

CHUTES AND LADDERS:
THE CAREER PATHS OF SCIENTISTS AND ENGINEERS

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This Thesis is
Dedicated to
My Parents,
Bill and Doris Roberts,
and
My Daughter,
Jessica DeVol

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ABSTRACT

An hypothesis was tested about the career paths of scientists and engineers using retrospective survey data collected by the Bureau of Census. The two-part hypothesis was that there are identifiable mobility and earnings patterns in the labor market for scientists and engineers, termed here as career paths, and that career paths systematically mitigate the lifetime earnings of scientists and engineers.

The results supported the presence of the hypothesized career paths, that scientists and engineers follow all-technical or technical then managerial paths that represent different sets of future job opportunities. There was also support for the hypothesis that over the course of their working lives, managers earn more and their earnings growth declines less rapidly than is the case with technical workers. However, much of the difference was captured by the dummy variables representing path, suggesting that there are aspects of this difference in earnings that do not occur gradually over one's work history.

Thesis Supervisor: Prof. William Wheaton

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Chapter I

PREAMBLE

Introduction

In an economy such as ours which is becoming increasingly reliant on sophisticated technology as a means of production, the skilled professional labor needed to manage, maintain, and advance that technology is an important economic resource. However, as valued as skilled white-collar labor seems to be, this portion of the labor market is one of the least studied by labor market analysts. A major reason for this is that this sector of the market has not traditionally been governed by collective bargaining agreements, resulting in a dearth of readily accessible data. Consequently, there is very little understanding of the empirical applicability of the major labor economics theories to this sector.

The purpose of this thesis is to examine a portion of the professional white-collar labor market, that of scientists and engineers, to better understand the influences that shape the labor-market experiences of this group of workers. In this chapter, the major questions are stated and findings discussed, concluding with an outline of the structure of the thesis.

I. What Was Asked

The two leading economic explanations of why a group or individual has any particular tenure, earnings, or unemployment experience are either that that experience is a function of that

person's human capital investment, the human capital model, or that that individual operates in a structured labor market where implicit or explicit administrative rules govern wage levels and employment stability, a segmented labor market model.

Human capital theory is the more generalizable in that, empirical difficulties aside, labor outcomes for any type of worker can be understood as resulting from the combination of their human capital accumulation and the changing value of that asset in the market place. A distinction within experiential human capital is made between general human capital that is of value in all firms and firm-specific that is of use only in the firm where it was acquired.

Segmented market theory is an empirically based theory, initially derived from observations of the blue-collar labor market. Labor market outcomes are hypothesized to be determined by institutions that have arisen for a variety of reasons, primarily to reduce uncertainty. The most studied and well-understood institution has been labor unions, where the rules that govern earnings, job security, and mobility are often clearly articulated. The presence of an underlying or implicit structure in the professional white-collar markets is a relatively unexplored topic. This gap in our understanding is due in part to the lack of appropriate data.

To approach this problem comprehensively, several types of information would be necessary. To test the hypotheses that emanate from the human capital hypothesis, information about the education, experience, and personal characteristics of each worker would be required. However, to examine the structural market hypothesis, both

data about individual interfirm mobility and job content, as well as information about the central administrative structure in the labor market, the firm, would be needed.

Because no such complex data set is available, certain conceptual accommodations have been made in the work done in this area to be able to use what data are available. The nature of the data shapes the questions that can be asked and answered.

One possible course is to use the individual firm as the unit of observation and, using personnel data, examine earnings and mobility patterns [see Medoff and Abraham, 1980a, 1980b]. This approach is based on the assumption that the firm is a microcosm of the labor market, and earnings and mobility patterns are examined and compared to what would be expected in the absence of structural influences.

Another perspective to take, the one implemented in this thesis, is to use individual survey information about human-capital attributes and to develop an indicator of the structural factors that are expected to influence earnings and mobility patterns. In this case, human-capital attributes are assumed to prevail in the determination of labor market outcomes, and hypotheses about how the market-structure variables would behave in a system dominated by returns to human-capital investment are generated and tested. How detailed a structure can be hypothesized depends on what information about job content, interfirm movement, and periods of involuntary unemployment is provided in the survey.

The data set used in this was the National Survey of Scientists and Engineers (PMS), a combination of retrospective and panel data

based on a random sample of self-declared scientists and engineers in the 1970 Current Population Survey. The possible presence of a structured market was proxied by a variable that measured career path. Because the sample was limited to scientists and engineers, possible career paths were represented by a dichotomous choice between two paths, technical and managerial.

This choice of paths was motivated by several generally known stylized facts about the labor force experience of scientists and engineers. First, this group enters the labor force having made a very large human capital investment in itself, which is going to affect the initial experience in the labor market. Second, it is common for workers who have entered the labor force as scientists and engineers eventually to move to jobs involving more general business functions, such as management, consulting, or sales. Third, there is a tendency for this technical labor to have relatively flat earnings functions. And, fourth, this type of labor, particularly engineers, experiences a well known cyclical sensitivity (Bailyn and Lynch, 1982; Cain, Freeman, and Hansen, 1973; Sirbu, et al, 1978; Leventman, 1981).

Assuming a human-capital framework, the two paths were hypothesized as offering different sets of human capital investment opportunities that would result in different patterns of earnings and employment stability. The primary difference between the two paths was hypothesized to be that the managerial path represents a set of primarily firm-specific human-capital investments, while the technical track offers investments in mostly general human capital.

The reason for this characterization of the two tracks is based on the literature describing work experiences of scientists and engineers, where they are confronted eventually with having to choose between two conflicting work orientations: one to their profession and its associated jobs that are of a technical problem-solving nature; and, the other to the firm, where job content emphasizes the management of firm resources. Bailyn, in her study of M.I.T. graduates, finds that of those who fall into her engineering category, which includes entrepreneurs, managers, business staff, consultants, engineering managers, and staff engineers, only about 56% were in technical jobs eleven years after graduation [Bailyn, 1979].

It is clear from the literature on scientists and engineers that to reduce the number of possible career paths available to these workers is an oversimplification, but one that was made to maintain analytical tractability.

The major implication of the difference in investments between the two paths rests on the rate of technological change that affects the value of the worker in the market, and so rate of return, to the two different types of human-capital accumulation. Because of its technical nature, the general human capital acquired by those on the technical track is more vulnerable to a rapid rate of depreciation as technological change redefines the skills that are necessary to stay technologically current. Firm-specific managerial human capital, however, is hypothesized to be less subject to rapid depreciation primarily because the skills needed to manage in a particular firm are less likely to change rapidly.

Translating these differences in investments into labor-market outcomes, it was hypothesized that those on the managerial track would have a higher lifetime-earnings schedule with a steeper slope that flattens at a slower rate than those of technical workers. This was hypothesized not only because of differences in the depreciation rates, but also because path choice implies a rigidity in worker mobility and once a career path is chosen, the chosen path determines the sequence of investment opportunities for the remainder of that worker's career. So, the advantageous managerial investment opportunities become increasingly preferable with experience.

Because the nature of paths is that they represent structures within markets, workers cannot jump from one to another except at certain decision points (In this simplified version of market structure, there is only one decision point). Once a path decision is made, each job along the path will offer investment opportunities that are essentially exclusive to that job. As managers move from job to job along their paths, they acquire relatively slowly depreciating human capital and thus experience relatively greater rates of return so that the earnings difference widens with experience. Because managerial human capital does not depreciate as rapidly, managers will have an incentive to invest for longer periods and thus their earnings schedules will flatten less slowly.

Another labor market outcome that would result from the differences in human-capital investment is the higher probability of interfirm mobility by technical track workers and the higher probability of involuntary unemployment. However, this aspect of the

hypothesis is not explored in this thesis.

To summarize, the objectives of this research were first, using a large data set, to establish empirically that career paths exist, that is, that there are constraints on inter-job mobility patterns that allow some types of work experience but preclude others. And, second, to explore the structural basis of these paths, where a series of hypotheses about earnings were generated that were consistent with human capital theory. Assuming career paths could be established, it was expected that by identifying those points where the human capital theory was supported or rejected would provide insight into the determinants of earnings and mobility in white-collar labor markets.

II. What Was Found

A. Establishing Career Paths

The first major objective of this research was reached: using the relatively crude indicators of career paths that could be derived from this data set, the presence of managerial and technical career paths was established. Because of the timing of the survey, three job sequences were considered to be evidence of a path: all of an individual's jobs were technical; all were managerial; or, the initial jobs were technical and subsequent jobs were managerial. Backtracking, going from a managerial to a technical job, was viewed as inconsistent with the path hypothesis. Two versions of career path were used, one based on the supervisory level of the individual (SUPATH) and one using the self-declared occupational category

(OCCMAN). Regardless of which definition was used, the careers of over 90% of the sample could be described by the three job sequences that were consistent with the hypothesis that scientists and engineers enter the market on a technical path and eventually choose between remaining on that path and moving to a managerial path.

In addition, using a simple earnings function, where types of human-capital investment were undifferentiated from one another, it was shown that earnings levels and growth rates varied systematically with path. In the model of earnings level, the rate of return to experience for managers was three times that for technical workers. And, in the model of earnings growth¹, the managerial earnings growth rate as experience increased was over twice that for technical workers.

Together, these findings provide support for there being a structure within this labor market that affects labor market outcomes. By separating work experience into different components that approximate the different types of human-capital investment, questions about what determines these paths, specifically whether or not they represent differences in investment patterns, can be examined.

Because two different definitions of career path were used, a comparison was done of the values of the two variables to learn what differences there might be that should be incorporated into an interpretation of the results. One major outcome of this comparison was that it was quite common for a worker to have significant supervisory responsibility and yet describe himself as belonging to a technical occupation. The reverse, a managerial occupation with low-

level supervisory responsibilities, almost never occurred. Also, those who described themselves as having a managerial occupation tended to be somewhat older and more experienced than those who did not. This suggests that there is a psychological component to career path choice, where the shift from a technical to a managerial orientation is gradual despite changes in actual job content.

B. Where the Paths Diverge

In the study of the contribution of different kinds of experience, two types of models were used, models of earnings levels and of earnings change. The earnings level models permitted an examination of certain dichotomous variables that would be expected to shift the entire earnings schedule, variables that would not appear in the earnings change model. The disadvantage to the earnings level models was that there was no measure of individual economic ability included, so that to the extent that ability was correlated with any of the other variables, in particular path choice, the coefficient estimates would be biased and inefficient. The earnings-change models were assumed to correct for this problem because individual ability was one of the shift parameters, in this case, a fixed-effect variable, that was eliminated in the derivation of the change models from the levels model.

Experience was broken down into three components, pre-firm (EXP), same-firm, different-job (NONTEN), and job tenure (TENURE). Pre-firm was assumed to measure general human capital, that which is of value

across firms. NONTEN included both general and firm-specific human capital. And, TENURE measured the combination of general, firm-specific, and job-specific.

Two versions of each model was estimated, one where a path dummy variable and a set of path-experience interaction variables were included to measure the differential returns to experience by path. And, a set of models was estimated where the sample was divided into current managers and technical workers (using the SUPATH variable) and the coefficients for each subsample were estimated separately.

In summary, although there is strong support for there being differences between paths in lifetime earnings, the difference cannot be clearly attributed to differences in the quality of human capital investment. There is no difference between paths in the rates of return to pre-firm general human capital, although it was expected that technical workers would gain more from that experience.

Using the supervisory-based model, there is a small, positive and significant advantage in the coefficient estimates for managerial tenure. A set of diagrams showing the effect of tenure over time shows a gradually increasing gap in earnings. When the earnings curves begin to flatten, the drop is slightly more precipitous for managers than technical workers. But, the drop begins sufficiently late in the work history that managers effectively never lose their advantage. However, the major difference does not appear to be associated with the shape of the experience-earnings functions. This is especially evident from the separate-regression change models when the only substantial difference between the paths is in the intercept.

There is also a very strong and positive shift effect associated with the managerial path, evident in the path coefficient in the single-regression, interaction model, and in the intercepts in the separate regression models, for both the level and change models. This shift effect is sufficiently large to counteract a lower rate of return for same-firm, different-job tenure for managers. The rate of return to the same-firm, different-job experience of managers is lower than for technical workers, but the rate of growth does not decline for managers while it does for technical workers.

That the major difference in path-earnings functions appears as a shift effect raises many questions about what exactly motivates the earnings gap. Two obvious unexplored possibilities are that earnings growth occurs more often from job change rather than in the course of a job; or, that technical workers experience more unemployment, slowing their earnings growth. Answers to these and related questions are the next step in understanding the dynamics of the white-collar labor market.

The next two chapters of the thesis are reviews of the literature on the labor market for scientists and engineers and the economic literature on the relationship between experience and earnings. In the fourth chapter, the model that is used to explore the questions outlined above is developed. The fifth chapter describes the data set that was used and the construction of the career-path variables. The following chapter is a presentation of the estimate results, including an empirical summary of the data set and a discussion of the two definitions of career path. The thesis is concluded by a chapter

summarizing the results and proposing future areas of research.

FOOTNOTES

¹ Unlike the change model estimated later, using the experience components, the continuous-experience change models were not derived and have only exploratory value. Earnings change is over the course of the current or most recent job, as it is for the components model, but the only control variable for length of that job is the change in the CPI, which is only an approximation of time. In addition, the experience variables do not represent change in experience, but rather total experience at the end of the job. so, the change in earnings is, in effect, hypothesized to be a function of one's total experience. Therefore, a model is presented where fixed effects are omitted, but that exclusion is not really appropriate.

CHAPTER II
REVIEW OF THE LITERATURE ON THE CAREER PATHS
OF SCIENTISTS AND ENGINEERS

Introduction

This chapter is a review of the literature regarding the labor market experience of scientists and engineers. This review is not comprehensive, but is sufficient to establish the importance of the choice between technical and managerial career tracks and the need for a theoretical understanding from a labor economics point of view.

This literature can be divided into two categories, that dealing with the construction of supply and demand models and that addressing problems of professionals in organizations, frequently with a focus on the incidence of technical obsolescence.

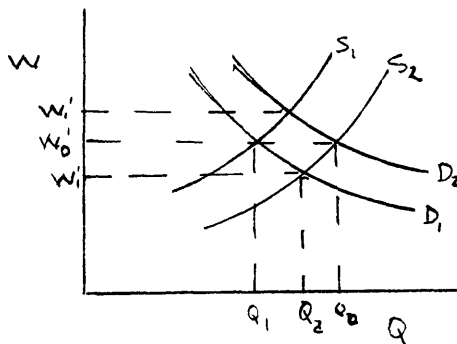
The first set of literature best describes the entry level labor market for technical labor, while the second set of papers concentrate on the work experience of scientists and engineers after those first few years. Based on the second set of literature, by mid-career, which occurs sometime in the early to mid-30s, it is evident that many technically trained workers run the risk of technical obsolescence and turn to managerial careers. So, by mid-career, what was an apparent homogeneity of labor at entry to the labor market has broken down. In this thesis, a simplified distinction is drawn between those who eventually pursue a managerial career track and those who pursue a

technical career track.

I. Supply and Demand Models

The economic approach to the labor market for scientists and engineers models the supply and demand for scientists and engineers, usually incorporating the well-known lag between increases in demand and availability of supply caused by the long training period necessary for such highly skilled labor. These studies are frequently prompted by the concern for the availability of technically skilled labor. However, they tend to focus on occupational categories and ignore the evolutionary process where some labor is trained in some specialization but develops into a different type of labor after several years in the labor market. Therefore, their results can only describe entry-level conditions.

Two examples of the supply and demand analysis of the economic approach are a monograph by Cain, Freeman, and Hansen [1973] and a paper by O'Connell [1972]. Cain, et. al, noting both the long training time needed to bring engineers into the labor market, as well as the prominent role of federally funded research and development programs in the demand for technically skilled labor, build a cobweb model of the market. They assume that individuals make their training decisions based on current demand and salary conditions, but that those decisions do not affect actual supply for four to five years, when demand conditions may have changed. Using a diagram similar to Diagram 1, they assume



the economy to be in initial equilibrium at Q_1W_1 . Demand shifts out exogeneously to D_2 , driving wages up to W_1' . Supply then shifts to Q_1' in response to higher wages. Increased supply drives wages down to W_2 , supply drops down to Q_2 , and so on until wages and employment eventually converge at Q_0W_0 .

Diagram 1

According to the authors, the reason the cobweb model is appropriate for the engineering labor market is that a long training period needed that prevents rapid equilibration. The assumption is that the quality of labor is a constant throughout this long equilibrating process. They acknowledge that this is an idealized picture of how this market operates, but it is worth noting that their model suggests the possibility of a very rapid exogenous demand shift but requires a protracted supply response. While this is accurate, they do not extend the discussion to incorporate the likelihood of repeated exogenous demand shifts, which does seem to be one source of volatility in this labor market.¹

Having surveyed and developed a theory of the labor market for engineers, the model which they actually estimate is a reduced form equation earnings function. They justify this choice by pointing out that "the salary rate...serve[s] to guide allocative decisions by employers and workers" [1973,p.42]. However, as O'Connell notes, interpretation of the estimated coefficients is necessarily ambiguous in such a model.

They use data from the 1962 Post-Censal Survey of engineers. The estimated relation is: $E_i = F(P_i, C_i) + u_i$, where E_i is the earnings of the i th individual; P_i are productivity characteristics,

including education, training, years of experience, and experience squared; and C_i are "compensating" variables such as geographical area. They also add in a series of demographic variables such as age, marital status, and father's occupational class. They estimate this as a simple linear relationship using ordinary least squares (OLS).

One of their interesting results shows that, holding experience constant, the peak year of earnings occurs at age 60-64 years, which is not surprising. But, what is surprising is that when they examine the rate of increase of salary with experience, the highest rate of increase occurs around age 45-49, later than most studies of engineering obsolescence would predict. It is worth noting, however, that these results are based on cross-sectional data. Those in the 45-49 year age category would have entered the labor market towards the start of the build-up for WWII, and their higher salaries might reflect that initial shock to the labor market.

O'Connell [1971] uses two stage least squares (2SLS) to estimate a two equation model of the engineering labor market. O'Connell has three purposes in his paper: to develop and estimate supply and demand functions for engineers, to examine equilibrating variables, and to analyze substitutability and complementarity between engineers and people in related occupations. His demand equation, which he estimates as a log-linear function is: $D_n = D(W_n, W_r, R\&D, I, u)$, where D_n is the quantity demanded; W_n is the price of engineers, expressed relative to a common labor group; W_r is the price of related labor; R&D, used instead of value added to capture the fact that labor is a derived demand, is the level of R&D expenditures; and, I is the ratio

of engineers to total male employment for 21 sectors.

His supply relation is $S_n = S(w_n, P, D, u)$, where w_n is absolute rather than relative earnings for engineers; P is the age-education composition of the population, a variable based on the assumption that there is little occupational mobility into engineering; and, D is the share of engineers of total number of college graduates. The unit of observation is the state, and he is using 1960 Census data.

He notes two problems with his data that may be responsible for his weak results. First, using a theoretical result developed by Melvin Reder [1955] that when faced with a shortage of labor, employers can either adjust wage rates or hiring standards, O'Connell notes that he has no controls for the quality of labor in his model and that this may lead to biased estimates. Also, because he is using cross-section state data on employment levels, he is forced to assume that each data point represents an equilibrium situation.

Despite these problems, he estimates his equations using both OLS, thus assuming that wages are exogenous, and 2SLS, which allows wages to be endogenous. His results are weak; however, he does find some support for the complementarity rather than substitutability between technicians and engineers, implying that upgrading technicians will not increase the supply of engineers. And, it is interesting that his model is least successful for civil engineers, suggesting that their labor market may differ from that for other engineers.

Together, the monograph by Cain, et al, and the paper by O'Connell demonstrate the difficulty in estimating a model of the market for this labor. O'Connell's direct attempt fails to get strong

results. And, Cain, et al, do not even attempt it, but rather assume that wages determine both supply and demand behavior and so focus their analysis on wages. In addition to the data deficiencies they mention, part of the difficulty in modeling this labor market is the failure to incorporate career stages into their model that would reflect the existing heterogeneity of labor in this market. A model such as O'Connell's would probably be more successful if it were applied only to the new entrant portion of the engineering labor market, where supply and demand more directly govern price and quantity relations.

II. Professionals in Organizations

The second type of literature that is concerned specifically with scientists and engineers emphasizes the problems of professionals working in large organizations. This literature tends to take a managerial perspective with a focus on identifying and reconciling the inherent conflicts between individual and group needs. The problem that is peculiar to scientists and engineers is described by Bailyn as a dilemma faced by many of "either following one's technical bent but becoming isolated and unrecognized within the organization, or moving into management and losing contact with one's technical goals and competence" [Bailyn, 1982c, p. 42]. This problem is sometimes referred to as technical obsolescence and has been recognized by many concerned with managing technically trained labor.

For the purpose of this review, this literature is organized

into two categories. The first type is primarily empirical, where the authors were prompted by a recognition of a tension between technically educated workers and their employers to explore and identify the nature and causes of the problem and develop empirically based typologies. The papers in the second category each begin with a theoretical presupposition about the inherent conflict between individuals and groups, in this case technically oriented workers and firms, and analyze the problems, particularly that of obsolescence, and solutions in terms their view of that conflict.

A. Identifying the Problem

In this section, works by Bailyn, Dalton and Thompson, Leventman, and Hall and Mansfield are discussed. Although each takes a different perspective on the mid-career issues for scientists and engineers, all begin by noting the discrepancy between the initial labor market experience for those workers and their expectations for the future and what actually takes place after several years on the job. All four see this labor group as entering the market with an extraordinarily high initial skill level. Bailyn and Leventman also discuss a kind of glamour associated with these technical occupations that was generated during the 1950s and 1960s, raising expectations for extremely promising futures. What all four writers discover is that, for a variety of reasons, those expectations are not met for many mid-career scientists and engineers and that for some whose strength remains in solving technical puzzles, this creates serious career problems.

A major theme is Bailyn's several studies of scientists and engineers at mid-career is their diversity and the absence of rigid stages and career paths that can be used to predict levels or performance, job satisfaction or work involvement. Having identified the problem of worker alienation among scientists and engineers, Bailyn's study of M.I.T. graduates at mid-career [Bailyn, 1980] establishes that while much diversity of individual talent and orientation exists among these workers, a similar variety of career options within organizations does not exist.

In 1970, Bailyn surveyed M.I.T. graduates of the classes of 1951, 1955, and 1959 (N=2223, although working sample was 1351 men). Bailyn's purpose was, first, to identify occupational categories within the sample that were both functionally based and captured the dominant set of work values embodied in that occupation; and, second, to examine individual reactions to these occupational roles, searching for systematic patterns of work involvement and orientation to work. Using job title and work activity information, Bailyn developed an eleven occupation functionally based classification system:² five were considered managerial occupations, three staff occupations, two educational, and other.

Using career data information, these eleven categories were collapsed into two occupational clusters that formed the basic units of analysis for her study. The first cluster, called engineering based careers (pattern E) included entrepreneurs, general and functional managers, business staff, consultants, engineering managers, and staff engineers. Those in this pattern tended not to

have Ph.D.s, to have had average grades, and have started their careers in staff engineering positions. The second cluster, scientific-professional careers (pattern SP) included both groups of professors, science managers, and staff scientists. These tended to have doctorates, good grades, and entered the labor market in other than staff engineering positions. Of those in pattern E, 56% have technical jobs, while 90% of those in pattern SP have technical jobs. Her point here is that educational and initial job experience influence the career path this labor will follow ten to twenty years after graduation.

Next, she examined the job values associated with these occupational clusters in order to identify what needs individuals would like to have met by their work and determine which cluster met which needs. The job characteristics included intrinsic values, that is, those associated with the work content itself versus extrinsic values that could be associated with meeting organizational objectives, societal goals, and/or personal objectives.³

While both patterns indicate an emphasis on intrinsic values, such as "challenging work" and "freedom to be creative and original," those in the SP pattern exhibit those values somewhat more than those in pattern E.⁴ But, those in the E clusters show a much greater adherence to extrinsic values such as earnings and leadership opportunities than do those in SP,⁵ establishing value differences between patterns.

She then examines how these groups differ by organizational level. Four types of technology-based careers emerge: engineering

based with high organizational positions (E/H), engineering based with low organizational position (E/L)(includes staff engineer and business staff), scientific-professional based with high organizational position (SP/H), and scientific-professional based with low position (SP/L)(includes staff scientist). Bailyn's results indicate that both occupational cluster and organizational level determine work involvement. E/H and SP/L show an approximately normal work involvement distribution; but those in SP/H are skewed toward high involvement (38% are highly involved) and those in E/L are skewed toward low work involvement (35% have low involvement) [1980,p.40]. Although there are many possible explanations for why SP/L would tend to be more involved in their work than E/L, one plausible reason may be that the myth that one is a failure if one has not made the transition from a technical career into management may operate more strongly on engineers than scientists.

Bailyn begins to set up her framework for policy analysis by exploring the relationship between individual orientations and occupational career paths. She identifies three different types of orientation: technical, human, and non-work. Those in the scientific-professional cluster show such similar orientations toward technical work regardless of organizational level.⁶ When comparing the percent with above average incomes (normalized within occupational/organizational groups) by orientation, about 45% of both SP/H and SP/L receive above average salaries (for their occupational/organizational group), suggesting a similar reward structure for orientation regardless of hierarchical position.

Within the E/H group, the highest percent with above average incomes are those with a human orientation,⁷ 41%, suggesting either a predisposition or the switch that many engineers make as they rise within organizations away from technical and toward managerial problems. Within E/L, 63% of those with a technical orientation receive above average salaries, as compared with 37% of those technically oriented in E/H. Bailyn interprets this as indicating that how workers are evaluated, as measured by relative salary, depends on congruence of orientation and organizational position. However, it is not clear from these data whether those in E/L with a technical orientation are paid more than average for their group because they perform best in their group or because they represent those with the greatest job tenure who have not made the transition to a human and therefore managerial orientation. That 29% of those in E/L show the human orientation and make above average within group salaries suggests that orientation is not highly valued at that organizational level and supports Bailyn's congruence argument.

Among those in the engineering cluster, Bailyn notes a lack of congruence between organizational rewards, career orientations and job satisfaction, suggesting the severity of the problem of the inflexibility of firms which do not recognize worker differences [1982d,p. 43].

After identifying this mismatch, Bailyn interviewed technical professionals in three high technology research and development firms to determine the contributing organizational factors [Bailyn, 1982a; 1982c]. In all three firms, external market conditions were changing

so that the firms were shifting emphasis from developing new technology to production using existing technology. Four contradictions emerged between management assumptions and those of the workers that disrupted job satisfaction and efficiency: 1) the misapplication of autonomy and the organizational controls, where research scientists and engineers had relative freedom to select projects but were subject to tedious firm controls during implementation (those interviewed preferred the reverse, close supervision in selecting projects which were consistent with company goals and more discretion over how to carry them out); 2) the tendency to reorganize company functions without attention to project group efficiency, frustrating researchers because of new problems of resource coordination; 3) lack of movement and involvement with a specific project or problem for too long, leading to stagnation (This proclivity was reinforced by both managers and workers: managers feared the loss of their most knowledgeable people, and workers feared loss of salary and position during their relearning period); 4) conflicting incentives where actions that might enhance productivity and efficiency were not necessarily the ones that would provide individual recognition and visibility and advance careers.

Bailyn recommends increasing firm flexibility, introducing temporary assignments to reduce the danger of overspecialization, using new career rewards other than hierarchical promotion to publicly signal performance, providing opportunities to report directly upper management, and rewarding productivity through the use of sabbaticals.

Dalton and Thompson also attempt to track careers paths of

scientists and engineers and identify the sources and possible resolution of the potential obsolescence dilemma faced by these workers. Using management performance evaluations, Kopelman, Thompson, and Dalton [1973] track the timing of the obsolescence problem: average performance rises steadily from entrance into the labor market in the early 20s to the early 30s, between the ages of 30 to 35. Performance begins to decline slightly until the late 30s, then declines steadily with age. However, when workers are grouped according to age, 21-30, 30s, 40s, and 50+, the high performers in the oldest group do perform higher than the average for all other groups, suggesting that some engineers retain technical competence.

In contrast to the age-performance relationship, salaries increase with age until the early 40s, then plateau at that highest level. Interpreted in terms of rate of salary increase, that rate increases until the mid to late 30s, then begins to decline steadily with age. Dalton and Thompson [1971] use this as evidence for why project managers do not want older engineers on their projects: they perform less well and cost more.

Dalton and Thompson then explore the question of whether management evaluation is a valid indicator of performance, or does it rather reflect a youth bias or some effort to rate young workers highly and therefore retain them. Using complexity of job assignment as a measure, based on the assumption that managers assign the most difficult problems to their best performers, the peak age for complexity of job assignment for technical workers is between age 26 and 30. It declines slightly until the late 30s, then plummets.

When managers are included, the age-performance curve shifts slightly upward and to the right, indicating that managers' performance peaks at a somewhat later age, closer to the late 40s, compared to the late 30s for engineers. That the shift is slight, however, suggests that the problem with technical obsolescence cannot simply be explained by better workers going into management, leaving the less able in technical jobs.

Kopelman, Thompson, & Dalton examine the effect of education and training on performance. For those holding a B.S. degree, the younger the age when the degree was received, the higher the performance rating. The highest pay-off to a degree was to those who received an M.S. between the ages of 30 and 34. They find that taking courses did not improve performance: the highest performers took the fewest courses, and when the lowest performers took courses, there was no resulting increase in performance, suggesting that they were taken too late.

Kaufman's [1974] evaluation of university versus in-house courses supports several of Kopelman, Thompson, & Dalton's findings. Kaufman's results show that those who take university courses receive higher salaries and more promotions. But, he also finds that there is a tendency for younger engineers to take university courses and older engineers to rely on the less rigorous in-house courses, so the overall relationship between performance and in-house courses taken is negative, because those courses are taken by the poorest performers who fear obsolescence.

Thompson and Dalton and Dalton, Thompson, and Price use a

subsequent survey of 200 scientists, engineers and managers to develop a four-stage model of the professionally trained employee's career. [Thompson & Dalton, 1976; Dalton, Thompson, & Price, 1982]. They contrast their model with the dominant existing models and show why those models lead to failed policy solutions.

They discuss the pyramidal model of organizations, where career development is synonymous with upward mobility and increases in all rewards, pay, autonomy, and status, are attendant upon upward movement. The failed policy solution based on this model is the dual career ladder which fails because upward movement is not what characterizes the development of a technical career. The other major competing model they mention is the obsolescence model, where rapidly changing technology makes the knowledge and skills of professionals obsolete and shifts employer preferences toward recent graduates. This model has prompted studies of the half-life of professional education. The unsuccessful policy solution spawned by this model is continuing education, both in-house and in universities.

In their model, they identify four stages of a professional's career. Organizations can be evaluated by the way in which they facilitate or impede passage through these states, the critical variable for successful movement being job assignments. Briefly, the four stages are: the apprenticeship stage, where one needs to balance routine work and challenge seeking while learning from a mentor; the start of independence, where one develops a technical or substantive expertise, at the risk of overspecialization, and begins to make more decisions; the mentor stage, which is when the tension between

managerial and technical interests and responsibilities is most acute, and one or more of three typical roles are played--the idea person, the manager, and/or the informal mentor; and, the final stage, where one becomes a higher level manager, internal entrepreneur, and/or idea innovator, and is not directing the organization toward specific goals. Not all workers can or do progress through all four stages. But, they note that an individual must progress beyond stage two or eventually be viewed as obsolete.

Hall and Mansfield [1975] take a psychological perspective on the relationship between age and seniority and several career variables of scientists and engineers [Hall & Mansfield, 1975]. The career variables of interest were job involvement, perceived organizational supportiveness, job challenge, and several personal needs, security, affiliation, esteem, autonomy, and self-actualization. Their methodology is somewhat questionable because they held two sets of "group interviews" of nonmanagerial scientists and engineers in twenty-two R&D firms in 1967 and 1969 and used the information from those interviews as data for their study. It does not seem likely that information gathered in a group setting could provide sufficiently precise measures of the career variables they study. Such a research methodology seems better suited to hypothesis generation rather than testing. However, the external labor market was tight in 1967 and loose in 1969, and the authors are able to provide some interesting insights into the effect of the external labor market on the internal labor market.

Briefly, they found that when external labor market conditions

loosened, there was a relatively positive effect on older workers. In 1967, they found a positive relationship between aspiration for job security and age. By 1969, there was no significant relationship, as younger workers became equally concerned with job security in loose labor markets. They also found that during bad times, in 1969, there was a tendency for firms to better utilize older workers because they had laid-off younger workers. In 1969, the level of job challenge increased with age as compared to no relationship in 1967. In 1969, older workers (age 50+) had higher job satisfaction than older workers in 1967. And finally, the measured peak of self-fulfillment opportunities on the job occurred for workers in their early 30s in 1967, but rose to those in their early 50 in 1969. Their conclusions suggest that external labor market conditions may dominate the effect of career stages and influence the utilization of human resources in a way which contradicts the inevitability of obsolescence.

In Professionals Out of Work, Paula Leventman [1971] interviewed 300 scientists and engineers in 1971 and again in 1975 to examine the effect of unemployment on these highly trained professionals. Her sample distribution was: 6% were vice-presidents, 16% middle management, 39% top level staff, and 39% staff personnel. Although much of her book discusses how these workers coped with unemployment, she examines several aspects of the labor market faced by scientists and engineers and how these workers function in organizations.

She establishes what she considers to be the dominant feature of this labor market, its dependence on federal government, particularly, defense spending. For example, she notes that due to cuts in defense

spending and the NASA budget, 200,000 aerospace engineers were laid-off between 1967 and 1972, with 10,000 scientists and engineers laid-off in the Boston area. By 1975, defense spending was back up again around route 128, but there was a shift away from research and toward production, and what research was done was product oriented. The importance of this dependence on federal spending was not just the volatility in employment, but the observation that once a scientist or engineer became involuntarily unemployed, career stability was never restored: of those unemployed in 1971 in her sample, 24% were reemployed and had that job in 1975, 34% were laid off and reemployed twice by 1975, 4% started their own businesses, 16% were reemployed three or more times, and 10% were never reemployed. Part of the difficulty with reemployment was the implied relationship between obsolescence and unemployment.

Based on respondent job descriptions, Leventman identifies six sources of conflict between professional goals which she defines as desire to use skills and understand context of job, and organizational demands, which she defines as predictability and control. The first is the microdivision of labor which results in skill underutilization and eventual overspecialization. Frequently, of those directly working on a project, only a project group leader would have some control over tasks, suggesting one incentive for technical workers to go into management. A second problem was a general problem of organizational constraints on professional autonomy, a problem which 85% of those interviewed described as inevitable. A third problem was staff-line conflict where professionals viewed managers who did not

fully understand technical problems as interfering. Many thought that the opinion was mutual and that dual career ladders were set up to keep scientists and engineers out of management.

A fourth problem was fear of obsolescence. Some viewed obsolescence as inevitable in the face of rapidly changing technology. Others saw it as a management induced problem where workers were deliberately overspecialized to increase obsolescence so that the firm could hire younger, cheaper labor. A fifth problem was a decline in felt utility due to the high level of waste that accompanied defense related projects. The high level of waste in defense related work resulting in a lack of cost consciousness is cited as one of the barriers to the mobility of defense engineers into commercial engineering in a 1967 monograph prepared by the Stanford Research Institute for the U.S. Arms Control and Disarmament Agency [Rittenhouse, 1967]. Eighty-one percent (81%) of Leventman's sample had spent part of all of their careers working on defense or aerospace contracts.

The final problem was a sense of the erosion of professionalism. She cites a problem which is discussed in more detail by Goldner and Ritti [Goldner and Ritti, 1967], the need to clarify the term professional when applied to scientists and engineers. Both Leventman and Goldner and Ritti note that unlike the prototype professional, medical doctors and lawyers, scientists and engineers lack independence, and the practice of the profession takes place in an organizational context. This dependence on a work setting conflicted with the orientation towards a profession learned during their

training.

She develops a typology of how workers adapt to the conflict between professional and organizational goals, where workers can be arrayed along a continuum from orientation toward organizational goals through professional orientation ending with a non-work orientation.⁸ Of interest is that only those with the strongest organizational orientation, reflected in part by success in the hierarchy, was significantly less likely to be laid-off during a downturn.

Aside from strong organizational orientation, she identified several variables which were associated with the probability of lay-offs. There was a positive relation between education and being retained. *Ceteris paribus*, those with doctorates in science, engineering or applied math were least likely to be laid-off. Scientists were less likely to be laid-off than engineers. There was a positive relationship between age and lay-offs. Also, certain types of subspecialties, such as reliability engineers, were laid off.

B. Theoretical Approaches to the Conflict between Professionals and Firms

In the previous section, the papers discussed explored career issues facing midcareer scientists and engineers and attempted to provide paradigms of their career stages. In this section, the papers are directed toward providing an explanation for the tension between scientists and engineers and the organizations which employ them.

Goldner and Ritti [1967] evaluate the use of dual career ladders as a forum for discussing the relationship between professionalism in

large organizations and career mobility. Their thesis is that professionalism is an inappropriate concept to apply to scientists and engineers working in large organizations and is synonymous with career immobility within organizations. The ideology of professionalism, is based on autonomy and loyalty to the profession rather than employing organization. Presumably, autonomy rather than upward mobility within an organization is part of the professional ethic. Using the results of attitudinal surveys of new engineers (N=676), Goldner and Ritti report results similar to Bailyn's [Bailyn, 1980], showing a strong orientation toward organizational goals, indicating that engineers themselves tend to have an organizational rather than professional orientation.

According to Goldner and Ritti, the application of the term professional to scientists and engineers in large organizations is an attempt to redefine failure to enter management in successful terms: firms have recognized that everyone can not rise in the hierarchy, and that there are non-managerial jobs within the organization which have to be done and which require skill and a high level of commitment to be done well. In an effort to reward technical competence, firms have tried to set up a reward structure that parallels the managerial hierarchy, the dual career ladder system.

The technical career ladder fails for several reasons, according to the authors. First, the technical career ladder is set up to reward individual performance by increasing autonomy. However, the nature of technical work is that it is frequently performed by a group of specialists who require coordination. In that setting, autonomy

could mean the loss to a project of a needed skill. Therefore, the work setting for many scientists and engineers does not allow for the autonomy usually associated with professionalism.

The second reason for dual career ladder failure is the lack of power associated with it. As professionals working solely on design problems, most engineers have no opportunity to decide upon the direction of project or company resources. According to a survey within a firm, entry level engineers view promotion into the two ladders as approximately equally attractive. As they approach the choice in their own careers, 71%, as compared to 29%, view promotion to the management ladder as more attractive, because, according to Goldner and Ritti, they recognize that control over resources is associated with management.

