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Superstars and Mediocrities: Market Failure in The Discovery of Talent

Marko Terviö*
Haas School of Business
University of California, Berkeley

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Abstract

A basic problem facing most labor markets is that workers can neither commit to long-term wage contracts nor can they self finance the costs of production. I study the effects of these imperfections when talent is industry-specific, it can only be revealed on the job, and once learned becomes public information. I show that firms bid excessively for the pool of incumbent workers at the expense of trying out new talent. The workforce is then plagued with an unfavorable selection of individuals: there are too many mediocre workers, whose talent is not high enough to justify them crowding out novice workers with lower expected talent but with more upside potential. The result is an inefficiently low level of output coupled with higher wages for known high talents. This problem is most severe where information about talent is initially very imprecise and the complementary costs of production are high. I argue that high incomes in professions such as entertainment, management, and entrepreneurship, may be explained by the nature of the talent revelation process, rather than by an underlying scarcity of talent. (JEL D30, J31, J6, M5)

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1 Introduction

The extravagant incomes of many entertainers and CEOs are a continuing source of astonishment—even outrage—to the lay public, who often argue that there are numerous, equally talented actors or managers available at a fraction of the wages of incumbents. Economists, however, maintain that the rents accruing to these "superstars" are a natural product of scarcity (or, occasionally, due to a failure of corporate governance). This paper argues that neither underlying scarcity of talent nor misgovernance is needed to explain these outsized talent rents. Nevertheless, these rents may be indicative of significant economic inefficiencies.

In many professions talent can be reliably assessed only based on actual performance on the job. As a consequence, when jobs are scarce then the supply of revealed talent has to be scarce even when talented people are not. I show how revealed talent can be much more scarce than it need be, due to the inability of workers to commit to long-term wage contracts and to pay for jobs ex ante. I study the impact of these standard labor market imperfections on a market with publicly observed on-the-job revelation of an industry-specific talent and show that firms will generally underinvest in learning about talent. The result is an inefficient selection of individuals into the workforce, with too many mediocrities populating the industry. This decreases the average talent in the industry but increases talent rents and wage dispersion. Ironically, the lack of long-term contracts also leads to careers that last too long on average.

When talent is general to a whole industry (instead of being firm-specific) then the problem of discovering talent is analogous to that of providing general on-the-job training, first analyzed by Gary Becker (1962). The basic problem in both cases is that firms lack the incentives and workers lack the means to invest in the quality of the workforce. It is clear where training costs come from, but what is the cost of discovering talent when it is revealed as an automatic by-product of working? On-the-job revelation of talent imposes an opportunity cost because someone else could be working in that same job. Investment in talent discovery (i.e., in "experimentation" with talent) means hiring someone with lower expected value (immediate cost) but with higher upside potential (possibility of future gain). I will show that, in this setup, the benefit from ameliorating market imperfections operates through higher exit rates for young workers and lower wages throughout the industry. This prediction is very different from those obtained with standard training and human capital models.

The basic economic problem that arises with on-the-job talent discovery has been well understood by economists at least since Johnson (1978) and Jovanovic (1979). The optimal solution to experimentation problems draws on the "bandit" literature, which shows how to account for the trade-off between output now and information that can help increase output in the future.[1] There are many papers that combine experimentation in a labor market with further features, for example, with multiple job types in MacDonald (1982) and Miller (1984), and with superstar economics in MacDonald (1988). Common to all these papers is that young workers absorb the full cost of learning. Realistically, market imperfections prevent young workers from paying up-front the full price of jobs that require significant resources. When individuals can not commit to long-term wage contracts then the value of information accrues as rents to those who turn out to be high talents and see their wages bid up, so firms ignore the option value of previously untried individuals. As a direct consequence of diminished experimentation, there is an inefficiently low level of exit of workers from the industry. If talent is revealed relatively quickly, then most of the active workforce may consist of "mediocre" types who would exit the industry in the efficient solution.

If individuals were able to buy their jobs then inexperienced individuals would pay for the chance to find out their talent, up to the expected value of lifetime talent rents. Entering workers would in effect "buy out" the mediocrities by compensating their employers for the difference in expected output. This would lead to the efficient solution, where relatively high talents exit the industry when their jobs have higher social value in trying to discover even higher talent. I show that if there is significant uncertainty over talent then the efficient buy-out price for jobs includes most of the complementary costs of production. The efficient starting wage can therefore be significantly negative, and a small ability to pay for jobs is therefore of limited help for efficiency as it only buys out few of the mediocre incumbents.

I use a simple one-shot learning process in order to study the market-level implications of constraints on individual liquidity and commitment ability. I assume ex ante identical individuals and finite lifespans, and a competitive industry that faces a downward-sloping demand curve for its total output. Some firms must hire new workers in any stationary equilibrium or else the industry disappears, so the price of output must adjust to allow for novice-hiring firms to break even. To highlight the source of the inefficiency, several commonly studied features of labor markets are ignored in this paper. There is no on-the-job training or learning-by-doing, so experience per se is not economically valuable. There are not any frictions such as hiring, firing, or search costs. Information is symmetric at all times: There are no effort problems, career concerns, or adverse selection. There is never a question of efficiency given the available workforce—the economic problem is the selection of individuals into the workforce.

This paper provides an explanation for extremely high wages in many industries that appear to be based on talent rents. This explanation is distinct from, and complementary to, theories based on scale effects (see, e.g., Mayer 1960 and Lucas 1978), superstar economics (Rosen 1981), and complementarities in matching (Kremer 1993). These theories are

[1] See Gittins (1989) for a general treatment of experimentation problems.

concerned with the efficient allocation of capital, consumers, and known talent, whereas the focus here is on the discovery process of talent under typical labor market imperfections. The previous explanations can still leave one to wonder, for example, why some alternative manager would not be equally good as the current CEO with his exorbitant compensation, scale effects and complementarities notwithstanding. Intriguingly, industries with the highest and most skewed pay levels—entertainment and top management—tend to have largely publicly observable performance.[2] The model suggests that this observability may be a key cause of high pay, and that fierce bidding for known top talent could indicate dramatic inefficiencies in the selection of individuals into these industries.

The empirical content of the model is in predictions about how a labor market with public learning would react to changes in individual commitment ability and liquidity. However, the model does not generate novel wage dynamics, so the inefficiencies cannot be detected even from the best wage data if the institutional setup remains constant.[3] Empirical detection of the excess talent rents and the welfare loss from inefficient hiring requires a particular natural experiment.

The plan of the paper is as follows. Section 2 presents the basic model. In Section 3 the model is used to analyze the equilibrium impact of a worker liquidity constraint on efficiency, wages, and turnover. Section 4 discusses the implications and the limitations of the model. Sections 5 and 6 analyzes two alternative specifications, where workers are risk averse and talent defines quality instead of quantity of output. Section 7 relates the predictions of the model to three potential empirical applications from the entertainment industry, and Section 8 concludes.

2 The Model

2.1 Assumptions

Consider an industry where any firm can combine one worker with other inputs at a cost $c > 0$ per period. The resulting output is equal to the worker's talent, θ. There is an unlimited supply of potential workers who face an outside wage $w_0 \geq 0$. Talent is drawn from a distribution with a continuous and strictly increasing cumulative distribution function, F, with positive support $[\theta_{\min}, \theta_{\max}]$. The talent of a novice worker is unknown, including to himself. Talent is industry-specific and becomes public knowledge after one period of work; the worker may then work in the industry up to T more periods, after which he ceases to be

[2] Observability does not require knowing *how* they did it but merely *how successfully* they did it.

[3] Due to the absence of long-term contracts, wage growth merely reflects the change in the expected output based on observed performance. For more general models that focus on wage dynamics under symmetric learning see Harris and Holmström (1982), Farber and Gibbons (1996), or Gibbons and Waldman (1999).

productive. Both workers and firms are risk neutral and there is no discounting.

Firms are potentially infinitely lived and maximize average per-period profits. Industry output faces a downward-sloping demand curve $p^d(q)$. The number of firms is "large" so that individual firms have no impact on total output and there is no uncertainty about the realization of the distribution of talent. The matching of individuals and firms is inconsequential. Hence, for simplicity, let the number of firms (and jobs) be a continuous variable, I, equal to the mass of the industry workforce. Finally, long-term wage contracts are not enforceable because workers cannot commit to decline higher offers from other firms in the future.

2.2 Average Talent

In both market equilibrium and in the social planner's optimal solution individual careers will proceed in a simple manner: After one period of work, those whose talent is revealed to be below a certain threshold level exit the industry, while those above the threshold stay on for T more periods. This exit threshold will be the key variable in the model.[4] As a preliminary step, I now derive the steady-state relation of the exit threshold, ψ, and the average talent of workers in the industry, A.

