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Overworked and Overpaid: the Costs of Learning-by-Doing

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Abstract

In medicine, law, consulting, and many other careers, a significant proportion of human capital is created through profession-specific learning-by-doing (LBD). In the absence of long-term wage contracts, if LBD effects are sufficiently large, then young workers should face a negative wage in return for high future wages. However, if workers are liquidity constrained, then young workers compete away these returns to experience by working inefficiently hard. This inefficiency results in higher lifetime earnings, causes older workers to exert too little effort, and tends to lower the observable (monetary) returns to experience. Unlike traditional models, this can explain “career concerns” in professions where effort and ability are observable. (D31, J31, J24.)

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1 Introduction

The usefulness of job experience in increasing productivity is a pervasive feature of most labor markets. This paper explores what happens when workers cannot pay for job experience that enhances productivity. This is an important question because, in many professions, learning-by-doing arguably contributes more to human capital formation than education or on-the-job training. The problems that arise when workers are not able to pay for general (as opposed to firm-specific) on-the-job training are well known, but the same question for learning-by-doing has been neglected as a potential source of market failure—probably because it is a passive by-product of working, while training is an active and thus a more tangible way for worker improvement.¹ But despite being costless in the accounting sense, passive on-the-job learning carries an economic cost: the opportunity cost that someone else could be working in the same job instead.

I use a simple model to analyze the effects of worker liquidity constraints in the presence of general (or “profession-specific”) learning-by-doing. I show that professions with strong learning-by-doing effects—those with a steep upward trend in productivity over the career—induce the young to exert inefficiently high effort as an entry payment into careers that promise higher returns to experience. Moreover, older workers will slack off and exert too little effort. The reason is that, in professions where the effort choices over the lifetime are distorted, output ends up being produced at an inefficiently high cost. The higher price of output makes the more experienced workers richer, and they use some of their increased wealth to consume more leisure (or to enjoy a more leisurely work pace). This distorted age profile of effort

¹For a discussion of the literature on market failure in on-the-job training, see Acemoglu and Pischke (1999).

will tend to decrease the growth in earnings over the career, thus dissipating the observed (monetary) returns to experience. Workers in the distorted sector are compensated by higher lifetime wages, but total welfare is lower than what could be achieved under long-term contracts or if workers could self finance the costs of production.

For an extremely stylized setup that highlights the core idea of the paper, consider an economy where careers last two periods, the value of experience is exogenous (i.e., there is no effort and the price of output is fixed). The labor markets are perfectly competitive and long-term wage contracts cannot be enforced, so the differences in wages between any two workers must exactly reflect the differences in their productivity; and there is no discounting. There are two industries: in the outside industry there is no learning and all workers earn \$50 per period. In the industry with learning, any worker who works there when young will produce $\$X$ more when old. The value of experience is general to the industry so the second period wage must be $\$X$ higher than the first period wage. Furthermore, for workers to be indifferent between entering the industry with learning and the outside industry, the first and second period wages must be $\$50 - \$X/2$ and $\$50 + \$X/2$ respectively. For example, with $X = 20$ the wages are \$40 and \$60—simple enough. But suppose the value of experience is \$500. Then the wages in the two periods would have to be $-\$200$ and $\$300$, i.e. the entering workers have to pay to work, and the required payment is much larger than the wage that workers could earn elsewhere. What if young workers are unable to accept a negative wage? Something has to adjust to dissipate the predictable returns to experience in professions where much of human capital is created by learning-by-doing. The goal of this paper is to analyze the mechanics and the implications of that adjustment.

I use a model with two-period careers and two market imperfections: one that is constant throughout the analysis, namely the inability of workers to commit to long-term wage contracts; and another that is varied as part of the

analysis, namely the extent to which workers are liquidity constrained. There are two sectors, a large “outside” sector, and a sector with learning-by-doing. The learning is predictable and general to the sector: work experience in any firm increases a worker’s productivity in the whole industry. There is perfect competition on both sides of the market: free entry of firms guarantees zero profits; and free choice of occupation by workers guarantees that the lifetime utility in the sector with learning is equal to that in the outside. Individuals and firms are homogeneous; for workers this means also that everyone is equally capable of benefiting from learning-by-doing. The model is used to analyze the implications of the credit constraint on the career profiles of effort and earnings, in comparison to the efficient benchmark where the credit constraint is not binding.

There are no other imperfections in the model beyond the standard labor market imperfections. In particular, there is no asymmetric information or uncertainty of any kind. While workers cannot commit to future wages, everything, including effort, is contractible in the short term. Implicitly the idea is that individual output is observable with a lag that is trivial compared to the length of the career, so that wages or employment decisions could be adjusted almost continuously. Due to spot labor markets, workers are then paid according to their output in both periods; knowing this workers choose their effort levels as if they were contractible. And finally, markets are perfectly competitive: there is no room for strategic behavior on either side of the market.

