be modified to investigate these issues. Increasing UI reduces total investment and shifts investment towards general skills and away from specific skills. While we assume that specific human capital is a dominated investment to heighten the contrast with standard under-investment predictions, in reality some specific capital investments are clearly socially optimal. The optimal policy prescription then hinges on whether individuals actually over-invest or under-invest in specific capital and in total human capital acquisition, which has yet to be determined empirically.

Brown and Kaufold (1988) provide a very different model of human capital investment in the presence of possible unemployment. They argue that risk-averse workers will under-invest in human capital, and they also argue that UI can increase investment in human capital. Here, we show that the internal rat race between firms can cause workers to over-invest in human capital and to distort investments towards firm-specific human capital and away from general human capital.

Finally, when individuals choose whether to stay in school and acquire general skills, or to drop out and develop specific skills on the job, higher UI compensation may induce individuals to stay in school. Indeed, one can motivate higher UI payments in areas where unemployment is higher, because greater UI payments may induce individuals to make the riskier but more efficient investment.

V. Conclusion

This paper characterizes the investments by workers in general and specific human capital when workers internalize the consequences of their investments for layoff probabilities. Workers understand that firms will lay off

workers in inverse order of profitability. Investing in specific rather than general skills reduces the outside value of the worker to competing firms, thereby committing the worker to extracting lower wages through the subsequent wage determination process. As a result, a worker who invests more than his fellow employees in specific skills is less likely to be laid off. The rat race to avoid being laid off can induce workers to make costly investments in specific human capital and to *over-invest* in total skill development relative to the social optimum.

More generally, we show that in economies where workers make limited human capital investments, they invest primarily in specific skills; while in economies where total human capital investments are higher, an ever greater share is allocated towards general skills. Finally, we show that the forces that operate at the firm level also operate at the economy level: higher investments in general human capital at some firms drive down wages at other firms, making it less attractive for all workers to invest in specific skills.

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