The vacancies left by last period's novices who did not make the grade and by retiring veterans must be filled by a new cohort of novices. Denote the fraction of novices in the workforce by i; a fraction $F(\psi)$ of them exit. The remaining fraction of jobs $1-i$ are held by veterans; a fraction $1/T$ of these, the oldest cohort, retires each period. Equating the flows of exit and entry yields

$$iF(\psi) + \frac{1}{T}(1-i) = i \Longrightarrow$$

$$(1) \qquad i(\psi) = \frac{1}{1+T(1-F(\psi))}.$$

The expression $i(\psi)$ also measures the turnover in and out of the industry (as a fraction of the industry workforce) because all new entrants are of the youngest type. Its reciprocal gives the average length of careers in the industry.

The average talent of workers in the industry is

$$(2) \qquad A(\psi) \equiv i(\psi)\bar{\theta} + (1-i(\psi))\mathrm{E}[\theta|\theta \geq \psi].$$

Substituting the fraction of novices from (1) into (2) shows that average talent is

$$(3) \qquad A(\psi) = \frac{1}{1+T(1-F(\psi))}\bar{\theta} + \frac{T(1-F(\psi))}{1+T(1-F(\psi))}\mathrm{E}[\theta|\theta \geq \psi].$$

[4] The selection of types must be based on a single threshold whether there is a welfare-maximizing social planner or a market equilibrium: If some veteran type θ' stays in the industry then all types $\theta > \theta'$ will also stay, because all veterans have the same opportunity cost regardless of age or type.

2.3 Social Planner's Problem

Consider the problem of maximizing social surplus by choosing the exit threshold ψ and employment I. Social surplus consists of total benefit to consumers minus the opportunity costs of production

$$S(I,\psi) = \int_0^{IA(\psi)} p^d(q)\mathrm{d}q - I\left(w_0 + c\right). \tag{4}$$

It is apparent that, for any given choice of I, the exit threshold should be chosen to maximize the average level of talent A.

To maximize the average talent (3), take the first-order condition:

$$\begin{aligned} \frac{\partial}{\partial\psi}A(\psi) &= \frac{T\,f(\psi)}{\left(1+T\left(1-F\left(\psi\right)\right)\right)^2}\left\{\bar{\theta}+T\left(1-F(\psi)\right)\mathrm{E}[\theta|\theta\geq\psi]\right\} \\ &\qquad - \frac{T\,\psi f(\psi)}{1+T\left(1-F\left(\psi\right)\right)} = 0 \\ &\Longrightarrow\ \bar{\theta}+T\left(1-F(\psi)\right)\mathrm{E}[\theta|\theta>\psi]\ -\psi\left(1+T\left(1-F\left(\psi\right)\right)\right)=0. \end{aligned} \tag{5}$$

This can be rearranged to yield a more useful condition:

$$\psi-\bar{\theta}=T\left(1-F(\psi)\right)\left(\mathrm{E}[\theta|\theta\geq\psi]-\psi\right). \tag{6}$$

Denote the solution to (6) henceforth by A^*. (It will soon be shown to be unique).

It is useful to understand the economic intuition behind (6). The hiring of a novice instead of a veteran of above-average talent can be interpreted as an investment. The LHS gives the cost — the immediate loss in expected output from hiring a novice instead of the threshold veteran. The RHS shows the expected future gain, assuming that the same rehiring threshold ψ is still used in the future. The trade-off is that a higher threshold results in higher-quality veterans, but also in a larger fraction of the workforce being novices. The lowest talent to be retained is the marginal talent in the workforce, and, as usual, the average is maximized when it equals the marginal. Therefore the optimal exit threshold is also the maximum attainable average level of talent in the industry: $A^* = A(A^*)$.[5]

Uniqueness of A^* requires no further assumptions about the shape of the talent distribution.

Lemma 1 *The maximized average level of talent is equal to the optimal exit threshold, this threshold is unique and above the population mean.*

[5] With discounting, the maximizer would be below the maximum: a lower exit threshold amounts to a lower level of investment.

Proof. To see that the solution to (6) is a fixed point of A, first solve for the (linear) term ψ and then divide both sides by $1 + T(1 - F(\psi))$. This shows that ψ is equal to the objective function A, from (3), evaluated at ψ. To see uniqueness, note that the LHS of (6) is strictly increasing—it has slope equal to one—and the RHS is decreasing—with slope equal to $-T(1 - F(\psi))$. The LHS is equal to zero at $\psi = \bar{\theta}$, while the RHS is equal to $T(\bar{\theta} - \theta_{\min}) > 0$ at $\psi = \theta_{\min}$ and reaches zero at $\psi = \theta_{\max}$. Thus the unique solution to (6) is in $(\bar{\theta}, \theta_{\max})$.□

Finally, employment I should be set to equate total output with demand at the minimized average cost, so that $p^d(IA^*) = (w_0 + c)/A^*$. Note that the industry as a whole has constant returns to scale: To double the output, the amount of novices hired and total costs would both be doubled; this would double the amount of veterans as well.

3 Equilibrium Analysis

3.1 Equilibrium Conditions

I only consider the steady state. (I will later show that there is only one steady state equilibrium; Appendix A proves, for $T = 1$, that all market equilibria converge to the steady state.) In steady state all aggregate variables are constant over time, although individuals and their fortunes vary over time. The wage function $w(\theta)$, output price P, and employment I, must be consistent with the following four conditions.

First, firms must expect zero profits from hiring any talent, so

(7) $$P\theta - c - w(\theta) = 0$$

for all θ. Information is symmetric, so firms view novices as equivalent to workers with a known talent equal to the population mean $\bar{\theta}$. (The notation will exploit this and treat novices simply as $\bar{\theta}$-types.)

Second, as veterans have no upside potential, they exit if $w(\theta) < w_0$. Due to the continuum of types, the lowest type veteran worker, ψ, must be indifferent between exiting and staying and thus earns exactly the outside wage:

(8) $$w(\psi) = w_0.$$

Third, novices must be indifferent between entering the industry or the outside career, taking into account the option to exit for the outside career later on:

(9-A) $$w\left(\bar{\theta}\right) + T\mathrm{E}[\max\{w(\theta), w_0\}] = (1 + T)\, w_0.$$

Individual careers consist essentially of two periods, and T is the relative length of the veteran period. Condition (9-A) assumes that novices are financially unconstrained: Depending on parameters, this can mean accepting a negative wage. This efficient benchmark will be compared to the case of constrained individuals, where novices can not accept a wage lower than $w_0 - b$, where b is an exogenous ability to "pay" for a job. When b is a binding constraint then (9-A) is replaced by

$$w\left(\bar{\theta}\right) = w_0 - b. \tag{9-B}$$

Finally, output price must be consistent with the demand for industry output:

$$P = p^d\left(IA\left(\psi\right)\right), \tag{10}$$

where average talent $A\left(\psi\right)$ gives the average output per worker in the industry.

In labor market equilibrium, expected differences in talent must be consistent with corresponding differences in wages. It turns out that the equilibrium wage function can be defined conditional on the equilibrium exit threshold ψ. This insight will later simplify the analysis of financial constraints, as their impact can be captured by the distortion on ψ. Denote the equilibrium wage function conditional on the exit threshold by $w(\theta|\psi)$.

Lemma 2 *Given an equilibrium exit threshold ψ, the price of output is $P(\psi) = \left(w_0 + c\right)/\psi$ and wages are*

$$w(\theta|\psi) = \left(w_0 + c\right)\left(\frac{\theta}{\psi} - 1\right) + w_0. \tag{11}$$

Proof. A firm employing a threshold type gets revenue $P\psi$ and has costs $w(\psi|\psi) + c = w_0 + c$. For expected profits to be zero, the equilibrium price must make these be equal, so $P\left(\psi\right) = \left(w_0 + c\right)/\psi$. For firms to be indifferent between ψ and any other talent, the difference in wages must just offset the difference in revenue generated, so $w(\theta|\psi) - w(\psi|\psi) = P\left(\psi\right)\left(\theta - \psi\right)$. Combining this with the equilibrium price and $w(\psi|\psi) = w_0$ yields equation (11).□

3.2 Unconstrained Individuals

Competitive equilibrium with unconstrained individuals is socially efficient, so the social planner's solution already tells us that the exit threshold must be $\psi = A^* > \bar{\theta}$. Looking back at the wage equation (11), it is clear that novices must accept less than the outside wage w_0. After all, they have a positive probability of earning talent rents in the future while in the worst case they get the outside wage. Market equilibrium pins down the wage function from Lemma 2 as $w(\theta|A^*)$ and the price of output as $P^* = \left(w_0 + c\right)/A^*$.

