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Wage Compensation and Mobility Patterns Within Unionized Firms: The Role of Internal Labor Markets

1. Introduction

In contrast to the labor economists who stress human capital considerations and labor market contractual arrangements as determinants of individual worker job advancement and earnings growth, the landmark "institutional" work of Doeringer and Piore (1971) and Slichter, Healy and Livernash (1960) stresses the importance of administrative rules, workplace norms, and explicit contracts such as collective bargaining agreements.[1] While industrial relations researchers investigating firms internal labor markets have recognized the importance of both views, very little theoretical or empirical work has attempted to integrate knowledge of how the mechanisms by which internal labor markets operate in individual companies with traditional economic models of the determinants of within-firm worker mobility and compensation. This paper develops an integrative model that incorporates the joint roles of employee human capital characteristics and the firm's internal hierarchy as determinants of individual job changes and wage growth, and focuses on a unionized firm as a case to

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[1]Recent empirical studies in labor economics attempting to isolate the role of worker personal characteristics (such as ability and/or seniority) in determining promotions and earnings growth includes Medoff and Abraham (1981), Mincer (1981), Olson and Berger (1982) and Chaykowski and Slotsve (1986), for unionized workers; Wise (1975) for nonunion workers; Killingsworth and Reimers (1983) for the public sector; and Abraham and Medoff (1985) for a union-nonunion comparative study. An example of an attempt to model and empirically evaluate the role of firm hierarchy and workforce demographics is Stewman and Konda (1983) and Beckman (1978). Finally, Rosenbaum (1980) explicitly examines the mediating influence of level hierarchy on the effects of personal characteristics in determining earnings variation among employees within a single firm.

illustrate the determination of mobility patterns and wage growth within large firms.

There have been numerous explanations offered in the labor economics literature to explain observed seniority-wage and seniority-earnings profile shapes. Two explanations of observed seniority-earnings profile shapes are the incentive contracts and insurance contracts models.[2] However, recent empirical evidence, from a study by Abraham and Farber (1987), does not support either of the two preceding explanations.[3]

Other contributions include variations of human capital models [Becker (1961), Mincer (1974)] and job matching models [Jovanovic (1979), Johnston (1978), Slotsve (1987)]. According to human capital theory the concavity of the age-earnings profile is a result of the division between the worker and the firm of payments for training costs when firm specific human capital is accumulated. While part of the explanation for concave age-earnings profiles undoubtedly lies with these models, they may be supplemented by the job matching models.

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[2]With incentive contracts the firm pays a worker less than the value of their marginal product early in their career and more than the value of their marginal later in their career to keep the worker from shirking in the early part of their career (Lazear 1981). In contrast, under insurance contracts the firm learns a worker's productivity over time and initially pays the value of the marginal product minus an insurance premium. If a worker's productivity turns out to be low, the wage in all periods is the entry level wage; however, if the worker exhibits high productivity, the wage is bid up (Harris and Holmstrom 1982).

[3]Abraham and Farber (1987, p. 296) state: "While we conclude tentatively that the evidence from earnings functions is not consistent with simple earnings deferral models of incentive contracts or with the simple models of insurance contracts, it is clear that further analysis of the joint determination of job duration and earnings is necessary for a full understanding of long-run employment relationships."

In the job matching models a worker joins a firm and eventually learns the expected value of the worker-firm match. The worker remains at the firm until s/he receives a better offer. In these models, job matching heterogeneity plays the central role in both wage growth and turnover.[4] For example, Altonji and Shakotko [1985] find that the first year of tenure increases employee wages about 5 percent, but that additional years of tenure contribute little to wage growth. Altonji and Shakotko [1985, p. 5] find that when the heterogeneity of labor is accounted for, differences in the seniority-wage profile are dramatically reduced. Also, as may be expected on the basis of the theoretical job matching literature, Abraham and Farber [1987] find that for nonunion blue-collar workers the return per year to seniority is approximately one-quarter of one percent.[5]

Given this context of empirical research, we note that Livernash (1957, p. 78) and Kerr (1954) stressed the important role of "promotion-from-within" policies in the determination of job-changes within internal labor markets.[6] Doeringer and Piore (1971) also point

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[4]Slotsve (1987) develops a job matching model in which the value of a worker-firm match is characterized by the productivity of the worker, the promotion rule governing intra-firm mobility, and the grade ratio. The promotion model of this paper follows this model.

[5]However, Abraham and Farber (1987) cannot reject the hypothesis that the return to seniority is statistically different from zero.

[6]Livernash (1957, pp 78) notes that:

"...the vast proportion of job vacancies in any plant or company is filled today, not by hiring from the outside, but by promotion from within the organization."

This view is also supported by Kerr (1954, pp 101) who states:

"Not all jobs are open at all times to all bidders except in the structureless market. Even in the absence of institutional rules, most employees consider a job not open for bid so long as the incumbent out that two important factors that give rise to internal labor markets (and hence promotion systems internal to specific firms) are skill specificity and the task idiosyncracies of jobs within the organization.[7] In turn, Williamson, Wachter and Harris (1975) attribute task idiosyncracies to the existence of unique equipment, specific operating processes, informal teams, and firm-specific communication and information channels.[8] To the extent that task idiosyncracies are accentuated and become more pervasive as a

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fills it satisfactorily; and employers generally prefer to promote from within to canvassing the outside market."

The existence of a strict internal labor market is consistent with the view that the underlying promotion system is a critical determinant of within-firm worker mobility and wage growth.

[7]Doeringer and Piore (1971, pp 15-16) state:

"Almost every job involves some specific skills. Even the simplest custodial tasks are facilitated by familiarity with the physical environment specific to the workplace in which they are performed. The apparently routine operation of standard machines can by importantly aided by familiarity with a particular piece of operating equipment .... In some cases workers are able to anticipate trouble and diagnose its source by subtle changes in the sound or smell of the equipment. Moreover, performance in some production and most managerial jobs involves a team element, and a critical skill is the ability to operate effectively with the given members of the team. This ability is dependent upon the interaction of the personalities of the members, and the individual's work "skills" are specific in the sense that skills necessary to work on one team are never quite the same as those required on another."

[8]Williamson, Wachter and Harris (1975, pp 256-257) find that task idiosyncracies arise in the following ways:

"(1) equipment idiosyncracies, due to incompletely standardized, albeit common, equipment, the unique characteristics of which become known through experience; (2) process idiosyncracies, which are fashioned or "adopted" by the worker and his associates in specific operating contexts; (3) informal team accommodations, attributable to mutual adaptation among parties engaged in recurrent contact but which are upset, to the possible detriment of group performance, when the membership is altered; and (4) communication idiosyncracies with respect to information channels and codes that are of value only within the firm."

consequence of the introduction of new technologies, we expect the importance of such firm-specific institutional characteristics to increase.

