Pay Policy for Managers and Professionals at NewTech

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I. Introduction

The availability of firm personnel data has sparked interest in the determinants of firm pay policy and the evolution of pay over careers. In this chapter, I discuss some of the issues posed in working with personnel data, drawing on the example of a technology firm. In particular, I focus on the relationship between pay and two prominent features of this firm's internal organization—job grades and job classifications (titles). There is significant movement of employees between job grades and between job classifications in this firm. The former are more strongly associated with increases in pay but I argue it is misleading to identify moves between job grades with promotions or to identify the job grade structure with the firm's responsibility hierarchy. I also examine transitions between professional and manager job titles. It is commonly held that this transition is important for continued pay growth for technical professionals. I find, however, that moves from manager to professional job titles are also numerically important in this firm, suggesting that the career ladder for technical professionals is more flexible than is typically assumed in the literature.

II. Characteristics of the Data

Personnel records have been obtained from a large multinational technology firm based in the United States, which I identify by the pseudonym "NewTech." An annual year-end record is available for all individuals employed by the principal business unit of the firm during the years 1976-1994.[1] Total worldwide employment in the business unit fluctuated during the first half of the sample period but has remained quite stable since 1985 (Figure 1.1). During the sample period, employment in the business unit ranged between 40% and 50% of total employment in the firm (Figure 1.1).[2] Profitability of the firm (separate figures are not available for the business unit) has fluctuated over the period, with little evidence of a positive trend except for the last several years of the sample (Figure 1.1).

Because records are available only for the business unit, employees at the very highest levels of the firm's managerial hierarchy are not included in the data set. In addition, annual records are not available for employees in the principal business unit during the time that they may have worked in a different business unit in the firm. This restriction creates a special case of censoring for some observations in the data. For these employees, yearly observations on variables such as pay and job title are missing for periods during which they were employed at the firm but in a different unit. However, demographic variables and overall length of service at the firm are still available for such employees.

Descriptive statistics for the pooled sample of managers and professionals are reported in Table 1. Characteristics of the subsample of technical professionals, which comprise 50% of total sample observations, are also reported.[3] On average, technical professionals in the firm are younger, have less tenure, lower salaries, and more education than the overall sample. The overall level of educational attainment in this firm is high. Nearly 30% of the managers and professionals hold a master's degree and 6% hold a doctorate. Compared to previous studies based on personnel data, the proportion of highly educated employees is large. For example, fewer than 10% of the managerial and professionals employees in the Medoff and Abraham (1980, 1981) companies possessed master's degrees, and less than 3% held doctorates. Moreover, only 6% of the individuals in the NewTech sample have less than a four-year college degree. The corresponding proportion in the Medoff-Abraham companies was nearly 50%.

In Table 1, a distinction is made between managers, generally, and supervisors of non-exempt employees. Both types of employees are coded as managers under the Equal Employment Opportunity Commission's job classification scheme but important differences in the characteristics of the jobs and the employees in those jobs should be recognized. Managers, in addition to supervising other exempt employees, are likely to have a broader decision-making component in their work relative to supervisors of non-exempt employees. The career paths of managers and supervisors (of non-exempts) are also likely to differ. Managers are more likely to be hired from outside the firm or to move from a professional exempt job inside the firm. Many supervisors, in contrast, have been promoted from non-exempt jobs inside the firm after accumulating a significant amount of tenure. For these employees, a supervisory job is effectively the top level of a career ladder, even though such jobs are concentrated at the lowest managerial-professional grade levels. Accordingly, I have chosen to remove employees who have previously held non-exempt jobs in the firm from the pooled sample, which reduces the sample size by 5,185 employee-year observations, or 7.5%. This eliminates a group of employees who have relatively high tenure but remain in low job grades for relatively long periods of time, thus complicating the interpretation of the econometric analysis below. Supervisors who were hired from outside the firm into supervisory jobs remain in the sample.[4]

III. Organizational Structure

Several dimensions of the firm's internal organization are potentially relevant for pay determination. At any point in time, each employee's location in NewTech's organizational "space" can be described by a job grade, a job classification (or title), and the job's categorization as managerial or professional. In addition, job classifications are grouped according to function (for example, manufacturing, engineering, marketing, etc.) and each employee is affiliated with a department, a division, and a group within the business unit of the firm.[5] After brief descriptions of the main dimensions of the organizational structure and entry into the structure, I examine the effect of internal movement (between jobs and between job grades) on pay.