Investment into human capital can be considered “active” whenever the production of human capital results in a trade-off between current and future output; for example, training implies an investment into the worker that an already trained would not require, and active on-the-job learning may require a different use of time between tasks than required by the maximization of current output. When the enhancement of human capital is “passive,” there is no such contemporaneous trade-off between output and increase in human

capital—for that worker in that job. In this case the investment cost is an opportunity cost: a less experienced worker will produce less output in the same job as would a more experienced worker. In a frictionless labor market, firms should in equilibrium be indifferent between hiring workers of different levels of experience, so this opportunity cost must be borne by the inexperienced worker one way or another—and worker liquidity constraints will have real economic effects. In reality, active and passive features may be combined in any proportions, but for the theoretical analysis here I will concentrate purely in passive learning: the aim of the study is to think seriously about the implications of the economic costs of purely passive on-the-job enhancement of human capital.

The model suggests that workers in professions where a high fraction of the stock of human capital is created through to learning-by-doing are the most “overworked and overpaid,” i.e., have the highest wages and the most front-loaded effort profiles compared to peers with similar qualifications in other professions. The empirical implications of the model concern differences across industries and institutions. If there was an exogenous change in the level of imperfections, for example, if longer wage contracts suddenly became enforceable, then we should expect relative wages to decrease in sectors with strong learning-by-doing effects—and this would be a sign of improved efficiency and welfare. These sectors would also be likely to show an increase in the monetary returns to experience, meaning a steeper age-earnings profile. However, for a given the institutional setup and a given level of imperfections, the model does not generate any unusual predictions about wage dynamics—changes in wages simply reflect changes in productivity.

Earlier models that explain excessive effort by young workers have been based on asymmetric information. In the classic career concerns model employers observe workers’ past output but not its breakdown by the contributions of effort and ability, and young workers exert excessive effort to influence the employers’ assessment of their ability and thus increase their future

pay levels (Holmström 1982). This “signal jamming” results in a rat race that, in equilibrium, does not fool anyone. Excessive effort also results in a setup where effort is observable but effort costs are not, when types with low cost use excessive effort as a signal to differentiate themselves from high cost types prior to an irreversible admission into an income-sharing partnership (Landers, Rebitzer and Taylor 1996).²

In the absence of asymmetric information there would be no motivation for anyone to use inefficient actions in trying to influence one’s perceived type. Observable effort—like hours worked—cannot be used to “jam the signal” about true ability. And temporary overwork cannot help gain rents out of underwork tomorrow if the employer is not locked into to paying an above market wage in the future. I show that high effort can be a sign of a rat race even in professions without asymmetric information or lock-in. For example, there have been efforts in the medical profession to restrict work hours by young workers—the medical residents—and they have overwhelmingly supported the restrictions.³ (Note that in a signalling setup, the insiders should not support such restrictions.) The need for coordinated action suggests that some kind of a rat race may be going on, even though the hours are observable and the medical residents are not in a risky up-or-out situation like potential law partners—it’s more like up-and-out.

In practice, the information problems behind career concerns and the predictable returns to experience of this model are of course not mutually exclusive phenomena. What is common with this paper and the models of asymmetric information is the inability by workers to pay up-front for entry. If young workers were able to take a sufficiently negative wage then there would be no problem—just like in asymmetric information setups, if workers

²That paper is a more rigorous exploration of an idea suggested in Akerlof (1976).

³The 80-hour cap on weekly hours imposed in 2003 by ACGME (Accreditation Council for Graduate Medical Education) is routinely binding, and often neglected; see <http://www.hourswatch.org/>.

were able to post a bond, then efficiency would not be disturbed.⁴

The next section introduces and analyzes the model. The model is built in two steps: in the first model the increase in ability is fixed and exogenous, and the only method for rent dissipation is via imperfect smoothing of consumption; the second model adds the choice of effort. Section 3 discusses the effects of work regulation. Further issues and possible generalizations are discussed in Section 4, and Section 5 concludes the paper.

2 The Model

The basic ingredients of the model are a spot labor market and a competitive industry that combines each worker with other inputs at a fixed cost per worker. There is free entry of homogeneous workers and firms, so neither firms nor workers (over their lifetime) can earn rents over their outside opportunity. Individual workers and firms take the market wages as given. The spot labor market implies that any differences in wages between workers are linear in output y , with the slope being equal to the market price of that output. The market wages are fully described by the slope p and the “intercept” of the wage function. Firms must incur a fixed cost of production ϕ per worker, so the requirement of zero profits ties down the equilibrium price of output to the wage function:

$$(1) \quad w(y|p) = py - \phi.$$

This wage function, which incorporates both the zero-profit condition and the spot labor market equilibrium, will be used throughout the analysis without any reference to entry or exit of capital. The industry faces a downward sloping demand curve, but this is not explicitly used in the analysis. It is understood that a higher price of output is associated with lower output by

⁴If workers are risk averse and unsure of their own type, then there may also need to be insurance against type realization.

the industry. (Whether this translates into more or less employment and revenue in the industry would depend on the elasticity of demand and on a possible change in output per worker).

The final requirement for equilibrium is the indifference condition of entering workers. Workers have diminishing marginal utility both for consumption and for lack of effort or “leisure.” The equilibrium price of output must be such that workers are not making rents over their lifetime, while choosing the optimal effort levels given the equilibrium wage function.