Intuitively, note that unconstrained individuals bid for the chance to enter the industry up to the expected value of lifetime talent rents. As veterans of threshold type are available at the outside wage, novices have to pay $P \times (\psi - \bar{\theta})$ for their first period job: This payment exactly compensates a novice-hiring firm for its expected revenue loss (compared to what it would get by hiring a threshold type). In equilibrium, this novice payment must equal the expected lifetime rents: With threshold ψ, a novice has a probability $1 - F(\psi)$ of being retained, in which case he gets the excess revenue $P \times (\theta - \psi)$ as a rent on each of the T remaining periods of his career. This equality is the market equilibrium condition

$$P \times \ (\psi - \bar{\theta}) = (1 - F(\psi))\, TP \times (\mathrm{E}[\theta|\theta \geq \psi] - \psi)\,. \tag{12}$$

The price of output P cancels out of the equilibrium condition, which reduces to the first-order condition (6) of the social planner's problem and thus yields A^* as the solution. Uniqueness follows from Lemma 1. Payments by unconstrained novices raise the exit threshold to the efficient level. As is typical, the inability of workers to commit to long-term contracts does not cause problems when they are able to buy their jobs up-front.

The unconstrained payment (the price of a job) reflects the economic cost of the efficient level of experimentation. It is

$$b^* \equiv P^* \left(A^* - \bar{\theta}\right) = (w_0 + c) \left(1 - \frac{\bar{\theta}}{A^*}\right). \tag{13}$$

The fraction of the total costs of production, $w_0 + c$, that should be financed by the novice is increasing in $A^*/\bar{\theta}$, which is a measure of the upside potential of novices. For small values of b^* the novice payment would merely be a wage discount below the outside wage.

3.3 Constrained Individuals

Suppose now that the ability of individuals to pay for their first period job is constrained at some $b < b^*$ due to an exogenous liquidity constraint. Now condition (9-B) replaces (9-A) and the zero profit condition of firms pins down the novice wage as $w(\bar{\theta}|\psi) = w_0 - b$. Combining this with the wage equation (11) and solving for ψ yields the relation of the equilibrium threshold and the novice payment.

$$\psi(b) = \begin{cases} \left(\frac{w_0+c}{w_0+c-b}\right)\bar{\theta}, & b < b^* \\ A^*, & b \geq b^* \end{cases} \tag{14}$$

Clearly the exit threshold is increasing in b. It follows that the average talent in the industry is also increasing in b. When novices cannot "subsidize" their employers, then the price of output must adjust upwards to induce the hiring of novices into the industry.

Proposition 3 *As the ability of novices to pay for a job is increased, wages decrease for all levels of talent with the highest wages decreasing the most. Turnover in and out of the industry is increased and careers become shorter on average.*

Proof. First, using Lemma 2, note that $\frac{\partial}{\partial\psi}w(\theta|\psi) = -(w_0 + c)\,\theta/\psi^2$ and $\frac{\partial^2}{\partial\theta\partial\psi}w(\theta|\psi) = -(w_0 + c)/\psi^2$; both negative. Second, from equation (14) we get $\psi'(b) > 0$ for $b < b^*$. The effects on wages follow from combining these. Direct inspection of (1) reveals that $i(\psi)$ is increasing, so the effects on turnover $i(\psi)$ and average career length $1/i(\psi)$ follow immediately from the higher ψ.□

Definition. Mediocre types: *$\theta \in (\bar{\theta}, A^*)$. Talents that are above the population mean, but below the optimal rehiring threshold.*

In other words, "mediocrities" are people who are better than population average but who should not be working in the industry. Whenever novices are able to pay less than the efficient price of the job then some mediocre veterans will be working in the industry. The more novices are able to pay the wider the range of mediocrities they displace; the resulting lower output price also causes a decrease in the slope of the wage function and so the top wages see the biggest drop. The impact of the constraint on the distribution of talent and wages in the industry is illustrated in Figure 1.

The hiring of mediocrities causes a net welfare loss, as there is, of course, deadweight loss from the higher price of output. In addition, some of the consumer surplus gets transferred to talent rents. The sign of both of these impacts is clear, and their magnitudes naturally larger when the elasticity of demand is low, as then consumers cannot easily shift their expenses to other products. However, the change in the total (economic) cost of production, $I(w_0 + c)$, depends on the change in total employment, which is ambiguous.

Proposition 4 *As the ability of novices to pay for a job is decreased, employment in the industry is increased (decreased) for a sufficiently low (high) elasticity of demand.*

Proof. With threshold ψ and employment I industry output is $IA(\psi)$. Denote the demand function by q^d, set supply equal to demand $q^d(P(\psi))$, and solve for I. This yields employment as a function $I(\psi) = q^d(P(\psi))/A(\psi)$. Recall from (14) that ψ must be in $[\bar{\theta}, A^*]$ for all b. The derivative $I'(\psi)$ is ambiguous because $1/A(\psi)$ is decreasing for $\psi < A^*$ (see proof of Lemma 1), but $q^d(P(\psi))$ is increasing (Lemma 2). The first effect is guaranteed to dominate when demand is sufficiently inelastic, and the second effect is guaranteed to dominate when demand is sufficiently elastic. Since $\psi'(b) > 0$ for $b < b^*$ by (14), the result can be stated in terms of b.□

Intuitively, since the average talent of workers is lower in the constrained case, more workers are needed to produce the same output. If demand is sufficiently inelastic, then the hiring of mediocrities coincides with inefficiently high employment in the industry. This effect is not a case of excess talent rents attracting too many hopefuls to the industry, as in the setup of Frank and Cook (1995), but a rather distortion caused by an inefficient production method that increases the expenditure on an input that is used ineffectively.

3.4 Long-Term Wage Contracts

Under short-term contracts, the extent to which the upside potential of novices is taken into account depends solely on how much novices can pay for jobs. Worker ability to commit to long-term wage contracts would give another incentive for firms to hire novices over mediocre veterans: Firms would get a share of the rents to high talents as these would be forced to stay at the discovering firm at the original contract wage.[6]

Suppose now that novices can commit to a long-term wage contract, meaning that they can promise to work for their initial employer for $1 + S$ periods at some agreed wage. Firms can still fire workers after one period. For simplicity, let's also assume that $b = 0$. Firms can attract novices by offering a contract that matches the outside opportunity of constant wage at w_0. In case the worker doesn't make the grade, he will be fired and earns the w_0 outside the industry. How does the firms' retaining threshold ψ depend on S?

A firm that uses a retaining threshold ψ and keeps the retained workers for S more periods has a long-run average talent level as given by equation (3), but with the commitment time S replacing T. Let's denote this average by $A(\psi|S)$. The long-run average profits are $PA(\psi|S) - w_0 - c$; to maximize this a novice-hiring firm will choose a rehiring policy that maximizes $A(\psi|S)$. As nothing has changed from the social planner's maximization condition except the length of retainment, the solution to equation (6)—with S replacing T—gives the firms' optimal rehiring policy. Let's denote it by $\psi^*(S)$.

As for the free agents, i.e., workers who have served the full $1 + S$ periods, they stay in the industry until retirement. Other firms compete for them, bidding up their wages until firms make zero profits and talent rents accrue to the free agents. The wage equation (11) must thus hold for the free agents, so their wages are given by $w(\theta|\psi^*(S))$. No firm will hire workers discarded by another firm after one period—after all, they could achieve a higher average talent level at the same wage by becoming a novice-hiring firm themselves.

Proposition 5 *As the length of time for which workers can commit to a wage contract is increased, the wages of free agents decrease for all levels of talent with the highest wages decreasing the most. Turnover is increased and careers become shorter on average.*

Proof. First, totally differentiate equation (6) with respect to ψ and T, where T now stands for the contract length, and apply the envelope theorem. This yields

$$\frac{\partial \psi^*(T)}{\partial T} = \frac{1 - F(\psi)}{1 + T(1 - F(\psi))} \{\mathrm{E}[\theta|\theta \geq \psi] - \psi\} > 0. \tag{15}$$

The effects of the increased threshold on wages, turnover, and career length follow as in the proof of Proposition 3.□

[6] As before, this analysis assumes that the industry is in steady state.

Commitment to long-term contracts can be regarded as a type of a payment from workers to employers. Any commitment time beyond what it takes to reveal talent gives firms some talent rents and induces them to replace the worst mediocrities with novices instead of the lowest types of mediocrities. The longer the duration of commitment, the closer the solution is to full efficiency and the lower the wages of free agents of any given talent. Full efficiency is achieved only if novices can commit to a wage contract for the full length of the career.[7]

4 Discussion

To summarize, the main effect of the constraints on individual ability to pay for jobs and to commit to long-term wage contracts is that the standard of performance required for a worker to be retained in the industry is too low. The proportion of inexperienced workers and the average level of talent in the industry are both inefficiently low. Just as a matter of accounting, this implies that careers are too long on average. Furthermore, the inefficient selection of workers increases talent rents in two ways. First, rents accrue to the difference in units of output that an individual makes compared to the threshold type; this difference is higher for any retained type when the threshold is lower. (This is the standard Ricardian component of talent rents.) Second, the value of this advantage is increasing in the price of output, which is higher in the constrained case because the equilibrium price must allow novice-hiring firms to break even.