Jobs are narrowly defined by a unique 4-digit job classification code and associated descriptive title, such as "engineering manager" or "product engineer." A job classification is essentially a technological description of a particular job, indicating the tasks and skill set associated with that job. It contains no explicit designation of grade level, although this can be surmised in some cases. For example, an engineering manager is likely to be situated higher up in the level structure than a product engineer, given the managerial designation of the former job. Over the sample period, the number of job classifications increased by 75%, from 111 titles in 1976 to 195 in 1994. Fifty percent of the pooled sample observations in 1994 were concentrated in ten job titles, eight of which were technical professional titles.

Jobs are also grouped by function. The first two digits of a job classification code denote the corporate function to which the job belongs. Throughout the sample period, engineering is the largest function in terms of staffing by managers and professionals. (When non-exempt employees are included, manufacturing is the largest function by a wide margin.) Table 2 lists the largest functions, and the number of managerial and professional employees in each, for the beginning and ending years of the sample. The growth in engineering and research personnel during the period is striking. In combination, the engineering and R&D functions grew by 225% between 1976 and 1994. The aggregation of job classifications by function is a useful proxy for occupational and skill differences across managers and professionals. For example, most technical professionals are in the engineering and R&D groups.

Job grade is a principal indicator of an employee's place in the pay and level structures of the firm. Most managerial and professional job classifications are distributed across a set of 11 ordered job grades (A-K). Professional job classifications are not found in grades beyond K. Moreover, the highest ranking professionals in the grade structure (those in grades H-K) are predominantly in R&D job classifications. The six highest grades (L-P and S) are populated by a small number (29 in 1988) of department managers and other upper-level executives. Beginning in 1990, these six grades (grades above K) were consolidated into one grade.

Although average salary increases in job grade, there is substantial salary overlap across grades, which suggests that earnings are not determined solely by job grade. However, relative pay dispersion does not increase across grades, as is evident when salary is plotted on a logarithmic scale (Figure 2). The range of dispersion is approximately constant across grades, consistent with an interpretation of job grades as an administrative construct. Two implications follow from this definition of grades. First, although job grades will be able to explain much of the overall variation in pay when included in an earnings function, they are not a determinant of pay in a causal sense. Second, if administratively-defined pay ceilings exist for grades, some individuals will be bumped up to a higher job grade simply because they've reached the ceiling in their current grade. Hence, not all moves between grades in the data are necessarily indicative of promotions.

Unlike the simple internal labor market model, there are no well-defined ports of entry into this firm; entry occurs in many job classifications and in most levels of the job grade structure.[6] About half of those hired during the sample period entered into the lowest job. But entry also occurs in most of the grades in the bottom half of the grade structure. Educational degree is a good predictor of level of entry in the grade structure, as one might expect for a class of employees whose specialized training is schooling-based. Seventy percent of entrants with a bachelor's degree enter the firm at the lowest grade, A, accounting for almost 90% of all outside entry into that grade. Of entrants with a master's degree, 59% enter at Grade C, accounting for 67% of all outside entry into the grade. And 62% of entrants with a Ph.D. enter at Grade E, although Ph.D.'s account for only 29% of total outside entry into Grade E.

Table 3 decomposes the entrant population during 1976-1994 into manager and professional job classifications and into technical and non-technical jobs. Most hiring occurred in professional jobs. Only 14% of entrants were managers. This pattern is consistent with higher turnover rates and shorter employment durations for professionals relative to managers. However, it also appears to reflect firm policy. Far more managers were hired from outside for non-technical management positions than for technical managerial jobs. Only 9% of managerial entrants were in technical job classes. This suggests that the firm prefers to promote its own technical professionals into the more technically oriented managerial positions rather than hiring from outside.