2.1 A Model without Effort

Workers live for two periods, and their output is exogenously higher in their second period: $y_2 > y_1 > 0$. Lifetime utility is

$$(2) \quad V(c_1, c_2) = u(c_1) + u(c_2),$$

where the consumption levels in the two periods are $c_1, c_2 \geq 0$ and u is a utility function with the standard properties.⁵

Young workers are able to borrow an amount b against their future wages. Recall that the labor market equilibrium and zero profit conditions are both inherent in the wages $w_t = py_t - \phi$. The smoothed consumption levels are therefore

$$(3) \quad c_1 = py_1 - \phi + b, \quad c_2 = py_2 - \phi - b.$$

Setting $b = 0$ corresponds to a total inability to borrow, and $b \equiv p(y_2 - y_1)/2$ to the ability to completely smooth consumption over lifetime.

Young workers must be indifferent between entering or going to the outside sector, where they could earn a constant wage w_0 . The equilibrium condition that defines the price of output, and subsequently wages and consumption, is the condition of no lifetime rents:

$$(4) \quad u(py_1 - \phi + b) + u(py_2 - \phi - b) = 2u(w_0).$$

⁵ $u' > 0, u'' < 0, \lim_{c \rightarrow 0} u(c) = -\infty$.

With unconstrained borrowing $c_1 = c_2 = p\bar{y} - \phi$, where $\bar{y} \equiv (y_1 + y_2)/2$ denotes the average output of the workers over their lifetime.⁶ The closed form solution is

$$(5) \quad p^* = (w_0 + \phi) / \bar{y}.$$

This price is equal to the average cost of production. Wages are

$$(6) \quad w_t^* = (w_0 + \phi) y_t / \bar{y} - \phi, \quad t = 1, 2$$

and consumption is equal to the outside wage w_0 in both periods. The amount of borrowing required by a young worker is

$$(7) \quad b^* = \frac{w_2^* - w_1^*}{2} = (w_0 + \phi) \left(\frac{y_2 - y_1}{2\bar{y}} \right).$$

Note that the required borrowing is by no means restricted by $2w_0$, the lifetime income in the outside sector. The value of experience depends on the cost of complementary factors of production that the worker gets to work with, and the young worker should pay for a fraction of those costs—a fraction that is increasing in the deficiency of productivity that an inexperienced worker has compared to the experienced workers. When the borrowing ability is below b^* the workers are constrained and the efficient outcome is unattainable. With constrained borrowing the equilibrium price is in general only defined implicitly by equation (4).

Proposition 1 *A lower ability to borrow leads to a higher price of output and higher wages in both periods.*

Proof. Differentiate the equilibrium condition (4) with respect to p and b and solve for the slope of the implicit function $p(b)$:

$$(8) \quad \begin{aligned} \{u'(c_1) y_1 + u'(c_2) y_2\} dp + \{u'(c_1) - u'(c_2)\} db &= 0 \\ \implies \frac{dp}{db} &= -\frac{u'(c_1) - u'(c_2)}{u'(c_1) y_1 + u'(c_2) y_2} < 0 \end{aligned}$$

⁶Throughout this paper, only stationary equilibrium is considered, so the average output of workers over the lifetime is also the average output of the workers in the industry at any given time.

This inequality holds for all $b \in [0, b^*)$, because then $c_1 < c_2$ and the difference of marginal utilities in the numerator is positive. Only at $b = b^*$ does the numerator become zero as $c_1 = c_2$. The result that wages, $w_t = py_t - \phi$, are decreasing in the borrowing capability follows directly from the price of output being decreasing in the borrowing capability b . ■

Intuitively, a lower borrowing ability lowers utility since marginal utility of consumption in the first period is lower than in the second period when the earnings are higher. To attract workers to this sector, the price of output (and the value of experience) must increase. This is an inefficient way to attract workers into the sector because most of the increase accrues to experienced workers, who already have a lower marginal utility of consumption.

What are the welfare effects of a decrease in the borrowing ability? From the point of view of the workers, the inefficiency is first visible as the welfare lost due to low consumption of young workers. Workers are compensated in the form of higher lifetime wages to induce them to enter the industry, but consumers are not compensated: welfare is reduced as the price of output is increased. Lower quantity demanded leads to fewer workers in the industry, each making more money than before; total revenue and the sum of wages in the industry could increase or decrease depending on the elasticity of demand.

When could the inefficiency from constrained borrowing be substantial? We can see from (5) that the price of output is increasing in the non-labor cost of production ϕ . This means that the required amount of borrowing for full efficiency to be attained is increasing in ϕ . The young workers should literally pay to work if

$$(9) \quad w_1^* = \left(\frac{\phi + w_0}{\bar{y}} \right) y_1 - \phi < 0$$

$$(10) \quad \Leftrightarrow \frac{y_1}{\bar{y}} < \frac{\phi}{\phi + w_0}.$$

The impact of a credit constraint is large when the effect of experience on output is large (meaning that the left side of 10 is small), and when the

non-labor costs of production are relatively high (right side of 10). As is intuitive, the borrowing constraint will bite the hardest when the difference that experience makes to output is high, and when the cost of production is high.