When is the hiring of mediocrities likely to be economically significant, in terms of the welfare loss and the excess rents to talent? Inefficiencies are increasing in the discrepancy between the social value of experimentation, b^*, and what novice workers are able to pay for a job. There are two features that increase b^*: the costs of production per job and the upside potential of novices. This can be seen from (13) where b^* is a product of these two factors.

Consider first the costs of production, $w_0 + c$. When jobs require few inputs—as in the case of a street performer—then the production cost is mostly just the opportunity cost of the individual's own labor, and the novice wage is easily be positive and liquidity constraints are unlikely to cause problems. In this way the role of c is analogous to that of a training cost in a traditional human capital setup, where the provision of cheap training is not a problem because a modest wage discount will pay for it. However, when jobs are expensive, for example due to expensive equipment, then c could be orders of magnitude beyond the

[7] In practice, even career-long contracts would be unlikely to achieve full efficiency, since the ability to perform at the full talent level is inherently unverifiable and any renegotiation ability by workers would reduce the incentives to hire novices. For an analysis of renegotiation of labor contracts, see e.g., Aghion, Dewatripont and Rey (1994) or Malcomson (1997).

reasonable ability of novices to pay for. The production cost does not merely apply to inputs that the worker is physically handling, but to any costs within the firm that are necessary for the job to be real in the sense that the talent gets revealed. For example, for a manager, the entire wage bill of her subordinates could be part of the production cost, if the talent in question is for managing a large organization.

The other factor in b^*, the upside potential of novices $1 - \bar{\theta}/A^*$, measures the shortfall of expected novice output relative to the efficient threshold level (which is also the maximized workforce average talent). This shortfall is precisely the fraction of production costs that novices have to finance in the unconstrained case. Note that it is a purely "statistical" property of the distribution of talent and T. However, in a liquidity constrained world, an increase in the cost c results in a lower exit threshold.[8] We saw already that A^*, and therefore the shortfall, is increasing in T, as it is efficient to have tougher retainment standards when those retained can be kept for longer (equivalently, when talent is revealed relatively quickly).[9] Furthermore, the shortfall is higher when there is wide dispersion in the right tail of the talent distribution. Intuitively, the more right-skewed the distribution, the higher the upside potential that novices have and the higher the burden of financing they should bear. The effect of skewness can be explored succinctly by assuming that talents are drawn from the Weibull distribution, which has the feature that skewness is decreasing in the shape parameter.[10] Figure 2 graphs the shortfall ratio for various values of T as a function of the Weibull shape parameter. It shows that novices could easily have to finance a significant fraction (even most) of the production costs. Figure 3 shows the associated retainment probabilities. For more right-skewed distributions a smaller proportion of novices is retained; in the limit the proportion retained becomes arbitrarily small.

Additional market imperfections could partially alleviate the problem of inefficient hiring, in typical second-best fashion. For example, market power by firms in the labor market would encourage experimentation as it would allow firms to capture some of the returns. The mechanism would be the same as in the general training setup where imperfect competition (see, e.g., Acemoglu and Pischke 1999a, 1999b) and asymmetric information (Greenwald 1986, Katz and Ziderman 1990) induce firms to invest into general training. A collusive industry could also set up mitigating institutions, such as minor leagues in team sports where talent can be revealed in a cheaper way (but probably less accurately) . However, market

[8] Higher outside wage w_0 also decreases the threshold, but this is holding constant novice liquidity b which would in many cases bear some relation to w_0.

[9] On the other hand, for very quick revelation of talent the unconstrained novice payment gets smaller as a fraction of lifetime wages so borrowing constraints would likely be less of a problem.

[10] The Weibull CDF is $F(\theta) = 1 - e^{-\left(\frac{\theta}{\lambda}\right)^k}$. (Here the scale parameter can be normalized $\lambda = 1$ without loss of generality.) The distribution is Exponential at $k = 1$ and approximates the Normal distribution near $k = 3.5$, above which skewness is negative.

power in the labor market is likely to coexist with some market power in the product market. In a clear-cut extreme case the whole industry would be a single firm, i.e., a monopolist in the product market and a monopsonist in the labor market. Such a firm would minimize its costs by enforcing the socially optimal exit threshold. The monopolist would face a lower marginal cost than firms in a competitive industry, but it would also mark up the output price. The monopolist is thus better for welfare than perfect competition if demand is sufficiently elastic.[11]

4.1 Limitations of the Model

To keep the model simple it did not explicitly treat the dissipation of rents. Realistically, individuals entering careers where the scarcity of talent is due to the scarcity of opportunities for revealing talent should not earn expected rents over their lifetimes. However, rent dissipation does not imply that novices should earn zero wages (although some starving artists certainly do), only that the expected lifetime utility is equal across alternative careers pursued by ex-ante similar individuals. For workers with comfortable outside opportunities, the wage that is low enough to dissipate the expected lifetime rents from a career that involves a longshot at stardom can still be considerable, simply due to diminishing marginal utility. Some of the expected rents are lost (in the welfare sense) by having workers bear the risk in their uncertain success. Painfully high effort is another way in which any amount of rents can be dissipated with little increase in the monetary payment for jobs. In the movie industry, some talent rents are surely dissipated in the queuing for entry-level positions, by forgoing education or job experience in other sectors, and perhaps on the casting couch. Carmichael (1985) has shown that, in efficiency wage models,[12] arbitrarily small entrance fees eliminate involuntary unemployment as long as they lower the new hires' utility to the level of their outside utility. Here entrance fees are useful only to the extent that they "buy out" incumbent workers from their jobs. In professions with significant production costs and a right-skewed distribution of talent, small payments can only displace a small segment of the mediocrities, no matter how much novice utility they dissipate.

The assumption that novices are ex-ante identical is a simplified representation of the fact that the dispersion of prior expected values of talent is small compared to the actual dispersion of talent. A model where novices are heterogeneous by expected talent requires two thresholds and two distributions—one for novices and another for veterans—and results in expected talent rents for the inframarginal novices but yields no additional insights. The

[11] For example, with a constant elasticity of demand $\eta < -1$ and $b = 0$ the competitive output price is $(w_0 + c)/\bar{\theta}$ while the marginal cost for a monopolist is $(w_0 + c)/A^*$. A monopolist marks up its price by a factor $\eta/(1+\eta)$ and so is better for consumers if $|\eta| > A^*/\left(A^* - \bar{\theta}\right)$.

[12] See Shapiro and Stiglitz (1984).

efficient policy still requires the marginal veteran to be significantly better than the marginal novice. Under liquidity constraints the novice threshold is too high and the veteran threshold too low, and the two thresholds coincide at the extreme case $b = 0$.

In many industries talent is revealed in successive tiers of ever more demanding tasks. The inefficient selection of workers can also apply to such careers, for example where higher tiers mean managing larger and more complex organizations. Success as a low-level manager gives a noisy signal about the ability to be a higher-level manager, but those who succeed as low-level managers cannot all be tried out at the next level of hierarchy. Each level of promotion creates a bottleneck of talent discovery akin to the one-task model, but with heterogeneous novices (by expected talent). The relevant complementary cost in jobs where managerial talent can be uncovered includes the cost of capital under management and the wages of subordinates, so the experimentation cost and the problem of mediocre hires and excess rents would tend to get worse higher up in the hierarchy.

The one-shot learning process is a key simplification to keep the model tractable. A separate appendix[13] shows that the main results of the basic model have analogous counterparts in a setup where information about talent is revealed gradually over time. There the definition of the optimal exit threshold is more complex as the option to exit in the future must also be taken into account. In the absence of a liquidity constraint, the decision to exit for the safe outside wage is analogous to the optimal stopping policy in Jovanovic (1979), while under constrained liquidity the individually optimal stopping policy is inefficiently lenient. The additional insight brought by gradual learning is that saving by incumbents makes worse the inefficiency caused by the credit constraint. Saving allows "has-been" individuals who perform well early in their career but who fall below (but not too far below) population mean in perceived talent to outbid credit-constrained novices for positions. Their incentive to pay for positions is a gamble for resurrection: As talent is only revealed over time, even the has-beens still retain some upside potential, albeit less than the novices.

