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Dan Bernhardt and Steeve Mongrain

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Dan Bernhardt
Department of Economics
University of Illinois
Champaign, IL 61820

Steeve Mongrain
Department of Economics
Simon Fraser University
Burnaby, BC V5A-1S6

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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, to reduce layoff probabilities, workers invest in specific human capital. 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 downsizes, and the distribution of employment opportunities in the economy.

Key Words: Human Capital; Layoffs; Unemployment; Specific Skills; Bargaining

JEL: J41; J63; J65

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1 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 (1964). The conundrum is that workers incur all of the investment costs, but capture only a fraction of the returns to 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; and Carmichael (1983), Lazear and Rosen (1981), Prendergast (1993), Bernhardt and Scoones (1998), Gibbons and Waldman (1999) and (2003), 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, retaining workers who generate greater profits.[1] While transferable general skills strengthen a worker's outside option, 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 the 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 that both form of human capital are *perfect* substitutes in production if a worker remains at his employer. Because workers may be laid off, therefore, it is never socially optimal to invest in specific capital. Nonetheless, workers may do precisely that.

We consider an economy where wages are determined through worker-firm bargaining. Workers make their 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 (Grout (1984), Chang and Wang (1996), Zabojnik (1998), or Stole and Zweibel (1996)), workers under-invest in human capital in general,

[1] We focus on environments in which workers bear the costs (effort or monetary) of human capital investments. For analyses in which firms bear the costs, see Acemoglu and Pischke (1998, 1999), or Kessler and Lülfesmann (2004).

and specific human capital in particular, because they share the return with the firm, but incur all costs. That this under-investment incentive with bargaining should cause 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 to human capital is still present in our environment, but the rat race to reduce layoff probabilities provides workers with overwhelming countervailing incentives to make excessive human capital investments. Workers understand that firms will layoff employees in inverse order of profitability, and that greater investments in human capital (especially in specific capital), 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 toward *specific* skills and *over-invest* in total skill acquisition. This is because the benefit from 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 toward general skills.
- As human capital investments become sufficiently cheap, workers cease to invest in specific skills (dominated by assumption), but they 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 this improves the outside option at a given firm, reducing 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, this paper challenges the conventional wisdom that workers under-invest in human capital, and specific skills in particular. Investment in human capital is not easily observable, but indirect evidence suggests that workers make substantial investments in imperfectly-transferable

skills. Empirical work dating back to Parsons (1972) emphasizes the relevance of specific capital. Topel (1991) and others suggested that one way to measure specific human capital investment was to look at the wage reduction faced by displaced workers. Using PSID data, he found that a male worker in the US with ten years of seniority would suffer a wage reduction of up to twenty five percent upon separation. This is also feature of our model; wage grows with seniority, and workers who lose their jobs receive reduced wages due to the loss of specific human capital. More recently, researchers (e.g., Neal (1995), Parent (2000), Kambourov and Manovskii (2005), Lazear (2003)) have focused on industry or occupation specific skill acquisition, highlighting the importance of industry or occupation experience. The qualitative predictions of our model extend routinely if we interpret "firm specific" skills as industry or occupation specific skills—in the sense that workers extract a smaller share of the investment in less-transferable skills (e.g., because laid off workers may end up working in another industry or occupation). In fact, workers frequently change industry or occupation. 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 (2005) find that switching occupation is also frequent; 56 (74) percent of laid off worker switch occupation using one (three) digit definitions.

Other indirect evidence of the human capital investment pattern suggested by our paper is that in regions with high employment rates, workers are often highly specialized, with low levels of general education. For example, the correlation between regional unemployment rate 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 significantly higher and search takes far 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, Rebitzer and Taylor (1996), who argue that young lawyers work (inefficiently) long hours to signal their willingness to work hard in the future. Our paper identifies an important, distinct countervailing force to other under-investment sources, a force that researchers should account for.