2.2 A Model with Effort Choice

In this section contractible effort is introduced. A worker's ability θ is higher in the second period if she worked in the industry in her first period. This increase in ability—the benefit of learning-by-doing—is deterministic and exogenous. A worker's output is increasing in her effort e :

$$(11) \quad y_1 = \theta_1 e_1, \quad y_2 = \theta_2 e_2, \quad \theta_2 > \theta_1 > 0.$$

To keep the analysis manageable, a time-separable Cobb-Douglas utility function in consumption and “lack of effort” is adopted:

$$(12) \quad V(c_1, c_2, e_1, e_2) = \sum_{t=1}^2 [\alpha \log(c_t) + (1 - \alpha) \log(1 - e_t)],$$

where $0 < \alpha < 1$. This implies a separable, convex effort cost. Wages and consumption depend on the borrowing capability as seen above (3), the only difference being that now output depends on effort via $y_t = \theta_t e_t$.

Efficient Benchmark: Full Borrowing If b is not binding, then workers consume an equal amount in both periods. They take the market wages as given, and their lifetime utility is

$$(13) \quad V(p) = \max_{e_1, e_2} \left\{ 2\alpha \log \left(\frac{p}{2} (\theta_1 e_1 + \theta_2 e_2) - \phi \right) + (1 - \alpha) \log((1 - e_1)(1 - e_2)) \right\}.$$

The equilibrium output price is pinned down by the indifference condition of entering workers, where the outside opportunity can now be any combination

of wages and effort costs that yields the per-period utility u_0 . At the same time, the efforts must satisfy the first order conditions from (13).

$$(14) \quad V(p) = 2u_0$$

$$(15) \quad \alpha \frac{p\theta_t}{c} = \frac{1 - \alpha}{1 - e_t}, \quad t = 1, 2.$$

The equilibrium price does not in general have a closed form solution. However, efforts and consumption can be solved as a function of the price of output. Denoting the average ability over the lifetime by $\bar{\theta}$, these are

$$(16) \quad 1 - e_1(p) = \left(\frac{1 - \alpha}{p\theta_1} \right) (p\bar{\theta} - \phi),$$

$$(17) \quad 1 - e_2(p) = \left(\frac{1 - \alpha}{p\theta_2} \right) (p\bar{\theta} - \phi),$$

$$(18) \quad c(p) = \alpha (p\bar{\theta} - \phi).$$

Equilibrium price p^* is implicitly defined by inserting these into V in (12) and setting it equal to the outside utility $2u_0$.

Consumption depends on average lifetime ability. In standard Cobb-Douglas fashion, the ratio of non-effort “consumed” in the two periods, θ_2/θ_1 , is inversely proportional to the price of the two “goods,” which are here measured in the amount of lost consumption goods. Simply put, this requires that workers work harder when they are at their most productive.

Finally, the amount of borrowing necessary to equalize consumption is

$$(19) \quad b^* = \frac{p^*}{2} (\theta_2 e_2(p^*) - \theta_1 e_1(p^*)) = \frac{p^*}{2} (\theta_2 - \theta_1).$$

If the borrowing ability is below b^* , then the workers are constrained and the efficient equilibrium is not possible in a competitive labor market.

Constrained Borrowing The equilibrium conditions under constrained borrowing are slightly different because the workers are unable, at the margin, to transform second period effort into first period consumption. Now the

consumption levels depend on the borrowing capability b , but not directly on the other period's effort choice. Given a level of borrowing $b < b^*$, the worker's problem can be decomposed into two independent problems.

$$(20) \quad V(p|b) = V_1(p|b) + V_2(p|b) = \\ \max_{e_1} \{ \alpha \log (p\theta_1 e_1 - \phi + b) + (1 - \alpha) \log (1 - e_1) \} \\ + \max_{e_2} \{ \alpha \log (p\theta_2 e_2 - \phi - b) + (1 - \alpha) \log (1 - e_2) \}.$$

Again, the equilibrium price is such that lifetime utility equals the utility from a career elsewhere, while the effort levels are defined by their first-order conditions:

$$(21) \quad V(p|b) = 2u_0 \\ (22) \quad \frac{\alpha p \theta_t}{c_t} - \frac{1 - \alpha}{1 - e_t} = 0, \quad t = 1, 2.$$

Using the equations for consumption in (3) and $y_t = \theta_t e_t$, the effort levels and the consumption levels can be solved as functions of price:

$$(23) \quad 1 - e_1(p|b) = \left(\frac{1 - \alpha}{p\theta_1} \right) (p\theta_1 - \phi + b),$$

$$(24) \quad 1 - e_2(p|b) = \left(\frac{1 - \alpha}{p\theta_2} \right) (p\theta_2 - \phi - b).$$

$$(25) \quad c_1(b|p) = \alpha (p\theta_1 - \phi + b),$$

$$(26) \quad c_2(b|p) = \alpha (p\theta_2 - \phi - b).$$

As before, the parameter α gives the “expenditure shares” on consumption and non-effort in the usual Cobb-Douglas fashion, but the endowment is now different for the two periods. The distortion from full efficiency is visible in the ratio of non-efforts between the two periods, which is now $\theta_2 c_1 / \theta_1 c_2$ instead of θ_2 / θ_1 .