Variations in the type of the promotion system used may help to explain the above empirical findings since observing a worker with long service within a job grade implies that the employee has been passed over for promotions more often. Further, if the wage is attached to the job, (possibly with small tenure adjustments), as is the case in many internal labor markets, then we would expect small wage returns to within-grade seniority. That is, in both unionized and non-unionized firms we would expect that a promotion system where the most senior worker minimally qualified (based on training or ability) to perform the next job up the ladder receives the promotion to have a substantially different effect on the return to seniority within the firm than a system that uses ability as the sole promotion criterion. The result is that we expect wage growth in the short run to be strongly influenced by the particular promotion system used in an organization.

In many blue-collar environments the wage is attached to the job and not to the worker.[9] In a structural model of this environment human capital variables affect the probability of obtaining a job-change (which may involve a corresponding change in the wage rate). However, the probability of a job-change, and consequently the wage and earnings growth of the employee, is also affected by both the

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[9]For an in-depth discussion of this, see Doeringer and Piore (1971). Chaykowski and Slotsve (1986) provide a case study of the role of seniority as a determinant of job-changes in a unionized firm where wages are attached to the job-type.

particular internal hierarchical structure of the job ladder and the promotion criteria used by the firm.

In contrast to other studies, we propose to combine a human capital view with an analysis of how the structure of the job-hierarchy jointly determine worker job-change opportunities and hence earnings growth over time in a unionized firm. In this way we will be able to integrate, on the one hand, how personal worker characteristics such as seniority, ability or training affect job-changes and earnings, and how on the other hand the actual job hierarchy (wage structure) of the firm determines job-changes and earnings. This approach allows us to incorporate firm-specific institutional considerations into the basic economic framework of our analysis.

Then, using a particular unionized firm as a case, this study represents a further departure from previous work in two ways: first, we describe how a particular form of job evaluation system is used to allow the union and firm to jointly determine the wage hierarchy within the firm (that is, attach wages to job-types) and we discuss the determinants of within firm job-changes under the collective bargaining agreement; second, we analyze the likely impact on job-change opportunities and wage growth of changes in the structure of the internal job hierarchy (for example, as a consequence of the impact of technological changes that either add new job-types or eliminate existing job-types) and changes in the promotion rule used at the firm.

In the second and third sections we present a model of a typical promotion system used at unionized firms taking into account internal firm structure. In the fourth section we focus on a single refinery of a Canadian firm and we provide a description of the internal hierarchy of the particular firm, the collective agreement rules governing job changes, and describe the determination of the internal wage structure of the firm. This is followed by a brief conclusion.

2. Intra-Firm Job-Change Rules

In what follows we assume that employees are interested only in wage-increasing job-changes so that the relevant job ladder is the wage hierarchy.[10] In practice there are typically a different number of employment positions associated with each job-type in the firm, and there are many job-types associated with a given wage level. We assume that the composite skill requirements for each different job-type at a given wage level are comparable, so that with regard to skills, all workers at a given wage level may be eligible for promotion to job-types at the next highest wage level, regardless of their current particular job-type. Therefore, a "grade" level is defined to consist of the total number of employment positions across job-types at a given wage level: a grade maps the number of job-types of similar composite

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[10] There are several general measures of alternative observed wage hierarchies. Stewman and Konda (1983) examine the effects alternative grade ratios, vacancy chains and managerial selection preferences on a worker's "career prospects" in different firms. Stewman and Konda (1983) define the grade ratio (GR) as the ratio of the number of workers at job level j to the number of workers at job level i, where j>i; a multiple grade ratio (MGR) as the ratio of the total number of workers above job i to the number of workers at job i. The multiple grade ratio yields greater promotion opportunities through vacancy chains than the simple grade ratio at all but the highest job. However, the multiple grade ratio is also dependent on the definition of the job ladder.

There are two problems with grade ratios and multiple grade ratios. First, each measure should be weighted by the probability that workers above your current position will create a job opening. Second, rather than competing with all workers at your current job, a worker only competes with workers at his current level that are eligible for promotion and are ranked ahead of him according to the managerial selection criterion.

skill requirements at the same wage rate into a single classification (grade).

Section 2.1 characterizes a unionized employee's probability of a promotion given the job-change rules specified in a typical collective bargaining agreement. Then, in Section 2.2, we present the individual employee's mobility decision given the worker's assessment of the likelihood of receiving a promotion to the next grade level. The employee must decide whether to remain within their current job ladder, leave to join a new job ladder within the firm's internal labor market, or exit the firm.

2.1 The Probability of a Promotion

A grade g worker is "eligible" for promotion given the worker has successfully completed the required grade g+1 training. We will assume that all workers at grade g apply to receive the necessary training for grade g+1; however, only workers with ability draws, a, greater than a^*_{g+1} successfully complete the training courses for grade g+1 job-types.

A worker's ability draw is assumed to be unobservable to the firm. The firm only observes whether or not a worker at grade g has successfully completed the required g+1 training. That is, the firm observes the indicator function $T_{i,g+1}$, where:

$T_{i,g+1} = 0$ if the i^{th} grade g worker does not successfully complete the required g+1 training (i.e., $a_i < a^*_{g+1}$).

$= 1$ if the i^{th} grade g worker does successfully complete the required g+1 training (i.e., $a_i \geq a^*_{g+1}$).

Thus, in this model training serves two purposes. The first purpose may be thought of as increasing the worker's human capital. Whether general or specific human capital is augmented depends upon the type of training received. The second purpose of training is to screen low ability workers (workers with poor worker-firm job matches) from further promotion.[11]

We assume that all eligible employees (i.e., $T_{i,g+1} = 1$) working at wage grade g apply for a promotion to wage grade g+1 when a job opening occurs in grade g+1.[12] This assumption allows us to ignore the effect of the probability that a worker eligible for promotion will apply for a job-change on the probability of an actual promotion. We also assume that the probability of an opening occurring at wage grade g+1 is independent of the promotion probability from grade g to grade g+1.