Several trends in the composition of entering cohorts are evident over the sample period. The percentage of new hires with technical backgrounds (defined by engineering and R&D job classification) has increased steadily, from an average of 47% during the late 1970s to 63% during the 1980s and, on average, 72% during the 1990s. At the same time, the number of new managers entering the firm has fallen from over 20% in the late 1970s to under 5% in the 1990s. The percentage of entrants with advanced degrees (M.S. or Ph.D.) has followed a U-shaped pattern: above 40% during the beginning and ending years of the sample, while ranging from 25% to 30% during the 1980s.

IV. The Effect of Internal Movement on Pay

Before considering the effects of internal movement on pay, it is useful to examine the principal correlates of pay identified by a standard salary equation estimated using the pooled NewTech sample.[7] In Table 4, equations (1) and (3) estimate standard log earnings functions for the pooled sample of all managers and professionals and the pooled subsample of technical professionals. Conditional on previous experience and tenure, there is a large return to education in the firm. Wage growth associated with tenure in the firm is also sizeable, holding education and previous experience constant. However, the estimates imply that given equivalent levels of education and tenure, an employee who has five years of previous experience will earn only between 1% and 1.6% more than an individual with no prior experience. This small return to previous experience suggests that relative to insiders, outsiders with equivalent amounts of overall labor market experience are at an earnings disadvantage at NewTech.

When controls for job grade are added to equations (2) and (4) in Table 4, the size of within-grade earnings differentials become apparent. Little of the return to education occurs within grade-level in this firm, a finding that matches the result reported by Medoff and Abraham (1980). Only about 13% of the total earnings differential between those with a bachelor's degree and those with higher degrees occurs within grade. Evidently, employees with higher degrees are assigned to grade levels with higher average earnings than those with four-year degrees, as noted previously. Unlike Medoff and Abraham however, almost none of the wage growth associated with company tenure and little of the return to previous experience are attributable to higher within-grade earnings differentials. At the mean tenure level in the firm sample, only 1.6% of the differential associated with an additional year of tenure occurs within grade level. At the sample mean for previous experience, only 25% of the earnings differential associated with an additional year of experience occurs within grade. The small within-grade tenure differentials suggest that employees with long tenure within a grade may, on average, experience earnings stagnation or decline. Moreover, employees who experience positive earnings growth from year to year may systematically move through the grade structure, even if they are promoted relatively infrequently. (This is the bumping phenomenon referred to above.)

Promotion is held to be a major determinant of earnings growth inside firms. When jobs are organized into job ladders—sets of hierarchically related job titles—a promotion can be identified as a move from a job title at a lower responsibility level to one at a higher level. At NewTech however, employees move between job classifications and between job grades, and these two types of moves are only weakly correlated. In the pooled sample of managers and professionals, job grade changes were somewhat more prevalent than moves between job classifications. During the 1976-1994 period, 8,827 changes in job grade occurred compared to 7,519 changes in job classification. Approximately 4% of the job grade changes were moves to a lower job grade. The correlation between job classification changes and job grade changes is positive but not large (= 0.198). This pattern of movement indicates that NewTech employees can remain in the same job classification while progressing through multiple job grades.[8] "Horizontal" moves between job classifications, which do not entail changes in job grade, are also common.[9]

Moreover, the movement between professional and managerial titles in the firm is not uni-directional, as the literature on high-tech careers has generally assumed. In fact, a significant number of moves from managerial jobs to professional jobs are observed, suggesting that some technical professionals serve for defined periods of time as project or team managers, much in the manner of academics who serve a term as chair of their department. In the pooled sample of consecutive yearly observations of managers and professionals during 1976-1994, professional-to-manager transitions numbered 1,551, compared to 964 manager-to-professional transitions.[10]

Given the positive relationship that exists between average salary and job grade, we can predict that (upward) movements between job grades will be positively associated

with earnings growth. But it is less evident, *a priori*, whether to expect significant pay increases to be attached to movements between job classifications. The first case to consider is the transition from a professional job to a managerial job. If managerial jobs are assumed to entail an increase in degree of responsibility and require higher levels of ability and performance than professional jobs, then we would predict a pay premium to accompany a move, as employees with higher levels of ability and performance were selected into those jobs.[11] An alternate assumption—that ability and performance requirements for managerial and professional jobs are comparable, and that only the skill sets required for the jobs differ—leads to a prediction that a pay premium associated with a transition will be observed only if there are differences in market value between the two skill sets.