Even though the product market was assumed to be perfectly competitive, competition in the labor market is both necessary and sufficient for liquidity constraints to result in inefficient hiring. The crucial effect coming from the firm side is that competition between employers turns the discovery of new talent into a public good problem within the industry. If the price of output price were a fixed parameter (e.g., due to an exogenously fixed number of jobs and infinitely elastic demand) then the excess talent rents caused by a novice liquidity constraint would have to come at the expense of firms' profits (instead of consumer surplus). The model would then have to assume sufficiently large economic profits to firms in the unconstrained case, or else the constrained case results in the boring equilibrium of no production at all as firms couldn't break even at the fixed output price. A model with a com-

[13] Available from http://faculty.haas.berkeley.edu/marko/MediocritiesAndSuperstars_GradualLearning.pdf.

petitive product market is thus more parsimonious and, arguably for long-run equilibrium, also a more realistic assumption than a fixed price of output.

5 Risk Averse Individuals

The exogenous borrowing constraint of the basic model is merely a simplifying assumption. The analytical convenience of linear utility is that it allows for tractable closed-form solutions. However, if individuals are risk averse then similar results obtain even if they have unlimited ability to borrow or sufficient endowments to pay for their first job. In this case the exogenous liquidity constraint is replaced by an endogenous constraint: The wage discount that risk averse novices are willing to accept is less than b^* in (13). The inefficiency can be interpreted as a problem of incomplete markets, as individuals cannot perfectly hedge against the realization of their own initially unknown talent level.[14]

To briefly explore the risk averse case, assume now that individuals have some concave utility function u (but are still ex ante identical). The difference between the outside wage and the novice wage can be interpreted as the price of an option to future talent rents; the option value comes from the possibility to exit and switch to the outside wage if talent turns out to be low. This option must have a positive price in equilibrium. However, risk averse novices are willing to pay less than the risk neutral value of this option. This leads to the same inefficiencies as the exogenously assumed liquidity constraint of the basic model.

Proposition 6 *Equilibrium exit threshold is decreasing and wages for all talent levels are increasing in individual risk aversion.*

Proof. The exit threshold ψ that results in equilibrium wages that keeps expected lifetime utility equal with the utility from the outside career must satisfy

$$w_0 - w\left(\bar{\theta}|\psi\right) = T\,\mathrm{CE}_u[\max\left\{w\left(\theta|\psi\right), w_0\right\}] - Tw_0, \tag{16}$$

where CE_u is the Certainty Equivalent operator. Veterans stay in if $w\left(\theta|\psi\right) - w_0 > 0$, which still pins down the relation of output price and exit threshold as $P\left(\psi\right) = (w_0 + c)/\psi$. Lemma 2 applies, and (16) can be written as

$$(w_0 + c)\left(1 - \frac{\bar{\theta}}{\psi}\right) = T\mathrm{CE}_u\left[\max\left\{(w_0 + c)\left(\frac{\theta}{\psi} - 1\right), 0\right\} + w_0\right] - Tw_0. \tag{17}$$

The left-hand side of (17) is zero at $\psi = \bar{\theta}$ and increasing in ψ. The right-hand side is strictly positive at $\psi = \bar{\theta}$ and decreasing in ψ, but goes to zero as ψ reaches $\theta_{\max}$ (as the option

[14] Figure 2 shows the magnitude of the downside risk: The entry payment is wasted with the probability that novices are not retained.

will then never be exercised). Thus there is a unique equilibrium $\psi^u \in (\bar{\theta}, \theta_{\max})$. In the special case of risk neutral individuals, CE_u is just the expected value, and (17) reduces to (6), thus leading to the socially efficient solution. Compared to the risk neutral case, only the right-hand side of (17) changes, shifting down (because CE is always below Expected Value), so ψ^u must be lower than in the risk neutral case to restore the equality. By the same argument, and by the standard definition of comparisons in risk aversion, ψ^u is decreasing in risk aversion and reaches $\bar{\theta}$ in the limit of infinite risk aversion. The impact on wages follows from (11).□

6 Talent as Quality

In most markets talent is more naturally associated with the quality rather than the quantity of output. In this section the model is generalized to a case where talent is defined as the quality of output. The purpose is to show that the results are robust and, secondarily, to make a connection with the classic superstar model of Rosen (1981). To follow Rosen's setup, here producers choose their level of output, taking as given the unit price that it commands in the market. Due to consumer preferences, higher quality output faces a higher unit price so, in addition to standard Ricardian rents, the higher talents gain a further advantage by finding it optimal to produce more output than the lesser talents. Rosen found that this can cause modest differences in talent to result in vast differences in income, with a small number of top talents serving most of the market.[15]

On the consumer side, the difference to the basic model is that demand is assumed to come from a mass of identical consumers with quasilinear utility $u(x) + q\theta$, where q is the quantity and θ the quality of the good, and x is the composite of all other goods used as the numeraire. Consumers face budget constraint $M = x + p(\theta) q$, where M is the exogenous income and $p(\theta)$ the endogenous unit price of a good with quality θ. Differentiating $u(M - p(\theta) q) + q\theta$ with respect to θ and q yields the first-order conditions of consumers choice, which can be combined to the indifference condition

$$(18) \qquad p'(\theta) = \frac{p(\theta)}{\theta}.$$

Integration yields the "price-talent indifference curve,"

$$(19) \qquad p(\theta) = P\theta,$$

where P is now "the implicit market price" (Rosen's terms in quotes), arising as the constant of integration from (18). In equilibrium, consumers must be indifferent between all quality

[15] This section also draws on MacDonald (1988) which combined Rosen's superstar setup with public learning about a binary talent.

levels that are on offer.[16] The quasi-linear utility simplifies away the issue of consumer risk aversion with respect to uncertain novice quality: Consumers are willing to pay for the expected quality. This is reasonable when the good in question takes up a small part of consumer expenditure. As it will turn out, some quality levels will not be produced in equilibrium, but this does not affect (19) which must also hold for novices at $\theta = \bar{\theta}$.

On the producer side, the difference to the basic model is that firms control their level of output s; doing so they face marginal cost α and fixed cost c. Firm with a worker of talent θ faces price $P\theta$ per unit of its output. Free entry of firms and the competitive labor market result in maximized profits being driven to zero, so the earnings of a worker of talent θ conditional on the implicit price P are

$$\omega(\theta|P) = \max_{s \geq 0} \left\{ P\theta s - \alpha \frac{s^2}{2} - c \right\} = \frac{(P\theta)^2}{2\alpha} - c. \tag{20}$$

The profit-maximizing level of output is $s(\theta) = P\theta/\alpha$. As novice output is produced and sold before talent is known, (20) holds for them at $\theta = \bar{\theta}$.

The impact of a liquidity constraint works similarly as in the basic model. The efficient exit threshold is higher than the population mean, and novices should compensate firms that employ them for the expected difference in the market value of their output compared to the threshold type. In the constrained case the exit threshold will again be too low, and the implicit price of talent must adjust to induce firms to hire novices.

Proposition 7 *As the ability of novices to pay for a job is increased, the output and wages decrease for all levels of talent, with the highest levels decreasing the most. Turnover in and out of the industry is increased and careers become shorter on average.*

Proof is in Appendix B.

To summarize, the basic model is robust to modeling talent as quality. The additional result is that now the level of output per individual is also distorted in the constrained case: While workers are less talented on average, each worker type produces more output than they would in the efficient case.

In Rosen's superstar setup, technology and consumer preferences result in a nonlinear relation of talent and revenue. By imposing a linear relation of talent and revenue, the basic model here highlighted that the classic superstar effect and the market failure in talent discovery (mediocrity effect) are completely independent mechanisms, although both end up enhancing the wages of top talents.

[16] Rosen also included a private fixed cost per quality-level consumed, and discussed (informally) the implications of further introducing consumer heterogeneity with respect to the fixed cost. It would lead to consumers having heterogeneous preferences over the quality-quantity tradeoff and a single implicit price would no longer be sufficient to capture the equilibrium, rather $p(\theta)$ would be convex.

7 Applications

The prototypical talent markets are found in the entertainment industry. There job performance is almost entirely publicly observable and success of young talents hard to predict. Neither formal education nor on-the-job training seem to play a large role in explaining wage differences in these industries. The chance to reveal one's talent in a real job is precious, as is suggested by the queuing for positions. Auditions seem to have limited usefulness beyond working as a cut-off that reduces the number of candidates for any entry-level position; huge uncertainty over talent remains among many viable candidates. There simply is no good substitute for observing the success of actual end-products. Richard Caves (2000) calls this uncertainty the "nobody knows" property, as the first on a list of distinctive characteristics of the entertainment industry. It could be argued that finding out about someone's talent in the entertainment industry is more about finding out the tastes and whims of the public than about some objective measure of quality, but this distinction is not economically meaningful—the economically relevant interpretation of talent is the individual's ability to generate revenue.