The probability that the i'th individual who is eligible for promotion at wage grade g receives the promotion to wage grade g+1 is defined as:

$$\text{Prob (promotion } i\text{, grade } g \mid T_{i,g+1} = 1) \equiv$$
$$\text{Prob (opening at grade } g{+}1)\text{*Prob (promotion } i\text{, grade } g \mid \text{opening at grade } g{+}1 \text{ and } T_{i,g+1} = 1)$$

The first term on the right hand side of the equation is the probability of an opening at grade g+1 and the second term is the

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[11]The indicator function T can also be specified as a function of worker ability; that is T = f (ability). However, since the ability of the worker is unobservable to the researcher, human capital variables such as formal education, experience and previous training may be used to proxy ability. The researcher estimates the limited dependent variable equation T = f (formal education, experience, previous training, . . .). Thus, the usual human capital variables enter our model of earnings growth through the training indicator function.

[12]See Olsen and Berger (1982) for an earlier attempt at modelling promotion rules.

probability that individual i obtains the promotion from grade g to grade g+1, given that there is a grade g+1 position available and that individual i successfully completed the required grade g+1 training.

Openings in a given job ladder are presumed to occur when workers leave their current job ladder or when workers are terminated.[13] Openings are modeled as a Markov process where termination is the absorbing state. We will assume that the distribution of the number of positions opening due to termination is binomial with parameters N and γ where N is the number of positions and γ is the probability that a worker is terminated. Thus, the number of grade g positions available in a ladder as a result of a termination is a binomial distribution with parameters (N_g, γ) where N_g is the number of grade g employees.

Consider the following seniority-based promotion rule in a collective bargaining agreement clause governing job-changes at the firm:

Promotion Rule[14]: Given an opening occurs at grade g+1 within a job ladder, the most tenured person at grade g who is minimally able to perform the grade g+1 job requirements receives the promotion.

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[13]Here terminations are broadly defined to include a permanent health disability that precludes further employment with the firm, death, firing, or retirement.

[14]The firm in this analysis has a collective bargaining agreement covering an hourly-rated workforce of greater than 500 employees. In Canada, as of 1984, 39% of all collective bargaining agreements (with at least 500 employees), covering 33% of workers in all industries, had a seniority-related clause for promotions which is consistent with the use of seniority as the determining factor in the decision rule for filling a vacancy, when all other factors stipulated as requirements to capably perform the job are fulfilled by the applicants. Further, of all collective agreements covering at least 500 employees (as of July 1984), 11.9% of manufacturing collective agreements and 27.3% of non-manufacturing agreements had a promotions clause with seniority that stipulated straight seniority if other factors are sufficient or equal. See Table 8, p. 11, Provisions in Major Collective Agreements in Canada Covering 500 and More Employees, Labor Canada, 1984.

Under this contract clause, the probability that individual i at grade g is promoted, given a grade g+1 opening and that the individual is eligible for promotion, is given by the following expression:[15]

Prob (promotion i, grade g | grade g+1 opening and $T_{i,g+1} = 1$)

$= 1$ if $a_{i,g} > a^*_{g+1}$ and $t_{i,g} > t_{j,g}$ $j \neq i$ at grade g.

$= 0$ otherwise.

Here $a_{i,g}$ is the ability of the i^{th} individual at grade g; a^*_{g+1} is the minimum required ability level to be promoted to grade g+1 in the internal ladder; and $t_{i,g}$ is the tenure of the i^{th} individual at grade g. Note that successful completion of training is a necessary but not a sufficient condition for promotion.

Now consider a worker, eligible for promotion, ranked r at grade g in period t. A worker at grade g is faced with three cases of alternative transition probabilities in period (t+1). The first case corresponds to the probability of remaining at rank r and also remaining at grade g. The second case corresponds to the probability of obtaining rank s (r<s) but remaining in grade g. Finally, the third case identifies the probability of obtaining a promotion to grade (g+1) with a corresponding new ranking.

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[15]We cannot determine a priori how rigorously firm or collective agreement job-change rules will be enforced in practice. For example, we would expect different departments within a company or different supervisors within a particular department to interpret and implement a given job-change rule differently, depending upon variations in past practices and in individual judgement within an organization. Consequently, it is an empirical matter as to the precise relative weights that various criteria are assigned in determining job-changes.

Case 1

In the first case, the probability of remaining at rank r in grade g, (P^g_{rr}), is defined by the following expression:

$$P^g_{rr} = P_0(1-\gamma)^{r-1} \qquad \text{for } q=0$$

$$= 0 \qquad \text{for } q>0 \qquad (1)$$

where q is the number of voluntary quits that occur at positions above the rth ranked worker at grade g and P_0 is the probability that no workers terminate employment at grades above g.[16] The transition probability (P^g_{rr}) occurs when no openings are available above grade g and when no one ranked above rank r and grade g changes their position.

Case 2

In the second case the probability of remaining at grade g but changing from tenure rank r to tenure rank s, (P^g_{rs}), is given by the following expression:

[16]At any grade g workers can be divided into the following two groups: workers that are eligible for promotion ($a_{ai} \geq a^*_{g+1}$) and workers not eligible for promotion ($a_{ig} < a^*_{g+1}$). The workers who are eligible for promotion are then assigned their grade g rank based on tenure. That is, the most tenured worker eligible for promotion is assigned a rank of one and the least tenured worker eligible for promotion is assigned a rank of NE. NE is the number of workers eligible for promotion at grade g. Similarly, the workers who are not eligible for promotion are assigned their grade g rank based on tenure where the most tenured worker of this group is assigned the grade g rank NE + 1.

$$P^g_{rs} \mid q = \sum_{k=0}^{\mathrm{Min}(r-s-q,\ N^g-q)} P_k \binom{r-k-1}{r-k-s} \gamma^{(r-s-k)} (1-\gamma)^{(s-1+k)}$$

for $r>s$, $r-s \geq q$

$= 0$ for $r>s$, $r-s<q$ (2)

$= 0$ for $r<s$.

where $P_k = \binom{N^g-q}{k} \gamma^k (1-\gamma)^{N^g-q-k}$ is the probability of k openings at grade g+1 and N^g is the number of positions above grade g.

The transition probability P^g_{rs} occurs when either quits or terminations occur above grade g <u>or</u> when quits/terminations among employees ranked above rank r at grade g occur. Note that two types of "quits" may occur. The first occurs when a worker leaves their current job ladder by exiting the firm. (This will only occur for those who are ineligible for a promotion.) The second occurs when a worker transfers between job ladders within the firm thereby "quitting" their current job ladder. All quits are taken to be employee initiated.