Although Goldner and Ritti view the dual career ladder as a failed experiment, they conclude with the optimistic view that the dual career ladder represents an early stage in the development of alternative non-hierarchical definitions of success.

Bailyn [Bailyn, 1982b] views the alienation of midcareer technical professionals as the result of two conflicting myths about the expectations of engineers. The first is the academic myth, that engineers can expect a continuing technical challenge. This directly conflicts with the industrial myth that by age 40, a successful engineer has left technical work for management. The difficulties with these opposing myths are, first, they overgeneralize about the talents and preferences of engineering labor. And, second, adherence to one or the other myth leads many engineers to make less than

optimal career choices: to either strive to remain competent to technical challenges through continuing education, which has shown to be less than effective [Kaufman, 1974; Kopelman, Thompson, & Dalton, 1973]; or to move into management, which for some is not the best use of their talents. The reconciliation of these two myths depends in part on engineers themselves recognizing their own orientations, but also on firms providing what Bailyn calls "more imaginative career paths than are commonly found in major firms today"[Bailyn, 1982b, p.5].

Bailyn's assertion that part of the responsibility of technical obsolescence belongs to the firm is supported by many authors. Dubin [Dubin, 1973] makes the point that obsolescence, per se, can only exist in a larger context; in other words, the organization defines obsolescence. Leventman cites this problem when she notes that there was no apparent relationship between number of journal articles published or new patents issued and probability of lay-off. That organizational factors are a major determinant is also reinforced by Bailyn's results [Bailyn, 1980] that of those in the scientific-professional pattern with high organizational positions, most of whom are university professors, 77% are technically oriented, compared to 22% of the highly positioned engineers. Given each group represents comparable age cohorts, and so any age-obsolescence relationship would hold equally for both groups, it appears that the university structure encourages continuing technical competence but the firm organizational structure does not. While technological change is an important external factor in obsolescence, firm

organization which discourages the use of a wide range of skills and does not reward the continuing development of technical competence force the choice between management and obsolescence.

Miller [1974] sees four different types of obsolescence: 1) that due to lack of use of a specific skill; 2) functional obsolescence, when a technology becomes obsolete or a firm changes its technological direction; 3) motivational obsolescence, where an individual decreases work effort; and, 4) obsolescence due to a built-in bias toward youth, where experience limits rather than increases opportunity. According to Miller, variety of job assignment is the key variable to reduce the probability of obsolescence. Although some of these types are more amenable to firm control, firms must recognize the dynamics of the problem and show a commitment to resolving it.

Davis and Davis and Trist [Davis, 1974; Davis & Trist, 1974] see the problem of obsolescence as firm failure to recognize that work is done in a sociotechnical system. The two basic premises of sociotechnical theory are that, first, work output is produced jointly in a social and technological system, and efficient production requires joint optimization of these two systems. And, second, each sociotechnical system is embedded in the firm's culture and value system environment. Sociotechnical theory rejects the concept of technological determinism in the organization of work which they claim is the basic underlying assumption made by firms that generates obsolescence. They cite an example of a firm in the aerospace industry faced with problems of high engineer turnover and cost overruns. Analysis of the problem showed that engineers had developed

an industry rather than firm orientation to avoid stagnation and, as such, were not concerned with firm specific cost controls.

Recognition that fear of obsolescence was the underlying cause, the firm restructured its personnel allocation so that an immediate job represented the intersection of both task needs and career needs.

Pettigrew [Pettigrew,1973] sees the obsolescence problem as a dynamic process. His case study of programmers, which will not be detailed here, describes how one group of technical specialists, computer programmers, threatened by technological change and the firm's increasing use of systems analysts to bridge the gap between organizational objectives and the programmers' output, attempt to shelter themselves from loss of independence. The programmers' strategy was to declare themselves to be professionals and imitate prototypical professionals' efforts to safeguard their profession: claiming a unique knowledge base and attempted control over recruitment and training. In this case, the programmers isolated themselves into obsolescence. Pettigrew's analysis is consistent with points made by Goldner and Ritti who argue that professionalism is an inappropriate concept in an organizational context, and by Bailyn, who notes fear of movement as leading to stagnation [Bailyn, 1982c].

The final two papers take the perspective that obsolescence is the result of firm efforts to control the workplace. Both examine the use of computer programmers, but the tendency toward overspecialization that they document can be applied to scientists and engineers.

Unlike some of the other authors cited here, Greenbaum and Kraft

[Greenbaum,1979; Kraft,1977] view the application of the term professional to technical labor as emanating from firms as a means to avoid unionization. Greenbaum sees firms as encouraging overspecialization as a means to decrease worker mobility and gain control over task definitions and the pace of work. Like Davis and Trist, Greenbaum rejects technological determinism, but rather sees the organization of work as the outcome of the struggle for control over the workplace. She describes the problem with programmers as one where managers supervise lower level workers with higher level expertise, thus disrupting the firm's hierarchical structure. Overspecialization, or deskilling (the deliberate attempt by firms to increasingly divide labor thus reducing the skill needed by any given worker to perform a task) was the firm response.

Both Greenbaum and Kraft regard dual career ladders as control mechanisms. Greenbaum sees the establishment of technical ladders as a way to duplicate for technical personnel the method of control that has worked so well with managerial personnel, minute stratification to create the illusion of mobility. Kraft, on the other hand views the creation of dual systems as a way to channel "'acceptable' people into 'appropriate' jobs" [Kraft, 1977, p. 87]. According to Kraft, those on the managerial career ladder receive higher salaries and are more mobile because they become generalists which is a prerequisite for upper management and, he thinks, more interfirm movement. He sees the technical ladder as a palliative.

III. Issues Raised by this Literature

As was mentioned earlier, this literature review had two purposes, to establish the midcareer dilemma faced by many scientists and engineers between remaining in technical work and choosing management, and to indicate the need for an understanding of this problem in a labor market context.

That the implications of this career choice are not well understood in terms of labor market theory is clear from this literature review. Only two of the papers directly refer to the role of the external labor market in affecting career path outcomes. Hall and Mansfield note the effect of external market changes on job content and satisfaction of older technical workers. And, Leventman notes the differential lay-off and reemployment effects between those who are strongly oriented to firm goals and those who are not.

The human capital hypothesis would predict differences in outcomes as due either to an unwillingness of technical workers to continue to make the needed on the job human capital investment, or due to the fact that there is a ceiling on how much on the job experience can contribute to the productivity of a technical worker which reduces the difference between the productivity of younger and older workers. In fact, this theory would predict that experience would increase the productivity of managerial workers due to their increase in firm specific knowledge, but might actually decrease the productivity of technical workers due to external rates of technological change.

In the next chapter, the human capital literature is discussed as well as several papers that suggest that the productivity-wage may be mitigated by firm structure and implicit agreements between firms and workers about production, job security, and earnings.

FOOTNOTES

¹ Beyond their brief presentation of the cobweb model, the theoretical discussion is primarily limited to a survey of approaches to estimating the supply and demand sides of the engineering labor market. They devote an entire chapter to a discussion of choosing appropriate occupational categories: they argue for the use of categories which capture the concept of substitutability of inputs in the production process. But, they do not make use of this concept in their own selection of occupational categories.

In their discussion of modeling the demand side of the market, they emphasize the important role that marginal product plays in the demand function, which is characteristic of this type of study. By assuming that the marginal revenue product function of labor is the same as the demand schedule for that labor, they are forced to also assume some kind of intra-marginal homogeneity of labor. Other literature about engineers suggests that the career phase of a particular engineer strongly influences what that worker can produce and so challenges the assumption of homogeneity of labor within occupational categories. So, to be consistent with the model, any measure of Q should really be a measure only of new entrants to the engineering market and dQ should refer to those in, say, a queue of recently graduated engineers. Although they do not acknowledge this, their theoretical model really only applies to the new entrant portion of that labor market.

On the supply side, they present three different methods of analysis, all based on the human capital occupational choice model. The first is a straight forward calculation of rate of return on the investment made in an engineering education. They raise several questions about this method, one being the likely positive correlation between unmeasured ability and education, biasing the education coefficient upward, and another, which they fail to incorporate into the demand side discussion, that occupational status does not stay fixed over time.

The second method is a recursive method, where salary expectations are formed based on the current year, but the supply is not affected for several years. Using this approach, the lag structure is estimated. This method of estimation explicitly only applies to new entrants to the engineering labor market. They note

that to estimate the total supply schedule, which would also allow either for horizontal shifts or upgrading of technicians.

The third estimation approach is to construct a simultaneous model of the quantity of workers supplied and demanded in an occupation. The paper by O'Connell presents such a model, so comments about this method will be reserved for the discussion of that paper.

2 The categories include: entrepreneur, general manager, functional manager, science manager, engineering manager, staff scientist, staff engineer, business staff, science professor, engineering professor, and consultant.

3 In order to be certain that she was associating job values with actual occupational roles rather than just individual preferences, she used only the answers from that part of the sample which described themselves as successful (N=314).

4 76% of E rate challenging work as "very important" compared to 84% of pattern SP; 56% of pattern E rank freedom to be creative and original as "very important" compared to 86% of SP; and a sense of accomplishment is "very important" to 77% of pattern E compared to 86% of SP. Again using the percent rating a value as "very important", 47% of E versus 13% of SP valued opportunity for high earnings, 68% of E versus 35% of SP valued opportunity for advancement; 57% of E versus 25% of SP valued opportunity for leadership; and, 60% versus 39% valued contribution to organization [Bailyn, 1980, p.26-27].

5 In addition, she attempts to test a very important concept, whether those values which were exhibited are the result of preselection or career socialization. Her test is based on an admittedly questionable assumption that Ph.D.s, whether in science or engineering, have a similar value orientation upon graduation. Sorting the sample of successful respondents into E-no Ph.D., E-Ph.D., and SP-Ph.D., she looks at the percent of each category which exhibit intrinsic versus extrinsic values and finds support for the socialization concept.

The role of socialization is either implicitly or explicitly important in this literature which addresses the choice between technical and managerial career paths. The power of a dominant myth which Bailyn and others identify, that engineers, in particular, must become managers or be viewed as failures, depends in part upon the extent to which workers are socialized into adopting extrinsic rather than intrinsic values.

6 Of the sample, only 727 show an unambiguous orientation. Of those whose orientation could be identified, the groups with the largest share with a technical orientation were SP/L and SP/H, with 81% and 77%, respectively showing a technical orientation.

7 The group with the strongest human orientation was E/H, with 44%. And, the group with the strongest non-work orientation was E/L, with 54%.

8 Baily's [Baily, 1982b] four sources of stagnation encountered by those who continue on a technical career track parallel Leventman's paradigm. 1) a tendency toward overspecialization, due to both "burn out" after working on a narrow task too long, and, that as a technology itself becomes obsolete, it is difficult for an engineer with overly narrow skills to make the transition to new technologies. 2) the lack of firm rewards to and recognition of technical accomplishment. where the technical career ladder in a dual career ladder firm is perceived as and often is an alternative position for those who attempted but failed to rise on the management ladder. 3) the lack of scope, area over which engineers have responsibility. Unlike Goldner and Ritti who see as unreconcilable the problem of technical workers needing managerial coordination, Baily thinks that there are technical planning and coordination aspects of projects over which engineers can have control as they gain experience. 4) oversupervision: as engineers gain in experience, they should be permitted to monitor their own work and be accountable for a broader range of tasks.

CHAPTER III

Review of the Literature on
the Relationship between Earnings and Work ExperienceIntroduction

Since the early 1960s, when the idea that individuals invest in themselves, or accumulate human capital, to become more productive was introduced, an enormous amount of literature exploring the theoretical implications for and empirical effects of this investment decision has been generated. Gary Becker's monograph, Human Capital [1964], develops, among other topics, a theory of on-the-job human capital formation, distinguishing between two types, general and firm-specific experiential. Becker provides an explanation of the difference between general and firm-specific human capital and hypothesizes different labor market outcomes associated with each type of investment. Firm-specific training is a key concept in reconciling the human capital and institutional approaches to the labor market, because certain explanations of the existence of internal markets rest on the importance of specific training. The human capital focus is on who pays for and receives returns on that investment and how that affects wages and turnover/tenure. The institutional approach emphasizes the institutions which emerge to protect this investment. For example, Wachter and Williamson [1978] see firm specific skills as being so central to the labor market that bilateral monopolies result, and both workers and firms have strong incentives to minimize turnover

and bargain over wages.

However, there is some debate about the actual importance of firm specific training. Sherwin Rosen argues that the importance of firm specific training depends only on transaction costs and so has only a short term effect unless a formal structure arises to institutionalize those costs [Rosen,1977]. In an attempt to establish the point that the efficient operation of some internal markets may involve substantial turnover, Hall argues that it is possible that firm experience may be a prerequisite for a job, but has no economic value [Hall,1981]. In other words, no firm-specific human capital is acquired through experience.

The major difficulty in determining the effects of these two types of training is that the distinction between them rests on the relationship between wages and the marginal product of labor. Once the period-by-period assumption that wages equal the marginal product of labor is abandoned, the unobservable nature of the marginal product of labor complicates any empirical efforts. With the exception of Becker's monograph, the papers in this review in one form or another address this problem of the unobservability of the central human capital variables and the theoretical and empirical problems that arise from this feature of the hypothesis.

The literature review begins with a discussion of Becker's hypothesis. Rosen's 1977 survey of the literature best describes the major points and gaps in the human capital literature up to that point, and so the highlights of his survey will be reviewed. Additional pre-1977 papers and more recent papers addressing Rosen's

points will be integrated into that section. Section III is a survey of the turnover literature which concentrates on estimating returns to mobility and to tenure. Those papers represent efforts to separate the effects of aging and experience as a way of estimating the returns to specific human capital. In the final section, papers are discussed that challenge the link between productivity and earnings and argue that institutional arrangements determine wage and turnover patterns.

I. Becker's Analysis of Human Capital Investment

Although there had been previous studies of the economics of education, the first comprehensive statement of the human capital approach was Gary Becker's 1964 monograph, Human Capital. Becker's work is rich, spawning much subsequent research. The primary advance of the human capital theory was to characterize individual labor market outcomes as determined by individual decisions to forego present gains by investing in themselves, augmenting their human capital in order to receive greater income in the future. Previously, expenditures on education, health, migration, etc. were viewed as a form of consumption and analyzed in a utility-maximization framework [Blaug, 1976]. In developing his human capital investment approach where the internal rate of return was the decision-making criterion, Becker was able to begin to explain such phenomena as education, search for job information, and on-the-job training (OJT) in a rational economic framework, which did not rely heavily on individual tastes and utility.

Becker enumerates several different forms of human capital investment, but he restricts his own analysis to the calculation of the rate of return to investment in formal education and OJT. He begins his discussion of OJT with the equilibrium condition that would hold in a perfectly competitive market where the demand for labor is a derived demand: $MP=W$, where MP is the marginal product and W the wage rate. That condition is altered to $MP_t=W_t$, where t is the t th period. But once OJT is introduced, it is necessary to depart from this period-by-period equilibrium condition and consider the effects of present expenditures on future receipts. Human capital investment is characterized by the willingness to accept lower present earnings with the expectation of greater future gains. And, firms are seen as joint producers of both goods and services and training. The new equilibrium condition, which explicitly includes the relationship between present training costs and future returns, is :

$$MP_0 + \sum_{t=1} (MP_t / (1+i)^t) = w_0 + k + \sum_{t=1} (w_t / (1+i)^t)$$

where k is the actual outlay on training and the subscript, 0, signifies the initial period. That equation can be rewritten as

$$MP_0' + G = w_0 + c$$

where MP_0' includes foregone production, $G = \sum_{t=1} ((MP_t - w_t) / (1+i)^t)$, and is the difference between future receipts and future expenditures; and, c is the sum of opportunity costs of training and k , the actual outlay for training.

At this point, Becker makes a major distinction between two different types of training that occur on the job, general and specific. The key difference between the two is that the first has

value in firms other than the firm where the training took place; that is, general training would increase the worker's marginal product elsewhere. And, the second only has economic value within one specific firm. This is an important distinction, because limitations on where an individual can realize returns on training related human capital investment affects mobility patterns and increases the hardship associated with involuntary unemployment.

Becker's observation about the difference between these two types of training has inspired a large quantity of theoretical work. For example, the development of internal labor markets is often attributed to the presence of specific training. However, the separation of these two types of training has been difficult to make empirically, leaving the link between training and labor market outcomes, such as earnings and tenure patterns, in dispute.

A. General Training

Becker's argument for the concavity of the earnings function begins with the observation that, given that general training can be used in any firm, there is no incentive for firms to invest in general training if zero or even negative returns on their investment are likely due to turnover. Workers, and not firms, pay for that type of training. Putting that into an equilibrium framework, $G = 0$, so $MP_0' = w_0 + c$, which can be restated as $MP_0 = w_0 - k$, and therefore: $w_0 = MP_0 - k$; or, wages equal marginal productivity minus training costs.

Training is assumed to take place early in one's career in order to have the longest period over which productivity can be increased, and because, as productivity increases, the foregone costs of

investment rise. So, wages are less than the opportunity marginal product at the beginning of one's work life. After training is completed, a worker's earnings rise to the value of the new, higher marginal product. The higher the initial training costs, the steeper the earnings function during that transitional period. Diagram 1 shows this relationship, where TT is the earnings function of a trained worker, UU is that of an untrained worker, and T'T' is the earnings function which underlies TT.

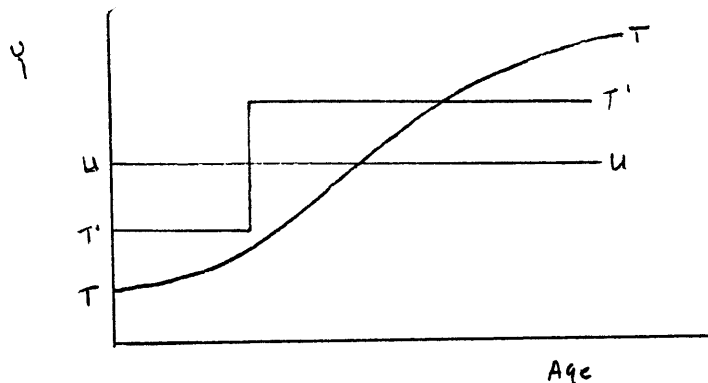


Diagram 1

B. Specific Training

Specific training is training that increases worker productivity only in that firm that provide the training and so is not useful in other firms. Therefore, a worker's opportunity wages are independent of the level of specific training.

Training and Turnover. Becker's discussion begins with the observation that the rational worker will pay for specific training only if that worker receives all the returns from that investment in the form of higher wages. Becker's point is to show how specific training affects the wages/marginal product relationship and how that

relationship depends upon the probability of turnover. If the firm were to pay all the costs, it would expect to receive all the returns. The equilibrium condition is: $MP_0' + G = w_0 + c$, where $G = (\sum_{t=1}^{\infty} ((MP_t - w_t)/(1+i)^t))$. Letting w be the opportunity wage, G is the net present value of the returns on the training investment. Assuming that $G = C$, initially, wages will equal the opportunity rather than the actual marginal product of labor. Once specific training, paid for by the firm, begins, the worker's productivity will rise. But, the firm will capture the benefits of that increased productivity because the firm paid for the training. So, wages will not equal the marginal product of labor, but will continue to equal the opportunity wage.

But, it is also possible to have an alternative arrangement, where workers pay for some or all of the training and share or collect all of the benefits. Here is where the probability of turnover becomes important: the willingness of either workers or firms to pay for specific training will depend upon the probability of turnover. Whoever pays for specific training will lose returns on that investment if turnover occurs. This then introduces the possibility that training costs are shared, and that these shares are determined, in part, by the probability of quits and layoffs.

Applying this argument to the question of the relationship between wages and marginal product, Becker starts with the previous equilibrium condition, $MP' + G = w + C$. Then, letting G' equal the share of returns going to employees, $G'' (= C)$ be the full equilibrium level of returns, and a be the share of G'' collected by firms, so that $G + G' = G''$ and $G = aG''$, the previous equilibrium condition can

be written as: $MP' + aC = w + C$ or $w = MP' - (1-a)C$. So, wages are diminished by the share of their own specific training for which workers pay.

Becker uses this conclusion about the relationship between wages and marginal product to develop a theory of turnover. Essentially, his argument is that first, a rational firm will pay generally trained workers their opportunity wage and specifically trained workers more than the external market wage. He makes the case in some detail that firms will have an incentive not to lay off specifically trained workers and will keep them even if their marginal product temporarily falls below their wage rate due to some temporary decline in product demand. Firms will use techniques such as increasing wages or offering high post-training wages to reduce turnover. His discussion of what workers would do is very brief and is summarized by the conclusion that changes in the employment level in response to the business cycle will be less dramatic for specifically trained workers than for those with general training.

Implications of the Training Distinction. This concept, that there are two different types of experiential training is important for several reasons. First, it provides an explanation which does not depend on the firm being a monopsonist of why wages may not equal marginal product even in an efficient labor market. Second, it provides a basis for a theory of turnover because, since specific training is not costless and yields positive returns only in a particular setting, whoever pays for the training will be hurt by turnover.¹

Third, it implies that there will be differential rates of return to firm tenure and interfirm mobility depending upon the relative size of the investment shares of specific and general training. A worker who has invested primarily in firm specific human capital should realize greater returns to tenure than an individual who, other things being equal, invested more in general training. And, a generally trained person should receive relatively higher rates of return on mobility than one specifically trained.

And, finally, Becker's conceptualization recognizes that firms are joint producers of both goods and services and training. And, that as such, the firm must operate along some training production function.

II. Rosen's Survey

In his 1977 survey of the empirical research done on human capital, Rosen enumerates several flaws and gaps in existing work. His discussion centers around efforts to address two types of problems: methods to estimate unobservable variables and the derivation of behavioral models with explicit structural foundations that explain the optimum investment choice.

The basic human capital investment equation is: $\max V_t = (Z / (1+r)^t)$, where V_t is net present value, Z is the accounting identity, the difference between two income streams, $Z_t = Y_t - X_t$ and r is the interest rate. The internal rate of return, i , is found by replacing r with i and setting $V_t = 0$. The investment choice then

depends on whether $i > r$.

Immediate problems occur because once the assumption of the homogeneity of labor is dropped, r is expected to vary with the individual and is therefore unobservable. In addition, comparison of the earnings streams by extrapolation requires strong assumptions about differences in life-cycle earnings patterns. Choice of an appropriate comparison group to proxy X_t and Y_t is complicated by the likely effect of self-selection. And, there is some debate about whether earnings is an adequate measure of income. So, although in this simple model the criteria are conceptually clear, individual choices about education and investment in on-the-job training are not simply estimated because the major variables cannot readily be measured.

A. The Ability-Schooling Problem

Although Rosen is discussing the education decision rather than the on-the-job training decision, his sample model underscores the self-selection problem. He begins with an earnings function: $Y=f(s,A)$, where s is years of school, initially a slope predictor, and A is ability, a shift parameter, exogenously given. The problem is to choose the level of s which maximizes the discounted value of future income: $V(s) = \int y(s,A)e^{-rt} dt$. The decision rule again is to choose s so that $r = i$. Diagram 2 shows the relationship: $\partial V/\partial s = r$, with $v(s)$ and $f(s,A)$ being tangent at $i = r$.

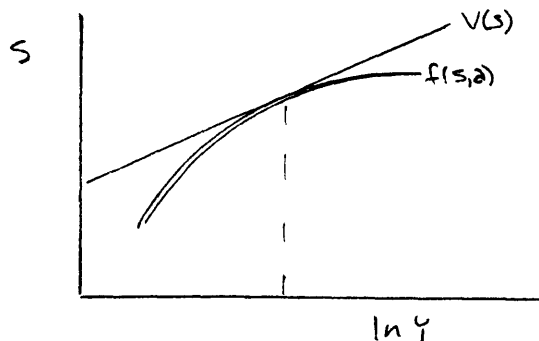


Diagram 2

The major problem with estimating this is that r and A are not independent and, therefore, the model is underidentified. Rosen notes that if separate measures of r and A were available, then the model would be exactly identified and thus could be estimated recursively. The primary implication of this interdependence between r and A is that a self-selection bias occurs in the schooling choice. Those who are more able are thought to face lower education costs. Therefore, what appear to be returns to education are actually returns to ability.

Much effort in the human capital literature has gone into controlling for this probable bias. A recent breakthrough in the resolution of this issue has been the recent availability of usable longitudinal data which cover a sufficiently long period of labor force experience.

Several efforts have been made to measure ability directly in order to eliminate the bias on the education coefficient. Taubman and Wales (1974) use the NBER-Thorndike sample of 75,000 males from the WWII Army Air Corps to attempt to estimate an unbiased rate of return to education by proxying ability and the interest rate, r , using several variables: education, test scores on general and mathematical ability, personal biographical indices, health, and father's education. They also test the screening hypothesis, that education is used as a sorting mechanism by employers and not because it provides necessary "affective" skills.

A recent paper that implicitly addresses the self-selection problem is by Randall Filer, who maintains that the structure of real human capital is poorly defined. He constructs and estimates a model that he argues reveals the underlying structural relationship between the different components of human capital and earnings. His model is a two equation model: $Y=f(K,z_1)$ and $K=g(s,x,z_2)$, where Y is income, I is a vector of human capital stocks, s is education, x is experience, z_1 is a vector of other variables which influence wages, and z_2 is a vector of other variables affecting human capital stock. The first equation is an hedonic wage equation and the second an implicit human capital production function.

He claims that, ordinarily, because of lack of data, a third reduced form equation is estimated: $Y=h(s,x,z_1,z_2)$. Filer uses a linear specification, and after testing for simultaneity with the Hausman specification test, estimates his model using OLS. Because of his unique data set that includes multiple personality and background measures, Filer can estimate what seems to be a more complete version of his second equation.

A possible criticism of his paper is that he is relying on indices of subtle personality traits that are difficult to measure such as objectivity, friendliness, and thoughtfulness. And, while many of these personality variables are statistically significant, their contribution to the explained variance is negligible in comparison to that from the conventionally used human capital variables.

In a paper by Nickell, a longitudinal data set is exploited to

control for unobservable variables that could bias estimates. He is studying the determinants of occupational success in Britain, using a human capital framework. Occupational attainment is a function of individual characteristics, such as ability and family background, and explicit human capital investment variables (education, training, experience, etc.). His model is: $Y_{it} = B_{0t} + \sum_{j=1} B_{jt} X_{jit} + f_i + u_{it}$, $u_{it} = u_{it} + e_{it}$, $\rho \rho < 1$, and $e_{it} \sim N(0, \sigma^2)$, where Y_{it} is earnings for individual i in time t , X_{it} is the set of j observable human capital variables, and f_i is the set of unobservable human capital characteristics.²

He estimates two sets of equations, one using data from the starting and ending points of the survey period (1965 - 1975) and one using the full set of longitudinal data. His two point model is the difference between the earnings equations for two points in time:

$$Y_{2i} - Y_{1i} = (B_{20} - B_{10} + 100w_2) + \sum_j (B_{j2} - B_{j1}) X_{ji1} + \sum_j a_{j2} X_{ji2} + \sum_j (d_{j2} - d_{j1}) Z_{ji} + 20w_2 e_{i2} + (u_{i2} - u_{i1}),$$

where e_i is experience and f_i are fixed personal characteristics. The affect of all fixed effects, including the unmeasurable f_i , can no longer be identified.

To use the full set of data, he estimates a log-linear model:

$$\ln Y_{it} = B_t + \sum_j B_{jt} X_{ijt} + f_i + u_{it}, \quad u_{it} = \rho u_{it-1} + e_{it}, \quad E(f_i, u_{it}) = 0.$$

He tests for this last assumption, that $f_i \sim N(0, I)$, but has to reject it. He therefore uses an instrumental variable technique to correct for that problem.

After identifying the difficulties of estimation of educational effects due to the interdependence of r and A , Rosen points out an alternative interpretation of the earnings function that Mincer

articulates in his 1974 monograph, Schooling, Experience and Earnings [Mincer, 1974]. Under Mincer's interpretation, labor productivity is not measured in marginal units, but rather each level of education teaches a discrete set of skills, and there is no substitutability between these different skill sets. Therefore, different earnings profiles represent the different rental rates to these different discrete skill groups. And, while individual ability, which in this context can be seen as aptitude for different types of skills, may be correlated with educational level, given the discrete nature of the different skill levels, it does not create an estimation problem. Under this "equalizing difference" hypothesis, $\ln(y) = \ln(E_0) + rs$ describes a behavioral not reduced form, relationship.

B. Human Capital Investment on the Job

Rosen's criticism of the investment framework used by both Becker [1964] and Mincer [1962] is straight forward. Individuals are again maximizing net present value. Here, the cost of investment is equal to the opportunity cost of the nearest alternative so that $z_t = y_t - x_t = r \sum c - c_T$. Rosen shows how this formulation can be converted into an earnings function where earnings depend on the share of each period spent investing rather than on earning. However, he notes the lack of constraints that make the model inadequate theoretically. The difficulty is that once the realistic assumption of a finite working life is imposed, the model is underidentified even with the assumption that c_N , the level of investment in the final period of work, equals zero. To solve the problem, the value of r is usually imposed exogenously.

According to Rosen, the difficulty with this type of calculation is that imposing r exogenously is essentially the same as constraining the marginal interest rate to equal the average rate, and that the assumed identity, $V_t = C$, is essentially the same as assuming the marginal costs, average costs, and marginal returns are all equal, disallowing over or under investment by individuals. He argues the need for restrictive assumptions about the unobservables (see Bartel & Borjas, 1978, for an example of the restrictive cost assumption).

The chief criticism of the models presented so far is their lack of ability to allow for estimation of the underlying structural parameters. According to Rosen, optimum accumulation models are preferable because they result in estimates of lifetime earnings trajectories that arc through a series of earnings functions where earnings are a function of embodied knowledge K and $K' (=dK/dt)$. By introducing what amounts to a learning production function, underlying parameters of the investment decision, such as r and learning depreciation can be estimated.

c. Optimum Investment Models

Two examples of optimum human capital investment models are those by Ben-Porath [1967] and Rosen [1972]. Ben-Porath uses a production function approach where individuals use human capital to produce human capital and are constrained by rising marginal costs. Individuals are assumed to be able to allocate their time between the production of human capital and the production of earnings in each period. He shows that because the marginal costs of human capital production increase over the life-cycle, the observed age-earnings profile of low earnings

early in life with earnings increasing at a decreasing rate until T , the last period of work, can be explained.

In Ben-Porath's model, earnings are a function of units of human capital employed in producing earnings and the rental rate: $Y_t = a_0 K_t$, where Y_t is earnings in time t , a_0 is the rental rate, and K_t is the service unit of human capital in time t . The human capital production function is: $Q_t = B_0 (s_t K_t)^{B_1} D_t^{B_2}$, where B_1 and $B_2 > 0$, $B_1 + B_2 < 1$, and $0 < s_t < 1$. Q is the flow of human capital produced; D is the quantity of purchased inputs at price P ; and, s_t is the fraction of time available in period t for the production of human capital.

Investment costs have two components, opportunity costs and direct costs: $I_t = (a_0 s_t K_t) + (P_d D_t)$. Individuals want to minimize their investment costs subject to some desired level of human capital production, Q_t , and possible limits on the amount of time in each period that can be spent on the production of K , s_t .

What he shows is that when the individual decides on the optimum course of investment, the relative price of investment (a_0/P_d), does not change the quantity of human capital produced, because an increase in a_0 increases the value of human capital by an equal amount. Therefore, the marginal investment (or human capital production) cost curve from is stationary over time. And, assuming that s , the time available for production, can vary from period to period and so does not act as a constraint, the demand for K is perfectly elastic and moves down over time as P increases. The series of intersections between the demand curves and the marginal cost curve define the optimal investment path for the individual.

Ben-Porath does not differentiate between general and firm specific knowledge, and unless a restrictive assumption about lifetime firm tenure were made, the perfectly elastic demand curves would apply only to general human capital.

Rosen's paper also considers only general human capital. His purpose is to explain the lifetime earnings profile. To do this, he uses a model where jobs have various levels of training opportunities associated with them, and firms essentially sell jobs to workers. He hypothesizes that workers select jobs based on their demand for learning which depends on the cost of investment. Using Ben-Porath's conclusion, he sees that cost as increasing with age as opportunity costs of learning increase due to increased embodied human capital stock. He describes worker choice as a series of job switches, where workers progress to jobs with ever diminishing learning opportunities and thus higher earnings.

He then discusses firm incentives to provide a series of learning opportunities. His argument is based on the production function of the firm and the relative prices of employing some level of human capital.

Although his model provides an interesting framework for examining worker job choice, his treatment of the costs associated with firm-specific human capital and its effect on job choice and earnings profiles raises a question about this approach being able to explain completely earnings over time. Rosen minimizes the role that firm-specific human capital plays in the long run and argues that in a competitive market, its importance depends upon the presence of

transaction costs and perhaps the degree to which those costs are institutionalized. As a result, although Rosen argues for the need for an exactly identified structural model, his own survey only cursorily mentions elements of training supply, that is, firm decisions about training. Individuals are assumed to make autonomous decisions about the optimum level of human capital investment, given some exogenous level of firm costs of supplying training.

III. Turnover

Becker explicitly links turnover and firm specific human capital in his discussion of the sharing of investment costs between workers and firms. The rational individual would not pay for firm specific skills. However, these costs are shared because of the non-zero probability of turnover and that the rate of investment in firm specific human capital depends on the probability of turnover. As in the case of the education decision, the cost of on-the-job training to the individual is equal to foregone earnings, where these earnings are hypothesized to be equal to the marginal product of labor.

Unfortunately, the investment costs, the opportunity wage, and the marginal product of labor are all unobservable. Consequently, studies of returns to turnover provide the current best means of estimating firm specific human capital: returns to job tenure can be used as a first approximation of returns to firm-specific human capital, and turnover can be thought of as either a loss of that capital or an indication that an investment was never made. Not all

of the papers mentioned in this section are explicit about this connection between turnover and firm specific human capital, but are included because of interesting techniques used or particularly relevant results.

Effect of Interruptions in Labor Force Participation. Two studies that address the question of firm-specific human capital accumulation are those by Mincer and Ofek [1982] and Lazear [1976]. Mincer and Ofek use longitudinal panel data on married women from the National Longitudinal Survey (NLS) to examine the rate of depreciation and rrestoration of human capital that occurs after an interruption in labor force participation. They assume that, after returning to employment, wages of leavers are less than those of stayers due to foregone general human capital. But, if return wages are lower than exit wages, the difference is due to loss of specific human capital. Diagram 3 shows the hypothesized relationship.

AB is flatter than JK if the interruption is anticipated.³

Mincer and Ofek estimate two earnings functions, one using retrospective (pre-1966) data and one using the panel data. Their model is: $\ln W = a_s + B e_0 + C e_1 + D h_0 + E h_1 + u_x$, where e_0 is past labor force participation, e_1 is current participation; and h_0 and h_1 are past and present non-participation. s and x are schooling and "other variables". Letting T equal the reentry time, e_1 becomes 0 and so: $\ln W = a_s + B e_0 + D h_0 + E h_1 + u_{x_T}$ is estimated using retrospective data. They find the long-run effects of experience (B) and withdrawal (D) to be significant. The short-run effects (C and E) are also significant and much larger than the long-run, supporting their hypothesis.

They then use the panel data to estimate sections of their model separately, $\ln W_T - \ln W_V$, and $\ln W_{74}$, the effect of withdrawal on the return period. The results on the first panel data estimation confirm the estimates made with retrospective data.⁴ They find that depreciation occurs only on general human capital and that the loss of specific human capital is a "once-for-all" occurrence resulting from job separation.

In his paper, "Age, Experience, and Wage Growth," Lazear looks at the effect of employment interruption on earnings as a means of separating the effects of aging from labor force experience. He expects that earnings growth will be based not just on age but on time spent on the job. He uses the NLS sample of young men and looks at the period 1966 to 1969. His model is: $W_{69i} = A W_{66i} e^{t+u}$ where W_{69} is the wage rate for individual i in 1969, W_{66i} for 1966, A is a shift

parameter reflecting cohort effects and the business cycle, δ_{it} is the rate of wage growth, and $u_i \sim N(0, \sigma^2)$. Because δ_{it} is a function of the changes in schooling and in job-related human capital, he works through a process to approximate a measure of the unobserved changes in OJT generated human capital.

Lazear's purpose is different from that of Mincer and Ofek in that he is not trying to separate general from specific human capital, but examines whether interruption in employment has a single shift effect or continues to influence subsequent earnings. He finds that an individual not working for one year out of the three in the survey period will experience a \$.148 per hour loss of earnings which will continue over the working life of that person. In addition, the job-experience effect resulting from foregone capital accumulation due to work interruption will affect the rate of earnings growth. He finds that the negative effect of work interruption on earnings is greater for younger workers, who are investing at a much greater rate, than for older workers who invest less with time.

Returns to Turnover. Three papers which examine returns to turnover are those by Bartel and Borjas [1978], Borjas and Rosen [1980] and Blau and Kahn [1981]. Bartel and Borjas in their study of the relationship between wage growth and turnover examine the difference in returns to quits versus layoffs. Specifically, they are interested in two questions: does mobility pay and is there a relationship between turnover and wage growth within the job. The argument they are making in this second question is that while it is accepted that mobility often acts as a shift parameter, they

hypothesize that for a given individual, tenure will lead to a steeper slope. This second question has implications for the specific human capital hypothesis because if those with longer tenure do indeed have steeper earnings profiles, that lends support to the hypothesis that the rate of firm specific human capital investment depends upon the probability of turnover.

They compare wage changes for movers versus stayers for two groups, older and younger males. Using a migration framework, they hypothesize that wage change is: dw (and $d\ln(w)$) = $f(\text{quits, layoffs, reasons for quits, push factors, pull factors, } X_i)$.⁵ In order to control for self-selection, they partition the survey time into three periods, 1967-69, 69-71, and 71-73, and restrict their sample to those who did not change jobs at all from 1967 to 1973 and those who moved only between 1969 and 1971. They then make the assumption that movers' earnings in the period from 1967 to 1969 can be extrapolated throughout the survey period to provide a definition of the alternative not taken.⁶

Bartel and Borjas derive their estimable model using a human capital investment framework and hypothesize that investment costs are a function of prior experience, π , current job tenure, e_n , and initial experience in the first job C_{0n} : (3) $C_t = C_{0n} - \sigma_n \pi_n - \beta_n e_n$. To estimate C_{0n} , they assume that it is positively correlated with the probability of separation: $C_{0n} = \alpha_n + \rho_n t^*$, where t^* is actual tenure as an approximation of expected tenure: $t^* = e_n + R_n$.⁷ Their final model is: $dY = (r_n \alpha_n + \beta_n + r_n \beta_n) - r_n \sigma_n \pi_n + r_n (\rho_n - \beta_n) e_n + r_n \rho_n R_n$.