A suitable natural experiment is needed in order to identify and quantify any inefficiency caused by the hiring of mediocre incumbents. The most useful experiment would be a large exogenous change in either the individual liquidity constraint or, more plausibly, in the length of enforceable wage contracts. The ideal experiment would be a surprise legal change from individual ability to commit to career-long wage contracts to spot contracting or vice versa. While empirical analysis of such natural experiments would require further elaboration, the model presented here can already shed light on stylized facts and suggests empirical applications. I will next briefly discuss three potential applications. (For a more detailed discussion of applications, see the working paper version of this paper).

Motion pictures The motion picture industry in Hollywood operated under the so-called studio system from 1920s to late 1940s. In this system, artists and other inputs were assembled together under long-term relationships. New movie actors made exclusive seven-year contracts with movie studios. This kept the compensation at moderate levels until the initial seven years came to an end even for those who became stars, allowing studios to capture much of the value of talent they discovered. The studios could rent artists to other studios on "loan-outs" but the artists had no right to refuse roles. The contracts did *not* provide wage insurance: Even though wages were specified for the whole contract period the studios retained the right to terminate the contract. At the end of their contracts, the salaries of the proven stars were bid up by the competing studios. The relatively low initial-contract wages indicate that pre-contract information about talent was very imperfect and that unrevealed talent was not scarce.

After several court rulings in the 1940s the long-term contracts became practically unenforceable and the studio system broke down. According to my model, the end of long-term contracting should have led to insufficient exit of mediocre entertainers, showing up as higher and more uneven incomes for veteran actors, and as lower total revenue. The wages of star actors on their initial contract during the studio system can be expected to be lower for obvious reasons. More interestingly, the situation of free agents (those past the initial seven years) under the studio system is comparable to actors with the same amount of experience under spot contracting, but the end of long-term contracts should have increased their pay, despite of an accompanying decrease in industry revenue. There is clear evidence of a post-war decline in revenue and output at movie studios but wage data for actors is lacking.[17] An empirical analysis would require a dynamic model that takes into account how an industry adjusts from one steady state to another, and how it reacts to demand shocks, such as the advent of television in the 1950s. (The unusually poor substitutability across age groups–as most roles must be casted with an actor from a certain age range–may also be a significant factor). Interestingly, in terms of quality, the era from the 1920s to the 1940s is often referred to as the golden age of Hollywood movies.

Record Deals Exclusive record deals, by which musicians agree to make a certain number of albums for the same record company, are a form of long-term wage commitment. This commitment is enforceable because record deals are not treated as employment contracts by the courts. The music industry is very competitive at the entry level, where upstart bands and artists are free agents, but agree to exclusive contracts in exchange of production, distribution, and promotion by the record company.

Long-term record contracts have always been threatened by the attempts to renege or renegotiate by artists who turn out to be big stars. Furthermore, there is a recurring lobbying battle in Congress about the enforcement of multi-record contracts.[18] Were the current system to break down, the proportion of new artists and new releases could be expected to be reduced, while the proportion of new artists whose record earns profits and who go on making a second record should go up. Currently about 80-90% of records by new artists make a loss, so a reduced proportion of "failed artists" would probably be regarded by many as a sign of a more judicious choice of artists by the record companies, when in fact it would be a sign of reduced experimentation and lower efficiency.

[17] According to Caves (2000, p. 389), "*no systematic data have been assembled on whether the studios' disintegration brought more rents into the stars' hands, but casual evidence suggests that it did.*"

[18] The protagonists are RIAA (Recording Industry Association of America), representing record companies, and AFTRA (American Federation of Television and Radio Artists), representing incumbent artists.

Professional Team Sports Professional team sports have very unusual labor markets, mainly because firms depend on mutual cooperation within leagues that are arguably natural monopolies. Many leagues have been able to enforce rules that restrict firms from competing for each others' employees. Talent in team sports may in part be interpreted as the capability to benefit from learning-by-doing, and opportunities to play at the top level are naturally scarce. Thanks to long-term contracts, clubs have incentives to take into account the upside potential of their young players instead of just picking the best squad according to current expectations.

Changes in the duration of contracts can allow inefficient experimentation and excess rents to talent be measured. Increasing (re)negotiation power by players should lead to longer careers and higher salaries. There has in fact been variation in the contracting rules and practices in several team sports. For example, the long-term contracts in American baseball were for a long time challenged by the players' union which eventually achieved a six-year cap on the initial contracts. However, this change was by no means a sudden surprise. (The number of teams and players have also been growing, so the steady-state model is again not sufficient for empirical analysis.) A more drastic experiment may yet begin in European football, where the EU is considering a complete ban on long-term contracts.[19]

8 Conclusion

According to Raymond Cotton, a lawyer who specializes in contract negotiations for college presidents, "what all universities are trying to do is find a successor who has been someplace else as president."[20] The main message of this paper has been that any profession where the ability of inexperienced workers is subject to much uncertainty, and where performance on the job is to a large extent publicly observable, is a likely candidate for market failure in the discovery of talent. This market failure would manifest itself as a bias for hiring mediocre incumbents at excessive wages. Markets for lawyers, fund managers, advertising copywriters, and college professors are among other possible cases not explored in this paper. It can be argued that differences in talent that are only discovered on the job are in fact the main source of talent rents in the economy. If that is the case, then much of observed superstar incomes could be, instead of a rent to truly scarce factors, a symptom of inefficiencies in the discovery process of talent, largely resulting from limitations to legally enforceable contracts. A system of enforceable long-term non-compete clauses would then not only enhance efficiency, but

[19] Terviö (2006) shows that tradable long-term contracts are needed for efficient experimentation in industries where firms are heterogeneous by the marginal product of talent, and predicts that the ban would lower industry revenue but increase the average age and the wages of star players.

[20] "College Leaders Earnings Top $1 Million." *New York Times*, 11/14, 2005.

would also reduce income inequality.[21]

Whether a particular labor market exhibits the inefficiency and excess rents described in this paper, and whether these are economically significant, is of course an empirical question. An empirical analysis would require a specific type of a natural experiment, namely an exogenous change in the level of imperfections behind the inefficiency. A few potential cases from the entertainment industry were discussed in this paper, but the building of an empirically geared model was left for future work.

Appendix A: Convergence to the Steady State

This appendix proves that all equilibria converge to the steady state derived in Section 3 when $T = 1$, i.e., when workers live for two periods. Denote the mass of novices entering the industry in period t as j_t and call $t = 1$ the initial period. The initial stock of potential veteran workers, j_0, is given by history ("potential" because those of sufficiently low talent will choose the outside option). The task is to derive the rational expectations equilibrium for the paths of j_t and p_t, beginning in $t = 1$, for any history $j_0 \in [0, \infty)$.

There are two types of possible histories depending on whether or not novices are induced to enter in the initial period. It will be shown later that novices enter if and only if j_0 is below a particular value $\hat{\jmath}$. I will first show stability for a normal history $j_0 \leq \hat{\jmath}$ and then separately for an extreme history $j_0 > \hat{\jmath}$.

Novices entering in period t care directly about prices in periods t and $t+1$ because that affects their expected lifetime income. They also know that the next cohort of novices has rational expectations about the price in periods $t+1$ and $t+2$, and so on. Recall that there is no aggregate uncertainty. The entire price path $p_1, p_2, p_3, \ldots$ must satisfy the dynamic equivalent of market equilibrium conditions (7) and (9-A). Equating the expected lifetime income with the outside opportunity results in conditions

$$p_t\bar{\theta} - c + \int_{\frac{w_0+c}{p_{t+1}}}^{\infty} (p_{t+1}\theta - c) f(\theta)\,\mathrm{d}\theta + F\left(\frac{w_0+c}{p_{t+1}}\right) w_0 = 2w_0 \qquad (21)$$

for all for entering generations in $t = 1, 2, 3, \ldots$ For convenience, define

$$h(p) = \left(1/\bar{\theta}\right)\left(\int_{\frac{w_0+c}{p}}^{\infty} (p\theta - c) f(\theta)\,\mathrm{d}\theta + F\left(\frac{w_0+c}{p}\right) w_0\right) \qquad (22)$$

and $\phi = (2w_0 + c)/\bar{\theta} > 0$. The equilibrium condition (21) can now be written as a simple nonlinear difference equation

$$p_t + h(p_{t+1}) - \phi = 0. \qquad (23)$$

[21] See Adler (1999) on the lack of enforceability of even the modest one-year non-compete clauses currently allowed by law in some U.S. states.