<u>Case 3</u>

Finally, the third case involves the probability of a worker moving from grade g (given the worker is ranked r) to grade g+1, (P^g_{ro}):

$$P^g_{ro} \mid q = \sum_{j=\mathrm{Max}(0,1-q)}^{N^g-q} P_j \gamma^{\mathrm{Max}(0,r-j)} \quad \text{for } r \leq N_{g+1}-q \text{ and } a_{ig} \geq a^*_{g+1}$$

(3)

$$= P_{(r-1,0)}\, \gamma \quad \text{for } r > N_{g+1}-q \text{ and } a_{ig} \geq a^*_{g+1}$$

$$= 0 \quad \text{for } a_{ig} < a^*_{g+1}$$

where $P_j = \binom{N^g - q}{j} \gamma^j (1-\gamma)^{(N^g-1-j)}$.[17]

A nonzero transition probability requires that sufficient vacancies be created by quits or terminations above grade g in order to allow all employees ranked at least r at grade g to be promoted into grade g+1.

Equations (1), (2) and (3) will allow us, in what follows, to separately identify four factors affecting a worker's career: (1) the number of quits, q, that occur above a worker's current grade; (2) the minimum ability level required to be promoted to the next grade; (3) the number of positions at the next grade; and (4) the effect of the number of positions above a worker's current rank via vacancy chains. Next we describe the solution to the worker's mobility decision under the above promotion rule.

2.2 Workers Job-Change Decision Rules

Workers are assumed to be infinite-lived risk neutral wage maximizers and heterogenous with respect to ability. In each period all workers have the same fixed, exogenously determined probability, γ, of moving to an absorbing state, termination. The value of the absorbing state is set equal to zero and we assume that when a worker is terminated a new worker is generated. Workers maximize the present discounted value of an expected wage function of the following form:

$$V_\tau = \text{Max} \sum_{k=\tau}^{\infty} \beta^{k-\tau} (1-\gamma)^{k-\tau+1} E_\tau(W_{j,k}) \tag{4}$$

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[17] It is assumed that workers must remain at each grade for at least one period in order to be eligible for promotion. This waiting period can be thought of as a training period. Consequently a worker cannot be promoted from grade g to any grade above g+1 in one period.

where β is a fixed and known discount rate, $(1-\gamma)$ is the probability of not being terminated, E denotes an expectation operator where expectations are taken with respect to the information available at the end of period $(\tau-1)$, and $W_{j,k}$ is the wage of the worker at firm j at time k. Workers are not allowed access to capital markets and each period consume all of their earnings.

In what follows we consider the information structure available to workers in determining the expected value of staying at their current job ladder at the firm. We assume that when workers first join a firm they must remain there for at least one period and that when workers quit the firm they never return to the same firm. Once they join a firm, workers must remain at each grade level for at least one period. Workers decide to stay at or leave their current job ladder (or their current firm) without information about how many of their co-workers move to the absorbing state of termination. However, workers will be able to determine which and how many of their current co-workers in their job ladder will decide to quit. After workers make their decision to stay or leave, the firm follows the promotion rule to determine which workers receive promotions, in order to fill current vacancies. The firm then hires enough workers to fill the number of entry level job openings created by the vacancy chain.

Since our model is a "pure matching" model (following Jovanovic (1979)), it is not unreasonable to assume the number of quits are known by the worker. In a "pure matching" model the expected value of employment at other firms is constant. Therefore the outside market does not influence quits. Only the expected value of staying at the current firm changes as a worker moves through the hierarchy. Thus, whether or not a worker quits is a function of their grade and their promotion eligibility. However, employees can observe all other workers' current grade and whether or not training required for a promotion has been successfully completed by all of their co-workers. This information is sufficient to determine which workers will quit since the expected value of employment at other firms is constant and the same for all workers.[18]

When a worker joins a firm s/he observes whether or not their ability draw, a, from the ability distribution, G(a), is above or below the minimum ability level required to be promoted to the next grade. As a worker proceeds up the job hierarchy s/he knows with certainty whether or not their ability is great enough to be promoted to the next grade. However, given s/he knows the ability draw is currently great enough to be promoted to the next grade, the employee is also able to calculate the probability that their ability draw will be great enough to be promoted to any other grade above their present level in their job ladder.

Ability is assumed to be independently and identically distributed across workers and firms. Further, we assume that upon entering a firm's job ladder workers observe which of their co-workers are eligible for promotion and the corresponding tenure ranks of eligible co-workers.[19] Given this information and consistent estimates of the

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[18]A possible extension to the model would be to endogenize quits. This would entail specifying a quit probability for each worker as a function of the worker's outside offers; that is, specifying a mixed "matching-search theoretic" model.

[19]That is, workers know which of their co-workers have successfully completed the training required to be promoted to the next grade level.

parameters of the model, workers can calculate the promotion probabilities given by equations (1), (2) and (3). Then, using this information, workers are able to calculate the expected value of staying in their current job ladder or leaving. Let $r=1, 2, \ldots, N_g$ index a worker's grade g tenure rank where of the workers eligible for promotion, the worker with the greatest tenure has an index of $r=1$.

The value of staying in their current job ladder at the firm, in time τ, given the worker has rank r at grade g and <u>is</u> eligible for promotion, and that q quits occur, is:

$$(V^g_{\tau,r}|q, a_{i,g} > a^*_{g+1}) =$$

$$(1-\gamma)\ \beta[W_g(1-(P^g_{ro}|q)) + E(V^{g+1}_{\tau+1})\ (P^g_{ro}|q) + \beta \sum_{s=1}^{N_g} (P^g_{rs}|q)\ V^g_{\tau+1,s}] \qquad (5)$$

where the expected value of being promoted to grade g+1 is:

$$E(V^{g+1}_{\tau+1}) = \text{Prob}\ (a \geq a^*_{g+2}|a \geq a^*_{g+1})\ (V^{g+1}|a \geq a^*_{g+2})$$

$$+ \text{Prob}\ (a < a^*_{g+2}|a \geq a^*_{g+1})\ (V^g|a < a^*_{g+2})$$

and $P^g_{ro}|q$ is the probability of the r'th ranked worker being promoted to grade g+1 and $P^g_{rs}|q$ is the probability that the worker moves from rank r this period to rank s next period at grade g.

The value of staying in a job ladder at the current firm given the worker is at grade g and is <u>not</u> eligible for promotion is:

$$(V^g|a_{i,g} < a^*_{g+1}) = W_g[(1-\gamma)\beta/(1-\beta(1-\gamma))] \qquad (6)$$

Each period the worker has the option of leaving the current firm and joining another firm. The value to the worker of leaving the current firm, V_L, is given by:

$$V^L = V^E[(1-\gamma)\beta/(1-\beta(1-\gamma))]-\beta(1-\gamma)c \tag{7}$$

where V^E is the expected value of an offer in the outside labor market and c is the mobility cost. We assume that V^E is constant.