A rationale for incentive provision in the case of "horizontal" moves between professional job classifications (or between managerial classifications) is less obvious. If such moves are commanded by the firm there is no reason to expect that a pay premium should be timed to accompany a move. Alternately, job classification moves might be induced not by firm policy but by the effects of work organization in technology-intensive settings on individual behavior. Because technical knowledge evolves at a rapid rate, skill obsolescence is likely to be a significant concern for technology professionals.[12] Hence horizontal job moves may be an important means for professionals to update existing skills or acquire new ones. Under this rationale, we would not expect to observe pay increases coincident with the timing of a move between job classifications.[13] However we might find that multiple moves over the course of a career are correlated with higher lifetime earnings than no moves.

To assess the impact of one-time job grade and job classification changes on salary changes, an earnings growth equation is estimated:

$$(1) \qquad -W_{it} = \quad I + T_{it} + Z^{*}_{it}\,,^{*} + u_{it} \ .$$

Here the dependent variable is the change in log real monthly salary between year t and t-1, T_{it} is firm tenure, and Z^{*}_{it} is the set of earnings determinants which change over time, and includes indicator variables for job grade changes, job classification changes, and moves between professional and managerial classifications. $,^{*}$ is the corresponding coefficient vector. Unbiased estimates of the parameters of (1) will obtain as long as $E(u_{it} \mid T_{it}, Z^{*}_{it}) = 0$.

Estimates of the effect of internal movement on salary growth are presented in Table 5. The effect of a job grade change on salary growth is large. A move to a higher job grade more than doubles an employee's rate of salary growth. For example, the annual salary increase of an employee with 2 years of tenure would jump from 3.8% to 7.9% (the tenure coefficients are not reported in Table 5). A move to a lower job grade decreases the rate of salary growth by 3.7 percentage points, on average. The magnitude of these estimates suggests that when employees are promoted or demoted, they change job grades. Of course, because these estimates are conditional expectations, they do not rule

out the possibility of job grade changes accompanied by relatively small salary changes, as might be expected when employees are bumped to a higher grade because of adminstratively imposed limits on salary dispersion within grade.

Job classification changes have much less of an impact on salary changes (Table 5, equation (3)). A horizontal job change between two professional job classifications is associated with an additional 0.4 percentage point salary increase. A move from a professional job classification to a managerial job entails an extra 1.8 percentage points of salary growth. This gain appears relatively modest in size when compared to the gain associated with a move to a higher job grade. Of course if job grade changes and moves from professional to managerial job classifications are highly correlated, then the actual salary gain is underestimated by considering only the coefficients on job classification moves. This is the case for approximately half of such moves: conditional on moving from a professional to a managerial classification, 47% of movers also change job grade. Finally the estimates in equation (6) indicate that the effect of moves from managerial to professional job classifications on salary increases is negative but very close to zero. It is interesting to note however, that among such movers, 18% also move to a higher job grade at the same time. This suggests that "backtracking" is not necessarily penalized in the firm and is sometimes associated with the higher pay increases that come from job grade changes.

V. Conclusion

In contrast to a relatively rigid structure of well defined vertical job ladders, the internal organization of NewTech appears to be quite fluid. Horizontal moves between job classifications are common, as are "backward" moves from managerial jobs to professional jobs. Moreover, much of this movement between job classifications is separate from moves in the salary structure (between job grades). Movement upward in the job grade structure is correlated with much larger than average salary growth whereas time within job grade is associated with slow or stagnant salary growth. This aspect of the promotion system accords with the promotion-based incentive systems found in other firm-based studies.

