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A Theory of Careers in Hierarchical Internal Labor Markets

Thomas J. Dohmen[1]

Abstract

The paper develops a model that explains a broad pattern of evidence on careers in multilevel organizations. It shows how job mobility inside firms depends on changes in the size of the organization. Promotion rates rise (fall) during a corporate expansion (contraction). Economic conditions therefore affect individual career mobility and earnings profiles. The model analyzes how the interaction between human capital accumulation and learning impacts on the assignment of workers to jobs at different levels of authority in the corporate hierarchy. The model makes predictions about the timing of the provision of formal training.

Keywords: Career Mobility, Learning, Sorting, Job Assignment

JEL codes: J00, M10

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[1] IZA, P.O. Box 7240, D-53072 Bonn, Germany.
Email: dohmen@iza.org
Tel.: +49-228-3894-531, Fax: +49-228-3894-510.

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1 Introduction

A growing recent empirical literature, that studies the internal economics of firms, documents patterns of job mobility and earnings dynamics that are at odds with the conventional labor market model.[1] Although the pairing of workers and jobs is essential to any employment relationship, the standard theory of competitive labor markets largely neglects the importance of firms and jobs. It also ignores career mobility inside hierarchically organized firms.A revival of a job-based analysis of labor market outcomes seems a promising route towards a better understanding of labor market outcomes (see Lazear, 1992 and 1995b for a similar argument).

This paper develops a model of careers inside organizations that is consistent with the collage of evidence about the internal workings of firms. It amalgamates different theoretical concepts – including human capital accumulation, learning, job assignment, and a hierarchical production technology with scale of operation effects – to show how worker heterogeneity and the firm's demand to staff different job positions determine career mobility and affect the life-cycle evolution of labor earnings. Motivated especially by the empirical finding that promotion rates rise during corporate expansion and fall during contraction (see Dohmen, Kriechel and Pfann, 2002), the model highlights the relation between internal mobility and changes in the size of the workforce. It thereby advances a recent theoretical literature on careers in organizations (e.g. Bernhardt, 1995; Demougin and Siow, 1994; and Gibbons and Waldman, 1999a), which has not yet addressed this issue.

The model in this paper considers a hierarchical organization of jobs, that stems from a recursive production technology – as built on by Williamson (1967), Calvo and Wellisz (1979) and Rosen (1982) – in which the final good is produced only on the lowest level. Managerial output in higher levels augments production at lower levels. A manager's output raises marginal productivity of all his subordinates multiplicatively, thereby magnifying the impact of his skills on final good production. Thus, output increases by more than the difference between two employees' productivity when the more productive manager is assigned to the higher job level. The firm's output maximizing planning problem is to staff hierarchical jobs according to the productivity ranking of its workers.

Although I focus on the sorting of workers to jobs inside a single firm, that has already optimized the number of hierarchical levels as portrayed by Williamson (1967), the model can be extended to a general equilibrium

[1] Lazear (1992) and especially Baker, Gibbs and Holmstrom (1994a, 1994b) inspired a recent empirical economic literature (see e.g. Ariga et al., 1999; Seltzer and Merrett, 2000; Gibbs and Hendricks, 2001; Dohmen, Kriechel and Pfann, 2002).

framework.[2] The relative number of jobs in hierarchical levels is fixed because the command production technology necessitates time-consuming supervision.Supervision cannot be separated from other managerial tasks. The implications of limited job slots in different hierarchical positions are little studied in the literature on careers in internal labor markets – an exception is the model by Demougin and Siow (1994).

Job assignment becomes a dynamic problem, that crucially impinges on individual career mobility, because information about workers' talents is only revealed over time by noisy observations of output.%footnoteThe literature has typically treated static This is modeled as a normal Bayesian learning process. I assume that a worker and his current employer share the same information regarding his productivity and learn symmetrically about his talent. But outside firms can infer talent only from observing job assignment, wages or verifiable training experiences.Another source of career dynamics is on-the-job human capital accumulation as described in the work of Becker (1962, 1964), Mincer (1962) and others. Interactions between learning, ability and human capital accumulation affect job mobility and wage dynamics.

The paper is organized as follows. Section 2 reviews key findings and stylized facts that emerge from the empirical literature on internal labor markets. Section 3 describes the firm's internal organization of labor that stems from the production technology and outlines the firm's assignment problem. Section 4 derives the model's implications for career mobility and works out the impact of changes in the workforce size on mobility rates. Section 5 sketches implications for the provision of formal firm-specific training courses. Section 6 concludes.

2 Stylized Facts of the Internal Workings of Firms

The recent empirical literature has turned anecdotal and heuristic evidence of the internal economics of firms into stylized facts. Since a model of careers should be consistent with empirically observed patterns of job and wage mobility, I briefly review some key results of this literature.

All econometric case studies based on personnel data, that I am aware of, report that labor is organized in jobs at different hierarchical levels . A

[2]The sorting of talent to jobs across different firms generates empirically observed skewed income and firm size distributions in a general equilibrium framework. It explains why superior managers control larger firms and receive more than proportionately higher incomes, as Rosen (1982) illustrates.

hierarchical organization of jobs is typical for firms around the globe, both in the manufacturing sector and in the service sector.[3]

A key finding of these studies is that wages are related to hierarchical job levels. Wages associated with job levels increase towards the top of the hierarchy so that workers enjoy wage raises upon promotions. Typically, substantial within job level wage spread is found, and immediate pay increases earned at a promotion are only a fraction of the difference between average wages of adjacent levels (see especially Baker, Gibbs and Holmstrom, 1994a; Treble et al., 2001; and Dohmen, Kriechel and Pfann, 2002). Demotions are much less frequent than promotions (see e.g. Baker, Gibbs and Holmstrom, 1994a; Treble et al., 2001; and Dohmen, Kriechel and Pfann, 2002). Nominal wage decreases, even at a demotion, are rare (see especially Gibbs and Hendricks, 2001; and Dohmen, 2002). Changing jobs is crucial for sustained wage growth.

The probability of being promoted to a higher hierarchical job level, conditional on the time already spent on the job, rises initially and then starts to decrease. Lazear (1992) reports evidence of a hump-shaped hazard rate of upward job mobility. Baker, Gibbs and Holmstrom (1994a) and van Gameren and Lindeboom (2000) find that promotion rates fall with time spent on the previous job.