Now consider an establishment with two internal job ladders as exists at the unionized firm examined below in Section 3: the job ladder corresponding to employees involved in production responsibilities is referred to as Operations and the job ladder corresponding to employees responsible for maintenance is identified as the Maintenance job ladder. The three choices confronting a worker currently in the Operations job ladder include the following: remain in the Operations job ladder; transfer from the Operations job ladder to the Maintenance job ladder; and to quit the firm. Note that for a worker to be eligible to transfer from Operations to Maintenance, they must in practice pass an aptitude test. In the event that a worker is not eligible for a transfer the remaining choices faced by a worker are to remain in the Operations job ladder or to leave the firm. In what follows we will consider the workers decision problem under the cases where the worker either _is not eligible_ or _is_ _eligible_ for a transfer into an alternative job ladder, respectively.

Decision Rule for Workers Not Eligible for a Transfer:

A worker who is not eligible for transfer to another job ladder may have one of two value functions in the Operations job ladder. The first value function, given by equation (5), is for a worker of rank r, grade g, and whose ability draw is greater than or equal to the minimum ability level required to be promoted, a^*_{g+1}. In this case the value to the r'th ranked worker of staying one more period at the current firm is βW_g times the probability s/he is not promoted next period. The second term is the expected present discounted value of being promoted times the probability s/he would be promoted next period. The last term is the expected present discounted value of remaining at the firm for more than one period at grade g given s/he is not promoted to grade g+1 next period. The second value function given by equation (6) is for a worker of grade g, who is not eligible for a promotion.

Since the worker is ineligible for a transfer, in deciding whether or not to leave the firm, s/he compares the value of remaining at the firm (given by equation (5) if s/he is promotable and equation (6) if s/he is not promotable) to the value of leaving the firm (given by equation (7). We conjecture that the worker's decision rule is of the form[20]:

If $a_{i,g} > a^*_{g+1}$ then stay at the current firm.

If $a_{a,g} < a^*_{g+1}$ then quit iff $c < c_g$

stay iff $c \geq c_g$

where c_g is the reservation mobility cost at grade g.

If $a_{i,g} < a^*_{g+1}$ then the worker receives the value given by the expression of equation (6) if s/he stays at the current firm and the value given by equation (7) if s/he leaves the current firm.[21]

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[20]See Chaykowski and Slotsve (1987) Appendix 1 for proof.

[21]Equating the value of staying and leaving the current firm yields the reservation mobility cost:

$$c_g = [V^E - W_g]\ [1/1-\beta(1-\gamma)].$$

Thus, if $a_{i,g} < a^*_{g+1}$ then quit iff $c < c_g$

stay iff $c \geq c_g$

The steady state value function for a grade g worker in the Operations job ladder, in matrix form, is given by[22]

$$V^g|_{a \geq a_g^*} = \left[\frac{0}{Q_g[I-\beta Q_g]^{-1}W_i^g} \right] \qquad (8)$$

where 0 is the value of the absorbing state, and the first element of $Q_g[I-\beta Q_g]^{-1}W_i^g$ is the expected value of being promoted to grade g+1. The remaining elements are the value of being in the state (grade-g, rank-r, quits-q). (See Appendix 2. of Chaykowski and Slotsve (1987) Q is a matrix of transition probabilities as long as a worker is alive and W_i^g is a column vector of the wage attached to each grade.

<u>Decision Rule for Workers Eligible for Transfer Between Job Ladders</u>:

A worker who is eligible for transfer must choose between two distinct movement possibilities available, including the choice of leaving the firm and the choice of transferring from the Operations to the Maintenance job ladder within the firm. For those employees deciding to exit the firm the decision rule is the same as above. Therefore, in what follows, we consider the decision rule for those workers who wish to transfer between job ladders.

Workers transferring from grade g in the Operations job ladder must enter at the port of entry level grade (g-N) in the Maintenance

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as conjectured. Note that if the wage is increasing as a worker moves up the grade hierarchy, the c_g is decreasing as a worker moves up the grade hierarchy. Assuming that the mobility cost, c, is the same for all workers, then if $c=c_g$ all workers not eligible for promotion who are at grade g or above stay at the firm and all workers not eligible for promotion who are below grade g quit the firm.

[22]Refer to the Appendix 2 of Chaykowski and Slotsve (1987) for the derivation.

job ladder. A worker compares the value of remaining in the Operations job ladder, $[(V^{g}_{\tau,r}|q,a_{ig}\geq a^{*}_{g+1})]$, to the value of transferring to the Maintenance job ladder, $[(V_{\tau,r}|q^{'}_{1},a_{i,1}\geq a^{*}_{g})]$, (noting that the value function in either job ladder is defined analogously).

Now, the value of remaining at grade g in the Operations job ladder is given by:

$$(1-\gamma)\ \beta[W_g + \{E(V^{g+1}_{\tau+1}|q') - W_g\}\ (P^{g}_{ro}|q) + \beta\sum^{N_g} (P^{g}_{rs}|q)\ V^{g}_{\tau+1,s}] \qquad \text{(Operations) (9)}$$

The value of moving to grade i in the Maintenance job ladder is:

$$(1-\gamma)\ \beta[W_1 + \{E(V^{2}_{\tau+1}|q') - W_1\}\ (P^{1}_{ro}|q) + \beta\sum^{N_1} (P^{1}_{rg}|q)\ V^{1}_{\tau+1,s}] \qquad \text{(Maintenance) (10)}$$

A worker's decision to move from the Operations to the Maintenance job ladder involves three elements. The first element consists of the transition probabilities. A decision to transfer from the Operations to the Maintenance job ladder requires that the Maintenance job ladder have greater transition probabilities between grade levels, ceteris paribus. The second element involves the magnitude of wage changes between grades within the Maintenance job ladder. If larger wage changes are associated with promotions within the Maintenance job ladder a worker may choose to transfer, ceteris paribus. The third element relates to the required ability cutoff-levels associated with a movement between grades. A worker will choose to move from the Operations to the Maintenance division if the conditional probabilities for a promotion are greater in the Maintenance job ladder.

Under these conditions there will only be a uni-directional movement between job ladders. Note that in practice transfers between the Operations and Maintenance divisions may occur for nonpecuniary reasons such as working conditions and/or an absence of shift work. Finally, the steady state value functions for either job ladder have the same form as given above in the preceding sections.

3. A Manufacturing Case: the Internal Structure, Promotion Rules Under the Collective Agreement, and Wage Determination

The installation studied as a case is a single refinery of a multi-plant Canadian industrial company. The company is a world leader in its product line in the manufacturing private sector and has significant international operations. The employees in the refinery that form the focus of analysis are entirely hourly-rated and blue-collar and reside in an Ontario urban center. A collective agreement covers all of the blue-collar employees at the refinery and was negotiated by a single local of a large international industrial union.