Their results allow them to conclude that, first, there is a

difference between age groups. Mobility pays for younger workers but not for older. However, if either move for "pull" reasons, that is, finding a better job, both experience wage gains. For younger workers, movers gained more than stayers. However, if holding labor force participation constant, there a strong positive relationship between tenure and positive lifetime earnings growth. Borjas [1978] also finds strong support for this result.

Borjas and Rosen [1980], aware of the support for the finding that movers tend to have flatter lifetime earnings profiles than those with more stable job histories, examine whether turnover is or is not an efficiency mechanism. In effect, they are examining two empirical questions: whether or not expectations of earnings affects the probability of turnover; and, to what extent does mobility pay off to movers in comparison to stayers and tenure to stayers in comparison to moving.

They estimate both a structural and reduced form model. They start with a statement of expected wealth of each alternative depending upon future marginal product: $V_{si} = \pi_{0i} + \sum (\pi_i^s / (1 + r_i)^t)$ compared to $V_{ci} = \pi_{0i} + \sum (\pi_i / (1 + r_i)^t) - M_i$. Earnings are assumed to grow at a constant rate, ρ_{ji} . They construct a structural probit model: $I_i = \ln(r_i - \rho_{si}) - \ln(r_i - \rho_{ci}) + \ln[1 - m_i(r_i - \rho_{ci})]$, where $I_i = \ln(V_{ci}/V_{si})$, and $r_i, \rho_{ji}, \pi_{0i}, \rho_{ci}$, and m_i are all random variables, and $m_i = (M_i/\pi_{0i})$, or mobility costs measured in terms of time. Taking a Taylor series around the mean values, this is simplified to: $I_i = \alpha_0 + \alpha_1 \rho_{ci} + \alpha_2 \rho_{si} + \alpha_3 r_i + \alpha_4 m_i$, where the α s can be expressed in terms of ρ_s, ρ_c, r and m .

They then address the fact that ρ_c, ρ_s, r_i and m_i are all unobservable. They hypothesize that r_i and m_i can be expressed as functions of family background variables. And, they proxy ρ_s and ρ_c with wage growth: $r_i = z_i \gamma_i + \epsilon_{r_i}$, $m_i = z_i \beta_i + \epsilon_{m_i}$, $\rho_{ci} = X_i B + \epsilon_{si}$.

In order to estimate the structural probit equation, they first construct a reduced-form equation for the probability of turnover. This permits them to get estimated values for r_i and m_i . To obtain estimates for ϵ_{si} and ρ_{ci} , they observe that expected productivity is conditioned on the alternative chosen and that because ϵ_i include individual effects, $E(\epsilon_i)$ is also conditioned on the chosen alternative and is not equal to zero. To get unbiased estimates of the coefficients, they estimate the conditional values of ρ_i from the reduced-form model, which enables them to get predicted values for $\hat{\rho}_{ci}$ and $\hat{\rho}_{si}$ and estimate the structural model. Interestingly, the results of the structural and reduced-form probit equations are not significantly different from one another. Their results support their hypothesis that turnover is an efficiency mechanism as well as their assertion that the quit-layoff distinction is not important in predicting the rationality of turnover.

Blau and Kahn [1981] examine propensity to quit as well as returns to quitting by sex and race. They combine search and human capital approaches in their model. Compared to Borjas and Rosen, their reduced form turnover probit model is quite simple: $p(q) = f(o, c, sc, Y, L, J)$ where q is a dichotomous variable; o , the characteristics of the external wage-offer distribution, c is search costs, sc is specific human capital, Y is present discounted earnings

in the current job; L is the layoff probability in the current job; and, J is other job characteristics. They use non-stochastic proxies for unobservable variables and so can estimate the quit equation directly with probit analysis.

In their wage equations, they estimate both long- and short-run returns for quitting, using an instrumental variable technique to correct for the bias that exists due to a correlation between the error terms and the quit variable. In contrast to Borjas and Rosen, they find greater returns to quitting than staying for all of their sample. They attribute this difference in finding to the fact that they use a sample of only young men and women and so are unable to compare returns to staying and quitting for older workers.

The contrast between the relatively complex formulation of Borjas and Rosen and the simple model estimated by Blau and Kahn raises a question of the value of structural versus reduced-form models when their focus of study is comparative rather than absolute rates of returns.

IV. Institutional Approaches to the Relationship between Earnings and Experience

The papers described so far begin with the premise that skills are acquired on the job that increase productivity and that there is a link between productivity and earnings. The nature of that connection is then explored. In the papers in this section, it is accepted that

earnings usually increase with experience, but challenge the intermediate connections between experience and productivity and productivity and earnings. In this section, there is a brief review of the well-known internal labor market literature, followed by a discussion of several empirical papers that raise questions about the productivity-earnings relationship.

A. Internal Labor Market Theory

Origins. Doeringer and Piore's book, Internal Labor Markets and Manpower Analysis, [1972] sets forth the basic concepts that compose internal labor market theory. An internal labor market is defined as "an administrative unit, such as a manufacturing plant, within which the pricing and allocation of labor is governed by a set of administrative rules and procedures" [p.1-2]. Thus, a key difference between internal labor market theory and human capital theory is that earnings and employment levels are administratively determined rather than solely dependent on differences in human capital investment.

Doeringer and Piore argue that the internal labor market arises for technological reasons where workers use firm specific rather than exclusively general skills on the job. Skill specificity is acquired by OJT which is provided in part to new workers by experienced workers and in part by trial and error and experimentation. Because the nature of skill specificity is such that skills learned on the job have limited or no value outside the specific firm, there is a vast reduction in turnover, creating a stable work environment. Out of this environment, both worker and firm expectations about how work is organized, what the wage structure is, what the career paths are, what

the basis for promotion is, and what rules govern involuntary turnover solidify, so that customary law becomes one of the supporting mechanisms of the internal market. Workers are thought to prefer this stability because of the increased job security and advancement prospects, and employers prefer it because of reduced turnover costs.

This description highlights another major difference between internal market theory and human capital theory, that of the role of career paths within firms. Within the human capital literature, intra-firm mobility is essentially ignored with the exception of Rosen's theory of job switching as a means of securing earning opportunities.⁸

Wachter and Williamson [1978] describe the evolution of internal labor markets as a bargaining solution. They observe that the reliance on firm-specific skills results in a bilateral monopoly. Within the bargaining environment created by this bilateral monopoly there are transaction costs, specifically, "bounded rationality" and "hazards of opportunism" which can be minimized through the choice of a particular, efficient contracting scheme. Bounded rationality refers to the fact that the complexity of any given bargaining problem is beyond the human capacity to comprehend, so rational decisions are made with incomplete information.⁹ Hazards of opportunism refers to the potential in any situation for one party to use guile or misleading information for personal gain; opportunism must be controlled by the creation of a governance structure which prevents this type of exploitation. They show that this kind of governance structure can be generated by several different contracting schemes,

the best being obligational market contracting which is sufficiently long-run to overcome the costs of recurrent spot contracting and creates the needed governance structure. In a labor market setting, the internal labor market with its structured employment relationships and rules is a form of an obligational market contract.

Mobility Patterns. Using Doeringer and Piore's description of the allocative structure, internal allocation rules cover the degree of openness of the internal market, including ports of entry, criteria for entry, and ports of exit, and the scope and structure of the internal market which includes the mobility patterns within the internal market. Ports of entry refer to the points of contact between the internal and external labor markets; the more ports of entry to the internal market, the more open it is. A rigid internal market would be open primarily at the lower entry level jobs and vacancies elsewhere within the market would be filled from the internal labor force. Doeringer and Piore describe mobility patterns within an internal market in terms of mobility clusters, groups of jobs related by similarity of skills and/or levels or commonality of function. Mobility can be vertical, and thus defined by skill differences, or horizontal, reflecting the degree of specialization or division of labor at any given level. Both ability and seniority determine internal mobility patterns and rules governing involuntary exits. Seniority rights dominate the order of involuntary lay-offs and interact with ability and training in promotion patterns.

Paul Osterman [1978] adapts the blue-collar based theory to white-collar markets. He argues that employment structures within

white collar firms can be divided into three categories, industrial, craft, and secondary subsystems. Firms, because of their preference for stability of both factor prices and supply, are described as frequently in the process of trying to convert craft subsystems into either industrial or secondary subsystems. Osterman, therefore, envisions firm manipulation of work structures as an effort to stabilize factor prices or supplies.

B. Empirical Challenges to the Earnings-Productivity Relationship

In the papers discussed below, the earnings-productivity relationship that is the basis of human capital theory is challenged empirically. In two of the papers, those by Lazear [1979] and Hall [1980; 1982], the authors accept the human capital premise that earnings depend on productivity, but argue that the intemporal aspects of that relationship generate institutional arrangements that explain more about worker earnings levels and mobility patterns than individual productivity. Medoff and Abraham [1980a; 1980b], examine the productivity-experience relationship, providing evidence for a stronger counterargument to human capital theory, that there is no relationship between experience and productivity and so the explanation for the positive experience-earnings relationship must be found elsewhere.

Lazear [1979] develops a rationale for the use of mandatory retirement in terms of the intemporal deviation from the human capital identity that wages equal the value of the marginal product. Briefly, his argument is that firms prefer to pay a worker less than the VMP_L to a younger worker and more to an older worker, because that payment

scheme reduces the incentives to workers to "cheat" and not work hard. Workers who expect to receive the greater share of their earnings later in their careers will not want to risk involuntary separation from the firm. The difficulty with this payment scheme for the firm is that the older a worker becomes, the greater the difference between the VMP and earnings, and so the less likely that worker will want to leave the firm at the optimal point when lifetime marginal product equals lifetime earnings. Lazear argues that the date for mandatory retirement is set to be equal to that optimal point and is instituted to assure that workers leave before their earnings exceed their product. The implications of his paper are first, that increased earnings are not necessarily due to increased productivity, but rather to an administratively determined payment scheme; and, second, he establishes a rationale for firm attachment and low turnover that does not depend upon firm-specific human capital.

Taken together, Hall's two papers establish both the longevity of the relationship between workers and their employing firms and how firms can adjust output to changing macro conditions without changing either wage levels or employment levels. In "The Importance of Lifetime Jobs in the U.S. Economy," [1982] he uses an age adjusted probabilistic framework to calculate expected job tenure and is able to show that, contrary to what has been thought to be the case, what is essentially lifetime firm tenure is a common phenomenon for American workers. And, the reason that average firm tenure has previously been thought to be relatively short, three to four years, is due to a small, very mobile group of workers. He is able to show

in his paper, "Employment Fluctuations and Wage Rigidity," [1980] that the high incidence of lifetime tenure does not necessarily impose efficiency constraints on firms in their ability to adjust to macro fluctuations. The purpose of the paper is to examine the macro efficiency of worker allocation in the economy. His question is triggered by the empirical observation that during macroeconomic fluctuations, wages appear to remain relatively stable, while employment levels adjust. His major empirical result in this paper is to discover that while employment levels of many firms remain stable, the intensity of work effort varies with macro conditions. The remainder of the paper is a discussion of the costs of this type of adjustment mechanism.

Medoff and Abraham, using firm microdata, test the hypothesis that productivity increases with experience. In "Experience, Performance, and Earnings," they use company administered performance evaluations as a measure of productivity. In addition to performance rating information, they also have educational and pre-firm experience data, as well as the current job grade level. Therefore, they are able to distinguish between the effect of being within a particular grade and performance levels. When grade level is excluded from their earnings models, the returns to education is positive and large. However, when grade level variables are included the explanatory power of education declines substantially, suggesting that those with more education earn more because they are put into grade levels associated with higher earnings. Inclusion of the performance rating variables, however, does not affect the coefficients on the human capital

variables, suggesting that education and experience do not proxy productivity as measured by performance ratings. In "Are Those Paid More Really More Productive?", in addition to conducting a cross-section study of the productivity-earnings relationship, they use longitudinal personnel data as a means to control for variation in individual ability. Their longitudinal results supported those from the cross-section models: time in the firm has a greater effect on salary position than it does on performance level; and, while there is a growth in relative earnings with firm tenure, there is no similar growth pattern in performance.

Conclusion

The human capital hypothesis provides a framework for the analysis of the differential employment outcomes associated with career paths. Given the nature of human capital formation, that it can be general or firm-specific, that it can be accumulated at different rates, and that it can depreciate, it is possible to construct a model that hypothesizes that these different elements of human capital vary systematically with career path. However, the papers in the latter section of this review raise the question that observed differences in career path may not be due to human capital but the result of agreements, in the case of scientists and engineers, implicit agreements, about earnings schedules and mobility patterns. In the next chapter, a model of earnings is presented that is based on the human capital hypothesis and, as much as is possible, separates firm-specific from general human capital to determine if differences in earnings are due to differences in patterns of human capital

formation associated with each path.

FOOTNOTES

¹ According to Becker, before his development of the human capital investment framework, turnover was ignored in neoclassical theory.

² He makes an interesting observation about his selection of this specification, rather than one using a lagged endogenous variable. His point is that if an individual "lucks into" a higher occupational category than would be expected, the two equation model, with $\alpha < 1$, allows for that person to stay longer in that occupational rank to counteract that initial luck. A lagged endogenous variable would not be able to predict that. He also notes that he cannot make the restriction that $E(X_{j,i}, f_i) = 0$, but given his estimation method, the lack of that restriction is inconsequential.

³ Note that FG is parallel to KL, an hypothesis that is tested and rejected by Bartel and Borjas [1978] and Borjas [1981].

⁴ The model which is estimated in the second section is:
 $\ln W_{74} = a_s + B e_0 + C e_1 + D h_0 + F(\text{TEN}) + u_x$. Wage growth in the post-interruption period is then the sum of B, C, and F. Examination of the results shows that of the post-interruption wage growth, only about one-third can be accounted for by tenure, meaning that growth in earnings is due primarily to returns to general, not specific human capital. D, the coefficient on h_0 , can be interpreted depreciation of human capital.

⁵ There is some debate about whether a distinction between quits and layoffs is necessary. Bartel and Rosen argue that turnover is an efficiency mechanism and so who initiates it is not important. Mortenson (1978) argues that unless the cost sharing results in a corner solution, both workers and firms have an incentive to set up a structure to protect their investments. So, the distinction does not matter. Although intuition suggests some difference, the layoff decision is complicated, and empirical results are difficult to interpret.

Hall [1972] examines males ages 45 and older and distinguishes between voluntary and involuntary turnover. Using a transition probability estimation approach, he examines the relationship between voluntary and involuntary unemployment and a set of personal characteristics. He finds that both quits and layoffs are more likely early in job tenure and for the first three years, the probability of quitting is two to three times more likely than layoffs. But, after that, the probabilities of turnover for either reason begin to

converge to within the small range of between 1.2 and 2.6. This suggests both that most movement takes place early in a job and that after some point, a joint decision (often implicit) is made by workers and firms to minimize turnover. While he does estimate returns to turnover without distinguishing between quits and layoffs and so does not address the question of whether both types operate as efficiency mechanisms, his results suggest that the probability of turnover declines with tenure, which is a necessary condition for specific human capital investment.

⁶ Kalachek and Raines [1967] and Mellow [1980] use a technique to measure individual deviation from market wage (wage differential) that could be adapted to control for individual propensities to move. Their method is to construct an hedonic wage equation, where wages are regressed on a vector of various human capital and demographic variables. The residual is then defined as the individual wage differential and is put into a turnover equation by Mellow and serves as an explanatory variable for wage structure by Kalachek and Raines. Using longitudinal data, a similar technique could be used to capture those unobservables that contribute to propensity to move by defining the residual to the pre-move period earnings equation, u_i , as: $u_{i1} = p_i + e$ where $e \sim N(0, 1)$ and p_i is the unobservable variables that contribute to propensity to move. u_{i1} can then be substituted into the post-move wage equation.

⁷ Borjas [1982] tests a similar hypothesis: he examines whether mobility has both a shift and slope effect on subsequent earnings. His hypothesis is that labor turnover provides a disincentive for specific training, so that workers with a high propensity to move will have a slower rate of within-job earnings growth. A difference between this and his paper with Bartel is that he attempts to specify expected tenure as stochastic.

He models investment intensity, $K_{0i} = \lambda_i + \rho_i t_i^* - \sigma_i \pi_i$, where π_i is previous experience, t_i^* is expected completed duration of job i , ρ_i is the importance of specific training, σ_i is the effect of aging. It is given that $t_i^n = e_i + R$, where e_i is previous time in job n , and R is the remaining time.ⁿ He hypothesizes that $R = \lambda + \zeta e_i^n$, where those with a higher e_i^n invest more and so have a longer R .ⁿ This relationship allows him to argue that t_i^n has a binomial distribution, where it equals e_i if $i < n$ and equals $\lambda + \zeta e_i^n$, where $\gamma = 1 + \zeta$, if $i = n$.

He can only estimate with panel data,ⁿ which allows actual duration to be observed. The obvious problem with this type of approximation, as well as that used by Bartel and Borjas, is that expected and actual duration are not the same phenomenon.

A preferable specification for remaining tenure should include a stochastic element, such as $t_0 = E(t_0) + u_1$, where t_0 is observed tenure and $u_1 = \{x_1 + e_1\}$, where X are a set of personal and employment characteristics that predict turnover and $e_1 \sim N(0, \sigma^2)$. But, Bartel and Rosen [1980] note the simultaneity problem in the relationship between the probability of separation and investment. Bartel and Borjas' results on the coefficient for R_n are probably weak

because $e_n + R_n$ does not proxy expected tenure, especially over such a relatively ⁿ short ⁿ actual period of time, six years (1969 - 1973).

⁸ Examples of stylized theoretical attempts to incorporate intra-firm mobility are: Ioannides and Pissarides [1981] and Oswald [1981a, 1981b]. In all three papers, the number of types of jobs available within a firm was limited to two to maintain theoretical tractability.

⁹ See Katz and Sabel [1979] for a discussion of earnings levels as having an indeterminate solution, the resolution of which requires a bargained solution.

Chapter IV

MODEL FRAMEWORK

Introduction

The purpose of this chapter is to develop a model that explains the variation in lifetime earnings of scientists and engineers. From the literature about the careers of scientists and engineers surveyed in chapter II, it is clear that many of these professional workers who enter the labor force with valuable technical skills eventually face the dilemma of having either to move away from primarily technical problem-solving jobs to more managerially oriented jobs, continuously update their skills to remain technically current, or risk stagnation. A plausible characterization of this experience is that there are specific career paths in this professional labor market, each with a different set of potential labor market outcomes, and workers eventually must choose which path to follow.

From the perspective of labor-market theory, there are two major competing explanations for these paths: the human-capital and the segmented-market hypotheses. As described in chapter III, according to the human-capital hypothesis, labor-market outcomes depend upon individual human-capital accumulation and investment decisions. The segmented market hypothesis rests on several possible explanations, including mutual preferences for employment stability by both workers and firms, the evolution of bilateral monopolies, and the efforts of workers to shelter themselves from changes in the labor market, all reinforced by custom.

The model presented here is based on the theory of human capital. Specifically, it is hypothesized that there are different patterns of human capital formation associated with different career paths. And, given external market conditions, the career path one follows can mitigate the effects of previous human capital investment, causing systematic differences in the rates of return; because, once a path choice is made, that choice determines the nature of the subsequent experiential human-capital investments that can be made.

While there are undoubtedly many alternative paths available to scientists and engineers, the path choice here is reduced to a stylized dichotomous choice between a technical career path and a managerial path. A sequence of models is developed where first, in order to establish that path affects labor market outcomes, earnings are hypothesized to be a function of experience on each path. Then work experience is redefined to measure the different types of human capital investment, general and firm-specific, to determine if these paths represent different investment opportunities offering varying rates of return.

The hypothesized effect of path choice on earnings growth is that workers on the technical track will have a flatter lifetime-earnings schedule than those on the managerial track, holding initial human capital investment, economic ability, and market conditions constant.

That there should be this difference in lifetime earnings growth is supported by the literature on the careers of scientists and engineers. It is common for this labor to enter the labor market with a high level of technical skills and for their initial jobs to be

primarily oriented toward technical problem solving. Eventually, many of them leave the technical jobs and start on a managerial career path. The reasons most frequently cited are fear of obsolescence resulting from rapid technological change or overspecialized job definition, and the structure of firms that rewards worker orientation toward firm rather than professional goals.

Putting this in terms of human capital investment, the model presented here hypothesizes that each career path represents a different set of investment opportunities, with different costs, depreciation rates, and rates of return. Of the workers in this sample, all enter with a high level of technical human capital. However, it is hypothesized that the investment in technical human capital is likely to depreciate more rapidly than managerial human capital. This is expected because the depreciation rate of experiential human capital is directly related to, among other things, the rate of technological change. As technological advances occur, the technical skills of scientists and engineers become less valuable unless they continue to invest in themselves and update their knowledge. However, it is rare that the structure of a firm will change so rapidly that firm-specific managerial skills will quickly depreciate. In addition, it is likely that the investment costs of updating managerial skills would be less than for technical skills. So, managerial skills would tend to depreciate more slowly than technical skills.

In his discussion of the cost sharing of human capital investment, Becker makes the point that firms are reluctant to invest

in general human capital where there is a high probability of turnover. A rapid depreciation rate is analogous to a high turnover probability in that in both cases, the period over which investment returns can be collected is truncated.

For this reason, the technical track represents a set of investment opportunities where costs are high and initial returns are high, but rapid depreciation necessitates a continuous level of high investment costs that the firm is unwilling to share. The managerial track offers a different set of opportunities: while the investment costs and rates of return to experience should be lower, the human-capital depreciation rate should be relatively small, and firms will be more willing to bear the cost of training.

Therefore, it is hypothesized that over their work lives, technical workers will have a flatter earnings curve that will also flatten more quickly than that for managers. Managers will experience a greater return to firm tenure than do technical workers and so have a steeper earnings curve. And, the rate of investment in firm specific human capital will decline more slowly for managers than for technical workers.

In the first section, the functional form for the earnings model is developed. In the next three sections, the continuous experience and earnings components level and change models are discussed. In each section, the specific variables to be incorporated into each model are discussed, including an elaboration of the human capital, external market, and career path elements.

I. Functional Form for the Earnings Equation

In his survey of empirical human capital research, Rosen [1977] argues that because earnings functions represent a reduced-form relationship, their results are difficult to interpret. However, Mincer, in his paper, "The Distribution of Labor Incomes," [1970] and in his monograph, Schooling, Experience, and Earnings [1974], maintains that an earnings function, properly specified, represents a behavioral relationship.

The schooling model provides the prototype used by analysts to examine returns to experience. Because investment implies foregone present earnings for higher future earnings, $V(s)$, the schooling model is usually expressed in terms of the net present value of an individual's earnings, $Y(s)$, at the start of school, discounted at some market rate of interest, or:

$$V_s = Y_s \sum_{t=s+1}^{\infty} (1/(1+r))^t. \quad (1)$$

Individuals are thought to compare alternative discounted earnings streams and select that level of schooling that provides the highest net present value of future earnings, given the interest rate. Because alternative paths are unobservable, and individuals are assumed to be rational,¹ this can be rewritten as:

$$\ln Y_s = \ln Y_0 + rs, \quad (2)$$

which states that the percent increase in earnings is a linear function of years of schooling.²

Because individuals continue to invest in their own human capital after leaving school, the fit is greatly improved with the inclusion

of experience in the model.³ A simple statement of the relationship describing net earnings in the initial entry period, is:

$$Y_0 = E_s - C_0 \quad (3)$$

where Y_0 is initial earnings, E_s is the opportunity level of earnings given some amount of schooling, s , and C_0 is investment costs in the initial period. This generalizes to:

$$Y_j = E_s + \sum_t r_t C_t - C_j = E_j - C_j \quad (4)$$

for period j . Gross earnings can be written as:

$$E_j = E_s + \sum_t r_t C_t. \quad (5)$$

The use of time equivalents, that is, the fraction of time rather than money spent in investment, permits the use of observable experience as a measure for the unobservable rate of investment, and also permits the logarithmic transformation of the earnings function.

The ratio of time spent in investment in period t , k_t , is defined as:

$$k_t = (C_t/E_t). \quad (6)$$

So, investment costs are some proportion, k , of gross earnings.

Because in each period, t , gross earnings are the sum of the gross earnings level in the previous period and the rate of return to the investment in the previous period,

$$E_t = E_{t-1} + rC_{t-1} \quad (7a)$$

$$= E_{t-1}(1+rk_{t-1}). \quad (7b)$$

Observable, or net, income, Y_t , is equal to earnings in period t minus investment costs in t , or

$$Y_t = E_t - C_t. \quad (8)$$

Assuming that r is the same for all periods and earnings in a

particular period are a function of the investment level in the previous periods, a multiplicative model can be specified:

$$E_j = E_0 \prod (1 + r_t k_t)^5. \quad (9)$$

Equation (9) can be approximated as:

$$\ln E_t = \ln E_0 + \sum_{t=0} r_t k_t. \quad (10)$$

If $\sum_t k_t = K$, and education is reintroduced into the model, the result

$$\text{is:} \quad \ln E_t = \ln E_0 + r_s s + r_k K. \quad (11)$$

The assumptions in this formulation are that the percent increase in earnings is a linear function of K .⁶ As was discussed in the literature review, the life cycle model of optimum investment (see Ben-Porath [1967]) disputes that view of investment, arguing that investment declines as experience increases both because of increasingly shorter periods over which to reap benefits and increasing marginal costs of investment. The concavity of the gross earnings function, that is, that earnings grow at a decreasing rate, can be seen to depend upon net investment increasing with experience but at a decreasing rate. The slope of the gross earning function is positive:

$$\text{since } E_j = Y_j + C_j, \text{ and} \quad (12a)$$

$$dY_j = r_j C_j - (C_{j+1} - C_j), \quad (12b)$$

$$dE_j = dY_j + dC_j \quad (12c)$$

$$= r_j C_j - (C_{j+1} - C_j) + (C_{j+1} - C_j) \quad (12d)$$

$$= r_j C_j > 0. \quad (12e)$$

In other words, the slope of the gross-earnings schedule is positive as long as investment levels are positive. And, the rate of growth declines with time, as long as the investment rate declines

with time:

$$d^2 E_j = r_j dC_j < 0 \quad (13)$$

(The net earnings profile is usually concave, although it is possible that it is convex early in a career if net investments grow at a faster rate than the rate of return, r). This declining rate of investment is incorporated into the model by expressing K as a function of time. In this case, investment is assumed to decline linearly with time. That is,

$$k_t = k_0 - (k_0/T)t, \quad (14)$$

where T is the total period of investment (See footnote 6 for a discussion of alternative assumptions). Net earnings can be written as:

$$\ln Y_{it} = \ln E_0 + r_s s + \sum_{t=0} K_t + \ln(1 - k_j), \quad (15)$$

(15) can be restated as:

$$\ln Y_{it} = \ln E_{0i} + r_{si} s_i + f((t/k_{0i}, \beta_i, r_{ti}) + i, \quad (16)$$

where r_s and r_t are the rates of return to schooling and post-school investments, k_0 is the initial post-school investment, and β is the rate of decline in investment. Because information on individual levels of investment and rates of return is not obtainable, average rates of return, initial investment and decline of investment are estimated instead. Because investment increases at a decreasing rate, the earnings function is parabolic. This can be approximated using a second order Taylor series, estimated in the following form:

$$\ln Y_t = a + b_1 s + b_2 t + b_3 t^2 + v, \quad (17)$$

$$\text{where } a = \ln E_0 - k_0 (1 + (k_0/2));$$

$$b_1 = r_s > 0;$$

$$b_2 = r_t k_o + (k_o / T)(1 + k_o) > 0; \text{ and,}$$

$$b_3 = -[(r_t k_o / 2T) + (k_o^2 / 2T^2)] < 0.^7$$

II. Behavioral Framework for the Model

Two types of models are presented, one where human-capital investment is a continuous function of experience, and one where investment is expressed in terms of job, firm, and pre-firm experience. The purpose of the continuous experience model is to establish that there are systematically different earnings outcomes associated with each path, while the experience components model permits examination of how the different types of human capital investment contribute to that earnings difference.

A. Continuous Experience Models

What follows is a description of the variables that are thought to influence earnings and a description of the continuous experience earnings level model.

1. Career Paths

The argument that underlies the model presented in this thesis is that human-capital investment is an important predictor of earnings variation, and the structure of the internal market, as measured by career path, is of primary importance in the relationship between human-capital formation and earnings. In the previous section, several variables were discussed which were to serve as indicators of the stability of the external market, based on the assumption that

external market conditions will influence the structure of the internal market. A more direct aspect of the internal market is the nature of the career paths within the firm that various workers might follow. Differences in career paths are hypothesized to represent differences in the opportunity for investment in experiential human capital, in the types of skills that are valued and rewarded, in the upper limit on earnings, in the potential for mobility, and in the vulnerability to involuntary unemployment. In the case of the scientists and engineers in this sample, the range of possible career ladders has been collapsed to two, the technical path and the managerial path. Although the use of only two paths is an oversimplification, it is expected that this stylized version of the alternatives open to this labor group will capture the major implications of the choices that actually are available.

The workers in this sample are hypothesized to enter the labor market with a relatively large stock of educational human capital. If a comparison were made to other workers, the intercept for scientists and engineer would be higher than for most other workers. Because of their large initial human capital investment in education, their beginning earnings are at A as compared to A' for workers of comparable ability but who do not possess the initial human capital (e.g., individuals with a B.A. level in humanities are less likely to possess skills offering a high rate of return immediately upon entering the labor force; see Diagram 1). During the early stages of

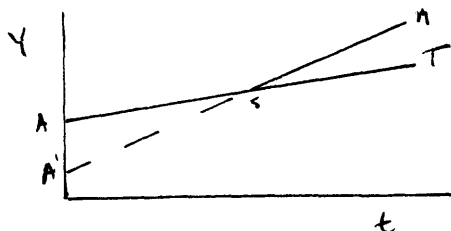


Diagram 1

their careers, technical workers are hypothesized to have relatively homogeneous careers with a technical orientation. They are investing in both firm specific and general human capital.

Eventually in their careers, most scientists and engineers are faced with the decision to either continue on a technical track, that is, continue to work on technical problems and therefore invest in human capital associated with a particular technical problem that may or may not be specific to their firm; or, to start on a management track, where skills that are of broader use within the firm are developed and investment is thus in more firm specific experiential human capital.

There are several possible reasons why such a career path split occurs. First, particularly for those fields where there is a high rate of technological change, it is possible that the value of the educational human capital of scientists and engineers depreciates rapidly, and the rate of investment in experiential human capital needed to maintain an upward sloping earnings curve is too high to be realistically sustained. This phenomenon is referred to by some authors as obsolescence, and there is some debate about its inevitability for scientists and engineers.

Whether obsolescence is a real or imagined danger, there is some consensus that those who stay on the technical track beyond a certain age are viewed as not having had successful work lives and that the move to the managerial track is a prerequisite for economic success. That this may be the case can be explained by the pyramidal structure

of most firms and that in most firms, as explained in the introduction to this chapter, differences in the depreciation rates of human capital lead to greater economic rewards for managerial, not technical, activities.

After the split occurs, it is hypothesized that the rate of earnings growth for those in managerial activities will be greater than for those on the technical track. The major reasons for this can be described in terms of the nature of the human-capital investment that is made. Although different technical skills will depreciate at different rates, it is hypothesized that all of them will depreciate faster than non technical managerial skills, because of technological change.

Two forces suggest that technical track workers will not invest at a high enough rate to overcome depreciation and experience wage growth that is comparable to that of managers. One is a life-cycle phenomenon that suggests that as the length of time over which to collect returns shortens and the marginal cost of investment increases, the rate of investment decreases. That is, as workers gain more work experience and increase their human capital stock, their marginal product increases. They are more valuable and can command higher wages. Since the major cost of experiential human capital investment is foregone income, this cost, the time spent learning that could be spent producing and earning, is greater the more potentially productive a worker. In addition, as a worker ages, the period of time over which returns to human capital investment can be received decreases. So, from a human capital investment perspective, there is

an incentive to decrease investment rates as experience increases.

Also, from the perspective of the firm, there is a disincentive to offer investment opportunities to workers to accumulate human capital that will rapidly depreciate if the firm has to share in the cost of that investment. Becker discusses investment cost sharing between firms and workers as a function of the probability of turnover. The underlying concept is the probable duration of time over which either investor can collect returns. The rate of human capital depreciation raises the same consideration for workers and firms. To the extent that human capital is firm specific, there is little incentive for workers to bear that cost. However, technical human capital is costly to accumulate and if it is expected to depreciate rapidly, firms also do not want to pay for it. Depending on the rate of advances in a particular technical area, it may be less costly for firms to purchase current technical human capital from those in the early stages of their careers where wages are relatively lower, and allow more experienced workers to continue producing using skills that are becoming increasingly outdated, leading to eventual technical obsolescence.

So, given some level of initial human capital and willingness to invest, opportunities to invest and depreciations rates vary so that there is a systematic difference in earnings growth rates.

2. Human Capital Variables

The basic impetus behind human capital theory is that variation in individuals' earnings depend upon differences in the level of investment made in individual human capital. The two primary types of

human capital investment are those made in education and during the course of work experience.

Education. As discussed so far, education has been expressed as a continuous variable, as years of education. The implication of this specification is that relatively small changes in the time spent in school can have a marginal effect on human capital accumulation that will lead to some increment in earnings. An alternative hypothesis is that it is degree level rather than years of education that affects earnings. Under this hypothesis, sometimes referred to as the credentialling hypothesis, employers view the attainment of a degree, rather than the number of years in school, as a signal of productivity and reward workers accordingly. In this case, education would be a discrete dummy variable which shifts the intercept of the earnings function rather than affecting its slope. In this case, the specification with dummy variables is used because it is assumed that degree attainment rather than years of school stratifies this labor force because of its professional orientation.

Experience. As discussed in the literature review, the major components affecting the relationship between experientially acquired human capital and earnings are: the rate of investment; the nature of that investment, that is, whether it is general or firm specific; the rate of depreciation; and, the rate of return. None of these components are directly observable. In order to derive an estimable function, time equivalents can be used as a proxy for investment and a series of assumptions about the rate of investment, nature of that investment, and rate of return can be made depending upon the

specification of the earnings function (See footnote 6).

Because the effect of path on earnings is of interest, work history is initially described in terms of experience on each path, where total experience is the sum of technical and managerial experience. The earnings function can be written as:

$$\ln y_t = a + b_1s + b_2t_m + b_3t_T + b_4t_m^2 + b_5t_T^2 \quad (18)$$

where t_m and t_T are the individual's managerial and technical experience, respectively. The rate of return to the time spent on both types of path is expected to be positive, and the investment rates for both are expected to decline with time, but based on the literature on scientists and engineers, it is expected that $b_2 > b_3$ and $b_4 > b_5$. It is expected that the lifetime earnings schedule associated with the managerial path is more steeply sloped and flattens more slowly because of the gradual accumulation of a type of human capital that does not depreciate rapidly. This is compared to the human capital of the technical workers that is initially valuable, but is expensive to augment and depreciates rapidly.

Geographic Mobility. Geographic mobility is considered to be another type of human capital investment. Individuals forego the present equivalent of the cost of the move (in both money and psychic terms) with the expectation of higher earnings in the future. In order to control for the effect of this type of investment, a dummy variable will be included that will equal 1 if a geographic move occurred between jobs, zero otherwise.

B. Labor-Market Conditions

Human-capital investments represent the rational individual's best guess about which time and resource allocation strategy will bring the greatest return. Given some level of human capital accumulation, the yield will depend in part on the market in which the human capital is utilized. Market rigidities, secular changes in demand conditions, and geographic disparities in prices can affect the rate of return.

Industry Structure and Product Demand. As is the case for any type of labor, the demand for scientists and engineers is a derived demand. Therefore, the external labor market conditions and the opportunities for the utilization of their human-capital investments will depend in part on product demand, product price elasticities, and input (wages, in this case) elasticities. The rate of technological change and the effect it has on the use of labor as an input in the production process is a factor for any labor group, but is often a salient aspect of the demand for scientists and engineers. And, a rapid rate of technological change can distort both investment patterns and rates of return.

A peculiar aspect of the labor market for scientists and engineers is its dependence on contracts from the federal government, particularly defense contracts and occasionally non-defense space related research. There are several hypothesized effects of this heavy dependence on federal contracts. First, of course, there are funding cycles, where, for instance, defense spending will be a government priority, then be sharply reduced due to a policy change. Second, this variable aspect to defense spending is hypothesized to

distort elasticities of factor demand. During peak demand periods, the demand for skilled scientists and engineers will be highly inelastic at a very high wage rate. When demand falls, that curve shifts downward, but remains inelastic.

A third hypothesized effect of federal funding is that for security reasons as well as production speed, there is a tendency toward an overly narrow specialization of labor on weapons development projects. This overspecialization would have two effects. First, it would permit only partial utilization of the existing skills of a worker. And, second, it would influence the nature of the experiential human capital investment a worker could make, limiting future inter-firm and inter-project mobility.

Another factor that will affect the rate of return to any human capital investment will be the structure of the internal labor market. This will vary from industry to industry, and probably to a somewhat lesser extent from firm to firm and occupation to occupation. The internal structure will be partly dependent on the factors mentioned above. Stable demand and a relatively even rate of technological change would generate a different internal labor market than would a cyclically volatile demand pattern where the demand for labor and ability to pay and willingness to train it would vary from period to period.

Geographical Location. Because scientists and engineers are such a highly skilled group, their labor market is national, and they are usually thought of as highly mobile geographically. Therefore, wage rates would be expected to be comparable across regions. However, it

is possible that there are differences between regional wages which reflect compensating differentials such as differences in the cost of living or local amenities.

The elements mentioned above, industry structure, rate of technological change, division of labor, overspecialization and reasons for compensating wage differentials, even ignoring problems of data availability, are difficult measure. For that reason, the variables that are used here to control for these effects are: dummy variables for industry and occupation category; the annual level of research and development spending by the federal government (in the change equations only); whether or not the particular job project was federally funded; and, dummy variables for geographical region.¹¹

4. Hypothesized Coefficients

The behavioral relationship described so far can be summarized as:

$$Y_t = Y(\text{EXPMANG}, \text{EXPTECH}, \text{ED}, \text{IND}, \text{OCC}, \text{GVTFND}, \text{REGION}, \text{GEOMOVE}, \text{R\&D}) \quad (18),$$

where career path is incorporated into experience. Table 1 shows the specific variables included in the model and their expected sign.