Internal job mobility is also influenced by changes in the size of the workforce. Dohmen, Kriechel and Pfann (2002) find that promotion rates increase during corporate expansion and fall during downsizing.[4] This dependence re-

[3]Medoff and Abraham (1980, 1981) and Lazear (1992) have personnel data from four different U.S. manufacturing firms. Baker, Gibbs and Holmstrom (1994a, 1994b) study the personnel records of a U.S. service sector firm and Gibbs and Hendricks (2001) has further evidence for a U.S. firm. Seltzer and Merrett (2000) analyze the records of a large Australian bank. Flabbi and Ichino (2001) study data of an Italian bank and Treble et al. (2001) those of a British financial institution. Ariga, Ohkusa and Brunello (1999) , Lima (2000) and Dohmen, Kriechel and Pfann (2002) have data from manufacturing companies based in Japan, Portugal and The Netherlands respectively. Lin (2002) has personnel records from a Taiwanese automobile sales and maintenance company. All studies find a hierarchy structure of jobs in the different firms.

[4]They analyze job mobility at the Dutch aircraft manufacturer Fokker, which has organized jobs in two subpyramids for blue-collar and white-collar workers respectively. The average annual promotion (demotion) rate for white-collar workers is 7.7% (2.7%) during workforce expansion from January 1987 until February 1993 and 6.4% (2.6%) during the episode of contraction from March 1993 until the bankruptcy on 15 March 1996. The change in job mobility rates is more drastic in the blue-collar ranks, which account for most of the employment variation. The annual promotion rate falls from 6.4% during expansion from January 1987 until February 1991 to 3.9% during contraction from March 1991 until the bankruptcy among blue-collar workers, while the demotion rate rises from 1.0% to 1.4%.

lation is not explained by theoretical models of careers in organizations that have been developed so far. Understanding its driving forces is important as career mobility affects a worker's welfare (see Dohmen, 2002). For example, if expanding firms offer greater chances of career advancement, workers should, ceteris paribus, prefer them to declining firms and industries. Moreover, adverse changes in career advancement prospects during contraction reduce workers' welfare beyond pure wage loss or job loss. A model of careers in internal labor markets should therefore address implications of employment changes.

3 The Model

The Production Technology, Hierarchy and Job Slots

I consider a firm that employs a recursive production technology, that is further defined below. Tasks have to be performed on different hierarchical job levels, but only workers on the lowest level manufacture the firm's final product. Employees in all other hierarchical levels engage in managerial activities such as supervision, research and development, forecasting, planning and administration, or selling the final product. Managers make an array of choices concerning product design, development, customer relations, product placement, the organization of production techniques, etc. The quality of these indivisible management decisions depends on the manager's competence. Managerial skills are nonadditive and noncombinable, so that it is not possible to team two managers to create a superior one. Only one employee can be assigned to a job slot. A manager's output is an intermediate good that serves as an input at lower levels of the production process and raises the productivity of all subordinated workers of his production line. Managerial output therefore results in total factor improvements and has strong scale effects at the firm level. These scale effects are congested by the need for time-consuming supervision; for a manager has to spend a fixed amount of time in order to communicate his ideas to his subordinated workers on the next lower hierarchical job level and to ensure their compliance with the management decisions. This need for supervision limits the span of control, i.e. the number of workers that a manager can supervise effectively, in the command production technology. Hence the number of job slots at each level of a production line is rationed. In this paper I assume that the number of workers that can be supervised efficiently is fixed by the production technology at each level in the hierarchy.

A 3-level firm is considered here because it suffices to study the important aspects of promotion and wage dynamics including fast-tracks and serial correlation in wage growth and promotions.[5] Such a firm consists of a production level L_1 and two higher levels L_2 and L_3. A worker k, who is assigned to the highest level, controls a production line. His span of control is s_3, so that he manages the output of s_3 employees on level L_2. Each of these managers controls an L_2-operation. Since the span of control of a manager on level L_2 equals s_2, he supervises s_2 workers assigned to level L_1 in his operation. Each production line has therefore $(1 + s_3 + s_3 * s_2)$ job slots. The size of the firm is determined by the number of production lines and the span of control at each hierarchical job level. The total number of job slots for a firm with K workers assigned to the highest level is given by

$$N = K + s_3K + s_2s_3K = (1 + s_3 + s_2s_3)K. \tag{1}$$

The set of all workers $S_{all} = \{n|n \leq N, N \in \mathbb{N}\}$ is partitioned into three subsets S_{L_1}, S_{L_2}, and S_{L_3} that contain workers assigned to levels L_1, L_2, and L_3 respectively, such that $S_{L_l} \subset S_{all}$ and $S_{L_l} \cap S_{L_m} = \varnothing$ for $l \neq m$, $l \in \{1, 2, 3\}$ and $m \in \{1, 2, 3\}$. The subset S_{L_3} has K elements that will be indexed by k, $k \in \{1, ..., K\}$. Likewise, subset S_{L_2} has s_3K elements indexed by j, $j \in \{K + 1, ..., K + s_3K\}$ and subset S_{L_1} has s_2s_3K elements indexed by i, $i \in \{K + s_3K + 1, ..., K + s_3K + s_2s_3K\}$. Let $S^k_{L_2}$ denote the s_3 workers who are subordinated to worker k; $S^k_{L_2}$ is a subset of all workers assigned to the second level, i.e. $S^k_{L_2} \subseteq S_{L_2}$, such that $S^k_{L_2} \bigcap S^l_{L_2} = \varnothing$ for $k \neq l$, and $\bigcup_k S^k_{L_2} = S_{L_2}$. If $k > 1$, $S^k_{L_2} \subset S_{L_2}$. Let $S^j_{L_1}$ denote the s_2 workers who are subordinated to worker j; $S^j_{L_1}$ is a subset of all workers assigned to the lowest level, i.e. $S^j_{L_1} \subset S_{L_1}$, such that $S^j_{L_1} \bigcap S^l_{L_1} = \varnothing$ for $j \neq l$, and $\bigcup_j S^j_{L_1} = S_{L_1}$.[6]

Let ω_n denote productive skills of worker n. Productive skills ω_n are an idiosyncratic trait of worker n. I assume here that skills are one-dimensional. The same set of talents and competences is used at every level of authority. In fact, this assumption implies that skills are fully transferable from one job level to the other. Consequently, job assignment is based on absolute advantage as a better production worker is also a superior manager.[7] The model is straightforwardly extended to capture a more realistic world, in which not all skills are useful in every job. In such a model, the index ω_n would be

[5] The analysis naturally carries over to "deeper" organizations, which have more hierarchical levels. However, their analysis is more complex but does not yield important additional insight.