The hierarchial structure of the refinery consists of two major divisions: Operations and Maintenance. Diagram A depicts a schematic representation of the composition of each division. Each of the Operations and Maintenance divisions form an individual job ladder, which together comprise the firm's internal labor market at this refinery. In general, the firm relies almost exclusively on in-plant on-the-job training for the skilling of its workforce. While people most tend to change jobs within either Operations or Maintenance, there are net flows from the various Operations groups into the Maintenance division.[23]

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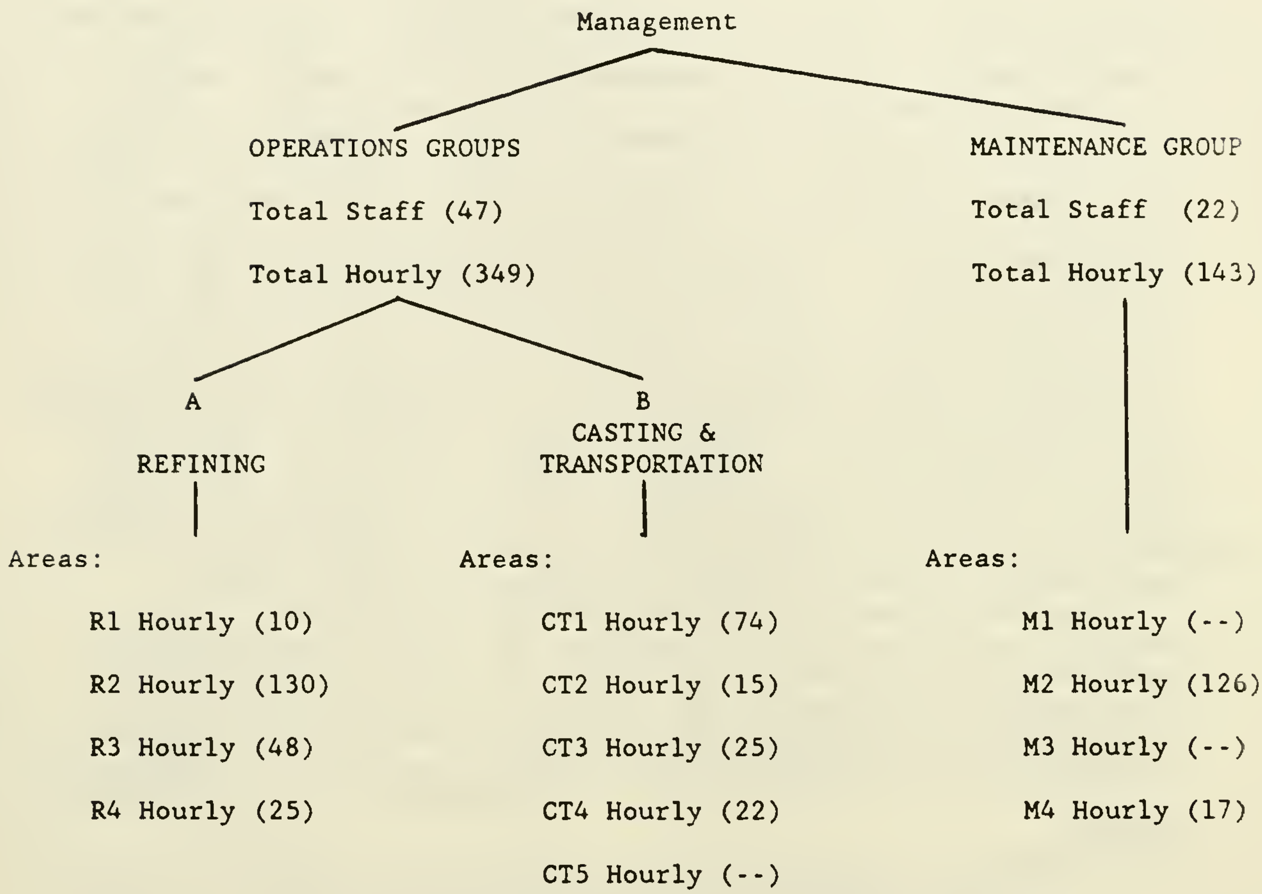
[23]Workers originating in the Maintenance division generally remain with that division.

Diagram A

Refinery Hourly Worker Organizational Structure



Each job-type in the Operations division has a specified amount of formal on-the-job training associated with it.[24] For each job-type, this training generally consists of two generic types. First, "core training" which consists of training modules, each of which covers one specific aspect of the job responsibilities. For example, modules could cover topics such as conveyers, valving, or tagging procedures when working on equipment. Each job-type has a set of such modules associated with it. The number of training modules associated with each job-type may vary from 1 to approximately 10 or 15. When an individual is deemed qualified in each area associated with a job-type then that individual is eligible to apply for that job. The second class of training is termed "operator training," and this may involve substantial on-the-job learning and evaluation by the foreman. Overall, as one moves up the hierarchy the levels of responsibility also generally increase and the worker is typically required to be knowledgeable in all previous jobs they have mastered in a cumulative fashion.

In general, if the k'th job-type has associated with it a fixed number, (n^k), of training modules each providing a given amount of training, (T^k), then the total training requirements associated with the k'th job-type is $n^k T^k$. For the employee occupying the k'th job-type in the Operations division, the total training accumulated by the employee since entering the Operations division of the refinery is

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[24]The emphasis upon specific training in this firm reflects the importance, in general, of task idiosyncracies and specific skills in the operation of internal labor markets. Refer to footnotes 3, 4, and 5 of Section I.

given by the sum of all training received on all job-types prior to and including the k'th job-type,

$$\sum_{i=1}^{k} n_i T_i .$$

Training in the Maintenance division occurs in a manner analogous to that in the Operations division but with important differences. Workers in the Maintenance division change job-types and move up the hierarchy by first fulfilling the training requirements of the next level job. The maintenance worker must complete specific training modules associated with each job-type. However, instead of operator training, the second component of the training requirements in the Maintenance division is on-the-job "apprenticeship." As in Operations, the effect of on-the-job training is cumulative as one moves up the job hierarchy. As in the Operations division, the need for outside training is minimal because in the Maintenance division the tradesmen are likely to have more expertise within the refinery than could be obtained outside the plant.