There is a large literature (e.g., Becker (1964), Bernhardt and Scoones (1998) or Gibbons and Waldman (1999), Bai and Wang (2003)) on human capital investment by workers when there are constant returns to scale in the firm, so that a worker's productivity does not depend on how many other workers are employed nor 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. Bernhardt and Scoones (1998) show that if worker ability varies and competing firms observe the 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 capitalin 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, which is similar to winning a prizes. Akerlof (1976) was the first to formalize the idea of rat races. Since then, rat races have been used in many contexts; from labor market decisions to patent races.

Finally, there is a large literature on internal labor market tournaments, where compensation also depends on relative performance (see e.g., Lazear and Rosen (1981), Carmichael (1983), Prendergast (1993), Zabojnik and Bernhardt (2001), Gibbons and Waldman (1999)).[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 the firm depends on both the worker's action and those of his cohort. The equilibrium need not have desirable welfare properties. For example, when 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 of which few workers to fire, rather than from the top, of which few workers to promote.

We next present and analyze the model in Section 2, characterizing how human capital investments depend on the economic environment. Section 3 discusses extensions and policy implications. For example, if the layoff rate 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 may dominate the equilibrium outcomes that we analyze. Section 4 concludes.

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

2 The economy

We consider a two-period economy without discounting, an environment rich enough to capture key features. The economy has many ex-ante identical, risk-neutral firms, and 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 a measure one 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_1. During period one, workers can make costly discretionary investments in both 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 $g_2 = G_2 + ag$, where $G_2 \geq G_1$ captures any passive learning-by-doing that occurs in the first period. 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 $G_2 + a(s + g)$, while her productivity at another firm is only $G_2 + ag$. Workers do not know their abilities when they invest. Workers' abilities are distributed according to a common probability density function $f(\cdot)$ with support $[\underline{a}, \bar{a}]$, where $\underline{a} > 0$. There is no aggregate uncertainty so that the realized distribution of worker abilities at each firm is $f(\cdot)$. To avoid having to deal with self-selection problem, we assume that workers do not know their actual ability when making their investment decision. A possible interpretation this assumption, is that workers are not aware of how good will they be at acquiring new skills. At the end of the first period, worker investments and abilities are publicly revealed.

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 $c(g+s)$. Hence, it is Pareto optimal to invest solely in general capital: the specific skill investment of a worker who leaves an employer is wasted. The cost function has the standard properties: $c(0) = 0$, $c'(0) = 0$, $c''(\cdot) > 0$, and $lim_{g+s\to\infty} c'(g + s) = \infty$.

At the beginning of date 2, each firm may be hit with a random employment shock $\lambda \geq 0$; and in such an event, the firm must layoff fraction λ of its workers.[3] We assume that the distribution over employment shocks, $H(\lambda)$, is the same at all firms. Note that this distribution function can be such that positive weight is put on $\lambda = 0$, so some firm may not have to layoff any workers.

[3]The implicit production technology is a Leontief technology in which a fraction λ of a firm's machines are destroyed. The qualitative properties of our analysis do not depend on this simplifying assumption.

Laid-off workers must search to find jobs and wages are determined through bargaining. With no aggregate uncertainty, a fraction $L = E[\lambda]$ of workers are laid off in the economy. Laid-off workers can seek employment elsewhere and there are $\frac{N}{L}$ new job openings per laid off worker. Fraction ρ of firms with openings find searching workers, so that the probability a worker finds a firm with an open slot is $P = \frac{\rho N}{L} < 1$. A worker who does not find an new job receives a payoff of u. This benefit u can be interpreted as a combination of home production plus unemployment insurance.

A 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 on an individual worker-firm basis, a firm cannot use wage offers to 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 that contribute least to its bottom line, or equivalently 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.[4] 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 $u < G_2$, 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 firm can bargain. We let $\hat{w}_2(a, g)$ be the yet-to-be-determined equilibrium wage of a *searching* worker with ability a who invested g in general human capital.

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.[5] It is socially efficient to invest solely in general skills. Given λ, a firm will layoff all workers with ability levels $a < a(\lambda)$, where $a(\lambda) = F^{-1}(\lambda)$. The surplus generated by an

[4]The new job openings can be attributed to new firms, or to existing firms that expand ($\lambda < 0$).