References

Bailyn, Lotte. 1991. "The Hybrid Career: An Exploratory Study of Career Routes in R&D." *Journal of Engineering and Technology Management*, Vol. 8, pp. 1-14.

_____. 1985. "Autonomy in the Industrial R&D Lab." *Human Resource Management*, Vol. 24, No. 2, pp. 129-146.

Baker, George, Michael Gibbs, and Bengt Holmstrom. 1994a. "The Internal Economics of the Firm: Evidence from Personnel Data." *Quarterly Journal of Economics*, Vol. 109, No. 4 (November), pp. 881-919.

Biddle, Jeff, and Karen Roberts. 1994. "Private Sector Scientists and Engineers and the Transition to Management." *Journal of Human Resources*, Vol. 29, No. 1 (Winter), pp. 82-107.

Kanter, Rosabeth Moss. 1984. "Variations in Managerial Career Structures in High-Technology Firms: The Impact of Organizational Characteristics on Internal Labor Market Patterns." In Paul Osterman, ed., *Internal Labor Markets*. Cambridge, MA: MIT Press, pp. 109-131.

Lazear, Edward P. 1992. "The Job as a Concept." In William J. Bruns, Jr., ed., *Performance Measurement, Evaluation, and Incentives*. Boston: Harvard Business School Press.

Medoff, James L., and Katherine G. Abraham. 1981. "Are Those Paid More Really More Productive: The Case of Experience." *Journal of Human Resources*, Vol. 16, No. 2 (Spring), pp. 186-216.

_____. 1980. "Experience, Performance, and Earnings." *Quarterly Journal of Economics*, Vol. 95, No. 4 (December), pp. 703-736.

Mohrman, Susan Albers, and Mary Ann Von Glinow. 1990. "High Technology Organizations: Context, Organization, and People." *Journal of Engineering and Technology Management*, Vol. 6, No. 3,4 (May), pp. 261-280.

Osterman, Paul. 1984. "White-Collar Internal Labor Markets." In Paul Osterman, ed., *Internal Labor Markets*. Cambridge, MA: MIT Press, pp. 163-189.

Roberts, Karen, and Jeff Biddle. 1994. "The Transition into Management by Scientists and Engineers: A Misallocation or Efficient Use of Human Resources?" *Human Resource Management*, Vol. 33, No. 4 (Winter), pp. 561-579.

Robinson, J. Gregg, and Judith S. McIlwee. 1991. "Men, Women, and the Culture of Engineering." *Sociological Quarterly*, Vol. 32, No. 3, pp. 403-421.

Table 1. Characteristics of the Sample, NewTech Managers and Professionals, 1976-1994

Means (Standard Deviations)				
	All Managers & Professionals		Technical Professionals	
	Pooled Sample	Individuals	Pooled Sample	Individuals
N	64,100	11,894	32,340	7,578
Highest Education Level:				
High School Diploma	.071	.053	.034	.031
A.A. Degree	.011	.009	.007	.006
Bachelor's Degree	.563	.590	.582	.593
Master's Degree	.297	.288	.300	.293
Ph.D.	.057	.059	.076	.076
Female	.109	.138	.100	.117
Single	.221	.291	.268	.315
Age (years)	37.1 (9.7)		34.2 (8.9)	
Pre-company experience (years)	4.8 (5.3)		4.2 (4.9)	
Company tenure	9.9 (8.6)		7.4 (7.3)	
Manager	.323		—	
Supervisor	.061		—	
Real Monthly Salary (1994 $)	4,707 (1,835)		4,278 (1,125)	

Table 2. Distribution of Managers and Professionals by Corporate Function at NewTech, 1976 and 1994

Function	1976 (n=2,095)	1994 (n=3,878)
Dept. Managers and above	51	42
Marketing	223	263
Engineering	708	1,902
Manufacturing	471	388
Quality Control	111	149
R&D	87	694
Information Systems	208	128
Support Functions	236	312

Notes: Employment numbers represent active employees as of yearend 1976 and 1994. Support functions include human resources, finance, facilities, legal and public affairs, contract administration and purchasing.