For the employee occupying the k'th job-type in the Maintenance division, the total training accumulated by the employee since entering the Maintenance division of the refinery is given by the sum of all training received before entering the refinery, (T_o), and on all job-types prior to and including the k'th job-type at the refinery, $\sum_{i=j}^{k} n_i T_i$ where j is the port of entry. Total training is $(T_o + \sum_{i=j}^{k} n_i T_i)$ where $T_o = 0$ and $j = 1$ for those employees transferring into Maintenance without previous maintenance skills.

Cumulative training records of employees are kept up-to-date and are used to determine whether an individual is qualified to obtain a particular job should s/he bid for that job when a posted vacancy arises. The seniority clause governing promotions in the collective bargaining agreement covering the employees of this firm is highly representative of the types of seniority clauses found in the Canadian manufacturing sector: two distinct factors are considered in deciding which applicant will actually fill a job vacancy.[25] The first criterion (factor 1) is the seniority of the applicant. The second criterion (factor 2) is the level of skills, training and ability of the applicant directly with regard to the requirements of the job.[26] The decision rule for filling a vacancy then follows: given that two or more applicants meet the requirements of factor 2, the employee with the greatest seniority will obtain the promotion. In practice, all employees need only fulfill the training requirements of the job to be considered "equal" with regard to factor 2. Consequently, since at this firm only those employees who have fulfilled the training requirements are considered for a job vacancy, seniority always governs, *de facto*. The only relevant ability-related issue is whether an employee's ability is sufficient to complete the requisite training for the next level of job-types in the hierarchy.

The actual wage growth of individual employees within internal labor markets of unionized firms arise through both general wage increases provided to all employees and individual promotion opportunities through the wage hierarchy of the firm. In what follows we discuss the institutional system that gives rise to the wage

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[25]An employee's seniority is defined as their continuous tenure with the company and is transferrable to all plants in the company's division.

[26]Presumably, in practice an applicant that has the requisite skills, training and ability to capably perform the job is deemed to preserve an "efficiency of operation" component of factor 2.

hierarchy observed in the unionized firm studied in this analysis. We concentrate on a unique form of job evaluation system which has been used to determine the wages attached to job-types of both blue-collar and white-collar hourly-rated private sector employees, the Cooperative Wage Study Job Evaluation System (CWS). Pioneered in Canada by the United Steelworkers of America in the steel industry (see Edwards (1973)), the joint union-management program is typically negotiated through collective bargaining and is jointly administered during the term of the contract by a CWS committee composed of representatives of the union and company. Currently, there are an estimated 85,000 workers in Canada covered by some variant of the CWS evaluation system, in the manufacturing, primary, and service sectors.

At the refinery in this study, under the terms of the collective agreement, representatives of the union and the firm form a CWS Committee whose task is to assess the job content of each job on the basis of a set of mutually agreed upon criteria. Essentially, under a CWS system each of four general factors, including the skill, effort, responsibility, and working conditions of the job, are assigned relative weights that determine the relative contribution of each factor in the determination of the wage rate to be attached to each job-type. Specifically, for each job-type the Committee determines the point score to be assigned to each of 12 specific criteria, including pre-employment training (β_1), employment training and skill, (β_2), mental skill, (β3), manual skill, (β_4), responsibility for materials, (β_5), responsibility for tools and equipment, (β_6), responsibility for operations, (β_7), responsibility for the safety of others, (β_8), mental effort, (β_9), physical effort, (β_{10}), surroundings, (β_{11}), and hazards,

(β_{12}). The sum of the point scores assigned each of the 12 criteria uniquely determines the wage level of the j'th job, where a higher total point score corresponds to a higher wage in the hierarchy:[27]

$$w^j = \sum_{i=1}^{12} \beta_i^j \qquad \text{for all } j.$$

In the short run, reasonably defined as the term of the collective bargaining agreement, w^j does not adjust to external labor market conditions nor do the spot wages necessarily reflect, on the margin, changes in the heterogeneity of labor across job-types within the internal labor market.[28] (The wages assigned to only a small number of job-types changes in the short run, so that the entire wage structure is characterized by considerable relative wage rigidity.) To the extent that wages are assigned to jobs on the basis of factors mutually agreed to by employees (through their union) and management, and to the extent that workers are only matched to wages indirectly through assignment to job-types, exclusive managerial discretion is eliminated in the short run.

Finally, it is important to distinguish the effects of union bargaining over general wage increases covering all employees at a single firm, and the determination of wages attached to specific job-

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[27]The determination of the short run wage attached to the job can be thought of as a function of the characteristics and requirements of a job. The specification used in this paper is just the particular form the function assumes at the firm under consideration.

[28]Typically there are many more job-types than there are wage rates. For example, at the firm examined in this study, there are over 90 job-types but only 23 wage rates.

types under the job evaluation system. In the short run, both processes will affect relative wages levels in the same occupation between firms in the local labor markets and across occupations in the economy. For example, a re-negotiation of the relative weights assigned the general factors of skill, effort, responsibility, and working conditions, would alter the point score assigned to each job, thereby resulting in an entirely different wage hierarchy of the job-types within the firm. An alternative wage structure would in turn imply a different structure of compensation within the firm and consequently a different relationship between the wage (and compensation) levels attached to the occupations within the firm relative to similar occupations outside of the firm's internal labor market.

4. The Effects of Changes in Firm Structure and Promotion Criteria on Employee Mobility and Wage Growth

In this section we explore the effects of two exogenous changes to the structure of the internal job ladder facing the worker. First, we consider the effect on the transition probabilities of an increase in the minimum required ability level to perform grade (g+1) job-types (case A). For example, case A may arise as a consequence of the introduction of new machinery or equipment (embodied technology) that requires higher levels of training at a given job-type. Second, we consider the case where the job hierarchy is restructured so that the number of grade (g+1) positions increases.[29] Case B may occur with the

[29] One important issue which we do not address is the dynamics of the transition process by which positions (hence employees) are added to or removed from the hierarchy. Specifically, in Case B we essentially consider a "before and after" hierarchy. This scenario corresponds to a situation in which employees are simply hired into the newly created positions from outside the job ladder. For example, this

introduction of a new production process that requires additional employment to perform the tasks of a particular job-type (or conversely, fewer employees may be required). Alternatively, in the situation where new technology results in additional job-type responsibilities, the CWS committee determines the new β factors associated with the job and may generate a finding that a new job-type (position) should be created at a new wage level corresponding to the recalculated value of the $\sum\beta_i$. Finally, the number of positions could increase in the Maintenance division, for example, if the firm decided to expand the repair tasks performed on specific types of equipment in the plant.

Given a worker is eligible for promotion, it is obvious that the steady state value function is increasing in W_g for workers at grades less than or equal to grade g and is constant in W_g for workers at grades greater than grade g. Further, the value function of workers currently at grades greater than or equal to grade g are unaffected if any of the employment levels at grade g or below are increased.