[6] $S^j_{L_1} \subseteq S_{L_1}$ iff $K = 1$ and $s_3 = 1$, i.e. if only one worker is assigned to level L_2.

[7] This rather unrealistic assumption which simplifies the assignment rule helps us to focus on the implications of limited job slots for career mobility. The main insights of the paper still hold if a different skill mix was required at every level and a worker's productivity across jobs was correlated, for example because some innate trait affects his performance in all jobs.

replaced for example by a three-dimensional vector with possibly correlated components that reflect productive skills relevant in the three different jobs.[8]

A worker's competence or productive skills do not change when he is assigned to a different job, but the impact of his skills on production alters at different levels of authority due to the command structure of the production technology. Suppressing physical capital for simplicity, the output of an L_2 operation, in which worker j, assigned to level L_2, controls the set of workers $S^j_{L_1}$ on level L_1, is given by

$$Y_j = g(\omega_j) \sum_{i \in S^j_{L_1}} f(\omega_j t_w, \omega_i). \tag{2}$$

Equation (2) illustrates that output produced by workers with productive skills ω_i on level L_1 is augmented by worker j's managerial output $g(\omega_j)$, which is a function of his productive skills ω_j, if $g(\omega_j) > 1$. These indivisible decisions of manager j improve the productivity of all workers assigned to level L_1 in his operation if $g(\omega_j) > 1$.[9] This scale effect is limited because manager j cannot spend all his time generating ideas to improve efficiency of his subordinates, but he has to devote a fraction of his working time t_w, $0 < t_w < 1$, supervising each of his directly subordinated workers to communicate ideas and ensure compliance with his decisions. The higher his competence, ω_j, the higher will be compliance with his aims. This is captured by the argument $\omega_j t_\omega$ in $f(\cdot)$.

Likewise, worker k, who is assigned to the highest level L_3, controls the output of s_3 L_2-operations. Total output of his entire production line Y_k is

[8] Such an extension has important consequences for the assignment problem. Absolute and comparative advantage do not have to coincide in such a model with multiple skill-dimensions. Assignment will be based on comparative advantage (see Sattinger, 1993) if different skills are used in different jobs. If jobs provide different opportunities for skill enhancement, job rotation might better prepare workers for positions in higher hierarchical levels. Moreover, if skills can only be observed on-the job, firms might find it optimal to rotate workers across jobs and receive different signals in order to infer a worker's comparative advantage or his innate ability.

[9] Equation (2) is consistent with a world in which not every laborer is a good manager, even though no explicit distinction is made between managerial skills and manufacturing skills. A worker's marginal effect on final good production might simply be insufficient in higher job levels. If a worker is endowed with so little (managerial) talent that $g(\omega_j) < 1$, he would ruin output of his production line when assigned to level L_2.

affected by his managerial skills ω_k:[10]

$$\begin{aligned} Y_k &= G(\omega_k) \sum_{j \in S^k_{L_2}} F(\omega_k t_w, Y_j) \\ &= G(\omega_k) \sum_{j \in S^k_{L_2}} F(\omega_k t_w, [g(\omega_j) \sum_{i \in S^j_{L_1}} f(\omega_j t_w, \omega_i)]). \end{aligned} \quad (3)$$

The firm's total production equals the sum of final good production of all its K different production lines. It is assumed that employees can only carry out the task they are assigned to but cannot help out in other activities at the same time. The functions $f(\cdot)$ and $F(\cdot)$ exhibit diminishing returns to supervision ($f_{11} < 0$ and $F_{11} < 0$) and complementarity ($f_{12} > 0$ and $F_{12} > 0$).

The static problem of assigning heterogeneous workers to different hierarchical job positions entails that the firm – in order to maximize output – ranks its $K(1 + s_3 + s_2 * s_3)$ workers according to their productivity and then staffs the K jobs on level L_3 with the highest ranked workers. The highest ranked K workers are identified by subscript k in terms of equation (3). The next highest ranked $s_3 K$ workers fill the positions on L_2 and the remaining $s_2 s_3 K$ workers are then assigned to L_1.[11]

However, job assignment becomes a dynamic problem because the ranking of workers according to their productive skills changes. This does not only happen because workers with finite careers retire or separate and have to be replaced, but also because workers accumulate skills at different rates. The

[10]Rosen (1982) considers a similar production technology, in which ω_n is a three dimensional vector with components s_n, r_n and q_n that capture a person's latent skills in levels 3, 2 and 1 respectively. The skills are latent because a worker only uses the skills that are relevant to the job level he is assigned to. Output of a 3-level operation – in which worker k his subordinates indexed by j in the set $S^k_{L_2}$, who in turn each control the output of a set of workers $S^j_{L_1}$ on the production level – would be given by

$$Y_k = G(s_k) \sum_{j \in S^k_{L_2}} F(s_k t_j, g(r_j) \sum_{i \in S^j_{L_1}} f(r_j t_i, q_i)).$$

A manager's productive skills are time-augmenting, which is captured by $r_j t_i$ (and $s_k t_j$). In addition, manager j (k) can choose the amount of time he spends supervising each of his subordinates i (j) so as to maximize output. The span of control is endogenous and depends on the quality of managers. Multiple skill dimensions and an endogenous span of control allow to study an array of further interesting problems for internal career mobility – including job rotation, the design of career paths, or limits to firm size.

[11]This assignment rule presupposes, however, that managerial output at any level of authority is positive so that workers do not destroy output. The firm would not exist if it could not recruit managers who augment the output of production workers.

rate of firm-specific human capital accumulation is determined by a worker's innate ability θ as productive skills are given by

$$\omega_n = \theta_n h_f(t), \tag{4}$$

where $h_f(t)$ is a non-negative function that measures accumulated opportunities to acquire firm-specific human capital during t years of firm-specific tenure. The specific capital accumulation function h_f exhibits positive but decreasing marginal returns ($h'_f > 0$ and $h''_f < 0$) to firm-specific tenure t.