Table 1

Continuous Experience Model Variables

Variable	Definition	Sign
EXPMANG ₂	Total years managerial experience	+
EXPMANG ²	Total years managerial experience squared	-
EXPTECH ₂	Total years technical experience	+
EXPTECH ²	Total years technical experience squared	-

EXPDK	Total years experience, path unknown	1
EXPDK	Total years experience, path unknown, squared	1
MOVEY	Dummy variable for geographic move (=1 if move occurred)	+
MOVEDK	Dummy variable if geographic move could not be determined	1
BS	Dummy variable for education (1=BA)	-
MS	Dummy variable for education (1=MS)	0
PHD	Dummy variable for education (1=PhD)	+
EDC	Years of Education	+
OCCENG1	Dummy variable for Aero.,Astro,Agric, Nuclear, & Other Engineer (1 if yes)	1
OCCENG2	Dummy variable for Chemical,Metal & Mat. Mining & Petro. Engineer(1 if yes)	1
OCCENG3	Dummy variable for Elec. & Elec. Engineer (1 if yes)	1
OCCENG4	Dummy variable for Mech.Enginr. (1 if yes)	1
OCCENG5	Dummy variable for Civil & Arch., Envir & San. (1 if yes)	1
OCCOMP	Dummy variable for Computer Scientist (1 if yes)	1
OCCMANG	Dummy variable for Managerial & Administrative (1 if yes)	1
OCCNASC	Dummy variable for Natural Scientists (1 if yes)	1
INDWAR	Dummy variable for Defense industry (1 if yes)	1
INDBASE	Dummy variable for Elec. Mach, Fab. Metal, Prim.Metal(1 if yes)	1 1
INDCHEM	Dummy variable for Chemical (1 if yes)	1
INDSERV	Dummy variable for Business, Finance, Trade, & Eng. Serv. (1 if yes)	1
INDPRO	Dummy variable for Prof.Soc. & Res. Inst. (1 if yes)	1 1
INDOTH	Dummy variable for Other ind (1 if yes)	1
INDKNO	Dummy variable for Can't Tell (1 if yes)	1
INDMANU	Dummy variable for Other MANU.(1 if yes)	1
RESDEV	Annual level of fed. R&D spending	+
GVTFND	Dummy variable for job supported by Federal Government funding	+

[†] No apriori hypothesis.

The linear human capital variables include MOVEY and the education variables. A geographical move is hypothesized to be a positive human capital investment, as is EDC, years of education. In

the actual estimation of the models, MS is omitted to avoid collinearity, and the coefficients for BS and PHD are interpreted as relative rates of return compared to MS. As is consistent with the hypothesized positive coefficient for EDC, the coefficient for BS is expected to be negative and that for PHD to be positive.

The industry and occupational dummy variable coefficients are shift parameters that indicate the relative earnings advantages of being in a particular industry or occupation. GVTFND, the presence of federal government funding support is also a shift parameter and is hypothesized to have a positive effect on earnings.

III. The Earnings Models

Two types of models are presented here, an earnings level model and a model of earnings change over the course of the job. The earnings level model represents a framework which explains the earnings of an individual at some point in time as a function of their human capital formation up to that point, certain external market circumstances, and career path.

Components of Experience. Experientially acquired human capital is composed of firm specific and general skills, $F(t)$ and $G(t)$, respectively. Incorporating this into the model, the earnings function can be rewritten as:

$$\ln Y_t = \ln Y_0 + r_2 F(t) + r_3 G(t). \quad (19)$$

The difficulty is that the $F(t)$ and $G(t)$ functions are unobservable: individuals are assumed to invest in both throughout their careers,

but how the investment is shared is not known. To approximate these different kinds of investment, experience is separated into that in the current firm and that prior to the current firm, t_c and t_p , during which $F(t_c)$, $G(t_c)$ and $F(t_p)$, $G(t_p)$ were invested, respectively. Substituting this two-period notation into the earnings function results in:

$$\ln Y_t = \ln Y_0 + r_1 s + r_2 (F(t_p) + F(t_c)) + r_3 (G(t_p) + G(t_c)). \quad (20)$$

Because firm specific skills are of value only in the firm where they are learned, it can be assumed that any returns on t_p are on general human capital only, even if both kinds of investment were made during work experience prior to coming to the current job. Therefore, $F(t_p) = 0$. Expressing investment as a quadratic function of experience, the log of earnings can now be rewritten as:

$$\ln Y_t = \ln Y_0 + r_1 s + r_2 \text{EXP} + r_3 \text{EXP}^2 + r_4 \text{CTEN} + r_5 \text{CTEN}^2, \quad (21)$$

where EXP is pre-firm experience, the time equivalent for investment in general human capital; and, CTEN is tenure in the current firm, a measure of both general and firm specific human capital.

Because of the focus on career paths, CTEN is further divided into two parts: TEN, current job tenure, and NONTEN, tenure in the current firm that preceded the current job. This delineation is made because it is assumed that path switching often occurs within firms, and in order to examine differences in human capital investment and returns by path, it is necessary to be able to distinguish between jobs that while in the same firm may have been on different paths.

The earnings function can now be restated:

$$\ln Y_t = \ln Y_0 + r_1 s + r_2 \text{EXP} + r_3 \text{EXP}^2 + r_4 \text{TEN} + r_5 \text{TEN}^2 + r_6 \text{NONTEN} + r_7 \text{NONTEN}^2. \quad (22)$$

The difficulty with this model is that it is not possible to include an adequate measure of individual ability and so, at best, it produces biased coefficients. The earnings change model corrects this problem; however, many variables which are assumed to affect earnings but have a constant effect throughout the course of the job can not be observed in the within-job change model.

A. Earnings Level Model

To summarize what has been said so far, the following model has been hypothesized:

$$\ln Y_{it} = B_0 + B_1 \text{ED} + B_2 \text{EXP} + B_3 \text{EXP}^2 + B_4 \text{TEN} + B_5 \text{TEN}^2 + B_6 \text{NONTEN} + B_7 \text{NONTEN}^2 + B_8 \text{MOVE} + B_9 \text{IND} + B_{10} \text{OCC} + B_{11} \text{REGION} + B_{12} \text{PATH} + B_{13} \text{GOVT} + \text{ABLE} + \mu_{it},$$

where ED is educational level; EXP is prior experience; TEN is current job tenure; NONTEN is pre-job tenure in current job; MOVE is whether a geographical move occurred; IND is industry category; OCC is occupational category; REGION is geographical region; Path is whether a job is on the managerial track; GOVT is whether the current job is government funded; and, ABLE is economic ability.

This model is an earnings level model, where the log of earnings is a linear function of a set of human capital investments, career path, and external labor market conditions. There are two alternative methods that can be used to test the hypothesized effect of career path, separate regressions for each path and a single regression with

interaction variables. Table 1 lists the variables included for the separate regressions, their definitions, and their expected signs.

Table 1

Earnings Level Variables

<u>Variable</u>	<u>Definition</u>	<u>Expected Sign</u>
TENURE	Tenure in current job, in years	+
TENSQ	TENURE squared	-
NONTEN	Tenure in current firm preceeding the current job	+
NONTENSQ	NONTEN squared	-
EXP	Years of Experience prior to current firm	+
EXPSQ	EXP squared	-
EXTEN	Interaction b/n EXP and TENURE	-
NONTNTEN	Interaction b/n NONTEN and TENURE	-

The three experiential human capital variables which have a nonlinear relationship with the log of earnings, EXP, TENURE, and NONTEN, are hypothesized to have the same directional effect on earnings. That is, the coefficients on the linear expression of those variables will be positive, and the coefficients for the square of those variables will be negative. Also included in the model are two current job tenure interaction terms, one with pre-firm experience, EXTEN, and one with NONTEN, NONTNTEN, both of which are hypothesized to have negative effects on earnings.

The second method, estimating a single regression, includes a set

of interaction variables between path and the components of experiential human capital. Table 1A shows the expected signs if those variables are included.

Table 1A

Path Interaction Variables

PATH	Dummy variable for managerial or technical job (=1 if managerial)	+
PATHTEN	Interaction b/n PATH & TENURE	+
PATHTENSQ	Interaction b/n PATH & TENSQ	+
PATHEXP ₂	Interaction b/n PATH and EXP ₂	0
PATHEXP ²	Interaction b/n PATH and EXP ²	0
PATHNT ₂	Interaction b/n PATH and NONTEN ₂	0
PATHNT ²	Interaction b/n PATH and NONTEN ²	0

The advantage to the separate regressions is that it is easier to determine to what extent the overall model describes the determinants of earnings for the different paths. It also permits the interaction of all of the predictor variables with the path variable. The advantage to the single regression with the interaction variables is that it permits statistically reliable comparison of the returns to the different types of human capital to the two paths.

The path variable is expected to have a positive effect, indicating that being a manager shifts the earnings level upward. In addition to an intercept effect, a positive slope effect is hypothesized: the coefficient for the interaction between path and tenure is expected to be positive because it is expected that workers on a managerial career path have the opportunity to invest in human capital which leads to a relatively higher rate of return. This

hypothesized better investment opportunity for managers is reinforced by the further expectation that the interaction between path and tenure squared will also be positive. Omitted from the model is the fixed affect economic ability variable. This omission is assumed to bias the coefficient estimates.

B. Within-Job Earnings Change

An alternative focus of investigation to the earnings level is the rate of change in earnings that occurs over the course of a job. The unit of time over which earnings growth is measured is one job, so the dependent variable becomes $\text{dln } Y_i (= \ln Y_{it} - \ln Y_{i0})$.

Economic Ability. Individual differences in what Becker calls "economic ability" can affect earnings. Economic ability can include cognitive intelligence, willingness to invest in human capital, attitudes, and the ability to work with others. It is necessary to control for those differences to be able to discern the true effects of investment and career decisions on earnings. In particular, in the context of the model being discussed here, in order to learn whether differences in the earnings growth between managers and professional/technical workers are due to the nature of their career ladders or because of differences in ability, ability must be explicitly incorporated into the model.

If as is hypothesized here, ability and career path are independent of one another, the omission of the ability variable will not have any effect on the career-path coefficient. It is likely, however, that there is a partial relationship between the two

variables. If that is the case, and the economic ability variable is not included, then the path coefficient will be biased.⁸

Economic ability is widely recognized as important in explaining earnings' variation, but there is a lack of consensus about how best to measure this variable. Becker suggests that, after holding investment variables constant, those workers with greater ability will have higher earnings. In other words, the variation in economic ability would be part of the residual. In some cases, personal background variables, such as father's education or socio-economic status, are included, as an indicator of motivation, exposure, and/or ambition. However, if the major influence of family background occurs through the investment decision or path choice and makes little independent contribution to earnings variability, then the inclusion of background variables will produce collinearity and add little to the explained variation.

Frequently, test scores, such I.Q. tests or math and verbal aptitude scores are included as measures of economic ability (see Taubman and Wales [1974] for an example of this). Also, because it is thought that personal variables other than intelligence, such as attitude, self-discipline, and ability to work with other people are important, scores on personality and attitude tests are also sometimes included in the earnings function.

In the data set used here, with the exception of some information about family background (father's education, occupation), none of these direct measures are available. However, there is currently no consensus about the validity of test scores as measures of the

intangible, but important, economic ability.

There are two major alternative assumptions that can be made about unobserved ability. First, it can be assumed to be a fixed effect that if omitted will violate the least-squares assumption that $E(\epsilon) = 0$ and result in biased estimates.⁹ The alternative is to assume that economic ability is a random variable and has a distribution. According to Hausman, the assumption that unobserved ability is a fixed effect when it is actually a random variable will violate the orthogonality assumption of OLS and result in biased and inefficient estimates.¹⁰

Economic ability is assumed to have a fixed effect in the models to be estimated here, which enables the assumption that economic ability is controlled for in the change model.

Real versus Nominal Wages. Because the length of tenure varies from observation to observation in this data set, it is necessary for comparability to express earnings in real rather than nominal terms. Rather than deflate earnings using one of the standard deflators, the CPI index will be entered as a variable. This is equivalent to assuming that earnings' changes are proportional to changes in the consumer price index, but that that proportion is not necessarily equal to one.

The model for earnings at the end of a job is essentially the same as for the levels equation:

$$\ln Y_{it} = B_0 + B_1 ED + B_2 EXP + B_3 EXP^2 + B_4 TEN_t + B_5 TEN_t^2 + B_6 NONTEN + B_7 NONTEN^2 + B_8 MOVE + B_9 IND + B_{10} OCC + B_{11} REGION + B_{13} GOVT + B_{14} RND_t + B_{15} CPI_t + B_{16} EXTEN_t + B_{17} NONTNTEN_t$$

$$+ B_{18} \text{PATHEXP} + B_{19} \text{PATHEXP}^2 + B_{20} \text{PATHNT} + B_{21} \text{PATHNT}^2 + \\ B_{22} \text{PATHTEN}_t + B_{23} \text{PATHTEN}_t^2 + \mathcal{M}_{it}.$$

Earnings at the start of the job can be written as:

$$\ln Y_{it} = B_0 + B_1 \text{ED} + B_2 \text{EXP} + B_3 \text{EXP}^2 + B_6 \text{NONTEN} + B_7 \text{NONTEN}^2 + B_8 \text{MOVE} + \\ B_9 \text{IND} + B_{10} \text{OCC} + B_{11} \text{REGION} + B_{13} \text{GOVT} + \text{ABLE} + B_{14} \text{RND}_t + \\ B_{15} \text{CPI}_t + \mathcal{M}_{it}.$$

Subtracting the second equation from the first, where t is the number of years of tenure and 0 represents the starting year (and suppressing 1):

$$\ln Y_t - \ln Y_0 = (\beta_t - \beta_0) + \delta_1 d \text{RND} + \delta_2 d \ln \text{CPI} + \delta_3 \text{TEN} + \delta_4 \text{TEN}^2 \\ + \delta_5 \text{EXTEN} + \delta_6 \text{NONTENTEN} + \gamma.$$

Table 2 lists the variables used in the model and their expected signs.

Table 2
Earnings Change Variables

<u>Variables</u>	<u>Expected Sign</u>
d RND	+
d ln CPI	+
TEN ₂	+
TEN	-
EXTEN	-
NONTENTN	-

As can be seen, the unmeasured ability variable is netted out, which is the equivalent to assuming that the effect of ability is constant throughout the length of the job. The coefficient estimates in this equation should be unbiased. Other variables whose effects can no longer be discerned are: MOVE, ED, OCC, IND, GVTFND, EXP²,

NONTEN^2 , PATH, and REGION. The effects of EXP and NONTEN can be examined through the coefficients of EXTEN and NONTNTEN.

B_{TENURE} is expected to be positive and B_{TENSQ} is expected to be negative, corresponding to the usual hypothesis that human capital stocks increase at a decreasing rate.

The external market variables which change over the tenure period, t , include the change in the CPI index and the change in the level of federal spending for research and development. It is expected that there is a positive relationship between earnings growth and the growth rates of these two variables.

Again, it is possible to combine the regressions into a single equation with the inclusion of interaction variables between path and other variables which are expected to vary with path. In that case, the final model would be:

$$\begin{aligned} \ln Y_t - \ln Y_0 = & (\beta_t - \beta_0) + \delta_1 d \text{RND} + \delta_2 d \ln \text{CPI} + \delta_3 \text{TEN} + \delta_4 \text{TEN}^2 \\ & + \delta_5 \text{EXTEN} + \delta_6 \text{NONTNTEN} + \delta_7 \text{PATHTEN} + \delta_8 \text{PATHTEN}^2 \\ & + \nu, \end{aligned}$$

where it is expected that $\delta_7 > 0$ and $\delta_8 > 0$. The interaction between path and tenure is expected to have a positive effect because of the expected relatively higher rate of human capital accumulation by managers. The interaction between path and tenure squared is also hypothesized to be positive, indicating a slower rate of earnings growth decline for managers.

FOOTNOTES

¹ In this case, rationality implies that the individual has a realistic estimate of r and so knows V and V^a . Mincer (p.10-11), shows how earnings differences depend upon r : $V = Y \int_0^s (1/(1+r))^t dt$, the present value of earnings with s years of school; ² put into continuous terms: $V = Y \int_0^s e^{-rt} dt = ((Y(e^{-rs} - e^{-rn}))/r)$; 3) an alternative plan is to be in school $(s-d)$ years: $V^{s-d} = (Y^{s-d}/r)e^{-r(s-d)} - e^{-rn}$; 4) to compare the alternatives and assume a fixed working life, their ratio is: $k_{s,s-d} = (Y/Y^{s-d}) = (e^{-r(s-d)})/(e^{-rs}) = e^{rd}$. This shows that the choice between alternatives will depend on the size of r , which is thought to vary with the individual and the differences between the alternatives. Since the alternatives are not known, the usual alternative used is $d=0$, so that $k_{s,0} = e^{rs}$.

² Filer argues that this is an overly simplistic formulation if aggregated because it would permit the rate of return to, for example, two eighth grade graduates to equal that of one college graduate.

³ This discussion follows closely Mincer's discussion in Schooling, Education, and Earnings, NBER, NY, 1974, p.19-20.

⁴ This can be rewritten to describe the distribution of earnings before investment as: $(\ln E_t) = r^2(s) + s^2(r) + (s)^2(r)$.

⁵ See Mincer, op.cit., p. 19 -20.

⁶ Using, alternative assumptions about the lifetime investment function, Mincer develops several ways to transform the unobservable investment costs into a form which can be estimated. He considers four different cost specifications: linear and log-linear net dollar investments, C_t , and linear and log-linear "time-equivalents" investment ratios, k_t :

$$\begin{matrix} C_t = C_0 - (C_0/T)t & C_t = C_0 e^{-Bt} \\ k_t = k_0 - (k_0/T)t & k_t = k_0 e^{-Bt} \end{matrix}$$

where the subscript 0 describes the initial period of experience, $t=0$; T is the total period of net positive investment; and, B is the rate of decline of investment. Putting the earnings function in continuous terms, the linear version is: $E_t = E^s + r \int_0^s C_j dj$, and the logarithmic version is: $\ln E_t = \ln E^s + r \int_0^s k_j dj$. By substitution, he is able to derive four different empirically estimable functions (Mincer observes that r is unobservable and, once the assumption of a perfectly competitive labor market is relaxed, varies with the individual. However, he is satisfied with using some average value of r and letting individual differences be part of the residual).

First, he develops the gross and net earnings functions under the assumption that the rate of investment is linearly declining. Gross earnings are: $E_t = E^s + rC_0 t - (rC_0/2T)t^2$; and net earnings are: $Y_t =$

$(E_0^s - C_0) + C_0(r + (1/T))t - (rC_0/2T)t^2$, where t is years of experience. The effect of experience is both linear and also enters in a quadratic form, resulting in an earnings profile concave from below.

Next, assuming a linear decline in the investment ratio, he develops the gross log-earnings function: $\ln E_t = \ln E_0 + rk_0 t - (rk_0/2T)t^2$; and the net log-earnings function: $\ln Y_t = \ln E_0 + rk_0 t - (rk_0/2T)t^2 + \ln(1 - k_t)$. In the linear case, dE_t/dt and dY_t^s/dt are linearly declining ($dE_t/dt = (rC_0(T-1)/T)t$ and $d \ln E_t/dt = (rk_0/t) - (rk_0/Tt)$), but $d \ln E_t$ and $d \ln Y_t$ are only approximately linear.

Substituting the cost equations where investments are assumed to decline exponentially rather than linearly, he develops his last two relationships. In the case of the linear earnings relationships, gross earnings are $E_t = E_0 + (rC_0/B) - (rC_0/B)e^{-Bt}$; and net earnings are: $Y_t = E_0 + (rC_0/B) - ((r+B)C_0/B)e^{-Bt}$. He shows that the log of the increment of earnings is linear, since: $dY_t/dt = (r +)C_0 e^{-Bt}$. In discrete form: $Y_{t+1} - Y_t = ((Y_{t+1} = E_0 + (rC_0/B) - ((r+B)C_0/B)e^{-B(t+1)}) - (Y_t = E_0 + (rC_0/B) - ((r+B)C_0/B)e^{-Bt})) = (1 - e^{-B})E_0 + (rC_0/B)(1 - e^{-B})e^{-Bt}$. If $e^{-B} = \beta$ and $E_0 = E + (rC_0/B)$ where E is peak earnings, then $Y_{t+1} - Y_t = (1 - \beta)(E - \beta Y_t)$ or $Y_{t+1}^s = (1 - \beta)E + \beta Y_t$, indicating a first order linear auto-regressive relationship.^p

Finally, he develops the case where the investment ratio declines exponentially. The earnings functions here are:

$\ln E_t = \ln E_0 + (rk_0/\beta) - (rk_0 e^{-Bt}/\beta)$ and $\ln Y_t = \ln E_0 + (rk_0/\beta) + (rk_0 e^{-Bt}/\beta) + \ln(1 - k_t e^{-Bt})$. He notes that $d(\ln E_t)/dt$ is exponential and $d(\ln Y_t)/dt$ is approximately linear. The earnings relationship where investment is expressed as a time equivalent ratio, which declines at an exponential rate can also be expressed in auto-regressive terms, adhering to a Koyck lag adjustment structure. The assumption behind the Koyck distributed lag structure is that the dependent variable is a function of past values of the independent variables. This can be simplified to the assumption that the influence of the coefficients decline geometrically. The functional specification for this is to include the current value of the independent variables and one lagged value of the dependent variable.

Nickell handled this auto-regressive functional form differently and more flexibly. See the text, p. II-5.

⁷ See Mincer, op. cit., p.91.

⁸ That is, if the misspecified model were: $\ln Y_i = b_0 + b_1 \text{path} + e_i$; and, the true model should include: $\text{path} = \text{ability} + \text{path}'$ and $e_i = \text{ability} + u_i$, where $u_i \sim N(0, \sigma^2)$; then, the true model should be: $\ln Y_i = B_0 + (B_1(\gamma) + \gamma) \text{ability} + \text{path}' + u_i$. In the case of the misspecified model, because ability is part of the path variable and also of the residual, $\text{cov}(X_i, e_i) \neq 0$, leading to a bias on b . Even when ability is explicitly incorporated into the model, if there is a relationship between ability and path, the coefficients on both variables may not be consistent. This can be seen where the specified model is $\ln Y = A + B \text{PATH} + C \text{ABIL} + u$, but career path depends in part on ability, $\text{PATH} = G \text{ABIL} + \text{PATH}'$. So the model should be $\ln Y = A +$

DPATH* + (BG + C)ABLE, where C is the direct effect of ability and BG is the indirect effect that operates through path selection. It is likely that there is some relationship between ability and path and unless further corrections were made, there would be a consistency problem.

9

If it can be accurately assumed that ability is a fixed effect, so that its only estimation effect is to bias the expected value of the residual, this non-zero mean can be subtracted from the error term and added to the intercept, biasing that estimate, but removing the bias from the remaining coefficients.

10

Hausman [1978] developed a test for the fixed effect specification. The earnings model is estimated twice, once with the fixed effects assumption, where the variables are expressed as deviations from the mean, and again using an instrumental variable estimator. The null hypothesis is that no misspecification is present. If the null hypothesis is not true, the fixed effects estimator is unbiased and consistent, but not efficient. The IV estimator is unbiased, consistent, and efficient. Both are consistent, unbiased, and efficient if the null hypothesis is true. By comparing $q = B_{fe} - B_{iv}$ with the variance of the difference in estimates, $M(q) = M(B_{fe} - B_{iv})$, the relative efficiency can be determined. The test statistic is: $m = q' [M(q)]^{-1} q$, which has a chi-square distribution.

11

Whether or not the job was located in an SMSA was excluded from the model because nearly 90% of the sample worked in an SMSA.

CHAPTER V

DATA SOURCES AND VARIABLE CONSTRUCTION

I. 1978 National Survey of Natural and Social Scientist and Engineers (NSSE)

With a few exceptions, all of the data analyzed here were collected as part of the National Sample of Scientists and Engineers, a biennial survey conducted by the U.S. Bureau of Census. The National Science Foundation (NSF) sponsored this longitudinal sample survey, in order to learn about the nature and availability of technical labor. The first survey was administered in 1972, and the respondents were resurveyed in 1974, 1976 and 1978. Of the 1970 Census of Population, 20% of the population provided information on labor force status, occupation, and education. Selected occupations in that twenty percent became the survey sample, and educational and career-related characteristics were reported for those in the following occupational groupings: Operations and Computer Specialists, Engineers, Mathematical Specialists, Life Scientists, Physical Scientists, and Social Scientists.¹ After careful comparison of the different questionnaires and their responses, problems of noncomparability arose so that only the data from the 1972 survey are used in this analysis. The noncomparability issues are discussed in Appendix 2.

The 1972 Survey. The survey, then called the Professional, Technical, and Scientific Manpower Survey (PMS) was conducted in 1972.

Five categories of information were collected: (1) demographic background (including age, sex, marital status, nationality, father's education and occupation, professional affiliations, and number of children); (2) education and training (including number of years of education, areas of course work, degree level, major field, and other nondegree training, including that provided by the employer); (3) employment status during the week prior to completing the questionnaire; (4) employment history (including current status, detailed information about the most recent as well as two previous jobs, occupation, industry, pay, distribution of activities on the job, how the job was found, reasons for leaving the jobs previously held, and geographic location; and 5) the number of weeks worked and earnings in 1971. Questionnaires were mailed in the winter and spring of 1972 to 101,835 people. The response rate was 73.1%, yielding a sample size of 74,483. Table 1 shows the occupational distribution of those sampled and the response rate by occupational category.

Table 1A

SAMPLE DISTRIBUTION

Occupation (1970)	% Sample Size ¹	Rate of Return ³
Computer Specialist	6.52	72.0
Engineers	24.68	74.7
Mathematical Specialists	2.94	74.0
Life & Physical Scientists	10.31	79.3/79.5 ²

Operations & Systems Researchers & Analysts	2.94	73.0
Social Scientists	6.49	73.1
Engineering & Science Technicians	17.03	68.6
Other	29.09	n/a

¹ Calculated from: "1972 PostCensal Manpower Survey List of Sample Groups," Characteristics of Persons in Engineering and Scientific Occupations: 1972, Bureau of Census, technical Paper #33, April, 1974, p.120-121.

² 79.3 refers to Life Scientists, and 79.5 refers to Physical Scientists.

³ Source: "Analysis of Response in the 1972 Professional, Technical, and Scientific Manpower Survey by Occupation and Education in 1970 and Age in 1972," in *ibid.*, p. 146-147.

In 1972, each respondent answered one of three questionnaires, here referred to as PMS1, PMS2 and PMS8. The PMS1 and PMS2 questionnaires contained eight pages, covering the five types of information mentioned above. The PMS8 questionnaire was two pages and was sent to an additional sample from the 1970 Census to gain a wider longitudinal survey base. Although the PMS1 and PMS2 questionnaires are similar, each was sent to a different group. The PMS1 questionnaire was sent to those classified as scientists and engineers. PMS2 was sent to those whose Census occupation was coded as an engineering or science technician. Of the 50,093 respondents in the in-scope sample size, 21,090 were administered PMS1, 4,956 received PMS2, and 24,047 answered PMS8. In this study, because of the interest in white collar markets, only respondents to PMS1 were

included in the sample. Appendix 3 contains a copy of the PMS1 questionnaire.

Only those respondents who could be classified as belonging to one of the seventeen in-scope fields were included. Those seventeen fields are:

- Computer Specialists (1)
- Engineers (2)
- Mathematical Specialists
 - Mathematicians (3)
 - Statisticians (4)
- Life Scientists
 - Agricultural Scientists (5)
 - Biologists (6)
 - Medical Scientists (7)
- Physical Scientists
 - Chemists (8)
 - Physicists and Astronomers (9)
 - Other Physical Scientists (10)
- Environmental Scientists
 - Earth Scientists (11)
 - Atmospheric Scientists (12)
 - Oceanographers (13)
- Psychologists (14)
- Social Scientists
 - Economists (15)
 - Sociologists and Anthropologists (16)
 - Other Social Scientists (17)

Source: "Selected Characteristics of Persons in Mathematical Specialities: 1978," Special Studies, Series p-23, no. 120, Bureau of Census, Washington, D.C., Sept., 1982, p. 30.

II. Sample Selection

Because the focus of this research is on the employment experience of professional scientific and technical labor, certain nonrandom criteria were used to determine which cases of the NSSE sample would constitute the sample for this research. The sample selection process had several steps. In the first stage, the

following criteria were used: completeness of information provided; educational level; scientific and technical field; industrial group; occupational category; and country of origin and employment.

The first criterion, complete information, referred to the fact that a particular respondent had answered all four survey questionnaires, and that as far as could be simply determined, the information provided in each was fairly complete (See Appendix 2 for a discussion of the procedure used to determine comparability which ultimately resulted in the use of the 1972 data only).²

The second criterion, educational level, was used to select cases because the emphasis of this research is on professional level scientific and technical labor. Although there are some older engineers who do not have a bachelor level degree and are still considered to be professionals rather than technicians, the assumption made in this study was that the absence of a bachelor's degree would probably be a serious barrier to upward mobility for most workers, regardless of age. Therefore, only workers who began their professional labor market experience with a minimum of a bachelor's degree were included in this sample.

Scientific and technical field was used to limit the sample to natural scientists and engineers and exclude social scientists and other types of workers. This was done in order to maintain the clarity of the critical question to be explored in this research, the move from a technically based to a management based career path. Although it is expected that this issue has relevance for many types of workers, the question is most easily explored by using types of

labor for whom technical work activities are easily identified. Table 2 lists the included scientific and technical fields.

Table 2
Scientific and Technical Fields

Computer Specialist	Chemist
Engineer	Physicist/Astronomer
Mathematician	Atmospheric Scientist
Statistician	Earth Scientist
Agricultural Scientist	Oceanographer
Biological Scientist	Other Physical Scientist
Medical Scientist	

The fourth criterion, industrial group, was used to eliminate government workers and secondary school teachers. These workers were deleted because their pay structure and unemployment patterns are frequently governed by civil-service rules or collective-bargaining agreements and so might not reflect the effects of making a choice between a technical and a managerial career. Referring to Table 3, the included industrial codes from the 1972 survey were 701 - 711 and 716 - 726.

Table 3
Industrial Codes

<u>Industry Title</u>	<u>1972 Code</u>	<u>1974-78 Codes</u>
<u>Manufacturing</u>		
Aircraft, aircraft Engines, parts	701	701
Chemicals & Allied Products	702	702

Electrical Machinery, Equipment & Supplies, Electronic Apparatus Electronic Computers, Office Machinery	703	703,704
Fabricated Metal Products	704	706
Machinery, Exc. Electrical	705	707
Motor Vehicles	706	708
Ordnance	707	709
Petroleum Refining & Related Industries	708	710
Primary Metal Industries	708	711
Professional & Scientific Equipment	709	712
Other	710	713
<u>Educational Institutions</u>		
College or Universities (at least B.A. level)	711	714
Junior Collete or Technical Institute	712	715
Medical Schools	711	716
Other	713	717
<u>Health Services</u>		
Hospital or Clinic	714	718
Other Medical or Health Services	715	719
<u>Other Kinds of Business</u>		
Agriculture, Forestry, & Fisheries	716	720
Business, Personal, & Repair Service	717	721
Construction	718	721
Engineering or Architectural Services	719	723
Finance, Insurance, & Real Estate	720	724
Mining & Petroleum Extraction	721	725
Private, Non-profit Orgs., Other than Ed. Inst. & Hospitals & Professional & Technical Societies	722	726,727
Research Institutions	723	728

Retail & Wholesale Trade	724	729
Transportation, Communication, or Other Public Utilities	725	730
Other, n.e.c.	726	731
<u>Public Administration</u>		
Uniformed Military Service & Federal Public Administration	727	732,733
State Public Administration	728	733
Local Public Administration & Other Government	729	735,736

Occupational category was used to provide a more definitive separation of engineers and natural scientists from those in other occupations. Besides those in the obviously nontechnical or scientific occupations, the specific occupations that were excluded in this sample were: social scientists, teachers and academicians, medical doctors and technicians. Social scientists were eliminated for the reason discussed above, the difficulty of identifying a technically based job in contrast to a managerial job. Teachers and academicians were eliminated because they frequently work in a formally structured internal labor market, where tenure is an important intervening variable that cannot be discerned from this data set, and where the pay structure is unusually flat.³ In addition, those workers often have a protracted technically based career in comparison to workers in the private sector. Medical doctors were excluded both because of the relatively flat pay structure and the low propensity of having to make the technical-managerial choice. Technicians were excluded for the reasons discussed in the paragraph on educational field and level. The occupational codes included in

the sample are 401 to 428 and 453 to 457 for the 1972 survey.

Table 4
Occupational Codes

Title	1972 Code	1974-1978 Code
<u>Engineers</u>		
Aero. & Astro	401	401
Agricultural	402	402
Civil & Architectural	403	403
Electrical & Electronic	404	404
Industrial	406	406
Mechanical	407	407
Metallurgical & Materials	408	408
Mining & Petroleum	409	409
Nuclear	410	410
Environ. & Sanitary	411	411
Other	412	412,413
<u>Computer Specialists</u>		
Computer Programmer	413	414
Computer Systems Analyst	414	415
Computer Scientist	415	416
Other Computer Specialist	416	417
<u>Mathematician & Statistician</u>		
Actuary	417	418
Mathematician	418	419
Statistician	419	420
Operations Research Analyst	420	421
<u>Natural Scientist</u>		
Agricultural Scientist, including foresters & conservationists	421	428
Biological Scientist including biochemist & medical scientists	422	429-433
Chemist	424	422
Earth & Marine Scientists, including geologists, oceanographers	425	423
Physicists	427	424
Other Physical Scientists	428	433

Administrators, Managers, & Officials

Administrator or manager, scientific & technical R&D	453	458
Administrator or manager, production & operations	454	459
Administrator or manager, all other, exc. self-employed	455	460
Self-employed proprietor	457	462
Accountant	458	463
Attorney or Judge	458	463

A final category that had to be considered was foreign workers and those educated or employed out of the United States. Although many degrees granted by foreign educational institutions were comparable to those given in the United States, no information was provided in the data set about in what foreign country the degree was earned. And, it could not be assumed that all science and engineering degrees were comparable world-wide. So, those educated out of the U.S. were deleted. This also eliminated all U.S. citizens who studied abroad.

Also it was possible that foreign employment structures and the choice between managerial and technical career paths differ from those in the U.S. However, it was also possible that employees of United States firms could work out of this country, but function in a domestic employment structure. Examples would be petroleum engineers working at foreign drilling sites or civil engineers designing infrastructure elsewhere but employed by domestic companies. To keep these cases in the sample, the assumption was made that those who were born and educated in the United States, but who worked out of the country, were employed by U.S. firms.

Using the above criteria to limit the sample, the resulting sample size was 7276.

Next, it was decided that because the majority of the sample were white males, it would be simpler to control for the effects of race and sex by limiting the sample to white males. So, all but white males were deleted from the sample.

The elimination of inconsistent cases and the limitation of the sample to white males trimmed the sample size to 3364.

III. Generating a Work History

The PMS contained both retrospective and panel data that had to be restructured into a format that described individual work histories. The 1972 survey provided retrospective information about three jobs. And, the subsequent surveys were panel data describing up to five additional jobs. So, if information from all four surveys was used, a work history could contain a maximum of eight jobs. As discussed in Appendix 2, it was not possible to derive a measure of career path that was consistent across all surveys, so that only the retrospective data from the 1972 survey were used.

The 1972 survey provided retrospective information about three jobs. Because respondents sampled in 1972 were at various stages in their careers, the number of jobs described in the survey across individuals. Older workers would be more likely to describe three jobs, but younger workers may have had only one job by 1972. The number of jobs described depended upon career stages and individual propensity to move. Because respondents were asked to describe their

current (or most recent) job and the two immediately preceeding jobs, a zero start date was assumed to indicate that no job existed.

The work histories were constructed using the starting dates for each job described. Jobs in the 1972 survey are referred to as JOBC, JOB2T, and JOB3T for the current, second to last and third to last jobs, respectively. If the start date for JOB3T was not equal to zero, it was assumed that all three jobs in the 1972 survey existed. If it did equal zero, the start date for JOB2T was examined; and, if that equalled zero, JOBC was designated as the first job.

Of the sample, about half, 53.5% of the respondents described their first job in the survey. The rest had had more than three professional jobs prior to 1972.

IV. Variable Creation

These include human capital, external market, and career path variables.

A. Human Capital Variables

Education. In the 1972 survey, individuals were asked to describe their most recent formal university training (ED72A), plus the two preceeding it (ED72B and ED72C). The variables selected from the survey to describe education were degree level, major and graduation year.

In order to determine the degree level at the time of a particular job, the dates of the job and degree were compared. The

highest degree granted before a particular job start date was defined as the degree level for that job. The disadvantage with this method was that if an individual received a degree before a job ended, the new higher degree level was not recognized until the next job began. In addition to listing degrees, respondents were also asked to indicate their highest degree held in 1972. If degree information was missing the default value was the 1972 degree level. This is equivalent to assuming that individuals with graduate degrees completed their educations before entering the labor market.

In the earnings growth model estimated here, dummy variables for three levels of education, bachelors, masters, and doctorate were used rather than years of school. The use of dummy variables is preferable given the nature of this data set. Because the sample represents a relatively homogeneous group that is highly skilled, it is likely that actual degree level is a more important credential than years of education. And, that education operates as a shift parameter, particularly early in one's career.

Experience and Tenure. In order to separate firm from non-firm experience and also be able to associate each job with a career track, total work experience was divided into three parts: EXP, pre-firm work experience, TENURE, current job tenure, and NONTEN, tenure in the same firm but in a different job. To measure these, total work experience was first calculated. Then interfirm moves were identified so that pre-firm experience could be subtracted from total experience. Job tenure was simply the ending date minus the start date, and NONTEN was the residual.

To make these separations, the following procedure was used. In the 1976 survey, respondents were asked how many years of professional experience they had had up to 1976. If this variable, PROFEX76, had a value then professional experience in 1972, PROFEX72, was set equal to PROFEX76 minus 4. If PROFEX76 had a missing value, then PROFEX72 was set equal to the individual's age in 1972 minus 25. If this yielded a negative number, PROFEX72 was set equal to zero.

If the individual reported all three jobs in the 1972 survey, experience prior to JOB3, EXP33, was defined first. First, EXP33 was set equal to PROFEX72. Then a variable describing whether or not an individual had changed firms before the current job, FIRMOV, was introduced.

The variable BNJOB (described in Appendix 2) provides information on the activity immediately preceding the job. If BNJOB was either missing or equal to employed, FIRMOV was coded as undefined. Otherwise, it equalled yes, a move took place. If FIRMOV was undefined, a variable, HOWJOB, describing how the current position was acquired, was applied to that case. If the response to HOWJOB was internal promotion, then FIRMOV was set equal to no interfirm move. Otherwise, it remained undefined. Next, a list of reasons for leaving the previous job was applied to those cases where FIRMOV was undefined. If the response was positive for any of the following reasons, FIRMOV was set equal to yes: lay-off, armed forces, retirement, family reasons, spouse's job, move to new geographical location, return to school, move closer to family, and other. If FIRMOV was still undefined, it was set equal to missing.