Finally, the steady state value function is increasing in the number of terminations from above, because when a termination occurs the worker knows with a probability of one that their rank will increase. If the termination had not occurred then s/he would only

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could occur if the introduction of a new technology gave rise to the creation of new job-types that also required skills and training not previously available within the firm. However, a second case that arises occurs when employees are chosen from within the job ladder to occupy the newly created positions--often on the basis of seniority in unionized firms. We do not consider this second case nor do we discuss the potential effects of transition adjustments on employee mobility or wage growth.

probabilistically increase their rank. The steady state value function is therefore not affected by the number of terminations from below.

CASE (A): An Increase in the Minimum Ability Level of a^*_{g+1}

We assume that when the grade g+1 minimum ability level increases, current grade g workers are covered by a grandfather clause. That is, all current grade g workers with $a_{ig}>a^*_{g+1}$ remain eligible for promotion even after the minimum ability level increases. Therefore, only future grade g workers are affected by an increase in the minimum ability level at grade g+1.

The unconditional value of being at grade g is given by

$$V^g = \text{Prob}(a_{ig}<a^*_{g+1}|a_{1,g}\geq a^*_g) \;*\; (V^g|a_{ig}<a^*_{g+1})$$

$$+ \text{Prob}(a_{ig}\geq a^*_{g+1}|a_{ig}\geq a^*_g) \;*\; (V^g|a_{ig}\geq a^*_{g+1}) \;.$$

Thus,

$$\frac{\partial V^g}{\partial a^*_{g+1}} = \frac{\partial \text{Prob}(a_{ig} \geq a^*_{g+1}|a_{ig} \geq a^*_g)}{\partial a^*_{g+1}} *[(V^g|a_{ig} \geq a^*_{g+1}) - (V^g|a_{ig} < a^*_{g+1})]$$

$$+ \text{Prob}\;(a_{ib} \geq a^*_{g+1}|a_{ig} \geq a^*_g)\;[(1-\gamma)\;\beta\;[\frac{\partial E(V^{g+1})}{\partial a^*_{g+1}}]\;(P^g_{ro}|q)] < 0$$

since $\frac{\partial \text{Prob}(a_{ig} \geq a^*_{g+1}|a_{ig} \geq a^*_g)}{\partial a^*_{g+1}} < 0$ and

$$\frac{\partial E(V^{g+1})}{\partial^*_{g+1}} = \frac{-\text{Prob}(a_{ig} \geq a^*_{g+2} \text{ and } a_{ig} \geq a^*_{g+1})}{[\text{Prob}(a_{ig} \geq a^*_{g+1})]^2}$$

$$* \;[(V^{g+1}|a_{ig} \geq a^*_{g+2}) - (V^g|a_{ig} < a^*_{g+2})] < 0$$

That is, increasing the g+1 minimum ability level decreases the unconditional value of being at grade g. As a consequence, the employee is more likely to leave their current job ladder, ceteris paribus.

CASE (B): An Increase in the Number of Positions in the Job Ladder, N_{g+1}

When the number of grade g+1 positions increases, the transition probabilities are affected only if a worker is eligible for promotion. For those eligible workers currently at grades lower than grade g+1, [if N_{g+1} increases to $N_{g+1}+1$], then the conditional promotion probability, $(P^{g}_{ro}|q)$, increases, and the conditional probability of remaining at the current rank, P^{r}_{rr}, decreases. This occurs because there are now more positions into which workers can move; consequently, given eligibility for promotion, workers are better off until they reach grade g+1. However, upon reaching grade g+1 the worker becomes worse off because s/he must now move through one extra rank.

The net effect on the value function of increasing the number of positions from N_{g+1} to $N_{g+1}+1$ is therefore ambiguous and depends on two factors. First, the net effect depends upon the amount of extra time a worker now spends in grade g+1 relative to the now faster movement through grades below g+1. (For example, suppose that the incremental increase in wages as a worker moves through the grades is constant; then the worker is better (worse) off if the relative amount of extra time spent in grade g+1 is less (more) than the time spent moving through ranks at grades less than g+1.) The second factor is the relative size of the wage changes between each grade. (For example, if the wage increments are larger beyond grade g+1 than they are below grade g+1, then workers may be worse off even if the relative amount of extra time spent in grade g+1 is less than the shorter time saved moving through ranks at grades less than g+1.)

5. Summary Remarks

We have developed a theoretical model of worker mobility and wage growth in the short run that explicitly incorporates both the hierarchial structure of the firm and individual worker ability levels. The model yields important implications for employee wage-tenure profiles and yields comparative static effects of changes in the internal structure of the firm and changes in worker ability requirements.

Specifically, a worker's wage path is determined by the stochastic process generating natural job openings, γ and a worker's own ability draw and the ability draw of their co-workers. The time stationary value function is increasing in tenure (through the stochastic process generating job openings and terminations) only as long as a worker is eligible for promotion. Consequently, the model yields a positively sloped tenure-wage profile for a worker only as long as s/he is eligible for a promotion or until she reaches the top grade in the internal hierarchy.

That is, given a worker is eligible for promotion, wages will increase with tenure as long as the worker moves through grades in the job ladder. In the short run, the exact shape of the tenure-wage profile is a function first of the magnitude of the wage change between each grade through which the worker moves and second, of the workers' probability of promotion. A worker's probability of a promotion -- or expected duration at a given grade -- is in turn a function of γ and N.

Note that in the long run the wage-tenure profile is also affected by general wage increases obtained during the renegotiation of the collective bargaining agreement. The particular effect of a general wage increase on profile shape will vary depending on whether the increase is "across the board" or "percentage." If an across-the-board increase occurs then the wage-tenure profile will shift upward in a parallel fashion. However, if a percentage wage increase occurs then the wage-tenure profile will shift and rotate upward.

Finally, it should be noted that over time the firm may experience employment increases as sales grow. As employment levels change, the firm may also determine new ability cutoff levels. The model of this paper may therefore be extended by accounting for an optimal firm design that involves the simultaneous determination of N_g and a_g^*.

The paper has also examined both the structure of jobs and the determination of wage compensation in the internal labor market of a representative unionized firm in the Canadian private sector. The internal labor market of the firm consists of two individual job ladders and workers may either move between the two ladders or exit the firm. Wages are attached to job-types on the basis of the job content of the job-type as determined through the firm's job evaluation system. Future work using the model developed in the paper will use firm-level data to characterize the firm's job structure, generate typical wage profiles, and explore the likely effects of changes in the job structure on wage patterns.

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