[5]Equilibrium is characterized by symmetric investments if and only if there is sufficient heterogeneity in worker abilities. See footnote 7.

investment g in general human capital is

$$S = \int_{\lambda} \left[\int_{\underline{a}}^{a(\lambda)} Pagf(a)da + \int_{a(\lambda)}^{\bar{a}} agf(a)da \right] H(d\lambda) - c(g).$$

The first-order condition characterizing the socially optimal investment can be written as

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

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.

Second Period Wages. We solve recursively for equilibrium outcomes. Consider first the bargain struck between a searching worker and firm. The surplus over which a worker and firm bargain depends on the worker's general human capital investment. A worker with ability a who developed general skills g generates output of $G_2 + ag$. Bargaining provides a searching worker with a wage of

$$\hat{w}_2(a, g) = \alpha[G_2 + ag - u] + u,$$

and leaves the firm with a profit of

$$\hat{\pi}_2(a, g) = (1 - \alpha)[G_2 + ag - u].$$

The wages and profits generated by 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

$$\begin{aligned} Z^w(a, g) &= P\hat{w}_2(a, g) + (1 - P)u \\ &= P\alpha[G_2 + ag - u] + u \\ &\equiv z_0 + \alpha Pag, \end{aligned} \tag{2}$$

where $z_0 = P\alpha(G_2 - u) + u$.

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 generated by an open slot. In turn, this threat point depends on the equilibrium mix of skill investments and ability levels of searching workers. A firm finds a potential hire with probability ρ, and $G_2 + E[ag|\text{laidoff}] \equiv G_2 + \nu$ is the expected productivity of a laid-off worker. It follows that a firm's threat point is given by

$$Z^f = (1 - \alpha)\rho[G_2 + \nu - u].$$

A worker' threat point is increasing in 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 is decreasing in u, but is increasing in 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:

$$\begin{aligned} w_2(a,g,s) &= \alpha[G_2 + ag + as - Z^f - Z^w(a,g)] + Z^w(a,g) \\ &\equiv w_0(Z^f,u) + \alpha[1+(1-\alpha)P]ag + \alpha as, \end{aligned} \tag{3}$$

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—and, in particular, 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 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:

$$(1-\alpha)[G_2 + ag + as - Z^f - Z^w(a,g)] + Z^f.$$

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 a worker extracts in bargaining from an investment in general skills, and hence the greater is the 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 general skills, as competing firms only value general skill investments.

Equilibrium Human Capital Investments. Once 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 affect a firm's profits according to $(1-\alpha)a[g+s-P\alpha g]$. At a firm that must layoff 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. That is, 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 determine the threat point Z^f for the firm.[6] A worker's expected payoff from human capital investment (g, s) is

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

In a symmetric equilibrium in which all workers in a firm make the same human capital investments, the only differences in the profits that workers within a firm generate are due to their different abilities.[7] As a result, a firm that lays off 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 clean comparisons with the socially optimal investment. Then, a worker's general capital investment solves

$$\begin{aligned} c'(g) &= \int_\lambda \Big[\int_{\underline{a}}^{a(\lambda)} \alpha P a f(a) da + \int_{a(\lambda)}^{\bar{a}} \alpha[1+(1-\alpha)P] a f(a) da \\ &\qquad + \frac{a(\lambda)}{g} [w_2(a(\lambda), g) - Z^w(a(\lambda), g)] f(a(\lambda)) \Big] H(d\lambda) \qquad (4) \\ &= \alpha E[a] + \int_\lambda \Big[(1-\lambda)\alpha(1-\alpha) P E[a | a \geq a(\lambda)] - \lambda \alpha (1-P) E[a | a < a(\lambda)] \\ &\qquad + \frac{\alpha a(\lambda) f(a(\lambda))}{g} [G_2 + ag - Z^f - Z^w(a(\lambda), g)] \Big] H(d\lambda). \end{aligned}$$

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

[7] The symmetric equilibrium exists if and only if workers differ sufficiently in ability. With too little heterogeneity in worker abilities, rat race incentives are so strong (because a marginal investment lets a worker pass "too many" ability types in the race to avoid layoffs) that investments are driven so high that some workers drop out of the race, and accept that they will be the first to be fired. Most starkly, if workers had identical abilities, a worker could guarantee retention by investing marginally more than other workers, so there cannot be a symmetric equilibrium. As long as there is enough heterogeneity, investments are characterized by common first-order conditions, so that only the symmetric equilibrium exists.