Having defined FIRMOV, if FIRMOV33 (move before JOB3) was equal to yes, EXP33 was set equal to PROFEX72 minus tenure in JOB3, TENURE33. Tenure was simply the end year minus the start year for each job. If tenure equalled zero, it was set equal to one. If it was missing because one or both dates was missing, it was set equal to the missing.

If no move occurred before JOB33, then EXP33 was set equal to PROFEX72 minus the sum of the tenures for JOB3 and JOB2. If FIRMOV23 (move before JOB2) was equal to no, the EXP33 was set equal to PROFEX72 minus the sum of tenure for all three jobs. If no move occurred before JOB1, experience was set equal to zero if the first job described the individual's first job in the labor market (an explicit question in the survey).

EXP23 and EXP13 were calculated using the same method. If calculated experience was less than zero, it was set at zero.

Geographic Mobility. Whether a geographic move (DIVCHG) took place before a particular job was an explicit question in the survey and required no restructuring beyond incorporating it into the job history data set format. Two dummy variables were created for geographic move: MOVEY was equal to one if a move occurred, zero otherwise; and, MOVEDK equalled one if DIVCHG was missing.

B. Labor Market Variables

These include industry, occupation, R & D spending, the presence of government funding, geographic location, and the level of the CPI.

Industry and Occupation. The industrial categories were recoded

into thirteen dummy variables, and the occupational categories were recoded into ten dummy variables. Table 5 shows the dummy variables and the categories which compose them.

Table 5
Occupational and Industrial Dummy Variables

<u>Occupation</u>		<u>Industry</u>	
OCCENG1	Aero & Astro (401) Agric. (402) Nuclear (410)	INDWAR	Aircraft (701) Motor Veh.(706) Ordnance (707)
OCCENG2	Other (412) Chemical (403) Metal & Mat.(408) Min. & Pet.(409)	INDBASE	Elec.Mach.(703) Fab. Metal(704) Prim.Metal(708)
OCCENG3	Elec. & Elec(405)	INDMACH	Elec. Mach(705) Prof. Equip(709)
OCCENG4	Mechanical(407)	INDCHEM	Chem (702)
OCCENG5	Civil & Arch.(404) Envir. & San.(411)	INDMANU	Other Manu (710)
OCCOMP	All Computer (413- 414)	INDED	College (711) Jr.College (712) Other Ed. (713)
OCCMATH	Actuary (417) Mathematician(418) Statistician(419)	INDWELL	Hospital (714) Other Med.(715)
OCCOPRES	Ind. Eng. (406) Op. Res. (420)	INDCON	Agriculture(716) Construct.(718)
OCCNASC	All Nat. Sci(421- 428)	INDSER	Business (717) Finance (720) Eng.Serv.(719)
OCCMAN	Managers & Administrators (453 - 457)	INDPROF	Prof.Soc.(722) Res. Inst.(723)
		INDMINE	Mining (721)
		INDTRANS	Transport.(725)
		INDOTHER	Other (726)

Federal Research and Development Expenditures. The change in Research and Development (R & D) expenditures for a given job was calculated by subtracting the level of federal R & D expenditures during the first year of the job from that for the last year. The earliest start date for the job in the sample is 1901, and there were

no consistent time series data sets for R & D expenditures that covered the entire period, so several different sources were used, and, in some cases, expenditure levels were estimated from existing data.

Research and development is defined here as basic and applied research in the life and natural sciences and engineering, and development activities. Using the National Science Foundation definitions, basic research is research with

the primary aim of the investigator being a fuller knowledge or understanding of the subject under study, rather than a practical application thereof ... [where] ... original investigations [are] for the advancement of scientific knowledge ... which do not have specific commercial objectives.

Applied research is "directed toward practical application of knowledge." Development is

the systematic use of scientific knowledge directed toward the production of useful materials, devices, systems, or methods including design and development of prototypes and processes.

Development excludes product testing, quality control, experimental production and training and information dissemination.

R & D funds include current operating costs, both direct and indirect, as well as depreciation. Federal expenditures is the aggregate of R & D expenditures for the separate federal federal agencies, and due to accounting practices of some agencies, represents obligations rather than actual expenditures in some cases.

In the series used in the earnings models, federal expenditures

on R & D plants is also included. Expenditures for 1971-1972 are from the NSF publication, Research and Development in Industry (see the bibliography for full citations of these references). Information for 1952-1970 is from Historical Statistics of the United States.

Expenditures for 1940-1951 are from an OECD publication, Country Reports on the Organization of Scientific Research. Data for 1920-1939 came from the Vannebar Bush report, Science, The Endless Frontier. In this source, the data exclude R & D plant expenditure. To account for this difference, the ratio of the 1940 expenditures in Country Reports to that in the Bush report. That ratio was 1.17. In addition, information was missing for 1920-1922 and for 1933 and 1939. Expenditures for 1933 and 1939 were estimated using linear extrapolation. Estimates for 1920-1922 were done by assuming that federal R & D expenditures changed at the same rate as industry R & D expenditures for those three years. No data were available for 1901 through 1919, so the average growth rate from 1920 to 1930 was assumed to be the same for 1910-1919 and the mean value was used. The same rate was applied to the 1910-1919 expenditures to make estimates for 1901-1909. Of the sample, .2% started jobs before 1919, so this rather crude estimation method should have little effect.

If one of the job dates was missing, so that the change in R & D expenditures could not be calculated, the case was deleted.

Government Funding. In all of the surveys, workers were asked if their work was supported by U.S. government funds. They were asked to indicate the areas of government supported work for each of the three jobs, choosing three from a list of twelve areas. Their responses

were recoded into four dummy variables representing different agencies/areas: defense, space, energy, and other; and, the question of government support was kept.

For the purpose of the earnings models, government funding support was recoded into a single dichotomous variable. If the response to the question of government support was yes, then the dummy variable for government funding, GVTFND, was set equal to yes. If not, the four dummy variables for government agency/area support were consulted. If any of them equalled yes, GVTFND was set equal to yes. Otherwise, it equalled zero.

Geographical Region and SMSA Status. In all of the surveys, the location of the job site and whether or not it was in a standard metropolitan statistical area (SMSA) were explicitly asked. There were 10 geographical regions: New England (ME, NH, VT, MA, RI, CN); Middle Atlantic (NY, NJ, PA); East North Central (OH, IN, IL, MI, WI); West North Central (MN, IA, MO, ND, SD, NB, KS); South Atlantic (DE, MD, DC, VA, WV, NC, SC, GA, FL); East South Central (KY, TN, AL, MS); West South Central (AR, LA, OK, TX); Mountain (MT, ID, WY, CO, NM, AZ, UT, NV); Pacific (WA, OR, CA, AK, HI); and, outlying areas (Puerto Rico, Guam, Virgin Islands).

Changes in the Consumer Price Index. As was the case in R & D expenditure levels, changes in the CPI index depended on the starting and ending job dates. The CPI index for the years 1901 to 1970 was taken from Historical Statistics of the U.S., and that for 1971 and 1972 from Statistical Abstracts (1973). Because percentage rather than actual change was of interest, the logarithmic value of the CPI

index for each year was used, the value for the starting year being subtracted from that for the ending year. If either date was missing, the case was deleted.

C. Defining Career Paths

The primary hypothesis of this thesis is that the earnings schedules and mobility patterns of scientists and engineers depend on what career path they follow. The major path distinction is between managerial and technical paths. There were three different variables in the the data set that could be used to define career paths: on-the-job activities, supervisory level, and self-defined occupational category.

Respondents were asked to describe their supervisory level for each job in the 1972 survey. The question about supervisory level allowed five possible responses: 1) supervised no personnel; 2) responsible for indirect or staff supervision (no line authority); 3) supervised team, unit, project, or section; 4) managed major department or division; and, 5) general management of organization. Supervisory level information was provided only in the 1972 survey.

Information about activities on the job was provided in each survey, however, the format of the questions differed from survey to survey. Appendix 2 provides a detailed discussion of these differences. In the 1972 survey, where the current and two previous jobs were described, respondents were asked to provide the percentage distribution of their time among twelve activities in addition to noting their supervisory level. Those activities are listed below.

Activity

1. Teaching and Training
2. Research
3. Development
4. Clinical Diagnosis
5. Design
6. Quality Control, Testing
7. Operations
8. Distribution
9. Statistical Work
10. Consulting
11. Computer
12. Other

As is discussed in Appendix 2, two management activities were included in the activity lists for the survey, and the attempt was made to make that information consistent with the supervisory level information provided in the 1972 survey. In addition, several tests were made to determine if Distribution and Consulting should be considered managerial or technical activities.

In addition to the activity and supervisory variables, respondents were asked their occupation in each survey. Table 4, above, shows the list of occupational codes for all surveys. If the occupation was one on the list below, the job was defined as managerial. Otherwise, the job was technical.

<u>Occupation</u>	<u>Code</u>
Administrator or Manager, scientific & technical research & development	453
Administrator or Manager, production & operations	454
Administrator, Manager, or Official, all other, exc. self-employed	455
Self-employed Proprietor	456

Accountant	457
Attorney	458

After several unsuccessful attempts were made to generate a consistent measure of career path that allowed use of all of the surveys, it was decided that the analysis would be limited to the 1972 survey data only. Two definitions of path were used, that using supervisory level and that using the self-declared occupation. Again, after several tests, it was decided that only those who managed a major department or division (SUPATH = 4) or were part of general management of the organization (SUPATH = 5) should be counted as managers. Chapter VI includes a discussion of the differences between the two measures and the likely biases each contains.

FOOTNOTES

¹ Respondents to the 1972 survey were divided into categories: those considered to be "in-scope," or in one of the fields of science and engineering in 1972; and, those who were "out-of-scope", or not in a field of science and engineering in 1972. The in-scope sample size was 50,093 and became the sample for all of the subsequent surveys. Survey responses from the 1974 PMS were matched with the individual survey response from the 1972 PMS; responses from 1976 were matched to those from 1974; and 1978 responses were matched to those from 1976. So, longitudinal information is provided. Of the 50,093 people sampled, 41,133 returned useable responses. An additional 362 cases were deleted because either occupation or professional self-identification had to be imputed from other information provided in the questionnaire.

² The first type of case to be deleted was those without a starting date for the current or most recent job in 1972. Although the survey describes people at different stages in their careers, this is the one

job which should be common to all respondents.

³ An exemption in this category was made for those with post-doctoral appointments. In PMS74 and PMS76, whether or not a particular job is a post-doc is explicitly asked. If a job is a post-doc and that is that individual's only academic job, then that case is kept. Otherwise, it is deleted. For the 1972 survey, the assumption is made that if what is described as an academic job (by industry and activity) lasts more than one year, then that individual is assumed to be a college teacher and is dropped from the sample. Because the ending date for the current job in the 1978 survey is not available, all of those defined as academicians must be assumed not to be recipients of post-doctoral appointments.

⁴ U.S. Dept. of Commerce, Historical Statistics of the United States, Part 1, Bureau of the Census, 1975, p. 961.

Chapter VI

SAMPLE FREQUENCIES AND ESTIMATED RESULTS

Introduction

This chapter has two purposes. First, because the primary hypothesis has been that career paths mitigate the effect of human capital investment on earnings, it is first necessary to establish that the hypothesized career paths exist. This is followed by a model where experience is expressed as a homogeneous continuous variable. Next, two sets of earnings models are presented, one of earnings levels and one of earnings change. Before these discussions, however, the sample is described.

I. Characteristics of the Sample

In order to gain a perspective on who is represented in this sample, descriptive statistics are presented here for the entire sample in 1972.

As discussed in the section on variable creation, the sample has been limited to white males who held at least a bachelor's degree at the time of entering the labor market. All workers in the natural and life sciences, mathematics, computer science, and engineering were included. Social scientists and miscellaneous occupations were omitted. Also, foreign workers were excluded, unless there was convincing evidence that a foreign worker was working for a U.S. firm at a foreign work site. The sample size is 3364.

A. Human Capital

Age, Experience, and Tenure. The mean age of the sample in 1972 was 41.1 years, with a standard deviation of 10.4. The median age is 40, and the range is 22 to 79. Despite this high maximum, only 41 people are over age 65, the traditional retirement age. Mean years of professional experience (equal to the answer to an explicit question in 1976 minus four) was 16.7 years, with a standard deviation of 9.7. The minimum was zero, for new entrants, the maximum 54 years, and the median 16 years. The table below shows the frequency distribution for years of experience.

 Table 1

 Years of Professional Experience in 1972

<u>Years</u>	<u>Frequency</u>	<u>% of Sample</u>
< = 10	1118	33.23
11 to 20	1115	33.14
21 to 30	830	24.67
31 to 40	282	8.38
40 +	19	.56

Two-thirds of the sample had been in the labor market for twenty years or less.

Job tenure in the most recent job was also calculated and grouped. In this case, current job tenure equalled seventy-two (1972) minus the starting year. This differs from actual tenure because most workers continued in that job beyond 1972. The frequencies for the tenure groups are:

Table 2

Job Tenure in the Current job in 1972

<u>Years</u>	<u>Frequency</u>	<u>Percent</u>
< 5	1754	52.74
5 to 9	802	23.84
10 to 14	361	10.73
15 to 19	177	5.26
20+	270	8.03

That three-quarters of the sample had been in their current job less than ten years despite the fact that the sample represents a fairly mature age cohort suggests a high rate of job mobility.

Education and Field. The highest degree held by a majority of the sample in 1972 was a bachelor's degree, with 2259, or 67.2% at that level. Eight hundred and twenty three, or 24.4%, has master's degree, and 282 (8.4%) had doctorates.

Table 3 shows the professional field distribution of the sample in 1972. As discussed in the section on variable creation, professional field is a composite measure, where respondents are sorted according to a set of ordered criteria, such as education, work areas, and professional activities.

Table 3

Professional Field Distribution

<u>Field</u>	<u>Frequency</u>	<u>Percent</u>	<u>Field</u>	<u>Frequency</u>	<u>Percent</u>
Computer	282	8.4	Medical Sci	3	.1
Sci.			Chemist	276	8.2
Engineer	2436	72.4	Physicist/	92	2.7

Mathematician	42	1.2	Astronomer		
Statistician	18	.5	Atmospheric	3	.1
Agricul. Sci.	32	1.0	Scientist		
Bio. Sci.	31	.9	Earth Sci.	131	3.9
			Other	18	.5

Clearly, the large majority of the sample are engineers, with only chemists and computer specialists constituting field groups of any significance.

B. Labor-Market Variables

The frequency distribution by occupation for the job held in 1972 is very similar to that for professional field, with a few additions that should be mentioned. Within engineering, there are twelve subspecialties. The dominant types of engineering specializations are chemical, electrical and electronic, and mechanical.

Table 4 shows the industrial distribution of the sample in 1972.

Table 4
Industrial Distribution

Industry	Frequency	Industry	Frequency
Air Craft	294	Chemicals	494
Elec. Mach	230	Fabr. Metal	96
Mach., exc. elec	202	Motor Vehicles	78
Ordnance	149	Primary Metals	132
Prof.&Sci.Equip	53	Other Manu	335
College, Univ.	29	Agric.,Fish,Forest	25
Business,Repair	21	Construction	72
Eng.,Arch. Serv.	273	Fin.,Ins.	32
Min. & Petr.	224	Prof.,Tech. Soc.	4
Res. Instit.	163	Retail,Wholesale	30
Trans.	154	Other	234

The largest single category, Chemicals and Allied Products, remains the modal category for all three jobs in the 1972 survey. Because educators were deleted from the sample, the very small number in the college or university category represents those working in university-affiliated research centers or those who are employed as engineers on the nonacademic staff of an academic institution. It is noteworthy that only 4.4% of the sample work in Ordnance while almost 20% of the sample were doing work supported by the Defense Department in 1972. With the few exceptions mentioned above, the distribution of workers by industry is relatively even, with a range between two and ten percent.

Of the different types of employers, 91.4% were private sector, 3.5% were private nonprofit, and 2.5% were self-employed.

Geographically, 87% of the sample were concentrated into six regions: 22.6% in the mid-Atlantic states; 17.4 in the east-north-central region; 15.1% in the Pacific region; 11.9% in the west-north central; 9.9% in the south Atlantic region; and, 8.2% in New England. Eighty-six percent worked within SMSAs.

II. Career Paths

In the earlier chapter which reviews the literature on the career paths of scientists and engineers, the major theme was that many of those workers, who enter the labor force with an interest in technical problem solving, eventually leave technically oriented jobs to begin a managerial career path. And, a major reason for this career-path

shift is that greater economic rewards are tied to managerial than to technical activities. In order to model the differences in reward structures that are associated with career path choice, it is necessary first to establish that most of the workers in this sample follow one of two types of career paths: all enter the labor market as technical workers; most remain technical workers due to the combined effects of their own proclivity for technical problem solving and the pyramidal shape of most hierarchical organizations; but, a significant number shift to, and remain on, a managerial career path.

A. Establishing the Career Split

As described in the discussion of variable creation, career path was not explicitly provided in the data set, but was constructed from related variables. Two versions are used in the empirical model of earnings changes, SUPATH, constructed from a direct question about supervisory level, and OCCMAN, constructed from the self-declared occupational code (See the chapter on variable construction for specific definitions of these variables).

Table 5a shows the frequency of managers and technical workers for each job, using the two different definitions.

Table 5a

Path by Job

<u>Job</u>	SUPATH			
	<u>Technical</u> <u>Frequency</u>	<u>Percent</u>	<u>Managerial</u> <u>Frequency</u>	<u>Percent</u>
Job1	2946	88.28	391	11.72
Job2	2202	80.87	521	19.13
Job3	1580	72.15	610	27.85
	OCCMANG			
Job1	2948	87.63	416	12.37
Job2	2357	82.56	498	17.44
Job3	2052	80.00	513	20.00

Table 5a shows the expected increase in both the actual number and percentages of managers relative to technical workers as careers progress from Job 1 through Job 3, regardless of which path definition is used. However, as careers progress, the number of managers increases more rapidly when the supervisory-level based definition is used.

The progression from technical to managerial paths was also documented by constructing a set of alternative career paths and examining their relative frequencies. The two major paths were, of course, all technical (T), and first technical then managerial (T to M). Because respondents were first questioned at different points in their careers, it was also possible that the first recorded job was after the path shift had occurred, so an all managerial path was possible (M). Then, three other paths were included that were

expected to describe the careers of a small minority of the sample: a backshift from managerial to technical (M to T); a backshift followed by a swing back (M to T to M); and, the expected shift followed by a backshift (T to M to T). Diagram 1 shows the frequencies of percentages of the different path alternatives using the two different definitions.

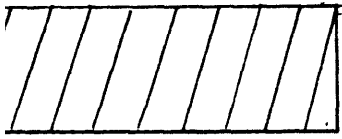
Regardless of which variable definition was used, that the career paths of most of the sample are either all technical, technical then managerial, or are described after the shift is supported by the diagram. Using SUPATH, 91.6% are described by the hypothesized paths, compared to 94.2% using OCCMANG. The major difference between the two variables is that, using OCCMANG, more of the sample stayed in technical jobs than when SUPATH was used.

Because the survey did not describe the first job after entering the labor market of all of the sample, these alternative paths did not necessarily describe the entire career paths of an individual. When the alternative paths were examined according to whether the respondent's first job was included in the survey, the result showed that fewer of those on the managerial track had described their first job, supporting the hypothesized eventuality of a split from a technical to managerial path. Using SUPATH, of those on the all-technical track, 60% had described their first job, compared to 30.5% of those on the all managerial track and 38.4% of those who had gone from technical to managerial. Using the occupational definition, 57.2% of those on the all-technical track had described their first job, compared to 7% of those on the all-managerial, and 34.1% who had

CAREER PATHS

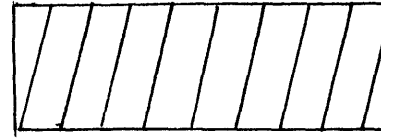
PATH

OCCMAN



69.3%

ALL TECHNICAL



74.7%



5.9%

ALL MANAGERIAL

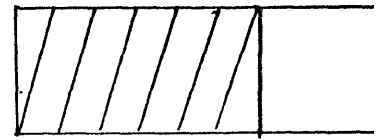


8.0%

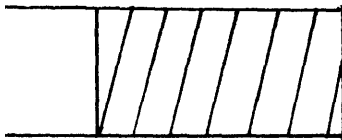


16.0%

TECHNICAL TO MANAGERIAL



10.9%



4.2%

MANAGERIAL TO TECHNICAL



3.9%



1.34%

TECHNICAL TO MANAGERIAL TO TECHNICAL

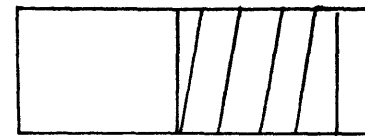


.4%



1.3%

MANAGERIAL TO TECHNICAL TO MANAGERIAL



2.0%

made the split.

B. Comparison of Path Definitions: A Phased Transition Hypothesis

It was expected that after undergoing the rigorous training needed for a scientific or engineering career that even those workers who had shifted to the managerial track would describe themselves as members of the occupation closest to their training; and, that therefore OCCMANG would understate the number of managers relative to SUPATH.

Because the use of a dichotomous variable was an admitted oversimplification of the career choices available to scientists and engineers, the possibility that the discrepancy between the two definitions occurred because each captured a different phase of the technical-managerial path transition was examined. In terms of the two definitions, it was expected that although a worker might be a manager according to supervisory responsibilities (i.e., SUPATH = 1) there could be a transition period when that worker retains a professional self-image as a technical worker (i.e., OCCMANG = 0) despite significant supervisory responsibilities on the job.

To test this, the sample was divided into four categories: those who were managers by both definitions, those who were technical workers by both definitions, and two groups of those who were technical by one definition and managerial by another. Table 5b shows the frequency distribution by group for the job described in 1972.

Table 5b

Comparison of Path Definitions

	<u>Frequencies</u>	<u>Percent of Sample</u>
Managers by Both Definitions	605	18.2
Technical Worker by Both Definitions	1437	43.23
Manager by Supervisory Level, Technical by Occupation	1222	36.76
Manager by Occupation, Technical by Super- visory Level	60	1.81

Table 5b shows that a significantly large number of workers with high-level supervisory responsibilities define their occupations as scientists or engineers and that very few describe themselves as managers but have few or no supervisory responsibilities, providing initial support for this explanation of the difference between the two path definitions. And, that there are more than twice as many of workers who are managers by supervisory level only as managers by both definitions does suggest a high degree of professional loyalty regardless of actual job content.

Assuming the transition from technical to managerial is phased, it would also be expected that there would be a difference in the age distributions of those who are managers by supervisory level only and those who are managers by both definitions. Table 5c shows the frequencies and percent distributions of those two groups by age group

for the job described in 1972.

Table 5c

Age Group	Managers, by Both Definitions		Managers, by Supervisory Definition		% Sample in Age Group
	#	%	#	%	
20-25	4	.66	25	2.05	3.52
26-30	45	7.44	131	10.72	14.78
31-35	73	12.44	194	15.88	15.97
36-40	94	15.54	209	17.10	16.13
41-45	124	20.50	210	17.18	16.00
46-50	113	18.68	211	17.27	15.31
51-55	80	13.22	117	9.57	9.06
56-60	42	6.94	68	5.56	5.20
61-65	19	3.14	41	3.36	2.95
66+	11	1.82	16	1.31	1.17

Assuming those who are managers by supervisory level only are in transition from technical to managerial and those who are managers by both as having made that transition, examination of the age distribution indicates that more of those who are in transition are below age 40 than those who have made the transition. Forty-five and three quarters percent of those who are managers by supervisory level only are under 45, compared to 35.7% of those who are managers by both definitions. Comparison of the distributions of years of experience yields similar findings: 64.3% of those in the supervisory-level managerial category have had 20 years or less of work experience, compared to 52.7% of those who are managers by both definitions.

In order to examine whether there were systematic differences between the two types of definitions, the probability of falling into

one of the four pathgroup categories was modeled. A logit model was used where $\log(P_i/(1-P_i)) = XB + \epsilon_i$, where P_i is the probability of being in one of the path groups and the X variables include experience group, degree level, and industry. The model is additive; that is, each of the X variables was expected to affect path group separately and no interactions between the X variables was hypothesized. All of the exogenous variables are categorical. The experience groups include: less than ten years, ten to twenty years, twenty to thirty, and over thirty years.

The chi-square statistic for each of the separate effects shows that the hypothesis that being in a particular pathgroup category is independent of experience, degree, or industry can be rejected at the .0001 level for all effects (degree level: $\chi^2 = 34.3$ (df = 6), industry: 118.15 (df = 45), experience group: 158.98 (df = 9)).

The underlying hypothesis is that the transition from technical to managerial career paths is gradual, and the specific expectation for that as experience increases, an individual will be increasingly likely to be a manager by both definitions rather than by supervisory responsibilities only. The effect of degree is expected to be that those with advanced degrees will have a greater loyalty to their technical training and therefore be more likely to be managers by the supervisory definition only. The effect of industry is expected to vary with the structure of the industry, and the industrial category variables were included primarily for control purposes.

The probability of being in a particular path group is $p_i = 1/(1+e^{-xb})$. Using the aircraft industry as an example, the

probability of being a manager by both definitions for an individual with less than ten years experience and a bachelor's level degree is: $p = 1/(1 + e^{-(-.508 - 1.04 - 1.2 - .085)}) = .0562$. The comparable probability for an individual with between twenty and thirty years of experience is .1462. The probability of being a manager by supervisory definition only for an individual with ten years experience and a B.S. degree is .3311. And, the probability of being in that pathgroup for a comparable individual with twenty to thirty years experience is .4878.¹

What these probabilities indicate is that for those in the aircraft industry with less than ten years of experience, while there is almost a 40% of having supervisory responsibilities, only 5.6% of those will describe themselves as managers. And, of those with twenty to thirty years of experience, there is about 63% chance of having supervisory responsibilities, but members of that group are about three times as likely to describe themselves as managers. Although this is only a single industry example, these probabilities provide support for there being a phased transition from the technical paths, where despite an actual shift in job content from primarily technical to primarily managerial responsibilities, it takes time to relinquish a primary loyalty to one's profession and adopt a managerial (and firm) orientation.

III. Estimation Results

As was described in a previous chapter, three types of models are

estimated, a continuous experience model, an earnings-level model and an earnings-change model. All use a loglinear functional form. Incorporated in the presentation of the estimation results is a discussion of the specification and interpretation issues associated with each variable.

A. Coefficient Interpretation of the Loglinear Models

The functional form of the cross section models can be written as: $Y = aX_1^{b_1} e^{b_2 X_2} e^{b_3 D}$ or $\ln Y = \ln a + b_1 \ln X_1 + b_2 X_2 + b_3 D + \mu$, where a is the intercept, X_1 and X_2 are continuous variables and D is the set of dummy variables. b_1 can be interpreted as an elasticity. In this case, the only variable which is entered this way is the change in the CPI index which appears in the earnings change models. The dummy variables act as shift parameters and are interpreted as indicating an effect relative to the deleted variable in each set of dummy variables. In the cross-section model, there are three sets of dummy variables. To avoid singularity, one variable was dropped from each set. They were MS from education, OCCENG1 from the occupational categories, and INDMANU from the industry classification.

The X_2 variables have a slope effect, and as discussed in chapter IV, are hypothesized to have an absolute effect on the log of earnings. An interaction between the dummy variable and a continuous variable is also expected to have a slope effect.

A general specification of the earnings change model is:

$d \ln Y_i = a + B_1 X_1 + B_2 D + \mu_i$, where X_1 are continuous variables and D

are dummy variables. In comparison to the levels model, when ability is assumed to be fixed and bias the expected value of the residual and thus the coefficient estimates, the net effect of ability in the change model is zero.

B. Continuous Experience

In an earlier section, the presence of career paths was empirically established. The next step is to document the differences in labor market outcomes between the two paths. The expected differences between managers and technical workers is based on a hypothesized difference in both the nature and quantity of their human capital accumulation. For this reason, the earnings models are specified to permit the observation of differences between general, firm-specific, and job-specific human capital. However, before examining the human-capital investment components of the two paths, a simple model that examines the return to each type of experience is estimated.

In this model, total work experience is the sum of technical experience (EXPTTECH), managerial experience (EXPMANG), and, because the entire career history of all of the sample is not always included in the survey, the amount of experience when path is unknown (EXPDK). To account for declining rates of investment, these three variables are entered in both the linear and quadratic form. The definition used for the managerial path was that based on supervisory level. The expectation was that the coefficients for managerial experience, EXPMANG, would be larger than for EXPTTECH, and the quadratic form

would be less negative. Four models were estimated, two earnings levels models (See footnote 3 for an explanation of the exclusion of the industry and occupational dummy variables) and two earnings change equations, each with and without the industry and occupational variables. Table 6 shows the estimated coefficients and their t-statistics for both the earnings levels and earnings change models.

Table 6

Continuous Experience Models

Variable	Level Models		Change Models	
Intercept	9.6872** (422.684)	9.5856** (562.477)	.0778* (1.952)	.0163* (.707)
EXPMANG	.03220** (15.8187)	.0346** (16.945)	.00919** (2.636)	.0097** (2.833)
EXPTECH	.0128** (8.493)	.0124** (8.181)	.0047* (1.802)	.0036 (1.379)
EXPDK	.0118** (10.792)	.0128** (11.607)	-.007** (-3.819)	-.0065** (-3.563)
EXPMANG ²	-.0005** (-7.715)	-.0006** (-8.271)	-.0004** (-3.543)	-.0004** (-3.595)
EXPTECH ²	-.0007* (-2.304)	-.0001* (-2.146)	-.0004** (-5.450)	-.0004** (-5.047)
EXPDK ²	.00003 (.651)	.00003 (.702)	-.0001 (-1.377)	-.00013 (-.6001)
MOVEY	.0148 (1.419)	.0108 (1.020)	-.0195 (-1.088)	
BAC	-.0875** (-7.259)	-.0794** (-6.526)	.0047 (.229)	
PHD	.1884** (8.663)	.1466** (7.050)	-.0816* (-2.209)	

GVTFND	.0298 [*] (2.255)	.0419 ^{**} (3.742)	-.0344 (1.531)	
NE	.0463 ^{**} (4.171)	.0433 ^{**} (3.888)	.0263 (1.392)	
OCCENG2	-.0850 ^{**} (-5.177)		-.0094 (-.335)	
OCCENG3	-.0697 ^{**} (-3.756)		.0003 (.008)	
OCCENG4	-.1068 ^{**} (-6.257)		.0066 (.230)	
OCCENG5	-.1353 ^{**} (-4.853)		-.0410 (-.867)	
OCCOMP	-.0767 ^{**} (-4.496)		.0041 (.142)	
OCCNASC	-.1650 ^{**} (-9.085)		.0461 (1.492)	
INDWAR	-.0106 (-.510)		-.0856 ^{**} (-2.421)	
INDBASE	-.0561 ^{**} (-2.851)		-.1028 ^{**} (-3.076)	
INDMANU	-.0330 [*] (-1.78)		-.083 ^{**} (-2.638)	
INDCHEM	-.0140 (-.740)		-.0870 ^{**} (-2.709)	
INDSERV	-.0192 (-.891)		.0280 (.764)	
INDPROF	-.1028 ^{**} (-3.866)		-.0562 (-1.244)	
INDOTH	-.013 (-.549)		-.0495 (-1.221)	
INDK	.0259 (.491)		-.0664 (-.742)	
LNCPICHG			1.603 ^{**} (20.386)	1.6044 ^{**} (20.518)

RNDCHG			.00004** (13.225)	.00004** (13.247)
R ²	.2956	.2599	.5499	.5415

In the earnings-levels equations, both sets of results provide support for a steeper earnings schedule for managers. But, managers appear to have a somewhat higher rate of decline in investment in the model which excludes the industry and occupational variables. The slope coefficients for managerial experience is .03 compared to .01 for technical workers. If it were assumed that one-third of a manager's career is first spent as a technical worker, then it would take 145.5 years for the earnings schedules of the managers and technical workers to cross.

The coefficients for the earnings change models are partially consistent with those for the levels variables: the rate of change for managers is greater than for technical workers, but the effect of the decline in investment is the same for managers and technical workers. Setting the partial derivative equal to zero and solving for total years of experience, it would take a manager 21.4 years to reach a zero rate of earnings growth, compared to 12.05 for a technical worker.

The results of these fairly crude models provide support for a steeper earnings curve for managers relative to technical workers, and at least in the model, for a slower decline in investment.

B. Experience-Components Models

Both the earnings level and earnings change models were estimated as separate path regressions and as a single regression with interaction variables. The path definition used to separate observations was the supervisory definition, SUPATH. The test used was the Chow-test, an F-test that tests whether the parameter estimates that result when the model is estimated using one sample hold when the model is reestimated using another. In this case, the benchmark estimates are from the total sample, and the sum of the separate regression estimates are compared to these. The null hypothesis is $B_T = B_M = B_A$, that is, that the coefficient estimates from the technical sample equal those from the managerial sample and so also those from the total sample.

For both models, the null hypothesis was rejected. For the cross-section level models, $F_{28, \rho} = 12.373$. And, for the cross-section change model, the test value was 10.468. That the null hypothesis can be rejected provides initial support for the argument that there are systematic differences in earnings profiles by career path.

1. Earnings Level

Single Equation with Interaction Variables. Based on the specification tests discussed in the previous section, four single equation-earnings level models were estimated: two using the supervisory-based managerial definition and two using occupation.² The two supervisory path models (Models 1 and 2) were the full model including all of the path-interaction variables and the second model

excluding the industry and occupational dummy variables.³ Both occupational path models (Models 3 and 4) included the industry and occupational variables, but one excluded the path interactions hypothesized to be equal to zero above.

The major distinction between the two path definitions to be kept in mind is that almost all of those who describe themselves as managers have supervisory responsibility, but only one-third of those who are managers according to supervisory level call themselves managers. So, for models 3 and 4, the non-managerial group includes many workers with significant supervisory responsibilities. In addition, as discussed earlier, there is some evidence that those who describe themselves as managers are more experienced workers and may be more senior managers.

Table 7a show the estimated coefficients for the earnings level models. The t-statistics are in parentheses.

Table 6a

Cross-Section
Levels Equations Results

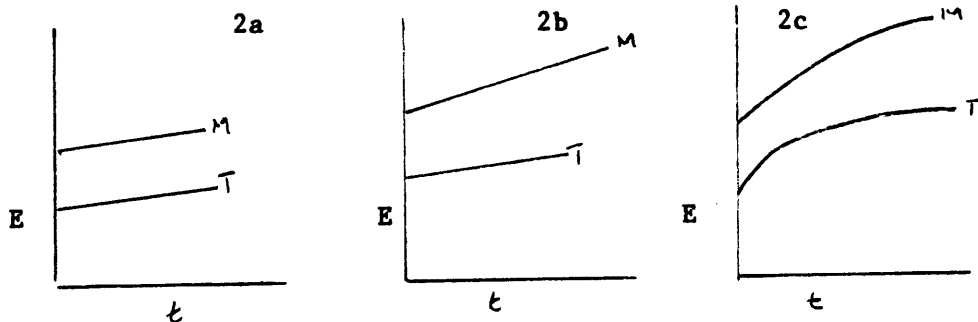
<u>Variable</u>	<u>Model 1</u>	<u>Model 2</u>	<u>Model 3</u>	<u>Model 4</u>
INTERCEPT	9.4034** (516.68)	9.463** (392.76)	9.4228** (360.88)	9.421** (367.24)
BA	-.0808** (-7.217)	-.0846** (-7.573)	-.0846** (-7.449)	-.0844** (-7.426)
PHD	.1505** (7.866)	.1899** (9.423)	.1726** (8.391)	.173** (8.407)
EXP	.0282** (10.928)	.0278** (10.826)	.0301** (12.187)	.0298** (13.191)

EXP ²	-.00041** (-4.614)	-.00041** (-4.639)	-.0005** (-6.334)	-.00048** (-6.400)
TENURE	.0309** (16.864)	.031** (16.926)	.0333** (18.081)	.0338** (18.599)
TEN ²	-.00043** (-10.469)	-.00043** (-10.473)	-.00046** (-11.260)	-.00047** (-11.525)
NONTEN	.0477** (17.017)	.0452** (16.110)	.0407** (14.303)	.0386** (15.142)
NONTEN ²	-.001** (-9.760)	-.00093** (-8.838)	-.0007** (-7.243)	-.00063** (-7.456)
MOVEY	.0247** (2.492)	.0273** (2.757)	.0237** (2.358)	.0241** (2.400)
MOVEDK	.0462* (1.852)	.0475* (1.923)	.0400 (1.577)	.0399 (1.588)
GVTFND	.0464** (4.459)	.027* (2.199)	.0297* (2.365)	.0296* (2.355)
SUPATH	.1699** (4.066)	.1332** (3.254)		
OCCMAN			.1672** (3.901)	.1920** (7.837)
PATH*EXP	-.00088 (-.0163)	.00077 (.146)	0.0012 (-.212)	
PATH*EXP ²	-.00004 (-.228)	-.00007 (-.413)	.00019 (1.006)	
PATH*TEN	.0114** (2.503)	.0131** (2.899)	-.0019 (-.375)	-.0049 (-1.035)
PATH*TEN ²	-.00027* (-2.261)	-.00031** (-2.588)	.00019 (1.216)	.00024* (1.613)
PATH*NT ²	.00078** (4.459)	.00068** (3.92)	.00026 (1.420)	
PATH*NT	-.0171** (-3.430)	-.0144** (-2.932)	-.004 (-.771)	
PATH*EXTEN	-.000089 (-.309)	-.00016 (-.569)	-.000001 (-.005)	.00026 (1.257)

EXTEN	-.00107** (-5.611)	-.001** (-5.464)	-.0009** (-5.350)	-.001** (-6.199)
NJTTR	-.0013** (-7.295)	-.0014** (-7.590)	-.00106** (-5.930)	-.001** (-5.845)
NE	.0421** (4.097)	.044** (4.270)	.0378** (3.604)	.0378** (3.603)
OCCENG2		-.0474** (-3.059)	.0218 (1.171)	.0214 (1.149)
OCCENG3		-.0256 (-1.459)	.0372* (1.872)	.0367* (1.844)
OCCENG4		-.0721** (-4.484)	-.0032 (-.172)	-.0033 (-.179)
OCCENG5		-.093** (-3.560)	-.0146 (-.518)	-.0163 (-.580)
OCCOMP		-.023 (-1.420)	.0364* (1.926)	.0385* (2.040)
OCCNASC		-.1236** (-7.209)	-.0501* (-2.473)	-.0503* (-2.482)
INDWAR		.0146 (.750)	-.0063 (-.319)	-.0067 (-.344)
INDBASE		-.0441* (-2.411)	-.0651** (-3.498)	-.068** (-3.668)
INDMANU		-.026 (-1.510)	-.0448* (-2.556)	-.0472** (-2.694)
INDCHEM		-.0049 (-.280)	-.0352* (-1.970)	-.0362* (-2.024)
INDSERV		.0138 (.691)	.02 (.977)	.0182 (.894)
INDPRO		-.0571* (-2.301)	-.0849** (-3.371)	-.0861** (-3.420)
INDOTH		.0213 (.959)	.0098 (.436)	.0075 (.333)
INDK		.0258 (.516)	.0347 (.697)	.0322 (.646)
R ²	.3771	.3977	.3768	.3749

-
- ** Significant at the .01 level or greater.
 * Significant at the .10 level or greater.
-

The underlying hypothesis about career paths has been that, given some set of external market conditions, career path mitigates the effect of human-capital investment. There are three ways in which path is hypothesized to affect lifetime earnings. First, it can have a shift effect: the transition from a technical to a managerial path can put an individual on a higher earnings curve. Diagram 2a shows the simple shift effect. Path may also have a slope effect, indicating a difference in the rate of earnings growth with time. Diagram 2b shows the combined shift and slope effect. And, path can also affect earnings in that it can slow the rate of decrease: although managers, too, will invest at a decreasing rate, the preferred set of investment opportunities will keep the rate of return higher than that marginal cost of investment for a longer period. Diagram 2c show the combined shift, slope, and quadratic effects.