A worker's innate ability is assumed to be person-specific and constant throughout a worker's career, but not directly observable. Instead, a worker's individual ability is a draw from the known population distribution of θ, which is assumed to be normal with mean μ_θ^0 and standard deviation σ_θ, i.e.

$$\theta \sim N(\mu_\theta^0, \sigma_\theta^2).$$

At distinct intervals during the employment relationship, for example at the end of each year, the firm obtains for each worker n a noisy signal of his ability, $\hat{\theta}_{n,t}$, from observing output during the observation period t at all stages of the production process. Since the signal is private to the worker and his current employer, potential employers can only infer a worker's expected ability from observed actions such as job assignments. The productivity signal is given by

$$\hat{\theta}_{n,t} = \theta_n + \epsilon_{n,t}. \tag{5}$$

The N individual signals are obtained recursively by using inverse functions Ψ_ℓ^{-1}, $\ell \in \{1, 2, 3\}$, of the production technology that map output measured with error at each level L_ℓ, into contributions of each worker's ability. It follows from the recursive structure of the production technology that such an inverse function at higher levels depends on the measured augmentation of output by the manager at his respective level and on all output signals of his subordinated workers down the production line.

The error term $\epsilon_{n,t}$ is an *iid* normal random variable with known variance σ_ϵ^2, i.e. $\epsilon \sim N(0, \sigma_\epsilon^2)$.[12] The firm uses the information of the signal to update its prior on θ_n in a Bayesian manner. It forms a new conditional expectation of ability according to a normal learning process as in Jovanovic (1979a) or Harris and Holmstrom (1982). Learning about ability is only gradual. Since

[12] Here, workers cannot engage in influence activities as analyzed by Milgrom and Roberts (1988). They cannot affect the output signal by sabotage or by choosing the level of effort. This rules out incentive problems or signalling problems associated with career concerns. The model could be extended, however, to allow for effort choices by introducing a decision variable effort provision in equation (5).

ϵ is drawn from the same distribution for all workers irrespective of job level assignment and time, the rate of learning is the same across jobs.[13]

To simplify notation, I write the rules for updating in terms of the precision rather than the variance. The precision of ability in the population is defined as

$$h_0 = \frac{1}{\sigma_\theta^2}, \tag{6}$$

and the precision of ϵ is given by

$$\gamma = \frac{1}{\sigma_\epsilon^2}. \tag{7}$$

The posterior beliefs about θ in period t, denoted by μ_θ^t, will be normal with precision h_t (see DeGroot, 1970). The rules for updating beliefs after having observed the output signal $\hat{\theta}_{n,t+1}$ are given by

$$\mu_\theta^{t+1} = \frac{h_t \mu_\theta^t + \gamma \hat{\theta}_{n,t+1}}{h_t + \gamma} \tag{8}$$

$$h_{t+1} = h_t + \gamma, \tag{9}$$

The mean follows a random walk, while the precision increases deterministically. Defining the history of $\mu_t = (\mu_\theta^1, ..., \mu_\theta^t)$, it can be shown that μ_θ^{t+1} and $[\mu_\theta^{t+1}|\mu_t]$ are normally distributed with means and variances given by

$$E[\mu_\theta^{t+1}|\mu_t] = \mu_\theta^t \tag{10}$$

$$Var[\mu_\theta^{t+1}|\mu_t] = (h_t h_{t+1})^{-1}. \tag{11}$$

The arrival of new information can lead to discrete jumps in expected productivity of a worker and thereby perturb the productivity ranking triggering re-assignment, which affects job mobility and individual careers. Assuming that there are no cost of re-assignment[14] and that the firm is risk-neutral, the simple dynamic assignment rule is to rank and re-assign workers each period according to the updated belief about their productivity.[15] Although the mean of the posterior distribution of ability converges to the true value

[13] If signals were noisier in some levels than in others, the firm would take such differences into account when making its assignment decision. For example, new hires are more likely assigned to jobs with the least noisy output signal initially because learning is fastest when workers are assigned to such screening tasks.

[14] Frictions like re-assignment costs reduce internal mobility. Under uncertainty, irreversible re-assignment costs also affect the timing of job mobility, via the option value of postponing re-assignment until more information accumulates.

[15] The model framework allows to address a number of additional issues that will not be the focus of this paper. For example, if it is costly to make "mistakes", i.e. costly to incur

of θ_n, the ranking of workers is never based on true productivity, not least because workers leave the labor market, and hence the firm, at a constant rate λ.

The Labor Market, Wages and Worker Turnover

The labor market is assumed to be segmented, for there are two types of firms. Primary sector firms employ the production technology described above. Secondary sector firms have no management levels. A worker in the secondary sector produces the same amount of output as he would produce on the production level of a primary sector firm. In absence of firm-specific skills, workers are equally productive at any primary sector firm for a given job level assignment.

Each period, young workers enter the labor market looking forward to a working life with an expected length of λ^{-1}. Workers always find employment in the secondary sector. But they prefer jobs in the primary sector because the prospect of becoming a manager raises their life-cycle earnings potential. I assume that there is excess supply for primary sector jobs so that a firm can always satisfy its labor demand by recruiting from the pool of workers without primary sector experience, whose expected productivity equals the population mean of θ.

To simplify the analysis, I assume that the condition

$$\mu_\theta^0 \leq E[\theta_j | \mu_{s_j}^j], \forall j \in S_{L_2}. \tag{12}$$

is always met, where $\mu_{s_j}^j$ is the history of output signals for an incumbent worker j who is currently assigned to level L_2. In that case, workers without primary sector experience are always hired into the production level L_1.

Firm-specific capital reinforces the tendency to hire workers into the lowest level. If $h_f(0) = 0$, the firm would never hire workers into level L_2 irrespective of labor supply conditions. Even if $h_f(0) > 0$, the presence of firm-specific capital makes it is less likely that a worker is hired into level L_2 for the his expected ability has to be more than $\frac{h_f(t)}{h_f(0)}$ times bigger than expected ability of the worst manager in level L_2 to compensate for the productivity advantage that the current incumbent manager has after having accumulated firm-specific skills during t years of tenure.

low output, the firm does not solely base its assignment decision on expected productivity, but also trades off the variance and expectation of a worker's expected productivity. Seniority then gains importance, both because observable investments in human capital become relatively more important and because the precision of the prior on θ increases with tenure. Likewise, seniority based promotions rules become more likely the noisier signals of individual productivity are, i.e. the slower firms learn.