Table 3. Classification of NewTech Entrants by Job Characteristics, Managers and Professionals, 1976-1994

Frequency Row Pct. Column Pct.	Manager	Professional
Technical Job Classification	72 .02 .09	3,332 .98 .66
Non-Technical Job Classification	720 .29 .81	1,742 .71 .34

Table 4. Salary Equations for NewTech Managers and Professionals, 1976-1994

	All Managers & Professionals Dep. Variable=log real monthly salary (N=64,100)		Technical Professionals Dep. Variable=log real monthly salary (N=32,340)	
	(1)	(2)	(3)	(4)
Intercept	8.06 (.005)	8.02 (.002)	8.07 (.006)	8.05 (.003)
High School	-.176 (.004)	-.004 (.002)	-.107 (.005)	-.003 (.003)
A.A. Degree	-.169 (.008)	-.007 (.003)	-.111 (.010)	.0005 (.005)
Master's Degree	.108 (.002)	.014 (.0008)	.097 (.002)	.016 (.001)
Ph.D. Degree	.303 (.004)	.040 (.002)	.310 (.003)	.041 (.002)
Previous Exper.	.002 (.0004)	.0005 (.0002)	.003 (.0004)	.0003 (.0002)
(Previous Exper.)^2 (x 10^2)	.015 (.002)	.003 (.0008)	.021 (.002)	.005 (.001)
Tenure	.044 (.0003)	.0007 (.0002)	.036 (.0004)	.0009 (.0002)
(Tenure)^2 (x 10^2)	-.082 (.001)	.002 (.0005)	-.074 (.001)	-.0003 (.0008)
Year Dummies	yes	yes	yes	yes
Job Grade Dummies	no	yes	no	yes
R^2	.529	.913	.562	.883

Notes: All regressions are OLS. Standard errors are in parentheses. Omitted education category is bachelor's degree. Each of the salary equations also includes controls for female, handicap status, and marital status.

Table 5. The Effects of Internal Movement Between Job Classifications and Between Job Grades on Salary Growth, NewTech Managers and Professionals, 1976-1994

	(1)	(2)	(3)
Intercept	0.016 (0.0003)	0.015 (0.0003)	0.015 (0.0003)
Job Grade Increase	0.042 (0.0005)	0.041 (0.0005)	0.041 (0.0005)
Job Grade Decrease	-0.037 (0.002)	-0.038 (0.002)	-0.037 (0.002)
Job Classification Change		0.006 (0.0006)	0.004 (0.0007)
Professional to Manager			0.014 (0.001)
Manager to Professional			-0.003 (0.0015)
Tenure Controls	yes	yes	yes
R^2	.186	.188	.190

Notes: OLS estimates are based on first differences of the dependent variable, log real monthly salary (1994 dollars). Standard errors are in parentheses. The sample consists of pooled annual records from 11,986 individuals and 43,406 employee-years during 1976-1994. 'Professional to Manager' equals one if a transition was made from a professional job classification to a managerial classification, and conversely for 'Manager to Professional.' Tenure controls are indicator variables for years of tenure, identical to the specification in Table 1.6.

[1] The other business units in the firm incorporate the technology of the principal business unit and are in related markets. A review of annual reports during the period suggests that internal reorganizations and acquisitions did not impact the boundaries of the principal business unit relative to other units to any noticeable degree.

[2] For ease of exposition, I use the terms "firm" and "principal business unit" interchangeably unless direct comparison between the two is made.

[3] Technical professionals were identified by job classification and consist predominantly of engineers.

[4] The sample is also restricted to permanent and full-time employees. This restriction is relatively inconsequential, leading to the elimination of only 148 employee-year observations. Temporary and part-time employment is rare in this firm, at least for managers and professionals.

[5] Departments are aggregated into divisions, which are aggregated into groups. In 1994, the principal business unit was organized into 17 groups, 80 divisions, and 348 departments worldwide. I do not consider effects of this dimension of the firm's organization on pay in this paper.