Proposition 2 *A lower ability to borrow leads to a higher output price.*

Proof. The proof of Proposition 1 for $dp/db < 0$ applies directly here, because $\partial V/\partial e_t = 0$ by the envelope theorem. ■

As the value of the outside opportunity is fixed, a lower borrowing constraint decreases utility when young, and increases utility when old, and these effects must wash out. However, as the better paid old have lower marginal utility of consumption, this will increase the cost of units of effort that must be included in the price of output. The average cost of output is minimized only if the workers find it in their interest to choose their efforts so as to maximize their lifetime income.

Proposition 3 *A lower ability to borrow leads to higher effort when young, and lower effort when old.*

Proof. Taking the derivative of $e_2(p|b)$ from (24) gives

$$(27) \quad \frac{\partial e_2}{\partial b} = \left(\frac{1 - \alpha}{p\theta_2} \right) \left(1 - \frac{\phi + b}{p} \frac{\partial p}{\partial b} \right),$$

which is positive, since $\partial p/\partial b < 0$ by Proposition 2. To obtain the result for $e_1(p|b)$, differentiate the first-order condition (22) to obtain

$$(28) \quad \left\{ -\frac{\alpha p^2 \theta_1^2}{c_1^2} - \frac{1 - \alpha}{(1 - e_1)^2} \right\} de_1 + \left\{ \left(\frac{\alpha \theta_1}{c_1} - \frac{\alpha p \theta_1^2 e_1}{c_1^2} \right) \frac{\partial p}{\partial b} - \frac{\alpha p \theta_1}{c_1^2} \right\} db = 0$$

$$(29) \quad \iff \frac{de_1}{db} = -\frac{\frac{\alpha \theta_1}{c_1} \left\{ \frac{\partial p}{\partial b} - \frac{p}{c_1} (\theta_1 e_1 \frac{\partial p}{\partial b} + 1) \right\}}{\{\text{negative term}\}}.$$

Therefore $1 + \theta_1 e_1 \frac{\partial p}{\partial b} > 0$ is a sufficient condition for $\partial e_1/\partial b < 0$. To verify that this holds, plug in the expression for $\frac{\partial p}{\partial b}$ from (8), use $y_t = \theta_t e_t$ and $u'(c_t) = \alpha/c_t$, and rearrange:

$$(30) \quad -y_1 \frac{\alpha/c_1 - \alpha/c_2}{\alpha y_1/c_1 + \alpha y_2/c_2} + 1 > 0$$

$$(31) \quad \iff \frac{y_1 + y_2}{c_2} > 0.$$

■

The tighter the liquidity constraint on the young, the less able they are to use money (in the form of a lower wage or a payment to the firm) to compete for the future rents to experience, instead they end up supplying more effort to compete for those rents. The supply of effort by the old is reduced, because the increased price of output increases the value of their endowment of effective labor, furthermore, they are also forced to be richer because they have a smaller debt to repay. They use some of this increase in wealth to consume more leisure (which could mean a more leisurely pace at work). However, they still produce and earn more than the young.

Proposition 4 *A lower ability to borrow leads to higher lifetime earnings.*

Proof. Lifetime income is equal to lifetime consumption. Using (25) and (26), the sum of lifetime wages is

$$(32) \quad w_1(b|p) + w_2(b|p) = \alpha (p(\theta_1 + \theta_2) - 2\phi)$$

and its derivative with respect to b is $\alpha(\theta_1 + \theta_2) \partial p / \partial b$, which is negative due to Proposition 2. ■

Proposition 5 *A lower ability to borrow leads to higher wages for young workers. It leads to lower wages for the old workers and lower monetary returns to experience, $w_2 - w_1$, unless the rate of learning is sufficiently high and the borrowing ability sufficiently low. In particular, the return to experience is higher in the fully constrained case iff the rate of learning θ_2/θ_1 is above a threshold $\hat{\delta}(\phi, \alpha) > 1$.*

Proof. First, recall that $w_t = p\theta_t e_t - \phi$. Differentiation with respect to b yields

$$(33) \quad \frac{\partial w_1}{\partial b} = \theta_1 \left(\frac{\partial p}{\partial b} e_1 + p \frac{\partial e_1}{\partial b} \right).$$

This is unambiguously negative, because both of the derivatives on the right-hand side are negative, by propositions 2 and 3 respectively. As for the second period wage, differentiation yields

$$(34) \quad \frac{\partial w_2}{\partial b} = \theta_2 \left(\frac{\partial p}{\partial b} e_1 + p \frac{\partial e_2}{\partial b} \right).$$

For sufficiently high b , $\partial w_2/\partial b$ must be positive because the negative term $\partial p/\partial b$ approaches 0 while $\partial e_2/\partial b$ remains strictly positive as $b \rightarrow b^*$, as can be seen from (27). But since the sign of $\partial w_2/\partial b$ is ambiguous in general, it is possible for small enough b that $w_2(b) < w_2(b^*)$ and, that $w_2(b^*) - w_1(b^*) < w_2(b) - w_1(b)$. It is shown in the appendix how $w_2(b^*) - w_1(b^*) < w_2(0) - w_1(0)$ if and only if θ_2/θ_1 is sufficiently large for given (ϕ, α) . ■

If the economic value of learning-by-doing is sufficiently large (and the ability to borrow is sufficiently low) then wages of both young and old are higher under a credit-constraint than in the unconstrained case. A higher value for learning implies that the magnitude of the distortion, captured by the increase in the price of output, is higher. A sufficiently large increase in the price increases the value of the skills of the old by so much that their earnings go up, even with a reduced effort.⁷

When it is not possible for young workers to pay sufficiently in money in exchange for future returns to experience, then a combination of higher effort early on in the career and slacking off later tend to diminish the monetary return to experience, which could be all that is observable to outsiders. It is true that workers will always use some of the returns to experience to consume more leisure, but in the absence of a credit constraint there is no need to “spend” all of those returns when old.