Even jobs on the production level are scare, so that the firm replaces all workers whose ability falls below a cohort-specific threshold value $\theta^*(t)$, which depends on the magnitude of excess supply and the population distribution of θ. A potential outcome, that is particularly convenient to analyze, is such that $\theta^*(1) = \mu^0_\theta$.[16] In that case, the firm replaces all workers whose expected ability after the first period falls below the unconditional population mean of ability. Since all firms have the same firing strategy, dismissed production workers will never receive a primary sector job offer again, because they are believed to be less able than an average worker without primary sector experience, and therefore have to work in the secondary sector until their labor market career ends.

As h_f rises with tenure, the relevant threshold value $\theta^*(t)$ is decreasing in firm-specific tenure t. The presence of firm-specific capital tends to reduce dismissal rates because it enhances the expected productivity of incumbent workers relative to that of workers queuing for primary sector jobs on the labor market. Without firm-specific capital, the firm would fire worker n after period 1 if

$$E(\theta_n|t=1) = \mu^1_{\theta_n} < E(\theta) = \mu^0_\theta.$$

With firm-specific capital he would only be replaced by a potential new hire if

$$\mu^1_{\theta_n} \int_1^{1+\frac{1}{\lambda}} \delta^{t-1} h_f(t)dt < \mu^0_\theta \int_0^{\frac{1}{\lambda}} \delta^t h_f(t)dt, \tag{14}$$

where δ is the discount factor.

Condition (14) is more likely to be satisfied, the smaller the incumbent's expected ability, μ^1_θ, is relative to the unconditional expectation of ability in the population, μ^0_θ. It is also more likely to be satisfied the less learning opportunities the job offers in the first period, of the employment relationship,

[16] This, and hence condition 12, can be justified as follows: Normalizing the number of workers without primary sector experience to 1, θ^* is given by

$$\theta^* = \Phi^{-1}(1-d), \tag{13}$$

where Φ is the cumulative distribution function of θ, and d denotes the amount of jobs to be filled in the primary sector as a fraction of supply of workers without prior work experience in the primary sector. The smaller d, i.e. the more excess supply there is, the more selective primary sector firms become and the larger is θ^*. Assuming that $d \leq 0.5$, the firm dismisses all workers whose expected ability conditional on the history of output signals falls below the unconditional expectation of ability. Consequently, expected ability of the least productive retained worker exceeds the expected productivity of a new hire without primary sector experience so that a worker without primary sector experience is assigned to the lowest level initially.

because the magnitude of on-the-job skill acquisition determines an incumbent worker's productivity advantage.

PROPOSITION 1: *The more firm-specific skills can be developed early during the employment relation and the slower firms learn about ability, the lower is turnover at the firm.*

Proof: After having observed the output signal of a worker n who has spent $s = t - \tau$ years of firm-specific tenure, the firm compares his expected ability with that of a potential newly hired worker. If

$$\mu_{\theta_n}^s \int_s^{s+\frac{1}{\lambda}} \delta^{t-s} h_f(t) dt < \mu_\theta^0 \int_0^{\frac{1}{\lambda}} \delta^t h_f(t) dt, \tag{15}$$

the firm fires worker n. The worker is less likely to be fired, the more learning opportunities employment at the firm offers in the first s periods, because the higher the difference in potential firm-specific skill is, the lower expected ability of an incumbent has to be to rationalize his dismissal.

If the firm learns slowly, expected period to period changes in updated beliefs of worker n's ability are small. But the smaller these changes are, the longer it takes on average until the arrival of bad information has reduced the updated prior sufficiently so that the worker is dismissed. The firing rate therefore increases with the speed of learning about ability.

QED

In order to keep the workforce constant, the firm has to hire on average $(\lambda + p)N$ workers to fill slots that become vacant because workers' labor market careers end, and because the firm dismisses production workers whose expected productivity has fallen below the threshold value; p is the probability of the latter event. Instead of hiring newcomers to the primary sector, the firm could attract workers from other primary sector firms. But I assume that the firm incurs a hiring cost to poach workers, which is increasing in the employee's expected productivity as revealed by his employment history and job assignment.[17] If these hiring costs for experienced workers are sufficiently large, the firm hires inexperienced workers into the lowest level and promotes incumbent workers to fill vacancies at higher levels. This is the case considered in the remainder of the paper.

Wages in the secondary sector equal the marginal product. A feasible wage schedule for primary sector firms requires wages to increase with job

[17] See Rosen, 1968 for evidence that hiring cost are higher for more skilled labor).

levels because a promotion reveals information about a worker's ability to the market when firms assign more able workers to higher levels.[18] In addition, in order to retain production workers, their wages have at least to match their income from working in the secondary sector, so that wages tend to rise with expected ability.[19] For simplicity, I assume here that remuneration is based on expected productivity as long as there are no rents that accrue from relationship-specific capital.

4 Career Mobility in a Stationary Environment

Since management positions are only filled from within, the firm promotes on average $[\lambda_3 + d_3]K$ workers to level L_3 and $\lambda_3 K + [\lambda_2 + d_2]s_{3K}$ workers to level L_2 in each period, where d_3 and d_2 are the demotion rates out of L_3 and L_2 respectively.[20] Since λ_3 and λ_2 are positive, the promotion rate is higher than the demotion rate.

A worker is demoted to a lower level if he descends sufficiently in the ranking of expected productivity. For a demotion from level L_3 to level L_2 to occur, the leat productive worker who is currently assigned to level L_3 must have a lower expected productivity than the $(\lambda_3 K) + 1$'st most productive worker j in level L_2.[21] The condition for the m'th demotion from level L_3 to level L_2 entails a comparison of the m'th worst ranked L_3-manager's expected productivity with expected productivity of the $\lambda_3 K + m$'th ranked worker on the lower level. The conditions for demotions from level L_2 to level L_1 are analogous. Each demotion triggers another promotion. Promotion and demotion rates are higher, the bigger and the more frequent changes in the productivity ranking are.

Individual promotion and demotion hazard rates depend on the rate at which human capital can be accumulated (i.e. on the magnitude and curvature of h_f), on the variability of the learning process (i.e. on the sequence of

[18] See also Waldman (1984b) and Bernhardt (1995) for a formal derivation of this insight.