This hypothesis was tested in the model by the inclusion of a dummy variable for path and path interaction with job tenure and

tenure squared. As discussed earlier, the interactions between path and previous experience were expected to be non-significant.

Using both of the path definitions, the shift effect was supported. The coefficients for the path variables ranged from .13 to .19, and all were significant at the .001 level or better. In the case of the tenure-path interactions, the coefficients for both the linear and squared variables were hypothesized to be positive because they are meant to describe the relative effect of path on the tenure-earnings relationship. In the case of both of the supervisory based models, the coefficients for PATH*TENURE was positive and significant at the .01 level or better. But, the coefficients for the interaction between path and tenure squared, although significant at the .02 level or better, were the wrong sign. Taken together, the results of models 1 and 2 suggest that career path shifts a worker to a higher earnings curve, where investment opportunities are such that earnings increase faster, but there is no disincentive for managers to slow their rate of investment, and they may actually slow it faster than non-managers.

In models 3 and 4, the path-tenure interaction coefficient is the wrong sign and insignificant. However, the effect of the path-tenure squared interaction is the correct sign, and, in the case of model 4, significant at the .1 level. So, using the occupationally based variables, path is expected to shift workers to a higher earnings curve, and the relative investment opportunities are about the same for managers and non-managers, but managers decrease their investment at a somewhat slower rate.

Path-Experience Interactions. In the earnings-level equation, it was expected that the interaction between path and experience, path and non-job tenure, and the interactions between path and those variables squared would have no effect. So, the null hypothesis for the earnings-level equation was: $B_{\text{PATH*EXP}} = B_{\text{PATH*EXP}}^2 = B_{\text{PATH*NONTEN}} = B_{\text{PATH*NONTEN}}^2 = 0$.

The reason for this hypothesis was because, given the way these variables were defined, they represented the interactions between current job path and past experience, not past paths and past experience. Hypothesizing these coefficients to be non-zero was equivalent to proposing that there is a difference in returns to previous experience. There are two likely sources of difference: either most of the pre-job experience of managers was managerial; or, there was no path difference in previous experience but there was some systematic quality about those who are currently managers that caused them to receive greater returns to past experience than non-managers. Because the pre-job path differences were not known and could not justifiably be assumed as randomly distributed between current managers and technical workers, the weak hypothesis tested here was that, holding quantity but not quality of previous experience constant, current managers did not profit more than non-managers from that experience. In other words, there was no systematic difference in economic ability that is being described by the path variable.

When tested using the supervisory-based variable, $F_{4, \infty} = 4.92$, so the hypothesis was rejected at the .05 level. However, using the occupationally based path definition, the F-statistic was 2.05, and

the null hypothesis could not be rejected at the .05 level. This inability to reject the null hypothesis using the occupational path definition supports the assumption that path and not ability account for the earnings differences described by the coefficients on the path related variables.

The null hypothesis is rejected when using the supervisory definition, suggesting there is a difference in the rate of return to prior experience. However, when the coefficients on the separate parts of pre-job experience, PATH*EXP and PATH*NONTEN (and their squares), which will be discussed in the next section, are examined, there is a large difference in significance levels between the EXP interactions and the NONTEN interactions, suggesting that the nature of the experience is a major factor in earnings level.

In the case of the interactions between path and non-job experience (hypothesized to have no effect in the previous section on model specification), for all of the models where the interaction between path and pre-firm experience and that squared are included, the coefficients are never significantly different from zero, suggesting that the rate of return to general human capital does not differ between managers and non-managers. The interactions between path and same-firm pre-job experience when the occupationally based definition of path is used are not very significant (that $B_{\text{PATH*NONTEN}} = 0$ can only be rejected at the 40% level, and that $B_{\text{PATH*NONTEN}}^2 = 0$ can only be rejected at the 15% level).

In models 1 and 2, both coefficients for the same-firm, different-job experience are highly significant, but the sign of the

coefficient is not in the hypothesized direction. A plausible explanation for these results is that, once in a firm, to become a manager, a worker must invest heavily in acquiring firm-specific human capital. Those investment costs result in an initial, pre-current job, relative decline in earnings. However, because of the expectation of overall higher earnings, the rate of decline in investment in the pre-job same-firm period is slower for managers than non-managers; so, $B_{\text{PATH*NONTEN}}^2 > 0$.

To summarize and interpret the results concerning the effect of path on earnings level, there is a strong positive significant shift effect, evident from the coefficient of the simple path variables. The insignificant coefficients on the path-experience interactions suggest that career path does not affect the rate of return to general human capital. Once a move is made to the current firm, it appears that there is an initial increase in investment costs by managers or those who eventually become managers. And, the rate of this investment decreases more slowly for this managerial group.

That this increase in investment costs occurs initially and may be because of expected eventual higher earnings is supported by the fact that the effect of path on pre-job same-firm experience is not significant for the occupationally defined managers, the older managers who may have been managers longer and whose careers have moved further from that initial investment burst that comes soon after joining the firm. For the relatively younger, supervisory defined, managers, there is a significant positive return to tenure, but not for the occupationally defined managers, suggesting that they are at

the point in their careers where the earnings schedule flattens. The anomaly in these results is the significant and negative coefficient on the path-tenure squared variable for supervisory level defined managers.

All of the usually defined human capital variables are of the correct sign and highly significant ($p=.0001$). The return to a bachelor's degree is less than, and that to a doctorate is greater than, the return to a master's degree.⁴ Experience, non-job tenure, and tenure all have a positive effect, and their values squared are negative. The interactions between current tenure and both experience and non-job tenure are negative and highly significant. This can be interpreted as saying either, the greater the pre-job experience, the lower the rate of return to current tenure; or, given some level of prior experience, as tenure increases, the return from that prior experience decreases. Both interpretations are consistent with the hypothesis that earnings increase at a decreasing rate.

The return to geographical move is positive and always significant at about the .01 level. The effect of government funding is highly significant when the industry and occupational dummy variables are omitted; its significance drops to between .02 and .03 when those dummy variables are included. The single regional dummy variable, NE, which equals 1 if the region is the New England and Mid-Atlantic states is also positive and highly significant.

Separate Earnings Level Regressions. These results are reinforced when the separate models are estimated for each path. Table 7b shows the earnings-level equations.

Table 7b
 Separate Regressions
 Cross-Section Earnings Level Models

<u>Variable</u>	<u>Managers</u>	<u>Technical Workers</u>
Intercept	9.611303** (126.810)	9.461145** (409.271)
EXPC	.026857** (3.992)	.028198** (12.618)
EXPSQ	-.000431* (-2.223)	-.000411** (-5.402)
TENURE	.041324** (5.876)	.031617** (19.287)
TENSQ	-.000676** (-3.867)	-.000441** (-12.139)
NONTEN	.027597** (3.868)	.046194** (17.856)
NONTENSQ	-.000186 (-.917)	-.000943** (-10.257)
NONTENTN	-.001179** (-3.199)	-.001510** (-7.105)
EXTEN	-.001130** (-3.445)	-.001046** (-6.312)
NE	.093671** (3.167)	.027999** (2.754)
BAC	-.094337** (-2.839)	-.083755** (-7.712)
PHD	.024625** (.418)	.233902** (11.872)
GVTFND	.066409* (1.833)	.018087 (1.500)
INDBASE	-.044871	-.045874*

	(-.955)	(-2.451)
INDCHEM	-.008508 (-.188)	-.003175 (-.177)
INDMANU	-.002335 (-.054)	-.032777* (-1.831)
INDK	.092591 (.713)	.003194 (.065)
INDOTH	.037145 (.653)	.014378 (.634)
INDPROF	-.058399 (-.685)	-.06106* (-2.558)
INDSERV	.018317 (.359)	.012493 (.608)
INDWAR	.078798 (1.296)	.010588 (.548)
MOVEY	.038859 (1.379)	.023565* (2.422)
MOVEDK	.061714 (.845)	.039145 (1.636)
OCCNASC	-.155050** (-3.054)	-.123745** (-7.266)
OCCOMP	-.091592 (-1.484)	-.009951 (-.647)
OCCENG2	-.056699 (-1.160)	-.043886** (-2.902)
OCCENG3	-.122665* (-1.968)	-.005924 (-.354)
OCCENG4	-.080605* (-1.65)	-.066525** (-4.236)
OCCENG5	-.080262 (-1.144)	-.100835** (-3.833)
R ²	.1936	.3873

As is the case in Table 7a, the path differences between the general human-capital variables, EXP and EXP², are negligible. Technical workers experience greater returns to same-firm, different-job human capital, but that advantage deteriorates fairly rapidly. Although the coefficient for NONTEN is smaller for the managers, the coefficient for NONTENSQ is not significantly different from zero, suggesting that what human capital managers acquire in the firm before their current job does not depreciate. Again, managers experience greater returns to job tenure than technical workers. Of the occupational categories, the most noticeable difference is for OCCENG3, electrical and electronic engineers, where managers experience significantly lower returns to that occupation compared to technical workers.

In Diagrams 3.1-3.8, in the pages that follow, two sets of earnings functions were plotted using the coefficients from the separate regressions. The example used in these diagrams is a bachelor's level chemical engineer in the chemical industry whose work is funded by the federal government. Diagrams 3.1-3.4 show the comparative earnings functions for this subgroup at four different possible combinations of pre-job experience: no pre-firm experience and two, five, ten and fifteen years of same-firm, pre-job experience, respectively. Diagrams 3.5-3.8 show the same group with five years of pre-firm tenure and two, five, ten and fifteen years of same-firm, pre-job tenure.

It is evident from diagrams 3.1 and 3.2 that the earnings functions for the two path are nearly parallel for the first decade of

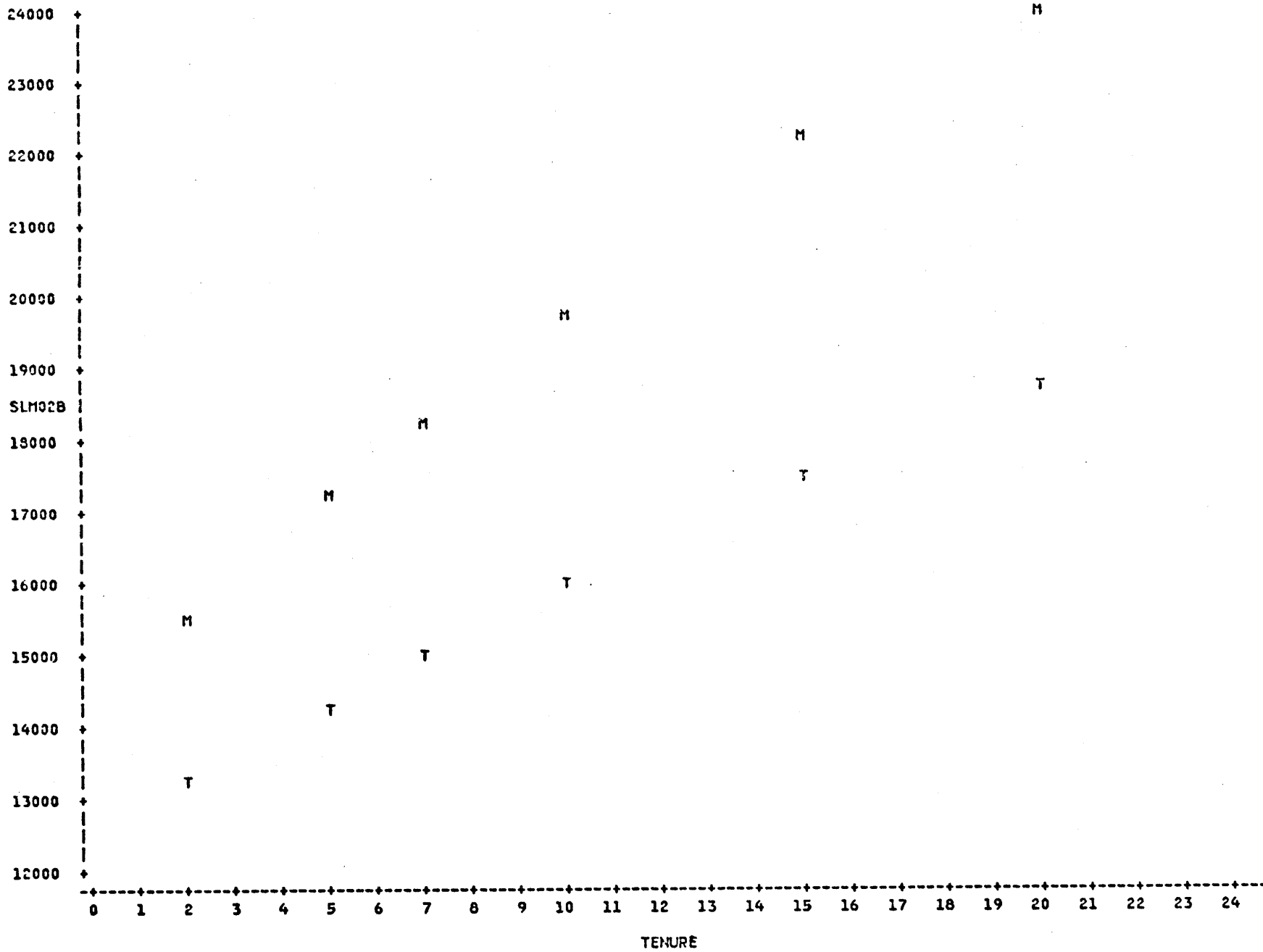
firm tenure. But after that, earnings for managers continue to grow while earnings for the technical workers begin to level off. By 25 years of experience, the technical earnings function has begun to turn down, while the managerial earnings function is just beginning to flatten.

In Diagrams 3.4 and 3.5, where workers have had five years of pre-firm experience, the period of parallel growth appears to last closer to fifteen years, before the technical curve slows; and, it is at about thirty years that the technical function turns down and the managerial path actually flattens.

Taken together, these two sets of diagrams suggest that while the managerial earnings function is consistently higher than the technical function, substantial divergence between paths does not occur until at least ten years of firm tenure has been accumulated. This suggests that both groups acquire human capital that is of value to the firm at comparable rates for those first ten to fifteen years, but after that the technical human capital begins to depreciate while managerial human capital appreciates, separating their functions.

2. Within Job Earnings Change Models. Five models of earnings change rates were estimated, three using the supervisory-based managerial definition and two using the occupational definition. Two of the models using SUPATH are full models which include the same variables as the levels equation (1 excludes the industry and occupational dummy variables and 2 includes them). And the third is the hypothesized change model discussed in the model chapter.⁶ Also, included are one full model using OCCMAN and one hypothesized model.

PLOT OF SLM02B*TENURE SYMBOL USED IS M
PLOT OF SLT02B*TENURE SYMBOL USED IS T

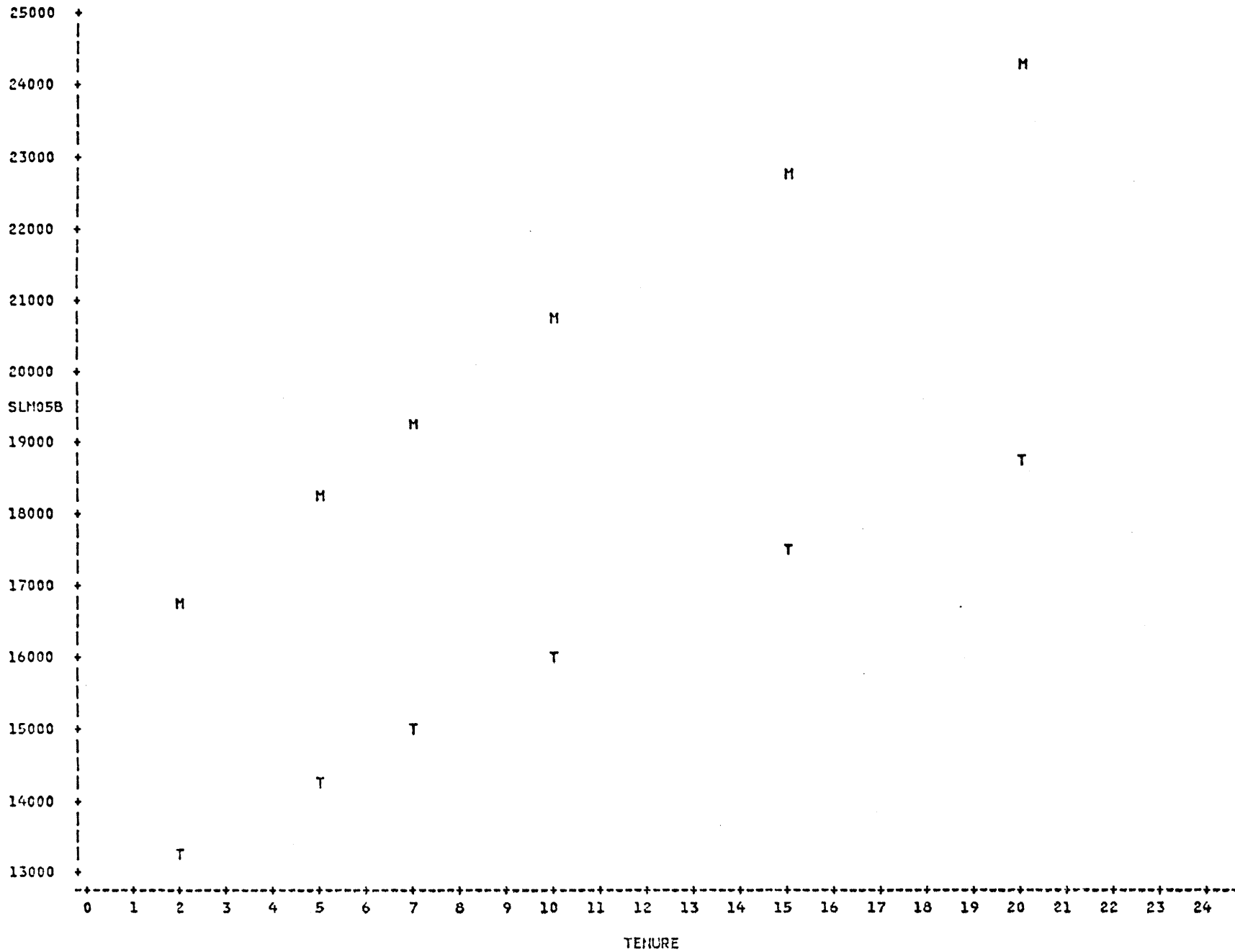


NOTE: 132 OBS HIDDEN

DIAGRAM 3.1

VI-342

PLOT OF SLM05B*TENURE SYMOL USED IS M
PLOT OF SLT05B*TENURE SYMBOL USED IS T

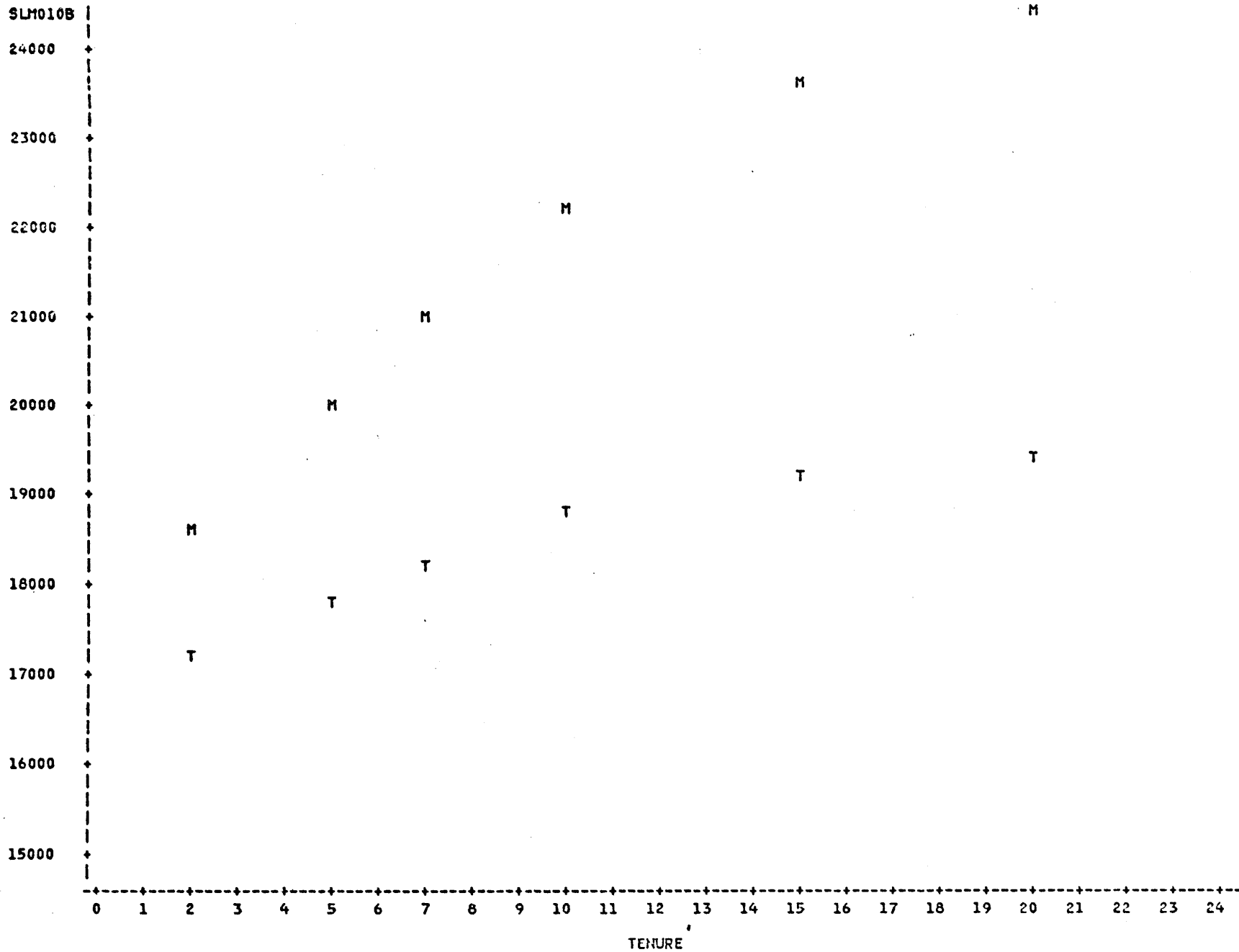


NOTE: 132 OBS HIDDEN

DIAGRAM 3.2

V1-34B

PLOT OF SLM010B*TENURE SYMBOL USED IS M
PLOT OF SLT010B*TENURE SYMBOL USED IS T

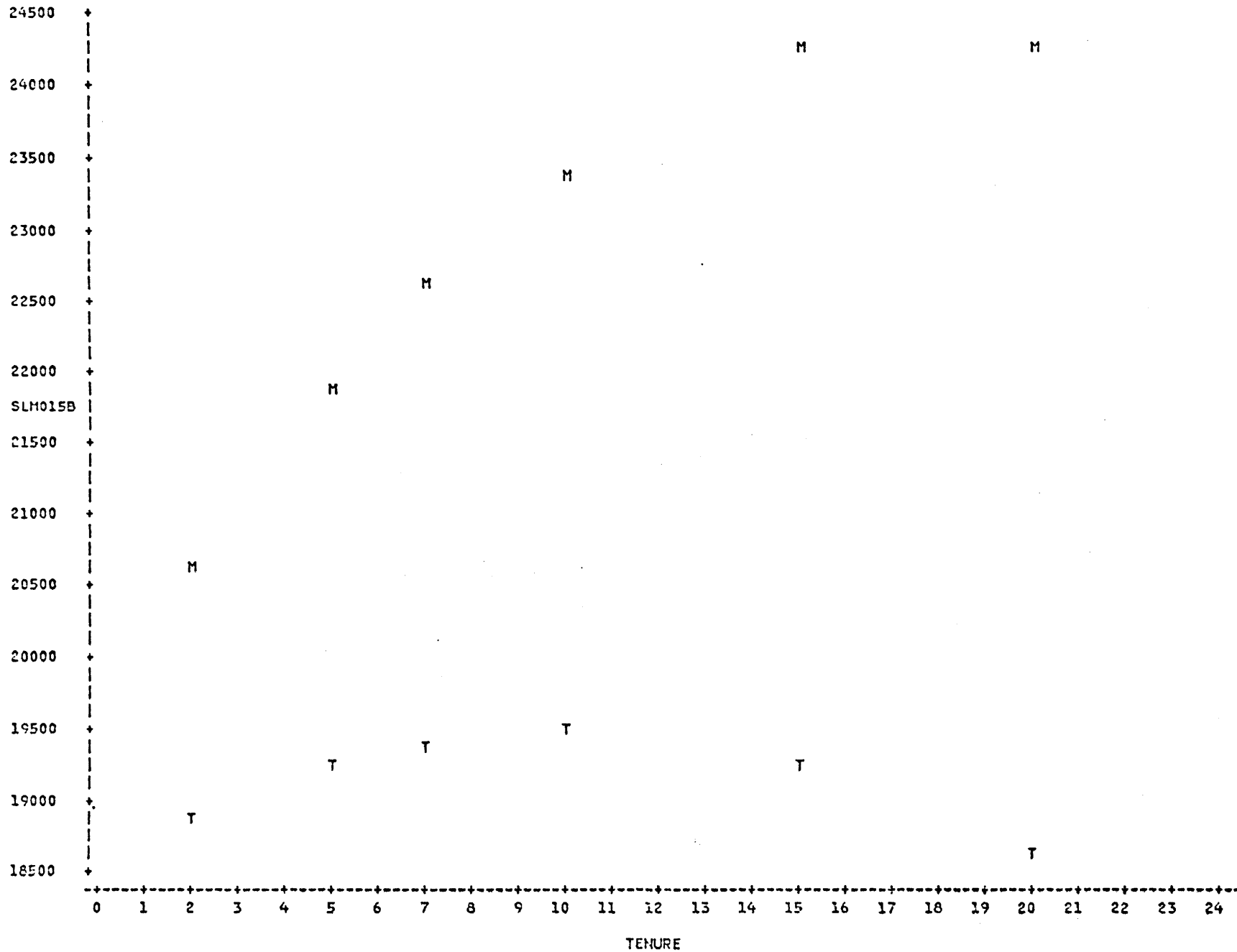


NOTE: 132 OBS HIDDEN

DIAGRAM 8.3

VI-342

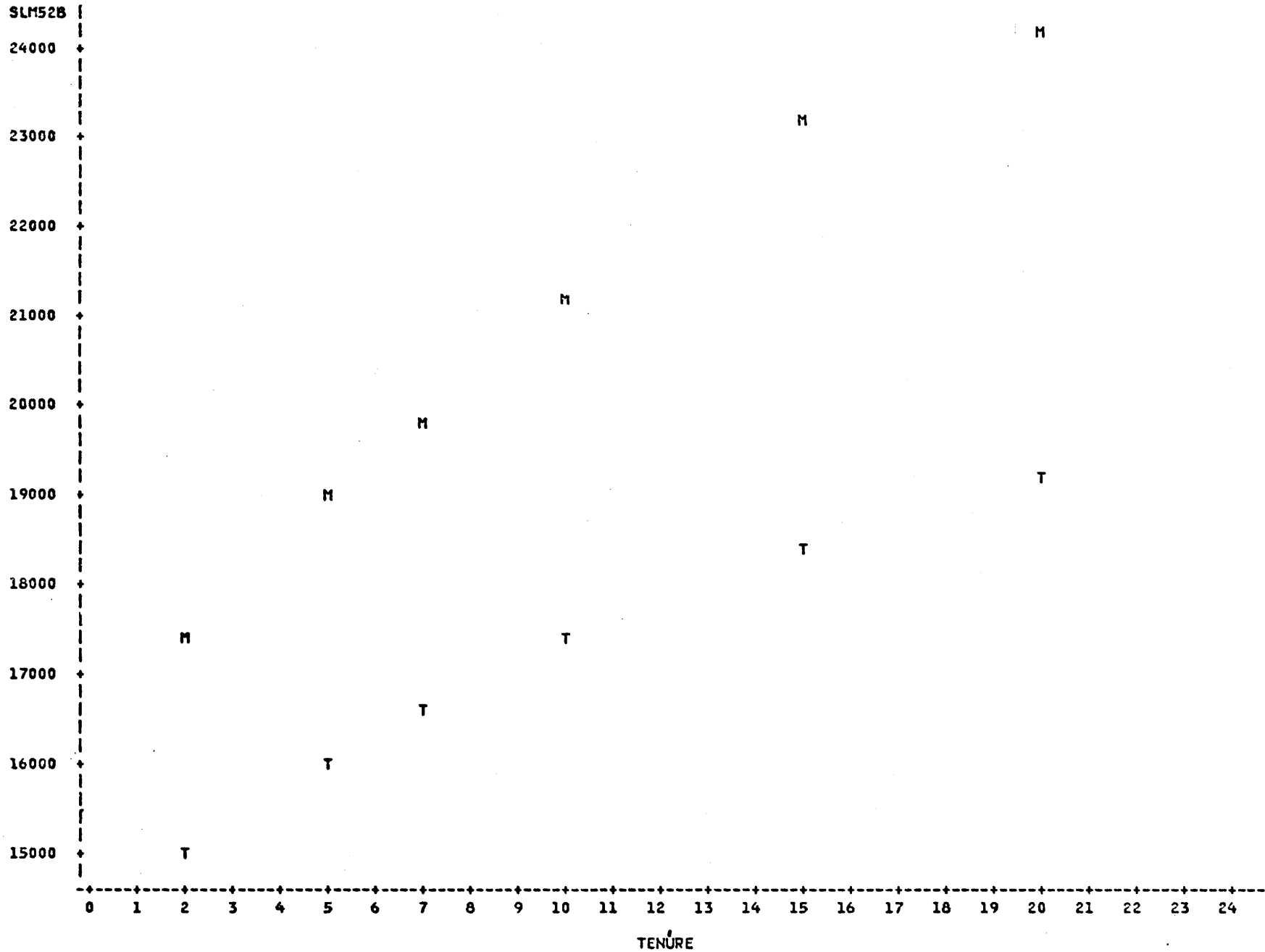
PLOT OF SLM015B*TENURE SYMBOL USED IS M
PLOT OF SLT015B*TENURE SYMBOL USED IS T



NOTE: 132 OBS HIDDEN

DIAGRAM 2.4

PLOT OF SLM52B*TENURE SYMBOL USED IS M
PLOT OF SLT52B*TENURE SYMBOL USED IS T

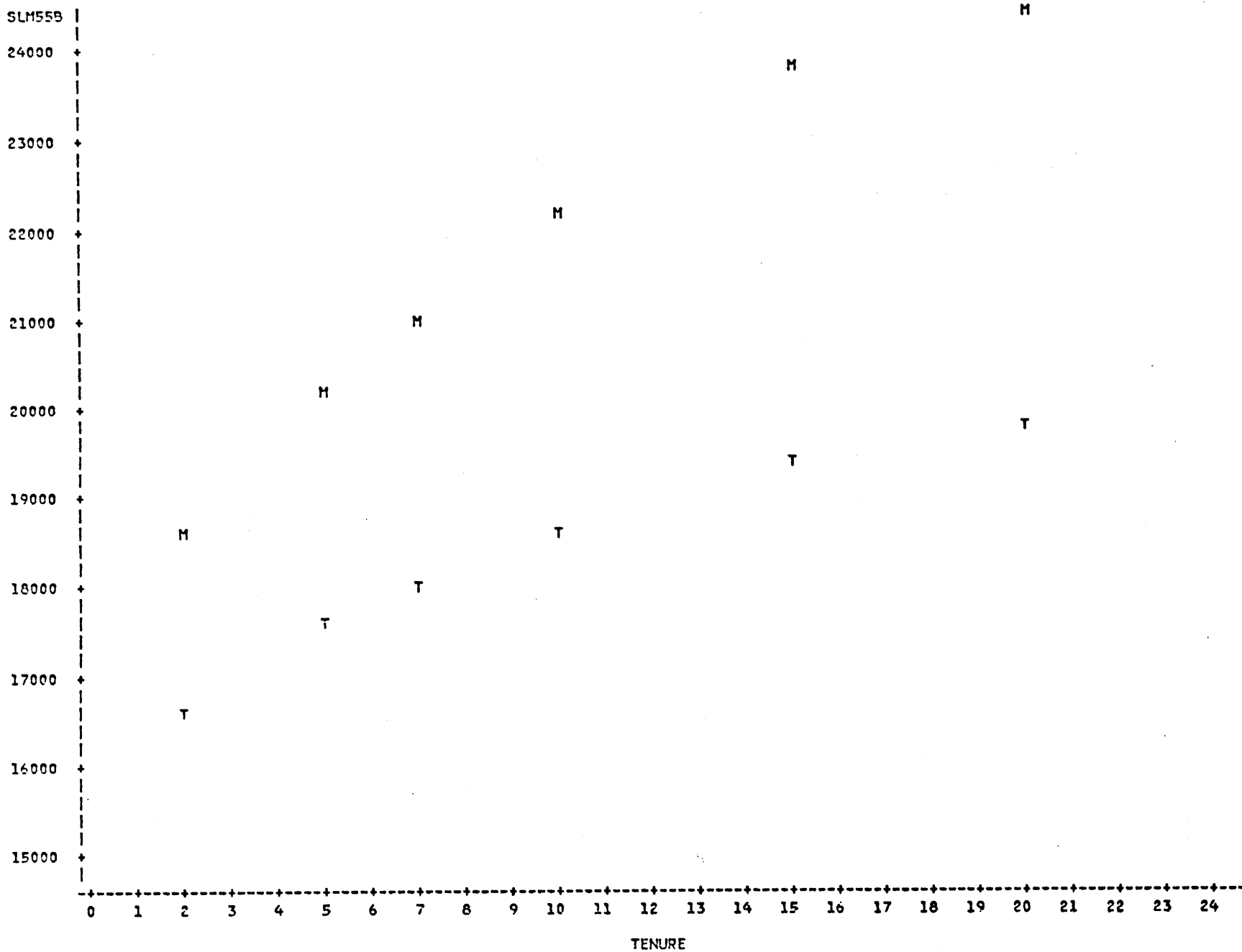


NOTE: 132 OBS HIDDEN

MANAGERIAL VS TECHNICAL

VI-34e

PLOT OF SLM55B*TENURE SYMBOL USED IS M
PLOT OF SLT55B*TENURE SYMBOL USED IS T

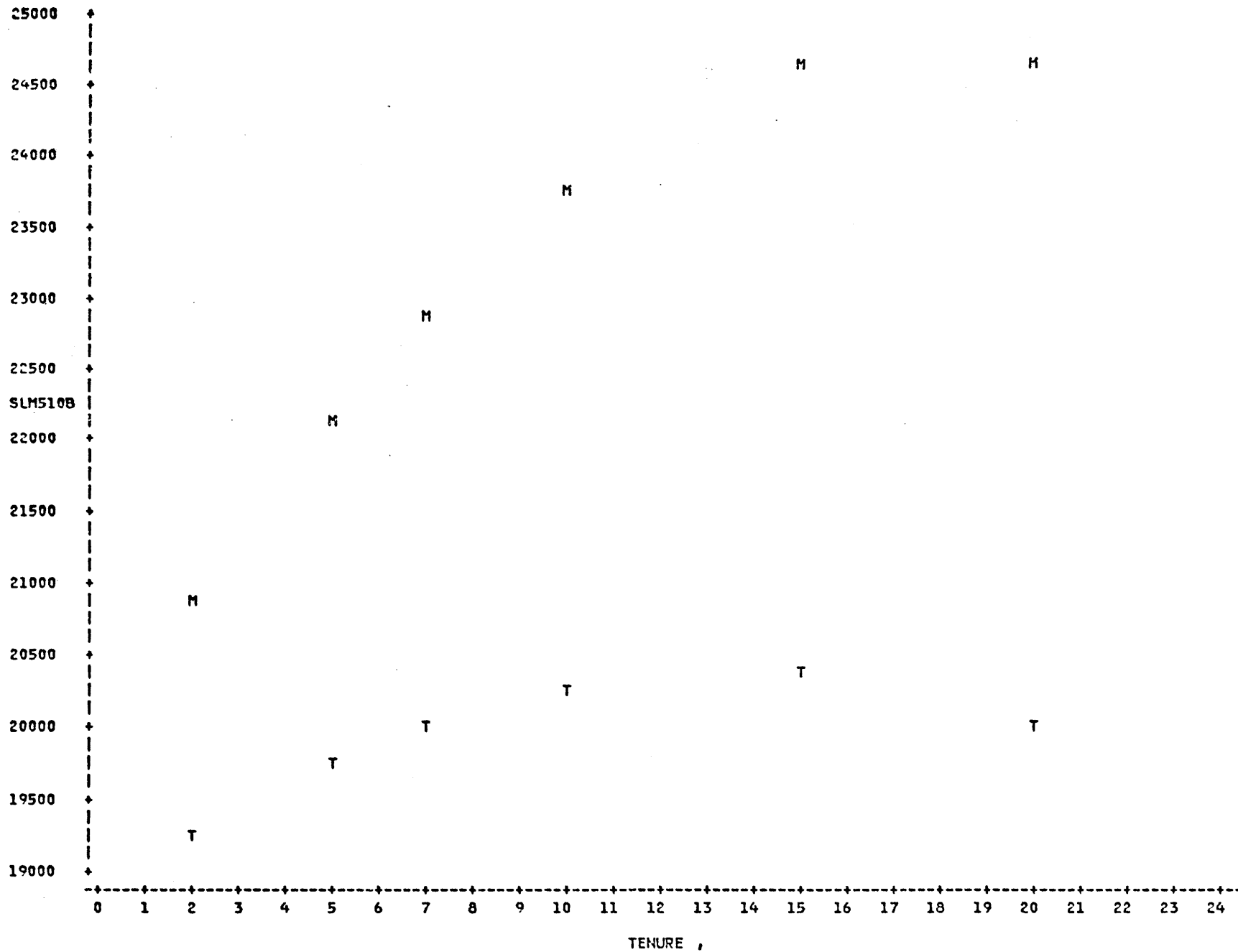


NOTE: 132 OBS HIDDEN

DIAGRAM 2.6

VI-344

PLOT OF SLM510B*TENURE SYMBOL USED IS M
PLOT OF SLT510B*TENURE SYMBOL USED IS T

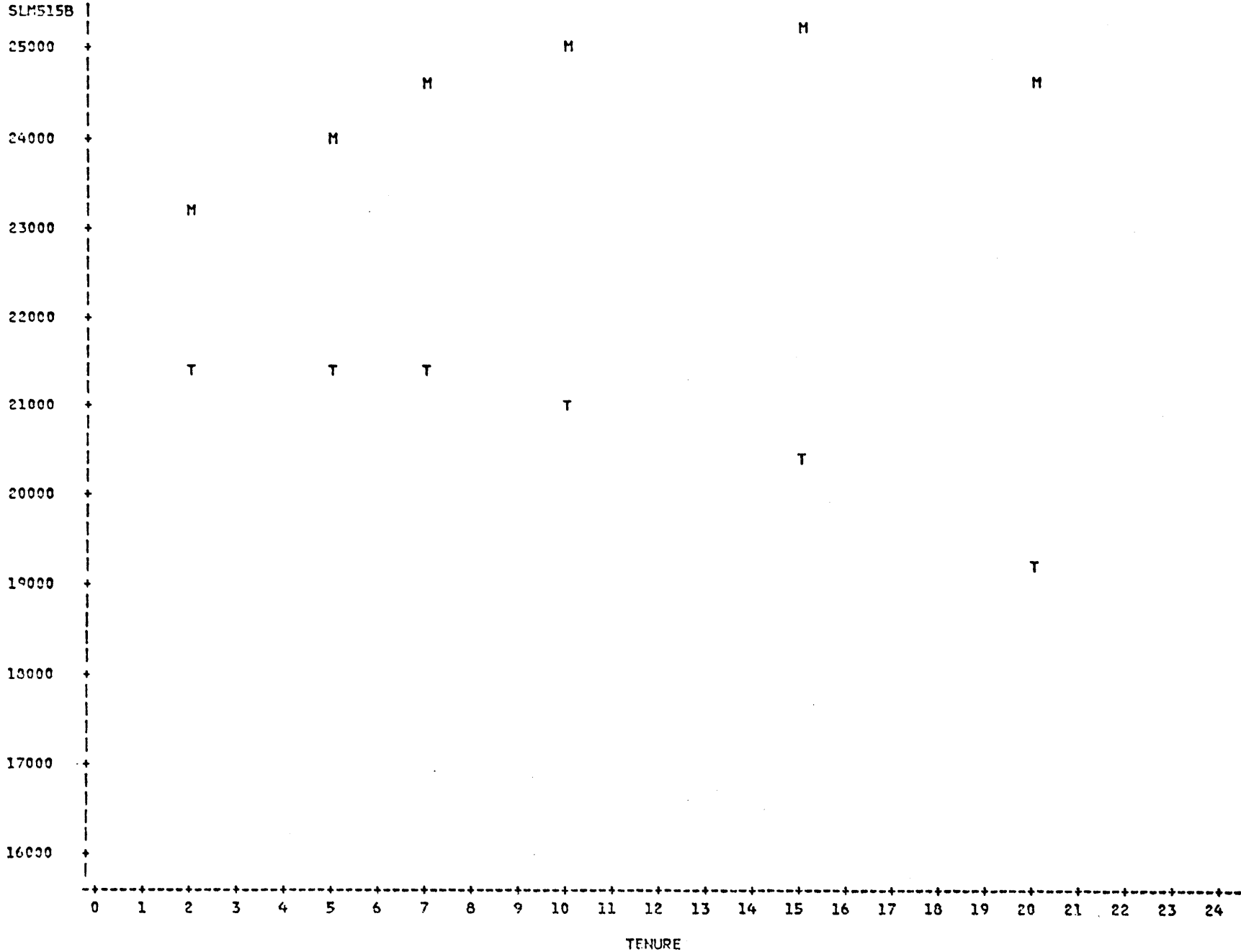


NOTE: 132 OBS HIDDEN

DIAGRAM 2.7

VI-345

PLOT OF SLM515B*TENURE SYMBOOL UGED IS M
PLOT OF SLT515B*TENURE SYMBOOL USED IS T



NOTE: 132 OBS HIDDEN

DIAGRAM 2.8

VI-34h

The advantage to the change model over the level model is that individual ability is assumed to be held constant and does not vary with path. Table 8b shows the coefficients and their t statistics for the earnings change models.