Differentiating (22) yields

$$h'(p) = \frac{\int_{\frac{w_0+c}{p}}^{\infty} \theta f(\theta)\,\mathrm{d}\theta}{\bar{\theta}} = \frac{\int_{\frac{w_0+c}{p}}^{\infty} \theta f(\theta)\,\mathrm{d}\theta}{\int_0^{\infty} \theta f(\theta)\, d\theta} \in (0,1] \quad \text{for} \quad p \geq 0.$$

Combining this with (23), we see that $\mathrm{d}p_{t+1}/\mathrm{d}p_t = -1/h' \leq -1$, with strict inequality for $p \in (\frac{w_0+c}{\theta_{\max}}, \frac{w_0+c}{\theta_{\min}})$. This implies that any initial price $p_1 \neq P^*$ would cause the price path to diverge (in an oscillating manner) so that p_t would, in finite time, either exceed $(w_0+c)/\bar{\theta}$ or become negative. Each would lead to a contradiction. First, it is not possible to have $p_t > (w_0+c)/\bar{\theta}$ because that would violate (21). (Intuitively, period t novices would be guaranteed to earn rents, even if they exited after one period). Second, $p_t < 0$ is not possible because it contradicts product market equilibrium in period t. Therefore the only price path consistent with rational expectations is one with a constant price at the steady state value P^*.[22]

To derive the path of j when $j_0 \leq \hat{j}$, note that the dynamic generalization of the equality of demand and supply for industry output (10) is

$$q^d(p_t) = j_{t-1} \int_{\frac{w_0+c}{p_t}}^{\infty} \theta f(\theta)\,\mathrm{d}\theta + j_t \bar{\theta}, \;\; t = 1, 2, \ldots \tag{24}$$

Substituting in the equilibrium value $p_t = P^* = (w_0+c)/A^*$, and defining constants

$$\alpha = q^d(P^*)/\bar{\theta} \quad \text{and} \quad \beta = \frac{\int_{A^*}^{\infty} \theta f(\theta)\,\mathrm{d}\theta}{\int_0^{\infty} \theta f(\theta)\,\mathrm{d}\theta}, \tag{25}$$

reveals (24) as the linear difference equation

$$j_t + \beta j_{t-1} - \alpha = 0. \tag{26}$$

This has a unique and stable equilibrium point since $\mathrm{d}j_t/\mathrm{d}j_{t-1} = -\beta \in (-1,0)$. Hence j converges to its equilibrium value (in an oscillating manner) starting from any $j_0 \in [0, \hat{j}]$.[23]

Now consider the case with an extreme initial state, $j_0 > \hat{j}$. Inspection of (26) reveals that $j_0 > \alpha/\beta \equiv \hat{j}$ would imply $j_0 < 0$, so then in fact $j_0 = 0$. This means that the novice entry condition (21) does not hold in $t = 1$ as no novices enter. Instead, the initial equilibrium price $p_1 < P^*$ is defined in a market where only veterans produce:

$$q^d(p_1) = j_0 \int_{\frac{w_0+c}{p_1}}^{\infty} \theta f(\theta)\,\mathrm{d}\theta. \tag{27}$$

[22] To see the connection with the steady state model, note that the fixed point equation corresponding to (23), after substitution $p_t = (w_0+c)/\psi_t$ for all t and rearrangment, is equivalent with (12). Thus Lemma 1 implies also that $P^* = (w_0+c)/A^*$ is the unique steady state equilibrium price.

[23] The fixed point $j^* = \alpha/(1+\beta)$ satisfies $P^* = p^d\left(j^*\bar{\theta} + j^*(1-F(A^*))\,\mathrm{E}[\theta|\theta \geq A^*]\right)$. This is just the steady state condition (10) expressed in terms of the mass of novices j instead of employment I.

Then, in period $t = 2$, the "history" is $j_1 = 0 < \hat{\jmath}$ so (21) will hold for every subsequent period.

In the liquidity constrained case the only difference is that, under a normal history, the steady state price is pinned down by the dynamic equivalent of (7) and (9-B) as $P(b) = (w_0 + c - b)/\bar{\theta}$ instead of P^*. An analogous argument shows that the equilibrium price can remain below $P(b)$ for at most one period, and that j converges to its unique steady state value from any initial value.

Appendix B: Proof of Proposition 7

First consider the unconstrained case. The exit threshold ψ is solved from $\omega(\psi|P) = w_0$ in (20), yielding its relation with the implicit price P.

$$\psi = \frac{\sqrt{2\alpha(c + w_0)}}{P} \tag{28}$$

Expected lifetime rents over the outside income, $(1 + T) w_0$, are

$$\begin{aligned} V(P) &= \omega\left(\bar{\theta}|P\right) - w_0 + T(1 - F(\psi)) E[\omega(\theta|P) - w_0|\theta \geq \psi] \\ &= \frac{\left(P\bar{\theta}\right)^2}{2\alpha} - (c + w_0) + T\int_{\psi}^{\theta_{\max}} \left(\frac{(P\theta)^2}{2\alpha} - (c + w_0)\right) f(\theta)\,\mathrm{d}\theta \\ &= \frac{P^2}{2\alpha}\left(\bar{\theta}^2 + T\int_{\psi}^{\theta_{\max}} \theta^2 f(\theta)\,\mathrm{d}\theta\right) - (1 + T(1 - F(\psi)))(c + w_0). \end{aligned} \tag{29}$$

Equilibrium requires that novices expect zero rents over the career. To separate out the role of the distribution of talent, denote

$$A^2(\psi) = \frac{\bar{\theta}^2 + T\int_{\psi}^{\theta_{\max}} \theta^2 f(\theta)\,\mathrm{d}\theta}{1 + T(1 - F(\psi))}. \tag{30}$$

Now $V(P) = 0$ can be written as

$$\frac{P^2}{2\alpha} A^2(\psi) - (c + w_0) = 0. \tag{31}$$

Novices' optimization requires (31) to hold, while veteran's optimization requires (28). Both hold simultaneously if and only if

$$A^2(\psi) = \psi^2. \tag{32}$$

Use ψ^* to denote the equilibrium threshold that satisfies (32). Equilibrium price is then $P^* = \sqrt{2\alpha(c + w_0)}/\psi^*$. The efficiency of competitive equilibrium means that ψ^* must be the maximizer of $A^2(\psi)$.[24] The marginal discarded type should be equally productive as the average type in the workforce. Due to quadratic variable costs, the economic surplus generated by individuals now scales with the square of (expected) talent. In classic superstar fashion, the adjustability of individual output levels provides an additional advantage for the highest types. Equilibrium wages are

$$\omega(\theta|P^*) = \frac{(P^*\theta)^2}{2\alpha} - c$$

$$= (c+w_0)\frac{\theta^2}{\psi^2} - c = w_0 + (w_0+c)\left(1-\left(\frac{\theta}{\psi}\right)^2\right) \tag{33}$$

Equilibrium wages requires novices to be able to accept a low income, $w_0 - b^*$, where the liquidity requirement is

$$b^* = w_0 - w\left(\bar{\theta}|P^*\right) = (w_0+c)\left(1-\left(\frac{\bar{\theta}}{\psi^*}\right)^2\right). \tag{34}$$

Now consider the constrained case. Constrained novices cannot accept a wage below some $w_0 - b$, where $b < b^*$ of (34). This pins down the equilibrium price: Solving P from $w\left(\bar{\theta}|P\right) = w_0 - b$ from (20) gives

$$P(b) = \frac{\sqrt{2\alpha(w_0+c-b)}}{\bar{\theta}}. \tag{35}$$

The exit threshold, solved from $\omega(\psi|P(b)) = w_0$, is

$$\psi(b) = \bar{\theta}\sqrt{\frac{w_0+c}{w_0+c-b}}, \tag{36}$$

resulting at the extremes of $\psi(0) = \bar{\theta}$ and $\psi(b^*) = \psi^*$. Combining (35) and (36) with (20), the wages are

$$\omega(\theta|P(b)) = (w_0+c-b)\left(\frac{\theta}{\bar{\theta}}\right)^2 + c.$$

This is decreasing in b and has a negative cross-partial with respect to b and θ. Thus Proposition 3 continues to hold in this modified setup. Output per worker $s(\theta) = P\theta/\alpha$ is higher in the constrained case since the price is distorted upwards. Propositions 4 and 5 generalize similarly.

[24] Furthermore, ψ^* is unique and in $(\bar{\theta}, \theta_{\max})$. The proof is analogous to that of Lemma 1 and is thus omitted.