[19] In principle, the firm needs to pay production workers less than their expected marginal product to prevent turnover, because they also value the discounted value of potential career advancement in the primary sector, which is associated with higher wages. Since this option value declines over time, wages tend to rise with seniority.

[20] In this notation, a promotion from level L_1 to level L_3 in one step accounts for two promotions: from level L_1 to level L_2 and from level L_2 to level L_3. Moreover, managers whose expected productivity falls short of expected productivity of new hires, so that they fired are counted as being demoted to the production level and fired from there.

[21] Note that the highest ranked $\lambda_3 K$ workers are promoted to level L_3 to replace the managers in the highest level who end their labor market careers.

μ_θ^t which depends on σ_ϵ^2 and σ_θ^2), and on the interaction between both forces.

PROPOSITION 2: *Workers are more likely to be promoted early in their career the more talented they are and the faster the firm learns about true ability.*

Proof: The productivity ranking among workers of the same cohort is solely determined by ability differences. The more able a worker is, the more likely he is to become highest ranked in his cohort. The speed of learning about ability determines how fast the ranking of workers of a given cohort converges to the true within-cohort ability ranking. To be promoted, a worker also needs to climb the within-level productivity ranking, i.e. has to compete with workers of older cohorts. Since a worker m of an x periods older cohort has benefitted from more opportunities to accumulate productive skills, worker n of the younger cohort has to be believed to be sufficiently more able to compensate for this advantage. In particular, to outperform the longer-tenured worker after t periods, the beliefs about the younger worker's ability have to satisfy the condition

$$\frac{\mu_{\theta_n}^t}{\mu_{\theta_m}^{t+x}} > \frac{h_f(t+x)}{h_f(t)}. \tag{16}$$

Such a belief requires a signal of sufficiently high ability which more likely manifests for truly able workers.

QED

COROLLARY 1: *The faster the firm learns about a worker's talent θ, the more likely are high-ability workers to be promoted early, and the less likely are low-ability workers ever promoted.*

The faster the within-cohort ranking of workers converges to the true ability ranking of workers, the more likely will high-ability workers of younger cohorts outperform low-ability workers of older cohorts in the productivity ranking early during their career, so that low-ability workers become less likely to be ever promoted.

COROLLARY 2: *The larger are on-the-job learning opportunities for workers between period t and period $t+x$ relative to past learning opportunities at time t, the more able a worker has to be relative to a colleague with x more periods of firm-specific tenure in order to become higher ranked after t*

periods.

The proof follows immediately from condition (16).

For a given speed of learning, the expected time to promotion for any worker depends on the functional form of h_f. The more concave h_f is, the earlier will ability differences become the dominating source of productivity differences between workers of different cohorts, as the ratio $\frac{h_f(t+x)}{h_f(t)}$ is smaller.

PROPOSITION 3: *Workers who have been promoted early in their career are likely to be promoted fast to level L_3. Career fast-tracks therefore exist.*

Proof: Workers who have been promoted early in their career are likely to be very able (Proposition 2). Therefore they accumulate skills fast and thus climb the productivity ranking within the firm quickly. Since workers with high expected productivity need to spend less time on-the-job to attain a particular productivity level, they outperform more senior, but less able workers, after a shorter period of time and therefore become more likely to be promoted a second time to level L_3. (Because of the concavity of h_f, a worker, who is z times more able than his colleague, needs less than $1/z$ of the time to become at least as productive.) This generates serial correlation in promotion and wage growth.

QED

PROPOSITION 4: *The individual promotion hazard rate rises initially with job tenure, but falls after having reached some maximum. The time after which this maximum is reached depends on the time-profile of on-the-job learning opportunities and on the speed at which the firm learns about talent θ. The faster the firm learns about a worker's θ, the earlier the promotion hazard starts to decline with job tenure.*[22]

Proof: Retained workers climb the productivity ranking after their first employment period simply because their expected productivity exceeds that of any potential new hire without primary sector experience. For example, workers who entered in period τ and are retained in period $\tau + 1$ are ranked higher than all workers of the new entering cohort in year $\tau + 1$. Although

[22] A hump-shaped promotion hazard is consistent with empirical evidence reported by Lazear (1992) and Gibbs (1995).

some workers of entry cohort τ, who have received a very favorable output signal, might be promoted after the first employment period, workers of this cohort are typically ranked below workers of older cohorts who are still at the same hierarchical job level. Since the highest ranked of them are promoted in the next period and because some of them will separate or fall behind after receiving a sufficiently bad output signal, the worker's of entry cohort τ with the best history of output signals will then climb the within-level productivity ranking unless more lower-ranked workers of younger workers outperform him. The most able workers of cohort τ are likely to climb the productivity ranking fastest and tend hence to be promoted first. Average ability among cohort τ's job stayers falls as the most able leave, so that more and more workers of the cohort will fall behind. The promotion hazard for workers of cohort τ who have not been promoted yet, starts decreasing.

The faster the firm learns about the true value of θ, the faster the pool of workers can be segregated into low-ability and high-ability workers and the higher are thus the chances of high-ability workers to become promoted early, while promotion perspectives of low-ability workers fall at the same time. If firms learn fast, the time-profile of expected productivity of exceptionally talented workers is steeper for two reasons. First, the prior distribution converges faster so that a higher expectation of θ becomes already more likely early in the career. Second, human capital accumulation reinforces the impact of higher perceived ability on expected productivity.

QED

As seniority increases, changes in expected productivity become smaller on average, because the conditional variance of μ_θ^t declines with t and goes to zero as t approaches infinity. Besides opportunities for skill enhancement diminish as the employment relationship proceeds ($h_f'' < 0$). Job mobility rates are therefore smaller for workers with longer tenure.

If firms learn slowly about ability because output signals are noisy, differences in seniority remain a dominating factor of expected worker productivity for a longer period. High ability workers then need on average more time until they are promoted. To illustrate the point, imagine that firms never learn anything about unobserved talent, i.e. μ_θ^0 and h_t remain unchanged. Then, talent never affects the assignment process because the ranking of workers according to expected productivity is solely determined by differences in seniority.[23] As a result, promotions are only based on seniority. Since expected

[23] Expected productivity differences between members of different cohorts decline due to the concavity of h_f, but rank differences remain because expected marginal productivity increases with seniority.

productivity is identical for all members of the same cohort, it is entirely random which workers of the most senior cohort in a given level are promoted first. In the other polar case, in which θ is revealed instantaneously upon hiring, the productivity ranking is always based on true ability, so that high ability workers become more likely to be promoted early in their career.