⁷The model without effort choice emerges as a limiting case when α tends towards one, as the marginal cost of effort $\alpha/(1 - \alpha)$ is limiting towards infinity. Sure enough, in the model without effort choice, wages in both periods, as well as the monetary returns to experience, are higher under constrained borrowing.

3 Work Hours Regulations

Could a rat race between workers who compete for valuable work experience be a justification for policies that shorten the workweek or lengthen vacation time? Effort that can be regulated would probably have to mean time spent at work, which is clearly not the same thing as effort. But suppose that hours worked corresponded to effort, and that it was possible to enforce a cap on maximum hours worked (which is perhaps possible in professions where work can not be taken home). It turns out that even perfectly enforceable work hour regulation would be counterproductive from welfare point of view.

It should be fairly obvious in the setup of this paper that if workers are not liquidity constrained then an effort cap can only do damage. Under a binding constraint, a cap on effort could have a potentially beneficial impact as if it causes the inefficiently high effort level to be reduced. There are three possible cases, of which the relevant one here is the case where the cap is binding (only) for the first period effort. Recall that there are three equilibrium conditions, given by (21) and (22). Now note that, thanks to the decomposition of the effort supply problem by period, a cap $\hat{e} \in [e_2(b|p), e_1(b|p))$ would not directly affect the choice of second period effort.⁸ First period consumption is determined by plugging in $\hat{e} = e_1$ into (22) for $t = 1$, but effort and consumption in the second period are still given by the maximizer of the second period problem, resulting in (24) and (26) respectively. The key is to understand that restricting the first-period effort supply will, other things equal, reduce the first-period utility of workers (it was maximized with respect to e_1 before the cap, after all). Then for the workers' entry condition (21) to keep holding, the price of output must increase. Consumers are surely hurt by the regulation. As for older workers, who are working inefficiently little to begin with, the higher price will further reduce their effort supply by making

⁸From (23) and (24), the condition for first period effort to be above the second period effort is $b < f(\theta_2 - \theta_1) / (\theta_2 + \theta_1)$, i.e., b must not be too close to f .

them more wealthy.

With unregulated effort choice, the returns to experience that young workers are unable to pay for are dissipated with as little loss in welfare as possible, as they are allowed to choose how much to “bid” for jobs in terms of effort and how much in terms of lower consumption. Putting a cap on hours worked distorts the choice, which is optimal given the level of the liquidity constraint, and results in a yet higher output price. Entering workers still have to buy their way into the industry, to make the employers consider them equally attractive to hire as old workers given their difference in productivity. Lowering the hours worked by all young workers does not eliminate the rat race, because the “race” is essentially against the experienced workers, who do not have to work as hard thanks to their higher ability.

4 Further Issues

To keep the analysis tractable, several important traits of actual labor markets were abstracted away in the model. The focus was on explaining wage and effort differences across experience levels and industries, so individuals were modeled as completely homogeneous. In fact, the meaning of differences in inherent ability (talent) would depend on further assumptions, as ability can in principle be either a complement or a substitute with experience. If ability is complementary to learning-by-doing then it allows the more able to pull ahead and increase their advantage in productivity, whereas if it is a substitute to learning then it allows the less able to catch up with the “naturals.”

On-the-job enhancement of human capital can also come in the form of better information—for example, a better knowledge about the productivity of the match between an individual and an occupation or a firm. Even though workers may be ex-ante homogeneous, such information-based human capital entails an inherent heterogeneity of talent. In the case of information-based

human capital the expected returns to experience are due to the option value of quitting, even if true productivity is not affected by experience. For example, in Jovanovic (1979), the value of the match between a worker and a firm is a form of firm-specific human capital that is acquired passively on the job. In an earlier paper (Terviö 2004) I explored the implications of worker liquidity constraints under public on-the-job learning about an industry-specific ability—i.e. about the quality of the match between a worker and an industry. The main result was that if untried workers are unable to pay up-front for their upside potential, then there will be too little experimentation with new talent, leading to a selection of too many mediocre workers into the industry, and to an amplification of rents to high talent. That paper abstracted away from effort, but the expected returns to experience would have a tendency for be dissipated through excess effort by young worker for the reasons shown in the current paper.

In this paper, the effect of experience was modeled as completely exogenous, so also independent of effort. The purpose of this assumption was to make it clear that the inefficiency is not due to workers investing the wrong amount of effort into learning—there is no active investment. In practice, the amount of work effort can have an impact on the strength of learning-by-doing. However, a model where the efficacy of learning-by-doing is increasing in effort would still exhibit the same inefficiency. Depending on the functional form of the relation between current effort and the increase in productivity, it is possible for the efficient first period effort to be higher or lower than the second period effort. Either way, the liquidity constraint will result in the young working inefficiently hard as long as their earnings are lower than those of the old. The young workers will still compete for the returns to experience. From the point of view of technological efficiency, learning-by-doing is too fast, and may lead to a higher skill-level than is socially optimal.