In particular, if workers have almost all bargaining power, i.e., $\alpha \to 1$, this becomes

$$c'(g) \;=\; E[a] - \int_\lambda \Big[\lambda(1-P)E[a|a<a(\lambda)]H(d\lambda) + \int_\lambda \Big[\frac{a(\lambda)}{g}(1-P)(G_2+a(\lambda)g-u)f(a(\lambda))\Big]H(d\lambda). \tag{5}$$

Comparing the equilibrium investment with the social optimum (equation (**??**)), reveals the following result:

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

Proof: The result follows directly from the fact that the first two terms on the left-hand sides of equations (**??**) and (**??**) correspond, but the last term in (**??**) is positive and has no analogue in (**??**). ■

This last term in (**??**) reflects the internal rat race between workers in the firm 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 skill investments in order to raise the probability other workers are laid off in their place. Privately, however, workers internalize the fact that if they invest more, then they are less likely to be left unemployed and receiving only the unemployment benefit, u: a marginally greater investment in general skills marginally reduces by $\frac{a(\lambda)}{g}$ the layoff probability at a firm that must layoff fraction λ of its labor force, and $(G_2 + a(\lambda)g - u)$ is the gain from escaping the layoff. As a result of this rat race, workers invest more than is socially optimal.

The comparative statics are straightforward. Differentiation reveals the following:

α: Investment is increasing in a worker's bargaining power: each of the three terms on the right-hand side of equation (**??**) is increasing in α. If α is reduced, workers receive a smaller share of any investment, but still incur all of the cost, and hence reduce their investments. As a result, skill investments exceed the social optimum if and only if α is sufficiently large.

$H(\lambda)$: As long as the density of worker abilities does not decline too quickly, i.e., $f'(\cdot)$ is not *too* negative,[8] then taking market conditions outside the firm as given, when layoffs within a firm are more likely, workers invest more in efforts to avoid being laid off.

[8] In particular, $\frac{d}{da(\lambda)}\{[\int_{\underline{a}}^{a(\lambda)} \alpha P a f(a)da + \int_{a(\lambda)}^{\bar{a}} \alpha[1+(1-\alpha)P]af(a)da + \frac{a(\lambda)}{g}[w_2(a(\lambda),g) - Z^w(a(\lambda),g)]f(a(\lambda))]\} = \frac{1}{g}[w_2(a(\lambda),g) - Z^w(a(\lambda),\underline{g})][f(a(\lambda)) + a(\lambda)f'(a(\lambda))$ is positive as long as $f'(\cdot)$ is not too negative.

Z^f: Investment is decreasing in the strength of the firm bargaining position. Most concretely, if workers outside the firm invest more, workers inside a firm invest less.

u: The greater is u, 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 the internal rat race incentives within firms.

$\bar{a} - \underline{a}$: If we impose a uniform distribution on ability, workers invest less in the symmetric equilibrium when they are more heterogeneous ($\bar{a} - \underline{a}$ is greater). This is because ability is the primary determinant of who is going to be laid off.