COROLLARY 3: *If output of individual workers is difficult to measure, the firm is more likely to base its promotion decision on seniority.*

The more difficult output is to measure, i.e. the noisier ϵ is relative to θ, the slower will expected ability converge to its true value. The distribution of priors, which starts out as a mass point on μ_θ^0 spreads out slower, so that expected ability differences within a cohort are smaller. It is therefore less likely that an able worker of a young entry cohort is ranked higher than a worker with x more periods of tenure, because it becomes less likely that condition (16) is satisfied.

Firm-specific capital tends to reduce internal job mobility rates, because it makes the productivity ranking of workers less volatile. Since workers have to learn on-the-job, it takes time until they have acquired sufficient firm-specific skills. A worker of a younger cohort thus needs a larger perceived ability advantage to be ranked higher than a longer tenured colleague. This requires more positive information about his talent to arrive, which tends to increase the time to promotion. But this means at the same time that the expectation about individual productivity at the time of promotion is more precise. Expected changes in the posterior mean from one period to the other will become smaller. As large downward adjustments of expected productivity are also required less often, demotions become rarer.

4.1 Corporate Expansion and Career Mobility

Next, I consider how corporate expansion affects internal career mobility when the technology is unaffected, i.e. when the firm grows by adding new production lines.

PROPOSITION 5: *The hierarchical job structure is stable during episodes of workforce expansion.*

Proof: It follows immediately from the production technology, that hierarchical levels grow at the same rate, because the span of control, and thus the number of job slots at each level is fixed.

QED

The assumption of a fixed span of control is crucial. If the span of control of more productive workers were higher, employment in higher levels would grow relatively faster because less able managers have to be promoted on the margin during expansion.

PROPOSITION 6: *The promotion rate rises in periods of employment growth, while the demotion rate falls. The more pronounced the expansion is, the bigger are the changes in mobility rates.*

Proof: Since workers enter only in the lowest level, all vacant positions in higher levels are staffed by promoting incumbent workers. The promotion rate has to rise during an expansion, because the firm has to fill additional vacancies in higher levels of new production lines. If M production lines are added, the number of promotions to level L_3 increases by M, and the number of promotions to level L_2 by $M + s_3 M$. Consequently, the promotion rate rises, and the increase of the promotion rate is stronger the larger M is relative to K.[24] The demotion rate falls at the same time because a worker in a higher level needs to fall further behind in the productivity ranking, because there are now more slots in his current job level. This requires a worse output signal. The demotion rate falls because larger negative output signals are less likely due to the distributional assumptions about ϵ and θ.

QED

As the firm has to promote more workers, average productivity among promotees – and hence average productivity on higher job levels – tends to fall. This is because the productivity of additional workers, who have to be promoted to fill the extra positions in higher levels that become vacant because of the expansion, is lower than that of the workers who would have been promoted without an expansion. The decline in average productivity is stronger, the more pronounced and faster the expansion is.[25] The firm

[24]The promotion rate would even rise if only a fixed fraction of positions that become vacant in management levels are filled by promoting incumbent workers. The rise in the promotion rate during an expansion is stronger, the larger the fraction of promoted incumbents is.

[25]Prescott and Visscher (1980) raise a similar point and argue that the firm growth rate is limited because the firm has to build up organization capital, which includes information accumulation of the type considered here.

has also accumulated less information about promoted workers, who tend to be promoted earlier in their career during an expansion, so that managerial output on higher levels becomes more uncertain. Individual wage tenure profiles are on average steeper in expanding firms, not only because upward career mobility is higher there but also because workers are promoted earlier in their career than they otherwise would be.

4.2 Corporate Contraction and Career Mobility

When the firm cuts the number of production lines, the layoff rate will increases. The hiring rate falls because the expected ability of workers without primary sector experience is lower than that of incumbent workers. Since the firm would like to retain its most productive workers, it fires workers on the production level first and then demotes managers to lower levels. Consequently, the demotion rate increases. Wages of demoted managers tend to fall. Note however, that demoted workers might find it therefore optimal to quit and start a new career elsewhere in the primary sector.[26] If the firm expects to enlarge employment again in the near future, it might want to retain (some of) the demoted managers whose accumulated firm-specific knowledge would otherwise be lost. In that case, the firm might find it optimal not to cut the demoted manager's wage.

The hierarchical structure will be unaffected after the employment adjustment is made, because relative number of job slots in different hierarchical levels is independent of the size of the organization, i.e. the number of production lines, as the span of control at each level is fixed. Since expected future rents are larger for more able workers, the firm tends to fire low-ability workers first. Moreover, it tends to dismiss predominately workers with short tenure for two reasons. First, they have lower levels of firm-specific capital. Second, fewer workers in young cohorts have exceptionally high expected returns because expected ability converges only gradually to the true distribution of ability.

Firing is likely to occur in all levels, because there are workers assigned to higher levels who have much firm-specific experience but mediocre ability. These workers are likely dismissed, while a very able but less experienced worker, who is currently less productive and hence assigned to a lower level,

[26]The gain from quitting is higher, the longer the remaining expected labor market career is and the higher expected productivity is. Young workers tend to be more likely to quit in the real world because their expected remaining labor market career is longer. However, this issue is not further analyzed here as the simplifying assumption that remaining labor market careers lasts equally long for all workers independent of their age and labor market experience.

but expected to climb the productivity ranking fast in the future, might be retained. Ability differences and the shape of the function that captures specific capital acquisition on-the-job therefore determine the individual layoff risk.

The firing policy also depends on the firm's expectation of future firm size. If the firm expects to grow again in the future, it has to trade off the cost of hoarding labor against lower future rents. Cost of hoarding labor are wages that have to be paid to workers who are not required to satisfy current product demand. Lower future rents result if the firm dismisses workers now, but increases employment in the future, because it takes time until new entry cohorts have built up the same stock of skills that is destroyed when workers are dismissed in the downturn.

The promotion rate decreases because fewer slots have to be filled. Expected productivity has to increase substantially for a worker to jump up to ranks that qualify for promotion. This requires a very positive output signal. Since large deviations from the mean become less likely, fewer workers are promoted.