Table 8b
Cross-Section
Earnings Change Estimates

Variable	Model 1	Model 2	Model 3	Model 4	Model 5
INTERCEPT	-.0925** (-2.662)	-.0561 (-1.251)	-.0468** (-2.674)	-.056 (-1.163)	-.0152 (-2.943)
EXP	.0054 (1.166)	.0049 (1.058)		.0072* (1.642)	
TENURE	.1022** (7.47)	.1026** (7.498)	.0912** (6.876)	.1077** (7.699)	.0921** (6.808)
NONTEN	.0075 (1.512)	.0083 (1.635)		.0053 (1.056)	
EXP ²	-.00004 (-.261)	-.00003 (-.216)		-.00017 (-1.16)	
TEN ²	-.0012** (-10.582)	-.0012** (-10.608)	-.0011** (-10.130)	-.0012** (-10.772)	-.0011** (-10.003)
NONTEN ²	-.0001 (-.546)	-.0001 (-.549)		-.0004 (-.218)	
EXTEN	-.0022** (-6.389)	-.0021** (-6.196)	-.0018** (-10.148)	-.0019** (-6.163)	-.0016** (-9.008)
NOTENTN	-.0026** (-8.042)	-.0027** (-8.137)	-.0022** (-10.618)	-.0024** (-7.434)	-.0019** (9.072)
SUPATH	.017 (.160)	.0072 (.098)			

OCCMAN			.0099 (.130)		
PATH*EXP	.0118 (1.237)	.0127 (1.331)	.0117 (1.131)		
PATH*NONTEN	-.0047 (-.531)	-.0028 (-.317)	.0094 (1.029)		
PATH*TEN	.0106 (1.306)	.0099 (1.218)	.0151** (3.557)	-.0129 (-1.418)	-.0032 (-.622)
PATH*EXP ²	-.0004 (-1.476)	-.0004 (-1.527)		-.0002 (-.661)	
PATH*NT ²	.00016 (.531)	.00008 (.273)		-.0003 (-.863)	
PATH*TEN ²	.000002 (.008)	.000002 (.110)	-.00011 (-.731)	-.00022* (2.362)	.00034* (1.67)
PATH*EXTEN	-.0001 (-.199)	-.00014 (-.292)		-.00013 (-.256)	
BA	-.0056 (-.285)	-.0027 (-.133)		-.0013 (-.065)	
PHD	-.0586* (-1.728)	-.0718* (-1.987)		-.0769* (-2.11)	
MOVEY	-.0153 (-.868)	-.0138 (-.776)		-.0202 (-1.131)	
MOVEDK	.0883* (1.996)	.0912* (2.060)		.0843* (1.894)	
GVTFND	-.0398* (-2.161)	-.0304 (-1.375)		-.0355 (-1.592)	
NE	.016 (.877)	.0222 (1.196)		.017 (.915)	
OCCENG2		.0026 (.097)		.0144 (.346)	
OCCENG3		-.0057 (-.182)		.0031 (.087)	
OCCENG4		.0115 (.399)		.0231 (.698)	

OCCENG5		-.0613 (-1.308)		-.037 (-.744)	
OCCOMP		.0189 (.654)		.0246 (.734)	
OCCNASC		.0529* (1.721)		.0609* (1.696)	
INDWAR		-.0748* (-2.143)		-.098** (-2.819)	
INDBASE		-.0864** (-2.632)		-.1031** (-3.126)	
INDMANU		-.0741** (-2.393)		-.0905** (-2.911)	
INDCHEM		-.0807* (-2.563)		-.1016** (-3.204)	
INDSERV		.0249 (.692)		.0226 (.625)	
INDPRO		-.0576 (-1.292)		-.0736* (-1.646)	
INDOTH		-.0408 (-1.026)		-.05 (-1.251)	
INDK		-.0885 (-1.008)		-.08 (-.906)	
RNDCHG	-.000005 (-.691)	-.000003 (-.696)	-.000002 (-.259)	-.000006 (-.878)	-.000001 (-.123)
LNCPICHG	.117 (.443)	.112 (.425)	.1916 (.726)	.0847 (.314)	.2211 (.821)
R ²	.5669	.5708	.5617	.5661	.5553

Of the path-tenure interactions, the coefficient for SUPATH*TENURE is positive and significant; but, that for OCCMAN*TENURE is not significant. The path tenure squared variable coefficient using SUPATH was insignificant, but that using occupation

was positive and significant at the .10 level. If occupationally defined managers are assumed to be those further along in their careers, taken together these coefficients suggest that initially the managers experience faster earnings growth. Then there is a period where the rate of growth of managers and non managers is the same. And, towards the end of their careers, the courses of the two earnings functions begin to diverge.

The signs of the job tenure and tenure squared variables are as hypothesized and significant. The interaction variables between pre-firm experience and job tenure and pre-firm experience and non-job tenure capture of effect of total experience in the labor market and are negative and significant, as hypothesized. Because the coefficient for the change in the logs of the CPI index is an elasticity, the null hypothesis is $H_0: B = 1$, rather than $B = 0$.⁷ Using an F-test, the null hypothesis could not be rejected for the coefficients for either model 3 or 5, indicating that earnings for scientists and engineers keep up with the changes in consumer prices.

Examination of the individual coefficients that were hypothesized to be equal to zero in the section on model specification shows that most are not significantly different from zero at the .01 level or better, with the exception of EXP (model 4, only), NONTEN², PHD, MOVEDK, GVTFND(model 1, only), OCCNASC, and most of the industry dummy variables.

Separate Earnings Change Regressions. Separate earnings-change regressions were also estimated for each path. Table 8b shows these estimates.

Separate Regressions
Cross-Section Earnings Change

<u>Variable</u>	<u>Managers</u>	<u>Technical Workers</u>
Intercept	.013304 (.219)	-.065659** (-4.895)
RNDCHG	.000003 (.168)	-.000004 (-.737)
LNCPICHG	.203689 (.264)	.151467 (.702)
TENURE	.096074* (2.375)	.095739** (8.913)
TENSQ	-.00101* (-2.469)	-.00112** (-13.755)
NOTENTN	-.00252** (-4.863)	-.001910** (-9.942)
EXTEN	-.00179** (-3.832)	-.001772** (-11.755)
R ²	.4016	.7068

Aside from the systematically higher levels of significance for the coefficients for the technical equation, due probably to their larger sample size, the only variable that is noticeably different between the two regressions is the intercept. That coefficient in the technical regression is relatively large, negative, and significant at the .0001 level, but the intercept is not significantly different from zero for the managerial regression, indicating that, holding ability

constant, technical workers can expect a lower level of earnings change that is due simply to their career path.

FOOTNOTES

¹ The table below shows the coefficient estimates and the probability that the null hypothesis of independence can be rejected.

<u>Variable</u>	<u>Estimate</u>	<u>Prob.</u>	<u>Variable</u>	<u>Estimate</u>	<u>Prob.</u>
Intercept	-.5077	.0001	Exper. Group		
	-1.6420	.0001	< 10	-1.0398	.0001
	.0032	.9648		-.7801	.0001
Industry				-.5600	.0001
Aircraft	-1.1946	.0001	30 >	.7272	.0001
	-.4056	.2265		.8563	.0001
	-.1389	.2922		.3518	.0023
Elec.Mach	.3243	.0142	10 - 20	.0240	.7768
	-.3615	.1991		-.2533	.1155
	.0431	.7067		.0841	.2291
Fab.Metal	-.0155	.9322	Degree		
	-.3939	.2836	BA	-.0852	.2919
	-.3664	.0158		-.5620	.0001
Ordnance	.1067	.6034		-.0171	.7951
	-.3022	.4392	MS	-.0269	.0077
	-.1199	.4762		-.2879	.0571
Prof. Equip.	.2975	.3953		-.0986	.1796
	.5805	.2074	Industry, cont.		
	.0620	.8376	Other Manu.	.2543	.0788
Elec.Mach.	.3787	.1558		.1224	.6382
	.3804	.3890		.0880	.4742
	.0589	.8105	Colleges	.0916	.8594
Prim. Met.	-.3816	.0244		1.1183	.0393
	-.9535	.0162		-.0238	.9490
	.0893	.4732	Eng. Ser.	-.9216	.0001
Construction	.8043	.0121		-.6700	.1052
	.9016	.0841		.1636	.2247
	.5987	.0413	Other	.7839	.0230
Res. Inst.	-.4176	.0600		.8878	.0876
	-.6449	.0732		.1934	.5503
	-.3185	.0607			
Transport.	.3217	.1373			
	.2310	.5643			
	.0815	.6649			

² Both the earnings-change and earnings-level equations were estimated

using both career path variables.

It is not possible to directly compare the two models which use the two different types of measure without violating the hierarchy principle. However, an impression might be formed by comparing each model to the full model to determine if the use of either of the measures affects the error sum of squares.

Using the earnings-level model, the coefficients were estimated excluding all path variables and their interactions. Then, the model was estimated that included SUPATH and its interaction with TENURE, NONTEN, EXP, those variables squared, and EXTEN. Thus the null hypothesis was: $B_{\text{PATH}} = B_{\text{PATH INTERACTIONS}} = 0$. The test was $((\text{ESS}_r - \text{ESS}_u)/P) / (\text{ESS}_u / (N-K)) = F_{8, P}$ where ESS_r was the residual sum of squares for the model which excluded the path variables, ESS_u that for the full model, P, the number of parameters hypothesized to equal zero, N the number of observations, and K the number of predictors in the full model. The F statistic equalled 29.89 which is significant at the .01 level, so the H_0 was rejected.

The comparable result for the model excluding the occupationally based path variables was 17.907, which was also significant, although less so. Both were significant at the .01 level.

Therefore, neither could be designated as clearly superior in explaining the earnings growth rate.

³ Because the industry and occupation dummy variables were included solely to control for a set of complicated external market effects, their coefficients could not be interpreted behaviorally. Therefore, the hypothesis that these coefficients were equal to zero was tested. Only the cross section models were used. An F-test was used to test the null hypothesis of the coefficients being equal to zero.

For the models of earnings level, using the supervisory-based managerial path definition, the calculated $F_{14, \infty} = 6.723$, allowing the rejection of the null hypothesis at the .01 level. However, when the same test was used comparing two earnings change models, $F_{14, \infty} = 1.798$, permitting the rejection of the null hypothesis at the .05 level, but not at the .01 level. This difference suggests that industries and occupations are more likely to have a shift effect rather than a slope effect on overall lifetime earnings.

The same test was run comparing the models using the occupationally based managerial definition. The results were similar but not as strong. The F-value for the level equation was 4.788, and that for the change equations was 2.80. Both hypotheses can be rejected at the .01 level, but the hypothesis for the change equation is very narrowly rejected. A possible explanation of the difference between the two types of models, those using the supervisory-based definition and those using occupation, is that, given the apparent "more-committed" managerial status of those who define themselves as managers by occupation, there may be a difference in the structure of earnings growth and so a difference in the earnings levels of senior managers by industry.

⁴ Models 1 and 2 were also run using a continuous education variable,

EDC, years of education. In both cases, EDC was positive and significant. In the model omitting the industry and occupational dummy variables, B_{EDC} equalled .0777 ($t=14.008$); and, when the dummy variables were included, B_{EDC} was .0902 ($t=14.988$). The substitution of continuous education variables for dummy variables has virtually no effect on the coefficient estimates of the other variables. The implication of this is that, for scientists and engineers, the return to education is a return to what is viewed as human capital accumulation; and, that the credentialling effect is not dominant.

5 As was discussed in chapter IV and summarized in Table 1 of that chapter, the effect of career path on earnings change is hypothesized to be different from that on earnings level. In the case of earnings change, path was expected to have an effect only through its interaction with current job tenure and tenure squared. In addition, the human capital and labor market variables which did not change in the course of the job were expected to have no effect and so were excluded from the model. In other words, the null hypothesis was:

$$B_{PATH} = 2 B_{PATH*EXP} = B_{PATH*EXP} = B_{PATH*NONTEN} = B_{PATH*NONTEN} = B_{NONTEN} = 0.$$

The reason for this hypothesis is that it was expected that to the extent that any of these variables had an effect on overall earnings during the current job tenure, that that effect would be a shift rather than slope effect, and so have no impact on earnings change.

It was necessary to test whether the exclusion of these variables from the model was appropriate. Again, using the F-test, where the unconstrained model was the full model, and the number of constraints tested (P) equalled thirty, the F-statistic was 1.94 using SUPATH and 2.28 using OCCMAN. The table value of F_{30} is 1.41 at the .05 level and 1.61 at the .01 level, so the null hypothesis was rejected. Examination of the full models suggests that the following variables which are usually thought to have a shift effect may have an effect on the rate of change: EXP, PHD, MOVE, GOVT, most of the industry variables, and OCCNASC.

6 The test of significance used was $((B - 1)^2 / (se_B)^2)$, which has an F distribution, with 1, T-K degrees of freedom.

Chapter VII

CONCLUSION

In this final chapter, the results of the different models are summarized and discussed. This is followed by a section on possible areas for future research suggested by the results presented here.

I. Summary of the Results

In the preceding chapter, the existence of career paths was established, and the results were presented for several versions of an earnings model, where the focus of attention was whether or not there was systematic variation in earnings that could be attributed to career path. The models that were estimated were: a continuous experience model, two types of earnings level models, one using pooled path data with interaction variables, and one using separate regressions for each path.

A. Establishing the Career Paths

Because no question about career path was asked explicitly in the survey, career path was measured by two different variables, one describing level of supervisory responsibility (SUPATH) and a self-declared occupational category response (OCCMAN). A comparison of the two variables showed that they measured somewhat different aspects of career path. In particular, it was possible that a person with significant supervisory responsibilities might not describe

themselves as a manager, while it was highly unlikely that those workers who described themselves as managers did not have supervisory responsibilities. A logit model showed that, given a high level supervisory experience, the probability of describing oneself as a manager increased with work experience. From this, the conclusion was drawn that career path transitions take place gradually and this is because the transition involves not just a change in job activities, but also a shift in personal orientation. It also suggested that the SUPATH variable would be the easiest to interpret because the non-managerial group would be more homogeneous with respect to managerial status.

That these paths exist was established by the examination of the frequencies of transitions from one path to another. The expectation was that the majority of job histories would be described by one of three paths: all technical, all managerial, and technical to managerial. Regardless of which path definition was used, over 90% of the sample followed one these three paths.

B. Earnings Models

Continuous Experience. In the models that were ultimately estimated, a human-capital framework was used to examine differences in earnings by path. In the earnings-level models, in particular, special attention was paid to path differences in returns to different types of human capital, general, firm-specific, and job-specific. A more simplified concept could be tested, estimating returns to total

experience on each track. This did not allow conclusions to be drawn about different types of human capital formation, but would establish that different paths implied different earnings schedules.

Therefore, two types of continuous models were estimated, an earnings level and an earnings change model. In both models, the coefficients for managerial experience were both larger (.03 compared to .01 in the level models, and .009 to .004 in the change model) and more significant than the coefficients for technical workers. In the change models, the quadratic experience variables were identical for the two types of workers, and in the level equation, the coefficients were more negative for managers in the equation that omitted industrial and occupational dummy variables, but less negative for the one that included them. The results for the earnings level model provide strong support for there being systematic earnings differences by path, which is reinforced by the results of the change model (where it is assumed that individual differences that may be correlated with path are controlled for by the structure of the model).

The next step was to separate experience into components that could approximate different types of human capital to determine what the underlying structure of the earnings differences between paths was.

Experience Components. The first type of model estimated was the earnings level model. The major disadvantage to this model was that there was no way to control for economic ability that is likely to be correlated with career path. In this case, the untested assumption was that economic ability had a fixed effect, that is, that all

individuals with the same economic ability would receive the same rate of return on that ability and that for any given individual the effect on earnings would be the same for all periods in their career. If this assumption were correct, the coefficient estimates for the correlated variables in the levels model could be assumed to be biased but consistent.

With that caveat, the results for the level models, both when estimated using interaction variables and using separate regressions generally supported the hypothesis that path systematically affects earnings. Regardless of which definition was used, the path shift parameter was large and significant, ranging from .13 to .19 in the models using interaction variables. In the separate regression, the intercept for managers was 9.611 compared to 9.461 for technical workers, representing a difference of \$2079.36. The path pre-firm experience interaction variables were never significantly different from zero. In the separate regressions, as would be expected, the experience variables are significant, but there is little difference between the coefficient size for the two groups: $B_{\text{EXPMAN}} = .0268$ compared to $B_{\text{EXPTECH}} = .0282$. The coefficients for experience squared are equal. The interpretation of this is that there is no difference between the returns to general human capital for managers and technical workers.

In both types of models, the return to same-firm, different-job tenure is greater for technical workers, but that advantage deteriorates quickly. Part of the explanation for the hypothesized earnings differences between the two paths has been that managers

invest more in firm-specific human capital, which ultimately is rewarded by the firm in the form of greater lifetime earnings. Together, these coefficients suggest that the accumulation of firm specific human capital is gradual, but non-declining. And, so it follows that to realize substantial positive returns, a worker would have to stay in the firm for a long time. In other words, managers would be more likely to experience lifetime same-firm tenure than technical workers.

When the supervisory definition of path is used, the path tenure interaction and the tenure variable in the managerial regression provide support for the expected greater return to firm- and job-specific human capital for managers. The decline is steeper for managers, however. The results from the separate regressions that were plotted, using chemical engineers in the chemical industry as the example, showed that, although the decline in earnings is more precipitous for managers, it does not begin until at least ten years after earnings growth has started to decline for technical workers.

In the earnings change models, the results differ according to whether the single-regression, interaction-variable model is used or separate path regressions are estimated. In the single regression model, the coefficient for the path-tenure interaction variable is positive and significant when SUPATH is used and insignificant when OCCMAN is used. Because there are many supervisory level workers in the non-managerial portion of the sample when OCCMAN is used, the insignificance of that coefficient is difficult to interpret. However, the coefficient for SUPATH does support the hypothesis that

earnings growth over the course of the job is greater for managers.

When separate regressions are used, the results are somewhat different. First, by using the separate regressions, the intercept is no longer constrained to be equal for both parts of the sample. When this is permitted, the intercept for managers is not different from zero, but it is negative and significant for technical workers. Of the variable coefficients that are significantly different from zero in the model, none differ in size or significance by path. In contrast to the single-regression interaction model, this suggests that managers have a higher rate of earnings growth, but it is not due to a constant return to tenure, as suggested in the interaction model, but rather a return to path, that actually operates as a negative shift parameter for technical workers.

II. Discussion of the Results

The hypothesis that has been examined in this thesis has been that career path choice systematically affects labor market outcomes, in this case, earnings. The framework that has been used to examine the role of career paths in the labor market has been the human capital approach, where individuals are hypothesized to make human-capital investment decisions that affect their productivity in the labor market and determine both their earnings levels and turnover patterns.

The major alternative hypothesis has been the segmented market hypothesis, where the labor market is seen to have discontinuities

that constitute barriers to mobility and constrain the earnings potential as well as the employment stability of various subsegments of the labor force, regardless of their potential productivity.

Because of the nature of the data set that was used in this analysis, it was not possible to differentiate between these two hypotheses. What can be said, however, is that career path systematically affects earnings. This is clear from the continuous experience models. Whether this is because of a difference in the investment choices and opportunities associated with each path, which is the terminology used in this analysis, or because of institutional differences that lead one path to one outcome and the other to another can not be discerned. However, some of the results suggest that the path differences in outcomes are probably not uninfluenced by institutional factors.

A primary difficulty in using the human capital framework is that it is difficult to separate investment decisions from innate economic ability. This problem was addressed here by the estimation of earnings change models, where individuals were assumed to be their own control group. Earnings level models were also estimated in order to get a glimpse of the effects of various shift parameters, but the probable bias in the coefficients was not known.

The major general finding in the change models is that the higher earnings of managers appears to be a return to path, not a consistently positive return to the path-tenure interaction. This does not appear to be the case for the cross-section change model, where in the model using SUPATH, there is a positive significant

coefficient for the path-tenure interaction. But, when the data are separated into two subsamples, tenure is insignificant, and the difference between the two paths appears in a shift parameter, the intercept.

In the earnings-level models, this same distinction occurs, but there is more support for a difference in earnings that grows with tenure. In the combined single-equation model, there are large, positive, and significant coefficients for the path shift variables, and, in the model using SUPATH, a relatively small, but positive, coefficient for the path-tenure interaction variable.

The significance of this distinction is that if the differences in earnings outcomes were due solely to patterns of human capital investment, one would expect no special return to path, but a consistently positive return to the path-tenure interactions. Recalling diagrams 2a-2c in the preceding chapter, these results provide strong support for Diagram 2a, that path shifts the earnings schedule, and mild support for 2b, that path affects the earnings growth rate. There are clearly greater lifetime earnings associated with the managerial career path; but, while there is some relatively greater earnings growth momentum over the course of each job associated with that path, constant higher growth rates do not appear to be the major source of differences in earnings.

A second major finding was the consistent lack of difference in the return to pre-firm experience between the two paths. Pre-firm experience was assumed to represent general experiential human capital. Part of the hypothesis was that managers would tend to

invest more in firm-specific human capital, while technical workers would retain a professional, rather than organizational, orientation and would invest more in general human capital. And, technical workers would experience greater returns to that human capital while managers would receive greater returns to firm-specific human capital. The lack of difference between the coefficients for pre-firm experience for the two paths indicates that there is no difference in the rates of return to general human capital for the two types of workers. This also suggests that, given comparable levels of labor force experience, any differences between the salaries of managers and technical workers is due to the path upon which they are embarking, not on what their previous experience has been.

This also raises a question about the extent to which path is a proxy for differences in individual ability. This lack of difference between paths in the coefficients to pre-firm experience occurs in the earnings levels models where no controls for differences in individual ability are assumed to be present. Unless it is assumed that pre-firm experience represents a search period (which is unlikely given that this is a long period for some workers), returns to pre-firm experience should be higher for managers if they are actually the more able.

The third finding was that managers had systematically lower returns to same-firm, different-job tenure tenure. This challenges the hypothesis that managers experience greater returns to firm tenure than technical workers. However, the advantageous position of the technical workers eventually disappears, as the coefficient for the

quadratic is negative and significant for technical workers but insignificant for managers. One possible explanation, as is hypothesized in chapter IV, is that those who come to the firm as technical workers are highly paid for their skills, but these skills deteriorate, while those who either come as managers or who are in the process of moving to that track have to learn managerial skills that do not grow dramatically in value but also do not depreciate.

Taken together, it can be concluded from these results that, first, there are clear career paths within the labor market for scientists and engineers, and there is not a lot of movement between them once the transition from the technical to the managerial path has been made. Second, there are earnings differences associated with these paths. Third, the differences are not clearly the result of incremental investment patterns, but seem to be a return to path choice. The failure of experiential human capital variables to explain earnings differences is particularly evident in the separate regression change models, where there are assumed to be controls for individual ability. And, fourth the lack of difference in returns to pre-firm experience suggests that these paths are not simply measures of differences in ability.

III. Future Research

The original motivation for his research was to examine the question of whether white-collar labor markets were governed by a set of implicit administrative rules that formed an internal labor market

that determined earnings and employment stability. Or, was it a relatively open market where earnings and employment depended on skills and both factor and product markets. Scientists and engineers were selected as the focus of the study primarily because of data availability. However, as representatives of white-collar labor, this groups has turned out to have some valuable qualities for the purposes of generalizability.

First, they are a relatively homogeneous group, so much of the diversity of the labor force that contributes to earnings variation is controlled for. Second, the career path choice they face as a group is a stylized version of a strategic dilemma many white-collar workers face, how to avoid overspecialization that leads to an organizational deadend. Rosabeth Moss Kanter, in Men and Women of the Organization, describes the fear of "getting stuck" as a major concern of white collar workers. While the technical-managerial dichotomy does not capture all of the elements of this problem, it does begin to address the relationship between the route one follows in an organization and earnings.

What has been shown so far is only an introduction to the problem of how labor market outcomes are determined in white-collar markets. The questions about to be posed would still not provide a definitive description, but would certainly add to the picture and can be addressed using the same data set.

As discussed earlier, a crucial distinction needed to be made is about the relationship between ability and career path, that is, whether path is simply an indicator of ability and the technical track

represents the career path of those who failed to enter management; or, whether path truly represents career ladders within an internal market and earnings and employment stability are attached to jobs rather than people. This problem was addressed by the use of change models, but this method required strong assumptions about the nature of economic ability. The pre-firm experience variable also provided some control the earnings level model.

Another way to test for this is to examine earnings functions in the career period before each individual made their career track choice and assume that any non-random portion of the residual represents a combination of unmeasured ability and willingness to invest on the job. Then holding constant that ability/willingness to invest by including the residual as an exogenous variable, examine the differences in earnings after the choice between career tracks has been made.

A major question raised by these results is, given that there is a difference in earnings by path and that most of this variation is explained by shift parameters, how does this difference occur? One possibility is that the major opportunity for earnings growth occurs between rather than within jobs.

Patterns of job tenure, per se, are not discussed in this literature. However, together, earnings and tenure patterns could be used to examine the different views of interfirm mobility and reemployment. In contrast to Leventman's view of mobility as a form of involuntary career instability, Davis and Trist [Davis & Trist, 1974] suggest that technical professionals use interfirm

mobility to avoid stagnation. In addition, technical workers may be more likely to to experience involuntary unemployment. Leventman [Leventman, 1981] sees technical workers as slightly more likely to be laid-off and experience continued career instability due to overspecialization. One source of earnings variation that could not be discerned from the results presented in the preceeding chapter is the incidence of involuntary unemployment. If technical workers become systematically involuntarily unemployed more often than managers their earnings would be lower.

A major question raised by the literature on scientists and engineers is whether the problem of technical obsolescence is due to an inevitable ceiling on technical competence or induced, either inadvertently or purposefully, by firm structure.

One question raised by several authors is the role of variety in job assignments in leading to or preventing successful passage to different career stages. A comparison of the evolution of work activities between those who eventually become managers and those who stay on a technical track should help document the role of overspecialization in obsolescence. In addition, by examining the relationship between the rate of increase in earnings and activity specialization, that is, which comes first, a flattening of the earnings function or an increase in job activity concentration, some insight into whether poor performance (as measured by flattening of the earnings function) leads to overspecialization or overspecialization induces poor performance.

Another important question is, if these paths do not represent

differences in ability, what motivates the worker choice between path. Bailyn [1980] found in her study of M.I.T. graduates a greater propensity for engineers, rather than scientists, to become managers. In the course of the research conducted here, because of a discrepancy between the number of engineers as defined by professional field and those defined by self-declared occupation, it also appeared that it was the engineers who are more likely to leave their technical area for the managerial occupations.

However, this was not supported when explicitly tested in this research. Using the supervisory-level based path variable, the distribution of scientists on each path was compared to that of managers. The null hypothesis was the hypothesis of independence, that the path and occupational distributions were independent of one another. This was tested using a chi-square statistic. The chi-square for the first reported job was .2501 (df = 1), so the null hypothesis could not be rejected even at the .25 level. The same test was then applied to the third reported job, with the expectation that by the third job more individuals would have made a path choice, and occupational differences in career paths would be more evident by then. The chi-square was equal to .3633 (df = 1), so that the null hypothesis could still not be rejected. According to these results, engineers are not more likely to leave technical jobs for managerial jobs. so, at this point, it can not be said with confidence that technical field predicts the probability of becoming a manager.

Each of the questions just presented represents an effort to shed light on some aspect of the white-collar labor market, to better

understand what accounts for the earnings distribution among a growing sector of the labor force. A better understanding of the true allocative mechanisms of white-collar labor is necessary to an accurate understanding of the composition of the productive resources available to the economy, helps educators and policy-makers best help supply the economy with what it needs, and aids individuals in deciding what is the best use of their own talents and resources as they progress through the labor market.

FORM PMS-1
(10-26-71)

U.S. DEPARTMENT OF COMMERCE
BUREAU OF THE CENSUS

1972 PROFESSIONAL, TECHNICAL, AND SCIENTIFIC MANPOWER SURVEY

NOTICE - Your report to the Census Bureau is confidential by law (Title 13, U.S. Code). It may be seen only by sworn Census employees and may be used only for statistical purposes.

Please read instructions carefully before answering questions.

Answer as accurately as you can by printing your reply clearly or by entering an "X" in the box next to the appropriate reply.

If the instructions for a question direct you to enter a code and description from a list, please refer to the Reference List Booklet enclosed with this questionnaire.

IF YOU HAVE MOVED, or if there are errors in the address label above, please enter the correct information about your current residence below.

Name	Number and street		
City or town	State or foreign country	010	ZIP code

Part I - SOME FACTS ABOUT YOURSELF

1. In what month and year were you born?	Month and year 011	2. Sex	012 1 <input type="checkbox"/> Male 2 <input type="checkbox"/> Female
--	-----------------------	--------	--

3. What is your present marital status?	013 1 <input type="checkbox"/> Now married 2 <input type="checkbox"/> Separated or divorced 3 <input type="checkbox"/> Widowed 4 <input type="checkbox"/> Never married
---	--

4. In what State or foreign country were you born?	State or foreign country 014	If foreign country - When did you come to the United States to stay?	Year 015
--	---------------------------------	---	-------------

5. Citizenship (Mark only one box)			
016: 101 <input type="checkbox"/> U.S.A. (native born)	160 <input type="checkbox"/> Canada	150 <input type="checkbox"/> Taiwan	169 <input type="checkbox"/> Cuba
102 <input type="checkbox"/> U.S.A. (naturalized)	110 <input type="checkbox"/> United Kingdom	149 <input type="checkbox"/> India	<input type="checkbox"/> Other - Specify _____
	122 <input type="checkbox"/> Germany	153 <input type="checkbox"/> Philippines	
If not U.S.A. - Are you a permanent resident (on immigrant visa) of the U.S.? 017 <input type="checkbox"/> Yes 2 <input type="checkbox"/> No			

6a. What kind of work did your father do when you were about 16 years old? (Enter code and description from List C.)	018: Code	Description
OR x <input type="checkbox"/> Father not living at that time		

b. What was the highest level of education that your father ever attained? (Mark only one box)			
019: 1 <input type="checkbox"/> Did not graduate from high school	3 <input type="checkbox"/> Attended college, but did not graduate	5 <input type="checkbox"/> College work beyond Bachelor's degree	
2 <input type="checkbox"/> Graduated from high school	4 <input type="checkbox"/> Received Bachelor's degree		

7. Have you ever served on extended active duty in the Army, Navy, or other Armed Forces of the United States?	From (Month and year)		To (Month and year)
	021		022
	From (Month and year)		To (Month and year)
	023		024
020: 1 <input type="checkbox"/> No 2 <input type="checkbox"/> Yes			

8. Are you currently a member of any national professional society or association? (For example, American Chemical Society, American Society of Civil Engineers, National Education Association.)	
025: 1 <input type="checkbox"/> No	2 <input type="checkbox"/> Yes - List in space at right →

9. Do you have a currently valid professional license, certification, or registration? (For example, engineering registration, medical license, teaching certificate.)	
026: 1 <input type="checkbox"/> No	2 <input type="checkbox"/> Yes - Give title(s) at right →

Part II - EDUCATION AND TRAINING

10. How many years of education and formal training have you COMPLETED? (Mark highest year COMPLETED)

Never attended school ⁰ - Skip to question 16

Elementary and high school (grade or year) ⁰²⁷ 1 2 3 4 5 6 7 8 9 10 11 12

Beyond high school - College, junior college, law school, technical institutes, etc. (academic years if full course or requirement load carried, otherwise equivalent number of academic years) ⁰²⁸ 1 2 3 4 5 6 7 8 or more

11. Did you receive a high school diploma? 1 No 2 Yes - In what year? 19 _____

12. While you were in high school, did you take courses in any of the following subjects? (Mark as many as apply)

⁰³⁰ 1 ← If you did not attend high school, mark the box at left and skip to question 16

2 <input type="checkbox"/> General science	5 <input type="checkbox"/> Government or civics	⁰³¹ 1 <input type="checkbox"/> Biology	4 <input type="checkbox"/> Training
3 <input type="checkbox"/> Economics	6 <input type="checkbox"/> Chemistry	2 <input type="checkbox"/> Psychology	5 <input type="checkbox"/> Shop work
4 <input type="checkbox"/> Physics	7 <input type="checkbox"/> Sociology	3 <input type="checkbox"/> Mathematics	

13. If you attended a school BEYOND the high school level, did you take courses in any of the following subjects? (Mark as many as apply)

⁰³² 1 ← If you did not attend a school beyond the high school level, mark the box at left and skip to question 16

2 <input type="checkbox"/> Chemistry	⁰³³ 1 <input type="checkbox"/> Mathematics	⁰³⁴ 1 <input type="checkbox"/> Computer Sciences	⁰³⁵ 1 <input type="checkbox"/> Health Fields
3 <input type="checkbox"/> Physics	2 <input type="checkbox"/> Statistics	2 <input type="checkbox"/> Economics	2 <input type="checkbox"/> Arts and Humanities
4 <input type="checkbox"/> Earth Sciences	3 <input type="checkbox"/> Agriculture or Forestry	3 <input type="checkbox"/> Psychology	3 <input type="checkbox"/> Business
5 <input type="checkbox"/> Engineering	4 <input type="checkbox"/> Biological Sciences	4 <input type="checkbox"/> Sociology	4 <input type="checkbox"/> Education

14. List below, beginning with the most recent and working back, each institution from which you have obtained or are currently obtaining formal training beyond the high school level, and give the other information as requested. Use academic years if full course or requirement load carried, otherwise the number of equivalent academic years. Designate degrees by abbreviations, for example, AA, BA, MA, Ph.D, I.I.B, MD, etc. Use a separate line for each degree granted, worked for, or for any change in major field of specialized study. Refer to enclosed List A for the code numbers of major fields. Do NOT include work taken by correspondence course, on-the-job training, apprenticeship, or at employer's training school (training of this type should be reported in question 16). If you need more space, attach a separate sheet of paper and give the same type of information for each additional school listed.