[6] This finding agrees with those of previous studies of managerial-professional internal labor markets, including Baker et al. (1994a), Lazear (1992), and Osterman (1984).

[7] For the moment we ignore potential heterogeneity bias in the sample. This issue is taken up in the following section.

[8] This pattern of movement does not necessarily imply that the promotion system at NewTech functions differently than a system based on job ladders. In both cases, the underlying criteria for promotion may be identical. For example, at another technology firm that is similar to NewTech in many respects, the concept of job level is explicit in job titles. Electrical engineers at this firm move through five closely related levels. Differences between levels are based on differences in job complexity and responsibility. Engineers ostensibly move through the level structure as they acquire more skill and experience in their job. An outside researcher examining this firm's personnel records will observe engineers moving between job titles, beginning with Electrical Engineer III, then Electrical Engineer II, and so on, with a top level of Staff Electrical Engineer. At NewTech, we observe engineers who remain in the same job classification, such as product engineer, but who move through job grades—A, B, C, etc. There is no reason to believe *a priori* that the two systems differ in respect to the ranking and promotion of employees.

[9] Several studies have suggested that horizontal moves between jobs are an organizational imperative in technology-intensive firms. For example, Kanter (1984) suggests that because of decentralized decision-making and a reliance on project teams and task forces, career (job) moves in such firms are "ad hoc responses to current needs" rather than based on prescribed job ladders (p. 121). Bailyn (1991) suggests that the careers of technical professionals may be characterized by four distinct types of moves: 1) a switch to a managerial job ladder, 2) progression through a series of professional jobs on a technical ladder, 3) project-based moves, or 4) a technical transfer in which the professional moves with a process technology from the development lab to a manufacturing facility.

[10] Assume that some of this movement from managerial to professional job classifications reflects "backtracking" by a manager who had earlier switched from a professional job. Then a matching model would predict that the probability of backtracking is correlated with relatively poor managerial performance and decreases with time in the managerial job (as the employee learns of her managerial capabilities). See the discussion in Biddle and Roberts (1994).

[11] Concern has been expressed by some observers, that the existence of such a premium creates incentives for professionals to shift to a managerial ladder in order to maintain advances in pay and perquisites, resulting in misallocation or loss to the firm of its technical talent. "Dual career ladders" or "technical ladders" are proposed as a response to this condition but there is no consensus that such ladders have effectively equalized pay differences between managers and professionals when established (Bailyn, 1991; Mohrman and Von Glinow, 1990).

However, Roberts and Biddle (1994) argue that the transition of technical professionals into management is efficient for the firm because high-performing professionals turn out to be high-performing managers as well. Using personnel data from a medium-sized defense contractor, they find that "good" technical employees (as

defined by annual performance evaluations) tend to become "good" managers. Whether such results can be generalized to other technology-intensive industries remains to be demonstrated. Selection bias may also be a factor in such results. Bureaucratic formalism is said to prevail in aerospace firms to a much greater extent than in the newer high-tech industries. Formal criteria such as seniority, education, and supervisor evaluations are primary determinants of promotion; job descriptions, lines of authority, and advancement criteria are explicit and standardized in the more mature aerospace industry (Robinson and McIlwee, 1991). The resulting "corporate culture" is likely to generate different incentives and behavior than the "quasi-formal structure" said to characterize the newer technology industries.

[12] Bailyn (1991) suggests that the average half-life of technical knowledge is five years. The chief technology officer of Sun Microsytems recently estimated that 20% of the firm's knowledge base becomes obsolete each year (John Markoff, "A Quicker Pace Means No Peace in the Valley," *New York Times*, June 3, 1996, p. C1).

[13] The existence of skill obsolescence also has implications for the transition from professional to managerial jobs. A standard life cycle model of human capital investment predicts that investment in new skills will decline with age as the horizon for realizing past investments shortens. If the probability of skill obsolescence increases with age, and is exacerbated in an industry where the rate of skill depreciation is relatively high, then the allocation of senior professionals into management may be efficient for the firm if technical professionals are as capable of managing as other employees.