5 Firm-Specific Training

In this section I consider the effect of firm-specific training on job mobility. Training is assumed to raise productive skills of worker n, which are now given by

$$\omega_n = \theta_n h_f(t, T), \tag{17}$$

where T is the number of units of training that costs c_T per unit to provide. Training costs are sunk costs as the training only raises productivity at the current employer. Expected returns to training rise with the worker's ability θ_n and are higher in higher job levels.

The training policy of a firm involves three decisions: (1) whom to train, (2) how much training to provide and (3) when to train. I consider two scenarios in turn. In the first, I abstract from the timing decision and assume that firms can only train workers in the first period, thus evading the complications associated with the value of the option option to postpone the irreversible training investment. In the second scenario, I assume that firms can train workers during their entire career.

5.1 Training in the First Period

Since expected ability μ_θ^0 is identical for all new hires without prior primary sector work experience, their separation rates and promotion probabilities are identical. As a result, the expected return on a training investment is the same for all members of an entry cohort. The firm therefore trains all workers equally. The amount of training depends on future expected rents captured by the firm, as the firm chooses the optimal amount of training to balance the cost and returns of the training investment. More training is provided the lower are separation rates after the first period, the more able retained workers are expected to be, the more a representative worker learns on the margin (i.e. the bigger $\frac{\delta h}{\delta T}$), and the higher are marginal returns to productive skills ω in each level.

PROPOSITION 7: *Training increases the promotion chances of more talented workers relative to those of less talented workers.*

Proof: Returns to training, i.e. $\theta\frac{\delta h_f(t,T)}{\delta T}$, are higher, given firm-specific tenure and training, the higher more talented a worker is, i.e. the bigger θ. More talented workers therefore increase their productivity advantage through training relative to less able workers.

QED

Training reinforces the role of ability in later promotion decisions. This is because workers with higher expected ability μ_θ^t after t years of tenure enjoy higher returns to the initial training investment in addition to the higher returns to knowledge acquired on-the-job and become therefore relatively more likely to be promoted fast. Training therefore reduces the time to the first promotion among high-ability workers. The amount by which a unit of training changes relative promotion prospects depends on the specific capital accumulation function h_f and the level of training.

5.2 The Timing of Training During the Employment Relation

Uncertainty about θ creates an option value for the firm to postpone the irreversible training investment. If training can be provided in all periods, the firm will provide less training in the first period, but more in later periods. A training decision will be made based on the updated prior μ_θ^t and its precision. The lower μ_θ^t, the smaller is the optimal amount of training. Less talented workers will therefore be trained less during their career.[27] The smaller is

[27] If the market perceives training investments as a signal on a worker's talent, firms may deviate from such a decision rule for strategic reasons. See for example Prendergast (1992).

the precision of the updated prior, the bigger is the option value of waiting. More formal training courses will therefore be postponed to later stages of a worker's career, the larger is the variance of θ in the population and the slower the firm learns about workers' talents, i.e. the larger is the variance of ϵ. As more is learned about θ over time, the option value to postpone training decreases with firm-specific tenure. The firm provides the training when this option value falls below the net return of the formal training course.[28]

The training decision also interacts with the assignment decision. Since ability is not observed, there is uncertainty whether and when a worker will be assigned to a higher level, which creates uncertainty about the rates of return to training. This uncertainty about rates of returns to training vanishes upon promotion. A promotion increases the rate of return to training and reduces the option value of postponing training. Therefore training becomes more likely shortly after the promotion decision is taken.

PROPOSITION 8: *Training will be provided throughout a worker's career. But formal training is concentrated around the time of promotion.*

Proof: Training investments are spread out over a worker's career because of the option value to postpone the training investment, which stems from uncertainty about rates of return to training. Returns to training rise for promoted workers, because of the magnifying scale effect of managerial decisions. As returns to training rise, the optimal amount of training also increases, so that additional training is likely to be provided upon promotion.

QED

If training and on-the-job learning are substitutes, the firm will provide more training during an expansion for two reasons. First, more workers are promoted, so that the returns to training jump for a bigger group of workers. Second, some workers are promoted earlier than they otherwise would be. Since these workers have a lower stock of specific human capital invested in them, the marginal returns of training will be higher for given talent due to the concavity of h_f.

Workers in higher positions of the job hierarchy are trained more on average. Firm-specific training makes demotions less likely, because it gives workers on higher levels an additional productivity advantage. Since the full return of the marginal training investment will not be realized in the lower

[28] If the remaining expected career duration decreases over time, returns to later training experiences fall because of the shorter amortization period of the investment. This would be taken into account.

level, the ability advantage of a worker on a lower level has to be stronger to lead to his promotion and a simultaneous demotion of the worker assigned to the higher level, who has received more formal training. To see this, consider two workers of the same cohort. Worker j is assigned to level L_2, while worker i is still on level L_1 because past output signals have been less favorable for worker i. Worker j has received additional training so that the stock of his training investments T_j exceeds those of worker i. Suppose now, that new information is revealed that pushes worker i's expected ability above that of worker j's. If there were no training, worker i would be promoted to replace worker j, who would be demoted. But assume that worker j is currently still more productive because of the additional training. The firm could provide additional training to worker i and promote him to replace worker j, but it has to take into account the lower return to the training investments in worker j. The firm will not train worker i as long as the net returns of the investment are lower than the foregone earnings associated with the assignment of the less talented worker j to the higher level. Therefore, re-assignment tends to require bigger differences in ability, when training is costly and workers in higher ranks have been trained more.

6 Conclusion

The paper has developed a model of careers in organizations that is consistent with a broad pattern of evidence provided by a growing recent empirical literature. Integrating learning, human capital acquisition and job assignment proved to be a valuable route towards a better understanding of career mobility and earnings dynamics of workers. The model emphasizes especially the scarcity of jobs on different hierarchical levels. I feel that impact of the firm's demand for different jobs has received too little attention in the theoretical literature. It is an essential element to explain promotion and turnover dynamics, especially in non-stationary corporate environments.

Directions in which the analysis can be extended include the integration of more general forms of human capital accumulation or extending the analysis to a general equilibrium framework. Important progress could also be made by directing attention to other aspects of the employment relation. For example, the provision of incentives has not been considered explicitly. It would be interesting to analyze, whether and how performance alters over a career when workers can choose effort levels, or how performance impacts on job mobility and earnings dynamics. The relative importance of job assignment, ability, human capital accumulation and effort provision for career advancement and wage growth should also be assessed in future work.

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