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

$$\begin{aligned} g: \quad c'(g+s) &\geq \int_\lambda \Bigg[\int_{\underline{a}}^{a(\lambda)} \alpha P a f(a) da + \int_{a(\lambda)}^{\bar{a}} \alpha[1+(1-\alpha)P] a f(a) da \\ &\qquad + \frac{(1-\alpha P) a(\lambda) f(a(\lambda))}{(1-\alpha P)g+s} [w_2(a(\lambda), g) - Z^w(a(\lambda), g)] \Bigg] H(d\lambda) \qquad (6) \\ &= \int_\lambda \Bigg[\alpha P \lambda E[a | a < a(\lambda)] + \alpha[1+(1-\alpha)P](1-\lambda) E[a | a \geq a(\lambda)] \\ &\qquad + \frac{(1-\alpha P) a(\lambda) f(a(\lambda))}{(1-\alpha P)g+s} [w_2(a(\lambda), g) - Z^w(a(\lambda), g)] \Bigg] H(d\lambda) \end{aligned}$$

$$\begin{aligned} s: \quad c'(g+s) &\geq \int_\lambda \Bigg[\int_{a(\lambda)}^{\bar{a}} \alpha a f(a) da + \frac{a(\lambda) f(a(\lambda))}{(1-\alpha P)g+s} [w_2(a(\lambda), g) - Z^w(a(\lambda), g)] \Bigg] H(d\lambda) \qquad (7) \\ &= \int_\lambda \Bigg[\alpha(1-\lambda) E[a | a \geq a(\lambda)] + \frac{a(\lambda) f(a(\lambda))}{(1-\alpha P)g+s} [w_2(a(\lambda), g) - Z^w(a(\lambda), g)] \Bigg] H(d\lambda), \end{aligned}$$

where the inequalities hold as equalities if the associated investments are strictly positive, and 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 (**??**) and (**??**) yields

$$\int_\lambda \frac{P \alpha a(\lambda)}{(1-\alpha P)g+s} [w_2(a(\lambda), g, s) - Z^w(a(\lambda, g))] f(\cdot) H(d\lambda) = \int_\lambda \Bigg[\int_{\underline{a}}^{a(\lambda)} \alpha P a f(a) da + \int_{a(\lambda)}^{\bar{a}} \alpha[(1-\alpha)P] a f(a) da. \qquad (8)$$

The left-hand side is the marginal gain from a marginal investment in 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 (**??**) does not vary with the human capital investments. Hence, we can characterize investments in each skill as a function of the *total* investment, $s+g$. More specifically, consider cost functions of the form $\beta C(s+g)$. For β large, the marginal cost of human capital investments is large, so that the equilibrium total investment is small. Inspection of the right-hand sides of equations (**??**) and (**??**), or equivalently of each side of equation (**??**), yields the following result:

Proposition 2: *There exists a $\bar{\beta}$ such that for $\beta \geq \bar{\beta}$ discretionary 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 (**??**) rises monotonically as $s+g$ falls, going to infinity as $s+g \to 0$, while the right-hand side is constant. ■

The economic intuition is that if discretionary human capital investments are small, the cost associated with a weaker bargaining position is slight, but there is a positive prize, $(1-P)(G_2-u)$, from being employed, rather than unemployed. As a result, the intra-firm rat race to avoid layoffs drives workers to direct all human capital investments inefficiently toward firm-specific skills. A worker can raise the likelihood of retention either by increasing the overall investment or by tilting the mix of investment toward specific skills. When marginal skill investments are more costly, the worker does better to shift investments toward specific skills.

If we reduce β, the marginal cost of investment falls and discretionary human capital investments rise, which reduces the left-hand side of (**??**). At $\bar{\beta}$, equation (**??**) holds as an equality at $g=0$.

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

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

The intuition is that as human capital investments are increased, their contributions grow relative to the non-discretionary component of the prize from being employed, $(1-P)(G_2-u)$. Phrased differently, there is more foregone compensation to discretionary specific human capital when the

investment is large relative to the non-discretionary prize.