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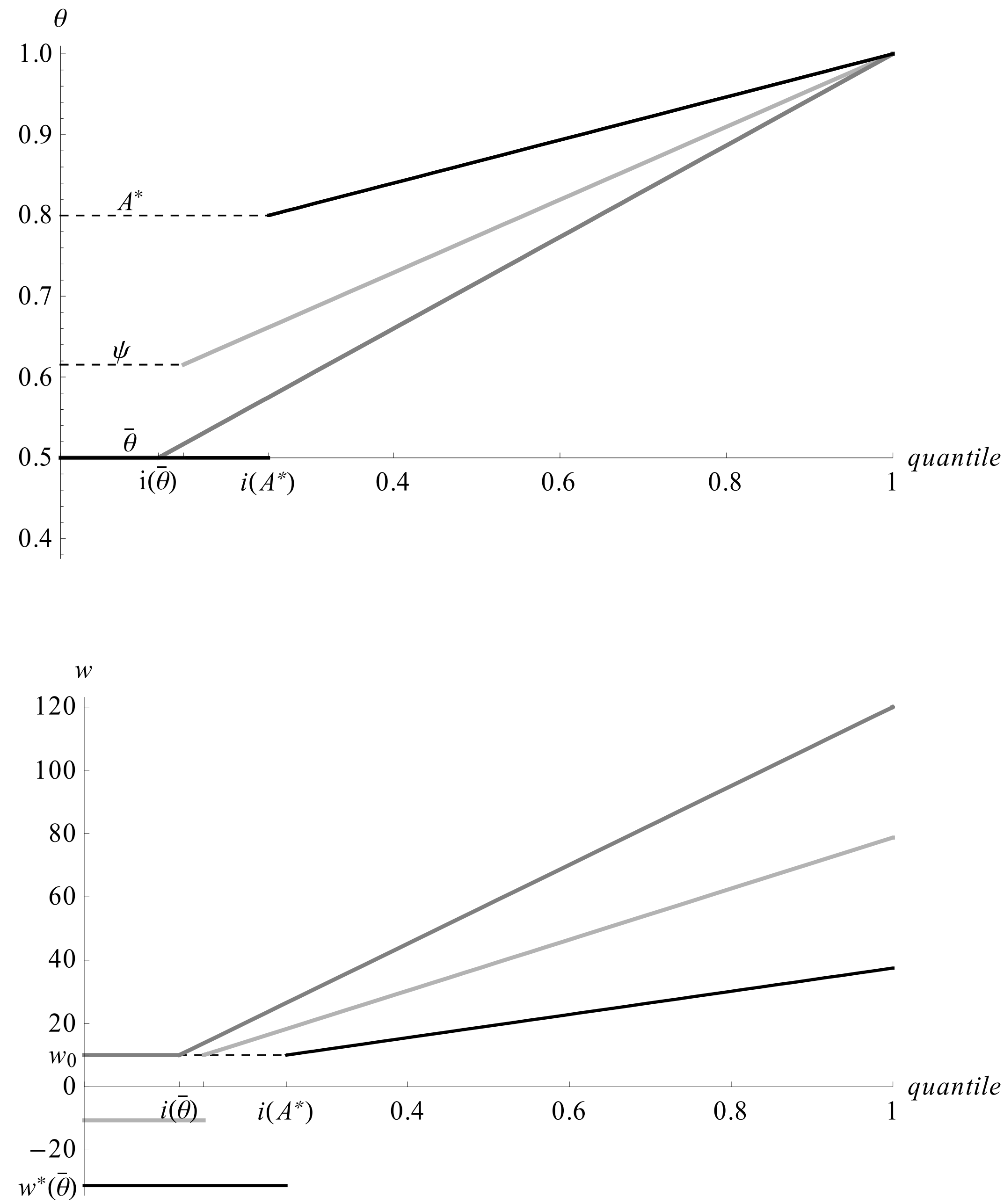

Figure 1. Distribution of talent (top panel) and wages (bottom panel) in the workforce. Black lines refer to the unconstrained case ($b \geq b^*$), dark gray to the fully constrained case ($b=0$), and light gray to a middle case ($b=b^*/2$).
The graphs were drawn assuming c=100, w_0=10, T=15, and talent drawn from the uniform [0,1] distribution. (The efficient threshold is then $A^* = \sqrt{(1+T)}/(1+\sqrt{(1+T)} =0.8$.)

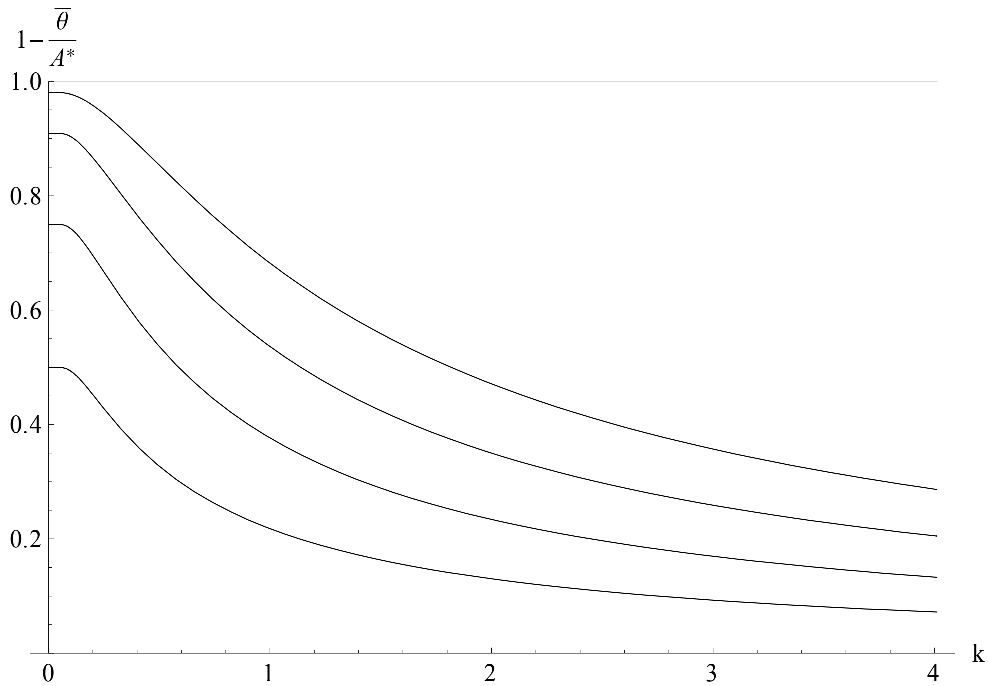

Figure 2. Shortfall of novice productivity relative to efficient threshold type, when θ~Weibull(k,λ) and T = 1,3,10,50 (from bottom to top), any λ >0.

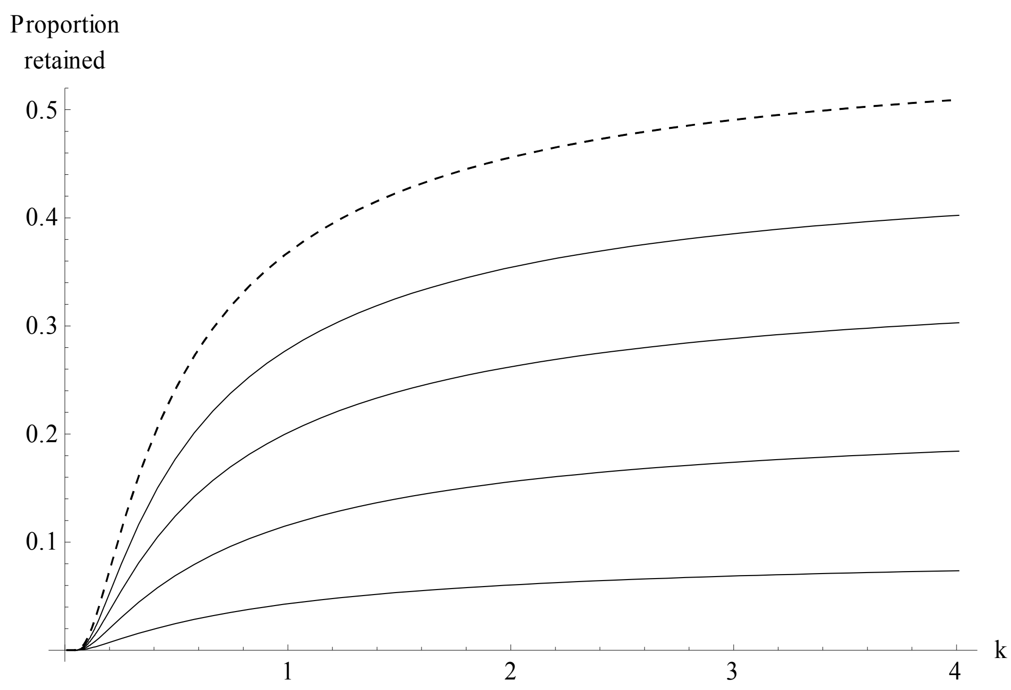

Figure 3. Solid lines show the efficient proportion of novices retained, when θ~Weibull(k, λ) and T = 1,3,10,50 (from top to bottom), any λ >0. Dashed line gives the proportion retained in the constrained case (b = 0) for any T.