In the continuous-time life-cycle model of human capital investment by Ben Porath (1967), the creation of human capital not only requires active

investment from the worker, but human capital also depreciates over time unless replenished by new investments. In that setup workers find it optimal to let their human capital diminish near the end of their career, because the return to investment into human capital gets lower as the career time left for using it gets shorter. Due to the assumed two-period careers, the current model is not equipped to deal with life-cycle issues, but a model with continuous time (or multiple periods) could yield interesting insights. In addition to the life-cycle, it could introduce two margins of practical importance into the career model: the choice of when to switch from education into a job, and when to retire. The presence of labor market imperfections can result in a socially inefficient choice at both of these margins. In particular, old workers in occupations with strong learning effects would be prone to retire inefficiently late, because they don't take into account the value of their job in creating human capital through learning and the youngest workers are unable to buy them out. At the other margin, subsidized formal education can displace some learning-by-doing that would be a more technologically efficient way for improving worker productivity. (Subsidized education may therefore be complementary with subsidized apprenticeships).

While only general human capital is considered here, the classification into active and passive forms of investment also holds for firm-specific human capital. As first pointed out by Becker, if human capital is firm-specific, then firms are willing to pay for on-the-job training, and the same result would hold true for firm-specific learning.⁹ However, investment into firm-specific human capital has its own problems. Regardless of how it is created, the value of firm-specific human capital is subject to bargaining between the firm and the worker, with the usual potential for hold-up, as well as for exogenous

⁹Additional imperfections, such as asymmetric information, can give firms incentives to pay for some general training as well, see e.g., Katz and Ziderman (1990), and Acemoglu and Pischke (1999). Additional imperfections serve to make the general human capital effectively more firm-specific.

separations. Firms will be willing to pay for the costs only as much as firms can capture the returns to firm-specific human capital.

5 Conclusion

Investment into human capital is a vast topic, as is the literature concerning the effects of market imperfections on this investment. The literature on the interplay of market imperfections and on-the-job enhancement of human capital has typically focused on active investments, probably because there the investment cost is very tangible, such as the cost of paying for a training program. In this paper I showed that even completely passive enhancement of human capital—learning-by-doing that is a pure by-product of work experience—is subject to inefficiencies under the standard labor market imperfections. Learning-by-doing leads to predictable returns to experience, and in a perfect market, the economic returns to experience in each occupation would be determined solely by technological factors—costs of production, malleability of skills. At the same time, young workers should be, *ceteris paribus*, indifferent between entering alternative professions that promise different returns to experience. Large returns to experience amount to very steep age-earnings profiles, so for that indifference to hold, the earnings in professions where learning-by-doing is particularly effective should start out very low, possibly negative.

When young workers can neither commit to long-term wage contracts nor self finance the production, it may be impossible to sustain the high monetary returns to experience that would reflect the technologically efficient returns to experience. In this case the returns to experience are dissipated via an inefficient allocation of consumption and leisure over the lifetime: basically by having to work harder and consume less when young. The flip side of this rat race among young workers is that the older workers underutilize their human capital: they do not work hard enough. The inefficient use of effort

in the industry increases the price of output, while the wealth endowment of the experienced workers is in effect increased, causing them to consume more leisure (i.e., to supply less effort).

The cost of employing an inexperienced worker instead of an experienced worker is a pure opportunity cost: the latter would produce a higher level of output in the same job. This cost, and therefore the level of borrowing required by young workers for efficiency to be achieved, is by no means limited by the level of outside wages—rather, the young workers may have to finance a significant fraction of the costs of complementary factors of production. To be sure, if the impact of learning-by-doing on productivity is small, then a modest wage discount for the young would be sufficient for the industry to function efficiently. But if the disadvantage of inexperienced workers in output compared to experienced workers is sufficiently large, then they would in effect have to pay for most of the costs of complementary factors of production. In the case of strong learning-by-doing, most of the “output” produced by an inexperienced worker comes in the form of human capital for the worker—and, in the absence of indentured servitude, the worker is inexorably the owner of her human capital.

Simply observing higher effort in some sectors is of course by no means a proof of inefficiency. It is in the society’s interest that workers in industries with a relatively high marginal product of effort work the hardest, and this higher effort must be compensated by more consumption goods. In a perfect market the “compensating differentials” between occupations would reflect differences in optimal levels of effort.¹⁰ The incongruity imposed by the lack of long-term wage contracts is that the compensating differentials between alternative careers—the role of which is to equalize the utility over

¹⁰By the same token, the more able should also work harder. Disentangling the compensating differential for optimal effort from returns to education, experience, or scarce talent, is of course the typical hard problem facing empirical labor economics which is in no way alleviated by this paper.

the lifetime—must be paid over the career in lockstep with the age-profile of output, which in turn depends on the nature of learning-by-doing and the resulting age profile of productivity in each profession. Problems arise in professions where individuals are unable to absorb the technologically optimal age profile of productivity into their age profile of net cash flows.