Importantly, when workers invest in both skills, they both distort their human capital investments toward specific skills *and* 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 $c'(s+g) = E[a]$. Hence, the worker's total human capital investment exceeds the social optimum.*

Proof: Using equation (**??**), substitute for $\int_\lambda \frac{a(\lambda)}{(1-\alpha P)g+s}[w_2(a(\lambda),g,s) - Z^w(a(\lambda),g,s)]f(\cdot)H(d\lambda)$ into equation (**??**) to obtain

$$c'(s+g) = \int_\lambda \Big[\int_{\underline{a}}^{a(\lambda)} af(a)da + \int_{a(\lambda)}^{\bar{a}} [(1-\alpha)]af(a)da + \int_{a(\lambda)}^{\bar{a}} \alpha af(a)da]H(d\lambda) = \int_\lambda \Big[\int_{\underline{a}}^{\bar{a}} af(a)da\Big]H(d\lambda). \quad \blacksquare$$

Finally, as β is reduced further, eventually the marginal costs of human capital investments fall by so much that workers invest solely in general human capital. In particular, there is a critical value of $s+g$ such that the left-hand side of (**??**) just equals the right-hand side at $s=0$. Thus, we have

Proposition 5: *There exists an $\underline{\beta} < \bar{\beta}$ such that 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 toward general skills.

Economy-wide market conditions. None of this analysis exploits the assumed symmetry across firms. It follows that if we take the initial distribution of workers across firms as given, we can characterize how human capital investments at one firm are affected by economy-wide market conditions. For simplicity, we focus on parameterizations in which workers in a 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. This raises the threat point of the employer, Z^f, because it increases the value of an open slot. In turn, this reduces $w_2(a,g,s) - Z^w(a,g) = \alpha[G_2 + ag + as - Z^f - Z^w(a,g)]$. Proposition 3 reveals that this change in Z^f does not affect a worker's total human capital investment. However, to maintain equation (**??**) as an equality, it must be that workers within the firm also shift their human capital investments toward general skills. Proposition 6 below follows immediately.

Proposition 6: *Economy-wide shifts toward general skill investments outside the firm induce shifts*

toward general investments within the firm.

Intuitively, if workers in the economy raise general skill investments, a worker has a smaller incentive to invest in specific skills because the benefit to being retained by an employer is reduced. It follows that the skill-investment externalities that operate at the firm level, also operate at the economy-wide level.

3 Extensions and policy implications

Ex-ante heterogeneity in ability. It would be worthwhile to extend our analysis to allow for ex-ante heterogeneity in worker ability. Wage negotiations lead both worker and firm to share the returns to ability so that, ceteris paribus, a more able worker is less likely to be fired. As a result, more able workers may invest more heavily in general human capital, because the impact on firing probabilities due to a general rather than specific skill investment may be less. This difference in skill investments also means that an able worker does not mind being fired by as much as a less able worker. As a result, it could be that more able workers are also *more* likely to be laid off—their greater productivity may be more than offset by the higher wages that they must be paid.

Schooling. In a similar vein it would 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 (2003) 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 worker who choose to drop out of school early specialize in specific human capital.

Layoffs according to seniority. Seniroity rules can have subtle effects in this economy. If worker are laid off not according to the relative profits that they generate their employer, but rather by other arbitrary rules then workers would not distort their human capital investments to avoid layoffs. As in Milgrom (1988), decentralization of the decision-making process can lead to inefficiency. In his paper, a worker uses wasteful influence activities to increase his or her probability of being retained. In our paper, a worker over-invests in specific human capital to achieve the same goal. 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. Obviously, the distortion introduced by the arbitrary 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-based layoff rules are likely to be optimal.

Unemployment Insurance. Government intervention may be able to induce workers to make more efficient investment choices. For example, higher unemployment insurance reduces the cost of being fired, and may encourage workers to shift investments efficiently toward general skills and away from specific skills, or to reduce excessive human capital investments. The lower is the probability of finding a new job, the more generous the unemployment insurance program would have to be. This provides an argument in favor of higher unemployment insurance in regions where unemployment is high and it is hard to find a job, 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 unemployment insurance reduces total investment and shifts investment toward general skills, away from specific skills. While we assumed 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, in fact, individuals over- or under-invest in specific capital and in total human capital acquisition, something that 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 that unemployment insurance 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 toward firm-specific human capital and away from general human capital.

Finally, when individuals choose whether to stay in school to 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 unemployment payments in areas where unemployment is higher, because greater UI payments may induce individuals to make the riskier efficient investment.

4 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 layoff 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 in specific skills than his fellow employees 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 toward 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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