In the absence of observations of how labor market outcomes would react to vastly different institutions, the results here are, of course, only suggestive. While the approach has been theoretical, and a clean empirical evaluation of the inefficiencies would require an improbable natural experiment, I hope the results are helpful in interpreting differences in earnings and age-earnings profiles across professions. Individual ability to incur debt is limited, but when it comes to the ability to experience marginal disutility from additional late night hours of work then sky is the limit. So what do we see when we see young people working hard towards high incomes later in life? As it stands, large amounts of welfare may be lost at late hours at countless offices. And if it is the case that the role of on-the-job creation of human capital is becoming more important over time in high-skill sectors, then we can expect young professionals to be working harder and harder, in expectation of relatively higher and higher wages, but to not necessarily be any better off than earlier generations in the same professions.

The idea that much of the modern workforce is involved in a futile “rat race” between workers has some popular credence, see for example Juliet Schor’s 1992 best-seller “The Overworked American” or the recent media campaign “Take Back Your Time.”¹¹ The behavioral explanation for overwork is based on competition for status: if people care about their relative level of consumption compared to their peers, then the desire to “keep up with the Joneses” leads to excessive labor supply—and everyone could be better off if labor supply could be restricted in a coordinated fashion. (If sta-

¹¹By the Center for Religion, Ethics, and Social Policy, see <http://www.simpleliving.net/timeday/>.

tus was measured in leisure time as opposed to consumption then presumably the opposite would be true). However, the story of the rat race proposed in this paper is most emphatically not due to society or individuals somehow valuing material goods too much relative to leisure. In fact, the nature of the inefficiency is such that the society ends up getting less material goods as well: the utilization of human capital, and therefore the production of output is inefficient in sectors with strong learning-by-doing, leading to a reduction in the supply of consumption goods. In the partial equilibrium analysis of this paper, the workers in the sectors with strong learning effects get more of the goods and less of the leisure than would be efficient, but, at the level of the economy, the rat race for experience could cause the total amount of both consumption and leisure to be lower.

5.1 Appendix

Proof that there exists $\tilde{\delta} > 1$ such that $w_2(0) - w_1(0) > w_2(b^*) - w_1(b^*)$ if and only if $\theta_2/\theta_1 > \tilde{\delta}$. Using the fact that $w_2 = c_2 + b$ and $w_1 = c_1 - b$, and applying (25) and (26), gives

$$(35) \quad w_2(b) - w_1(b) = \alpha p(b) (\theta_2 - \theta_1) - 2(1 - \alpha)b.$$

Let's denote $\Delta^* = w_2(b^*) - w_1(b^*)$ and $\Delta^0 = w_2(0) - w_1(0)$, $p^* = p(b^*)$ and $p^0 = p(0)$. Using $b^* = p^* (\theta_2 - \theta_1) / 2$ from (19) and applying it into (35) yields $\Delta^* = p^* (\theta_2 - \theta_1)$, while setting $b = 0$ yields $\Delta^0 = \alpha p^0 (\theta_2 - \theta_1)$. Therefore

$$(36) \quad \Delta^* \geq \Delta^0 \Leftrightarrow p^* \geq \alpha p^0$$

Now set $\theta_1 = 1$ and denote $\theta_2/\theta_1 = \delta \geq 1$.¹² As before, $\alpha \in (0, 1)$ and $\phi > 0$. By combining (23)-(26) and (12) into the equilibrium condition (21), then after some simplification and rearrangement of terms, we can define

¹²The normalization $\theta_1 = 1$ is absorbed in lifetime utility by defining $f' = f\theta_1$ and $u'_0 = u_0 - \log(\theta_1)$.

$p^0 = P^0(\delta|\phi, \alpha)$ as the implicit function

$$(37) \quad p \text{ such that } \log(p - \phi) + \log(p\delta - \phi) - (1 - \alpha) \log(p^2\delta) - A(\alpha) = 2u_0,$$

where $A(\alpha) = 2\alpha \log(\alpha) + (1 - \alpha) \log(1 - \alpha)$, and u_0 are inconsequential constants for what follows. Similarly, by combining (16)-(18) and (12) with (14), we can define $p^* = P^*(\delta|\phi, \alpha)$ as the implicit function

$$(38) \quad p \text{ such that } 2 \log \left(p \left(\frac{1 + \delta}{2} \right) - \phi \right) - (1 - \alpha) \log(p^2\delta) - A(\alpha) = 2u_0.$$

It is clear by inspection that $P^0(\delta|\phi, \alpha) \geq P^*(\delta|\phi, \alpha)$, with equality holding only at $\delta = 1$. Furthermore, it is easy to show that $\lim_{\delta \rightarrow \infty} P^0(\delta|\phi, \alpha) = \phi$ and $\lim_{\delta \rightarrow \infty} P^*(\delta|\phi, \alpha) = 0$. Therefore, there exists $\tilde{\delta} > 1$ such that $P^0(\delta|\phi, \alpha) > \alpha P^*(\delta|\phi, \alpha)$ for all $\delta > \tilde{\delta}$.

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