College, university, or other post high school institution Name, city, and State or foreign country	Was this a less than four-year institution?	Attendance				Number of academic years or equivalents	Type of degree worked for, if any, or none (AA, BA, etc.)	Year degree awarded or to be awarded	Major field	
		Year		Status	Enter code and description from List A					
		From	To		Code				Description	
MOST RECENT ⁰³⁷ <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	⁰³⁸ <input type="checkbox"/> Yes <input type="checkbox"/> No	⁰³⁹ 19 _____	⁰⁴⁰ 19 _____ OR x <input type="checkbox"/> Now enrolled	⁰⁴¹ <input type="checkbox"/> Part-time <input type="checkbox"/> Full-time	⁰⁴²	⁰⁴³ _____ OR x <input type="checkbox"/> None	⁰⁴⁵ 19 _____ OR x <input type="checkbox"/> None	⁰⁴⁶	Code	Description
SECOND-TO-LAST ⁰⁴⁷ <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	⁰⁴⁸ <input type="checkbox"/> Yes <input type="checkbox"/> No	⁰⁴⁹ 19 _____	⁰⁵⁰ 19 _____	⁰⁵¹ <input type="checkbox"/> Part-time <input type="checkbox"/> Full-time	⁰⁵²	⁰⁵³ _____ OR x <input type="checkbox"/> None	⁰⁵⁵ 19 _____ OR x <input type="checkbox"/> None	⁰⁵⁶	Code	Description

130

THIRD-TO-LAST	057	058	059	060	061	062	063	065	064	Code	Description
		1 <input type="checkbox"/> Yes 2 <input type="checkbox"/> No	19 _____	19 _____	1 <input type="checkbox"/> Part-time 2 <input type="checkbox"/> Full-time		OR x <input type="checkbox"/> None	19 _____ OR x <input type="checkbox"/> None			
FOURTH-TO-LAST	067	068	069	070	071	072	073	075	076	Code	Description
		1 <input type="checkbox"/> Yes 2 <input type="checkbox"/> No	19 _____	19 _____	1 <input type="checkbox"/> Part-time 2 <input type="checkbox"/> Full-time		OR x <input type="checkbox"/> None	19 _____ OR x <input type="checkbox"/> None			

15. How did you finance this post high school training? (Mark as many as apply)

Scholarship or fellowship (grant for which no services were required) from:

- College or university
- National Science Foundation
- Public Health Service or National Institutes of Health
- NDEA Title IV (U.S. Office of Education)
- Other - Specify _____

- Research or teaching assistantship
- Savings or other current earnings not included above
- Loans from public or private institutions
- Aid from parents, relatives, spouse, or spouse's relatives
- Veterans' Administration Educational Benefits (G.I. Bill, Vocational Rehabilitation, War Orphans Programs, etc.)
- Employer paid for training
- Other sources

Enter the code number, 1-12 from above, of the single most important source (in terms of dollar amounts) of funds used in financing your education

Approximately what percentage of your total expenses was covered by the most important source? ..

Undergraduate		Graduate or professional	
077	1 <input type="checkbox"/>	078	1 <input type="checkbox"/>
	2 <input type="checkbox"/>		2 <input type="checkbox"/>
	3 <input type="checkbox"/>		3 <input type="checkbox"/>
	4 <input type="checkbox"/>		4 <input type="checkbox"/>
	5 <input type="checkbox"/>		6 <input type="checkbox"/>
	6 <input type="checkbox"/>		6 <input type="checkbox"/>
079	7 <input type="checkbox"/>	080	7 <input type="checkbox"/>
	8 <input type="checkbox"/>		8 <input type="checkbox"/>
	9 <input type="checkbox"/>		9 <input type="checkbox"/>
081	10 <input type="checkbox"/>	082	10 <input type="checkbox"/>
	11 <input type="checkbox"/>		11 <input type="checkbox"/>
	12 <input type="checkbox"/>		12 <input type="checkbox"/>
083		084	
085	%	086	%

16. Aside from the formal training listed in question 14, have you ever received or are you currently receiving any of the following types of training? (Mark as many as apply)

- 087 1 Apprenticeships
- 2 Other formal on-the-job training programs
- 3 Military training applicable to civilian occupations
- 4 Extension or correspondence courses
- 5 Courses at employers training school

- 6 Courses at adult education center
- 7 Other training
- 8 None - Go to question 17

Of the types of training marked, which ones do you consider the most useful in your present or last job?

088
Enter codes _____
OR x None

Part III - WORK STATUS

17. Were you employed last week? (If you had a job from which you were temporarily absent due to vacation, illness, etc., answer yes.)

- 108 1 Yes - Skip to question 20
- 2 No - Go to question 18

18. If you were not employed last week, were you principally - (Mark only one box)

- 109 1 Looking for work
- 2 Retired
- 3 Housewife
- 4 Student
- 5 Other - Specify _____

19. 110 1 ← If you have never been employed, mark the box at the left and skip to question 45 on page 8.

Part IV - EMPLOYMENT PROFILE

In this part of the questionnaire, we are asking questions about your last **THREE** civilian jobs beginning with the major job you held last week (or the last job you held) and working back. Please include all jobs, not just scientific or technical jobs. In answering these questions, consider a change in jobs to have occurred if there were significant changes in your duties, level of responsibility, or occupation, even though you may have continued working for the same employer. Please answer each question for all three jobs. If you had more than one regular job last week, report on the one which you considered to be your primary or most important job. (Information about second current regular job should be reported in question 37.)

20. For whom did you work?

Name of company, business, organization, government agency, or other employer (or self-employed)

Location where you were employed

LAST CIVILIAN JOB Job held last week or most recent job Job A	SECOND-TO-LAST CIVILIAN JOB Job B	THIRD-TO-LAST CIVILIAN JOB Job C
Name	Name	Name
City or county 111	City or county 112	City or county 113
State/foreign country 114	State/foreign country 115	State/foreign country 116

21. What kind of business was this?

Enter code and description from List B. If the organization conducted its activities at different locations, enter the description of the activity at the location where you were employed.

Industry

117	Code	Description	118	Code	Description	119	Code	Description

22. What kind of work were you doing?
Enter code and description from List C.

Occupation

120	Code	Description	121	Code	Description	122	Code	Description

23. What were your most important activities or duties?

For example: design electronic mechanisms in the industrial instrument industry; or teach elementary and advanced courses in physics; or gather and analyze statistical data on wholesale price movements.

123	124	125

24. What was your job title?

25. Was any of your work being supported or sponsored by U.S. government funds?

If yes - In what area(s) was this work?

- 01 - Agriculture
- 02 - Atomic energy
- 03 - Defense
- 04 - Housing
- Education
- 06 - Health
- 07 - International
- 08 - Transportation
- 09 - Natural resources
- 10 - Public works
- 11 - Space
- 12 - Urban development
- 13 - Other - Specify

126	127	128
1 <input type="checkbox"/> Yes 2 <input checked="" type="checkbox"/> No 3 <input type="checkbox"/> Don't know	1 <input type="checkbox"/> Yes 2 <input checked="" type="checkbox"/> No 3 <input type="checkbox"/> Don't know	1 <input type="checkbox"/> Yes 2 <input checked="" type="checkbox"/> No 3 <input type="checkbox"/> Don't know
Enter code(s) from list at left	Enter code(s) from list at left	Enter code(s) from list at left
129	130	131

132

<p>26. Were you primarily -</p> <p>1 - Employee of private company, business, or individual for wages, salary, or commissions?</p> <p>2 - Employee of non-profit organization (except government)?</p> <p>3 - Federal Government employee?</p> <p>4 - State government employee?</p> <p>5 - Local government employee (city, county, etc.)?</p> <p>Self-employed in own business, professional practice, or farm -</p> <p>6 - Own business - not incorporated?</p> <p>7 - Own business - incorporated?</p> <p>8 - Working without pay in family business or farm?</p>	<p>(Mark only one box)</p> <p>132 1 <input type="checkbox"/></p> <p>2 <input type="checkbox"/></p> <p>3 <input type="checkbox"/></p> <p>4 <input type="checkbox"/></p> <p>5 <input type="checkbox"/></p> <p>6 <input type="checkbox"/></p> <p>7 <input type="checkbox"/></p> <p>8 <input type="checkbox"/></p>	<p>(Mark only one box)</p> <p>133 1 <input type="checkbox"/></p> <p>2 <input type="checkbox"/></p> <p>3 <input type="checkbox"/></p> <p>4 <input type="checkbox"/></p> <p>5 <input type="checkbox"/></p> <p>6 <input type="checkbox"/></p> <p>7 <input type="checkbox"/></p> <p>8 <input type="checkbox"/></p>	<p>(Mark only one box)</p> <p>134 1 <input type="checkbox"/></p> <p>2 <input type="checkbox"/></p> <p>3 <input type="checkbox"/></p> <p>4 <input type="checkbox"/></p> <p>5 <input type="checkbox"/></p> <p>6 <input type="checkbox"/></p> <p>7 <input type="checkbox"/></p> <p>8 <input type="checkbox"/></p>
<p>27. Did you usually work full-time or part-time?</p>	<p>135 1 <input type="checkbox"/> Full-time 2 <input type="checkbox"/> Part-time</p>	<p>136 1 <input type="checkbox"/> Full-time 2 <input type="checkbox"/> Part-time</p>	<p>137 1 <input type="checkbox"/> Full-time 2 <input type="checkbox"/> Part-time</p>
<p>28. Between what dates did you hold this position? (Enter month and year for each job)</p>	<p>From 138</p> <p>To 141 x <input type="checkbox"/> Or last week</p>	<p>From 139</p> <p>To 142</p>	<p>From 140</p> <p>To 143</p>
<p>29. About how much was your basic annual salary rate - (Report to nearest hundred dollars)</p> <p>1 - When you began the job?</p> <p>2 - If academically employed - For how many months was this?</p> <p>3 - When you left the job (or last week, if currently employed)?</p> <p>4 - If academically employed - For how many months was this?</p>	<p>(Exclude bonuses and profit-sharing plans. If self-employed, give an estimated equivalent salary rate, or report income before taxes and other deductions such as Social Security contributions but after deducting business expenses.)</p>		
<p>Beginning salary</p>	<p>144 \$</p>	<p>146 \$</p>	<p>146 \$</p>
<p>Number of months</p>	<p>147</p>	<p>148</p>	<p>149</p>
<p>Current or ending salary</p>	<p>150 \$</p>	<p>151 \$</p>	<p>152 \$</p>
<p>Number of months</p>	<p>153</p>	<p>154</p>	<p>155</p>
<p>30. In addition to your annual salary, did you receive any bonuses and/or participate in any profit-sharing plans (either cash payments or stock acquisitions)?</p>	<p>156 1 <input type="checkbox"/> Yes 2 <input type="checkbox"/> No</p>		
<p>If yes - Did these arrangements begin when you took this job?</p>	<p>159 1 <input type="checkbox"/> Yes 2 <input checked="" type="checkbox"/> No They began in 19__</p>		
<p>31. Was the change between this job and the previous one, or the acceptance of this job if not previously employed, associated with a change in your residence?</p>	<p>162 1 <input type="checkbox"/> Yes 2 <input type="checkbox"/> No</p>		
<p>If yes - Where did you live -</p> <p>Before assuming this job?</p> <p>After assuming this job?</p>	<p>City or county 165</p>	<p>City or county 166</p>	<p>City or county 167</p>
	<p>State/foreign country 168</p>	<p>State/foreign country 169</p>	<p>State/foreign country 170</p>
	<p>City or county 171</p>	<p>City or county 172</p>	<p>City or county 173</p>
	<p>State/foreign country 174</p>	<p>State/foreign country 175</p>	<p>State/foreign country 176</p>

133

134

32. Here is a list of activities. For each job, estimate the percent of total working time spent both in doing the work yourself, and in supervising and administering others doing the activities detailed below. Please account for total working time.	LAST CIVILIAN JOB Job held last week or most recent job Job A	SECOND-TO-LAST CIVILIAN JOB Job B	THIRD-TO-LAST CIVILIAN JOB Job C
	Percent of total working time	Percent of total working time	Percent of total working time
1. Teaching and training - preparing and teaching courses, guiding and counselling students or trainees	1. 177 %	1. 178 %	1. 179 %
2. Research - basic and applied research	2. 180 %	2. 181 %	2. 182 %
3. Development - product, process, and technical development	3. 183 %	3. 184 %	3. 185 %
4. Clinical practice - diagnosis, treatment, etc., for patients and clients	4. 186 %	4. 187 %	4. 188 %
5. Design - of equipment, processes, models; also drafting, drawing, blue prints	5. 189 %	5. 190 %	5. 191 %
6. Quality control, testing, and evaluation - of equipment, materials, devices, etc.	6. 192 %	6. 193 %	6. 194 %
7. Operations - production, maintenance, construction, installation, inspection	7. 195 %	7. 196 %	7. 197 %
8. Distribution - sales, traffic, purchasing, customer and public relations	8. 198 %	8. 199 %	8. 200 %
9. Statistical work - designing and conducting sample and other surveys, statistical analysis, forecasting	9. 201 %	9. 202 %	9. 203 %
10. Consulting - on technical aspects of professional, scientific, and management fields or products	10. 204 %	10. 205 %	10. 206 %
11. Computer applications - programming, data systems analysis, development of programming techniques, controlling computer operations	11. 207 %	11. 208 %	11. 209 %
12. Other activities - Specify _____	12. 210 %	12. 211 %	12. 212 %
YOUR ENTRIES IN EACH COLUMN SHOULD SUM TO 100% →	100 %	100 %	100 %
33. Mark the one statement which best describes your level of supervisory responsibility in each job.	(Mark only one box)	(Mark only one box)	(Mark only one box)
1. Supervised no personnel	213 1 <input type="checkbox"/>	214 1 <input type="checkbox"/>	215 1 <input type="checkbox"/>
2. Responsibility for indirect or staff supervision (no line authority)	2 <input type="checkbox"/>	2 <input type="checkbox"/>	2 <input type="checkbox"/>
3. Supervised team, unit, project, or section	3 <input type="checkbox"/>	3 <input type="checkbox"/>	3 <input type="checkbox"/>
Managed major department or division	4 <input type="checkbox"/>	4 <input type="checkbox"/>	4 <input type="checkbox"/>
Controlled management of organization	5 <input type="checkbox"/>	5 <input type="checkbox"/>	5 <input type="checkbox"/>

<p>34. How did you acquire this job? (Mark most important means)</p> <ol style="list-style-type: none"> Promotion within same organization Told of position by acquaintance in organization Told of position by acquaintance not in organization Contact by official recruiter or personnel officer of organization by letter or personal visit Found position at professional society meeting Found position through a public employment agency Found position through a private employment agency Found position through college placement office Answered want ad Began own business or professional practice Purchased business or professional practice Other 	<p>(Mark only one box)</p> <p>273</p> <ol style="list-style-type: none"> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> 	<p>(Mark only one box)</p> <p>274</p> <ol style="list-style-type: none"> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> 	<p>(Mark only one box)</p> <p>275</p> <ol style="list-style-type: none"> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>
<p>35. Why did you leave this job? <i>If still working at most recent job, mark here</i> →</p> <ol style="list-style-type: none"> Laid off from work or job terminated Higher salary, essentially same position and responsibility Higher salary and advancement Improved working conditions Change in type of work Better opportunity for advancement Association with outstanding specialists in my field Entered active duty in Armed Forces Retirement Stay home and take care of family Spouse's change in job Move closer to other family members Return to school Relocate in different city, State, region, or country Other <p><i>If more than one box marked - Which of the above was the most important reason?</i></p>	<p>(Mark as many as apply)</p> <p>x <input type="checkbox"/> Currently employed in this job</p> <p>276</p> <ol style="list-style-type: none"> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <hr/> <p>277</p> <ol style="list-style-type: none"> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <hr/> <p>278</p> <ol style="list-style-type: none"> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <hr/> <p>279</p> <ol style="list-style-type: none"> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <hr/> <p>280</p> <ol style="list-style-type: none"> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <hr/> <p>281</p> <ol style="list-style-type: none"> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <hr/> <p>282</p> <ol style="list-style-type: none"> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <hr/> <p>283</p> <ol style="list-style-type: none"> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <hr/> <p>284</p> <ol style="list-style-type: none"> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <hr/> <p>285</p> <ol style="list-style-type: none"> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <hr/> <p>286</p> <ol style="list-style-type: none"> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <hr/> <p>287</p> <ol style="list-style-type: none"> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <hr/> <p>Enter code</p> <p>288</p>	<p>(Mark as many as apply)</p> <p>277</p> <ol style="list-style-type: none"> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <hr/> <p>280</p> <ol style="list-style-type: none"> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <hr/> <p>283</p> <ol style="list-style-type: none"> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <hr/> <p>286</p> <ol style="list-style-type: none"> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <hr/> <p>Enter code</p> <p>289</p>	<p>(Mark as many as apply)</p> <p>278</p> <ol style="list-style-type: none"> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <hr/> <p>281</p> <ol style="list-style-type: none"> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <hr/> <p>284</p> <ol style="list-style-type: none"> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <hr/> <p>287</p> <ol style="list-style-type: none"> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <hr/> <p>Enter code</p> <p>290</p>
<p>36. What were you doing immediately prior to this job?</p> <ol style="list-style-type: none"> Employed Unemployed and seeking work In school At home caring for family Retired temporarily Ill In Armed Forces Other 	<p>(Mark only one box)</p> <p>291</p> <ol style="list-style-type: none"> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <p><i>If you have not already answered questions 20-36 about Job B, please do so.</i></p> <p><i>If you had a job at any time prior to this one, please answer questions 20-36 about Job B, if you have not already done so.</i></p>	<p>(Mark only one box)</p> <p>292</p> <ol style="list-style-type: none"> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <p><i>If you have not already answered questions 20-36 about Job C, please do so.</i></p> <p><i>If you had a job at any time prior to this one, please answer questions 20-36 about Job C, if you have not already done so.</i></p>	<p>(Mark only one box)</p> <p>293</p> <ol style="list-style-type: none"> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <p>Go to question 37</p>

Before answering the next questions, please be sure you have completed questions 20-36 for each of your last three jobs.

37. Second regular job - In addition to your major current job, did you have a second regular job last week?

294 1 Yes 2 No - Go to question 38

If yes - { What kind of work were you doing? 295 Code Description from List C

{ In what kind of business were you working? 296 Code Description from List B

38. First full-time professional job (Do not consider as your first full-time professional job part-time or summer employment.)

Was one of the jobs described above your first full-time professional job?

297 1 No - Go to question 39

2 Yes - Which of these was your first full-time professional job?

3 Job A, the job you held last week or most recent job

4 Job B, the second-to-last job

5 Job C, the third-to-last job

} Skip to question 40

39. What kind of work did you do in your first full-time professional job? 298 Code Description from List C

In what year did you begin this job? 299 19 ____

40. Prior to your first full-time professional job, did you hold a regular full-time NON-PROFESSIONAL JOB?

300 1 No

2 Yes { What kind of work did you do in your last regular full-time non-professional job before your first full-time professional job? 301 Code Description from List C

{ In what year did you leave this job? 302 19 ____

41. Complete the following statement: 303 Code Description from List C

Based on my total education and experience, I regard myself professionally as a (an) -

Part V - INCOME

42. How many weeks did you work at all jobs in 1971 either full-time or part-time? (Count paid vacation, paid sick leave, and military service as weeks worked.) - Mark only one box

308 1 13 weeks or less 3 27 to 39 weeks 5 48 to 52 weeks

2 14 to 26 weeks 4 40 to 47 weeks 6 Did not work in 1971

43. How much did you earn from all jobs in 1971 in wages, salaries, commissions and bonuses? (Estimate to nearest hundred dollars.) 309 \$ _____ x None

Income from sources such as royalties, consulting fees, etc., should be reported in question 44 below.

44. How much did you earn in 1971 from your own business, practice, or partnership? Report income before personal income taxes and other deductions such as Social Security contributions, but after deducting any business expenses. (Estimate to nearest hundred dollars) 310 \$ _____ x None

Income from wages, salaries, commissions, and bonuses should be reported in question 43 above.

Part VI - OTHER

45. In the event it is necessary to contact you to clarify some of the information you provide, may we contact you by telephone?

311 1 Yes 2 No

If yes - { Enter the telephone number on which you can be reached Area code | Number

{ If there is an alternate number on which you can be reached, enter it also. Area code | Number

46. Please enter the name of a person, other than yourself at an address other than yours, through whom you can be reached.

Name _____

Address - Number and street _____

City _____ State or foreign country _____ ZIP code _____

47. Date prepared _____ Print your full name _____

APPENDIX 2

Inconsistencies Between the Survey Years

The NSSE is a biennial survey, and data from the 1974, 1976 and 1978 surveys were available for analysis. There were changes made in the survey instrument from year to year, and a major task in this research was to reconcile these differences to derive consistent measures of the necessary variables. As was stated in the text, the crucial variable of interest, career path, could not be measured consistently from year to year, so ultimately, the post-1972 survey information was not used. This appendix describes the differences between the surveys and the efforts to reconcile the different types of information provided in each.

Response Rates to the 1974, 1976, and 1978 Surveys. The panel surveyed in the post-1972 surveys (here referred to as PMS74, PMS76, and PMS78, respectively) is a subgroup of the 1972 survey. Survey response rates varied by year. Of the 41,133 useable responses, 38,134 provided data from all survey years; 335 had data only from PMS72 and 78; 1,378 had data for PMS72, 74, and 78; and, 1,286 had data from PMS72, 76, and 78. According to NSF publications,¹ it appears that response rate was fairly constant across occupations, but there was a tendency for those at the age extremities, under 34 and over 70 in 1978, to respond at a lower rate.

There were questions in the 1974 questionnaire about education between 1971 and the date of the survey, February, 1974, and about jobs held in February, 1973 and February, 1974. In 1976, respondents

were asked again about education from 1971 and to describe the jobs they held in February, 1975 and February, 1976. In 1978, respondents were asked about education since 1971 and the job held in February, 1978. These three questionnaires are very similar and ask fewer questions than the 1972 survey.

Reconciling the Codes and Responses Between the Different Surveys. After eliminating unwanted cases (as described in Chapter V), the next step in the sample definition after eliminating unwanted cases was to achieve consistency between surveys. There were two types of inconsistencies. The first was either due to differences in the questionnaires or to the responses codes used in the different survey years. And, the second was due to respondents giving an answer in one survey year that was contradicted by their answer in another survey year.

Because it was expected the data from this panel study were to be converted into employment histories, it was necessary to put the information that was to be used to construct the work histories into a format that was consistent from survey to survey. This was necessary because once the work history was created, it would not be immediately possible to tell from which survey the information used to describe each job in the work history had been provided.

For the industry and occupation variables, the codes used in the 1974, 1976, and 1978 surveys were recoded to be consistent with those used in the 1972 survey. Tables 3 and 4 in chapter V list the industrial and the occupational codes, respectively.

The next step in the selection process was to identify those

cases that either described jobs with no starting dates or that provided inconsistent information. This latter type of problem was most likely to occur between survey years, when respondents would forget their response from two years earlier and provided inconsistent answers.

A zero start date could be a legitimate response if an individual were unemployed or not in the labor force, but a distinction had to be made between missing information and the possibility that the respondent had not been employed at the time of the survey. Respondents had been asked to provide the start date for whatever job they held during a specific week, in particular, the last full week of January, 1973 and 1974; February 9 - 15, 1975 and February 8 - 14, 1976; and, February 12-18, 1978. To determine if a zero start date represented no job, the following method was used.

If the value of a variable called EMP (73,74) was equal to 1 (working full time during the week in question) or 2 (working part time during that week), then a new variable, BNJOB (73,74) was created and set equal to 1, indicating employment. If EMP equalled 3 (not working), then another variable that described non-working status, NOEMP (73,74) was consulted. If NOEMP equalled 2 (temporary lay-off) or 3 (looking for work), then BNJOB was set equal to 2 to indicate unemployment. Depending on the other values of NOEMP, BNJOB was set equal to different values depending on whether the respondent was a student, not working due to family responsibilities, retired, out of the labor market for other reasons, or did not answer.

A slightly different process was used to generate values for

BNJOB for the 1976 and 1978 surveys. Essentially, the information provided from EMP and NOEMP in the 1974 survey was available from one variable in the last two surveys, and the same range of values could be generated for BNJOB for those surveys.

Having identified whether or not a person was employed on the date in question using BNJOB, a variable NULL was created for each date. NULL was equal to 1 when a zero start date meant there was no job (unemployment or out of the labor force) or 2 if the zero meant missing information. If there was a zero start date and BNJOB indicated that a job should exist, then the existence of an occupation was tested. If no occupational information was available, NULL was set equal to 1, and it was assumed that no job existed. If the occupational information was listed, then NULL was set equal to 2, indicating that the start date for that job was missing. Cases where NULL was equal to 2 were deleted.

Having eliminated the cases with missing start dates, the next step was to reconcile inconsistencies in the chronological order of the starting dates. These inconsistencies usually occurred between survey years when an individual would provide one start date for a job; then, when asked about their job in the next survey, would put a start state that preceeded that given in the prior survey. Respondents were permitted a two year margin of error when this occurred, and the start from the earlier survey was assumed to be correct and used for both dates.

And, the subsequent surveys were panel data describing up to five additional jobs. So, a work history could contain a maximum of eight

JOBC, signifying the beginning of a new job. Once a new job was found, that start date became the new basis for comparison to find the next new job. This process was continued until all job dates had been compared and jobs were ordered.

The frequency and percent distribution of the number of jobs described in all four surveys is:

Table A2.1

Frequency Distribution of Described Jobs

#	Freq.	%	#	Freq.	%
1	97	2.88	5	763	22.64
2	260	7.73	6	398	11.83
3	724	21.52	7	114	3.39
4	984	29.25	8	24	.71

Education. As was the case in the 1972 survey, in the 1974 and 1976 surveys, respondents were asked to describe their more recent and two previous educational experiences. Thus, it was possible that degrees reported in the three surveys were redundant. In the 1978 survey, respondents were asked about the highest degree they had received since 1972. A frequency run on those education variables showed that, with a few trivial exceptions, the only degrees reported were those in the 1972 survey, the most recent in the 1974 and 1976 surveys, and that in the 1978 survey. Therefore, only those degrees were retained in the variable list.

Government Funding---In the 1974 survey, the question was

rephrased, so that respondents could answer yes or no to support from eighteen different federal agencies (as opposed to areas). In the 1976 and 1978 surveys, respondents could answer yes or no to support from nineteen agencies. As described in the text, this list was collapsed into four categories: defense, space, energy, and other.

Career paths. Each respondents' occupational category was included in each of the surveys. Of the possible choices, six categories were considered managerial. Although this variable was consistent from survey to survey, as is indicated in Chapter VI, it significantly understated the number of managers. Therefore, attempts were made to use the information on job activities.

In the 1976 and 1978 surveys, respondents were asked to provide the percent distribution of time spent on the job, choosing from between nine (in 1976) and sixteen (in 1978) activities. They were also asked to specify their primary and secondary activities from a list of sixteen. In the 1974 survey, respondents were asked only to specify their primary and secondary activities from a list of the same sixteen activities. There was no accompanying question about the distribution of time among activities. The list below shows the sixteen activities and indicates whether the activity was included in the 1976 time distribution list.

<u>Activity</u>	<u>In 1976 Survey</u>
1. Management or Administration of Research and Development	yes
2. Management or Administration of other than R & D	yes

3. Teaching and Training	yes
4. Basic Research	yes
5. Applied Research	yes
6. Development	yes
7. Report and Technical Writing	no
8. Clinical Diagnosis	no
9. Design	yes
10. Quality Control, Testing	no
11. Operations	no
12. Distribution	no
13. Statistical Work	no
14. Consulting	yes
15. Computer Applications	no
16. Other	yes

One possible way to create a definition of the type of job career path that was consistent between surveys was to use the explicitly specified primary activity. If the specified primary activity was either of the two managerial activities (1,2), then the job was coded as managerial. If consulting was the primary activity, then the job was coded as consulting. If distribution was the primary activity, the job was coded as sales. And, jobs with any other primary activity were coded as technical.

There were two difficulties with this method. First, it was not clear which primary and secondary activities should be considered to be managerial. And, second, no primary and secondary activities were

specified in the 1972 survey.

Allocation of Sales and Consulting. Although the distinction between managerial and technical paths is of primary interest, there were four types of paths specified. This was done because in the case of consulting and sales, it was not immediately obvious whether those activities should be classified as managerial or technical or be considered as separate paths. By separating these two activities from other two paths, it was possible to create four versions of the path variables and determine empirically which definition produced the most stable paths.

The first definition defined as managerial a job which included the two management activities and consulting and sales. The second definition (CONPATH) incorporated sales into the management path, but allowed consulting to be a separate path. The third version (SALEPTH) included consulting in the definition of management and allowed sales to be an independent path. The last definition of the managerial path (NARPATH) included only the two management activities.

To determine path stability, four sets of variables (SPLIT-1,2,3,4) were created describing the transitions between jobs. One set of split variables was created for each managerial path definition. Each set had seven variables describing one job transition, e.g., the transition from job 1 to job 2, from job 2 to job 3, etc., indicating whether or not the job change represented a path change, and if so, between which paths. The transition from the technical path to the managerial path is expected. However, empirically, there is some backtracking, where a person goes from the

managerial track to the technical track. The purpose of separating the consulting and sales activities from these two tracks is to determine which definition of managerial and technical paths, those including or excluding either or both of the consulting and sales activities, will provide path definitions which minimize the amount of backtracking.

To examine this question, the number of people moving from the consulting track and the sales track to both the technical and managerial paths were compared. Using the consulting track as an example, if the number of people moving from consulting to technical was approximately equal to the number going from technical to consulting, then consulting would be considered a technical rather than managerial activity. If the movement between consulting and technical and consulting and managerial was about equal, that suggested that either consulting was its own path, or that it could be on either track and was thus indeterminate. If there were an approximately equal number of people going back and forth between management and consulting, and more than that going back and forth between consulting and technical jobs, then consulting was considered a managerial activity.

The table below shows the number going in each direction for each job transition and the probability of transition given the starting path at each transition and the job number in the career history. For instance, given that an individual is in a technical job in job 1, the probability of a move to a sales job in job 2 is .014. The comparable probability of a move to consulting is .036. Note that the

probabilities of a move to either sales or consulting will be relatively small because the sending paths, technical and managerial are much larger numerically.

<u>Job</u>	<u>SALES</u>				<u>CONSULTING</u>			
	<u>Trans</u>	<u>T to S</u>	<u>S to T</u>	<u>M to S</u>	<u>S to M</u>	<u>T to C</u>	<u>C to T</u>	<u>M to C</u>
12	37	24	17	27	94	53	25	40
23	25	23	16	28	75	68	34	37
34	18	13	14	20	64	51	29	46
45	12	14	8	7	30	30	15	16
56	4	4	4	1	11	14	6	6
67	1	0	1	0	8	1	3	1
78	0	0	0	0	2	1	1	0

TRANSITION PROBABILITIES

12	.014	.267	.031	.3	.036	.387	.049	.292
23	.011	.247	.017	.301	.034	.412	.038	.227
34	.010	.178	.013	.274	.035	.327	.028	.295
45	.010	.274	.008	.137	.024	.248	.016	.132

The conclusion drawn from this table is that the probabilities of movement in and out of sales jobs are small and relatively similar in either direction. So, rather than arbitrarily put sales jobs in either the managerial or technical category, cases where there was one or more sales job would be deleted. In the case of consulting, because the probability of moving from consulting to technical was fairly high, about 40% in two cases, and was higher than that for the move to managerial, consulting jobs were put into the technical category.

Defining Primary and Secondary Activities. In order to create 1972 survey job path definitions that would be as consistent as possible with those from the other surveys, the answer to the supervisory question was redefined into percent of time spent in

management. If the person said they managed a major department (SUPER=4) or were a general manager (SUPER=5), then the percent of time spent in management was set equal to 100. If they managed a team, unit, project, or section (SUPER=3), the percent of managerial time was set equal to 25. Otherwise, it was set equal to 0. This managerial activity was added to the activity list, and the activity which used the highest percentage of time was defined as the primary activity.

In order to determine if the created primary and secondary activities would be consistent with the explicit primary and secondary variables, job path was determined in the same manner as for the 1974, 1976, and 1978 surveys. The method of defining primary and secondary activities where they were not explicitly defined was tested using the 1978 survey data. In that survey, there was information about both distribution of time among activities and explicit primary and secondary activities. Comparison primary and secondary activities were created by identifying the two activities where the two highest percentages of time were spent and specifying them as the primary and secondary activities.

In some instances, an equal percent of time might be allocated to two or more activities. In that case, the activity which came first in the activity list (see the first page of this appendix for the list) would dominate, generating an arbitrary bias toward the top of the list and therefore toward management. Also, if the explicit primary and secondary activities were equal to zero, the created primary and secondary activities were set equal to zero.

Using this method, the correlation between the explicit and created primary activities was equal to .907 and that between the explicit and created secondary activities was equal to .789.

The values for the percent of time spent on managerial activity for each supervisory level had been arbitrarily selected. In order to determine if less arbitrary, "true", values existed, the following test was used. First, the cases where a person held the same job in 1975 as in 1972 were identified. Then, given the supervisory level reported in 1972 (SUPER = 2,3,4, or 5), the distribution of time reported in managerial activities was examined. In this case, time spent on managerial activities was the sum of the two managerial activity categories, management or administration, R & D, and management or administration, other than R & D. Cases where the sum of the reported times equalled zero were deleted on the assumption that for any worker who was actually a manager, a zero value indicated no response to the activity question. The table below shows the mode, median, mean and standard deviation of the sum of managerial activities for each supervisory level (SUPER = 2 is the lowest, and SUPER = 5 is the highest).

<u>SUPER</u>	<u>Mode</u>	<u>Median</u>	<u>Mean</u>	<u>Std. Error</u>	<u>N</u>	<u>90% Bound</u>
5	100	60	62.5	28.6	146	25.9
4	100	70	62.0	28.9	167	25.0
3	50	50	48.4	30.0	295	10.0
2	10	40	41.9	30.2	171	3.2

For all supervisory levels, it is clear that there is a large amount of dispersion of time in managerial activities, and that

there is not a clear cut-off point that separates managers from non-managers. The last column in the table shows the percent of time that could be used to assure that 90% of those in each category were included (this was calculated by $(X - 1.28(\frac{x}{x}))$). To use the lower bounds in the last column would seriously bias the job definition toward the managerial track.

Because of this dispersed distribution of percentage of time spent in activities and because career path was the central variable of interest, it was decided that consistency of measurement was preferable to a longer work history, so only information from the 1972 survey was used. Two alternative measures of career path were used: OCCMAN, the measure based on the self-defined occupational category, and SUPATH, based upon the response to supervisory level.

Footnotes

¹ "Analysis of Response in the 1972 Professional, Technical, and Scientific manpower Survey by Occupation and Education in 1970 and Age in 1972," in Characteristics of Persons in Engineering and Scientific Occupations: 1972, Bureau of Census, Technical Paper #33, April, 1974.

"Selected Characteristics of Persons in Mathematical Specialities: 1978," Special Studies, series p-23, #120, Bureau of Census, Washington, D.C., Sept., 1982.

Appendix 3

Industry Bridge

Industry Title (1974 Titles)	Code for 1974, 1976, 1978	Code for 1972	SIC Code (1967)
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Manufacturing

Aircraft, Aircraft Engines, Parts	701	701	372
Chemicals and Allied Products	702	702	28
Electrical Machinery, Equipment & Supplies	703	703	36
Electronic Appartus, Radio, T.V. & Communication	704	703	36
Electronic Computers, Accounting, Calculating & Office Machinery	705	703	36
Fabricated Metal Products	706	704	34
Machinery, Exc. Electrical	707	705	35
Motor Vehicles	708	706	371
Ordnance, incl. Manu. of Arms	709	707	19
Petroleum Refining and Related Industries	710	710	28
Primary Metal Industries	711	708	33
Professional & Scientific Equipment	712	709	38
Other	713	710	2

Educational Institutions

College or Universities (at least B.A. level)	714	711	8221
Junior College or Technical Institute	715	712	8222
Medical Schools	716	711	8221
Other	717	713	82 (exc. 8221, 8222)

Health Services

Hospital or Clinic	718	714	806, 8092
Other Medical or Health Services	719	715	801, 803, 807, 8099

Other Kinds of Business

Agriculture, Forestry, & Fisheries	720	716	01, 07, exc. 0713 & 073
Business, Personal & Repair Service	721	717	70, 72, 731, 734, 736, 7398, 7392, 7393, 75, 76, 893
Construction	722	718	15, 16, 17
Engineering or Architectural Serv.	723	719	891
Finance, Insurance, & Real Estate	724	720	60-67
Mining & Petroleum Extraction	725	721	10-14
Private, Non-Profit Orgs. Other than Ed. Inst.			

& Hospitals	726	722	3 892, 899, 861-865
Professional & Technical Societies	727	722	"
Research Institutions	728	723	7391, 7397
Retail & Wholesale Trade	729	724	50, 52-59
Transportation, Communica- tion or Other Public Utilities	730	735	40, 41, 42 44-49
Other, n.e.c.	731	726	3

Public Administration

Uniformed Military Service	732	727	9190, 9490
Federal Public Administration	733	727	9190, 9490
State Public Administration	734	728	9290
Local Public Administration	735	729	9390
Other Government	736	729	9390

Source: Standard Industrial Classification Manual,
Office of Statistical Standards, GPO, Washington, D.C., 1967.

Footnotes

¹ Based on the product description in the 1967 SIC manual, Rubber and Misc. Plastic Products, which are ordinarily SIC 30 are here included in the category, Chemicals and Allied Products, SIC 30, PMS74 code 702 and PMS72 code 72.

² Other Manufacturing includes the following SIC codes:

Lumber and Wood Products, exc. Furniture	24
Furniture and Fixtures	25
Stone, Clay, and Glass	32
Ships, Boat Building, & Repair	373
Railroad Locomotives	374
Mobile Dwellings	3791
Cycles & Misc. Transportation	375, 3799
Food & Kindred Products	20
Petroleum Refining	29
Tobacco Manufactures	21
Textile Mill Products	22
Apparel	23
Paper & Allied Products	26
Printing, Publishing, & Allied Products	27
Leather & Leather Products	31

³ Other Kinds of Business, n.e.c. includes the following SIC codes:

Entertainment & Recreation	78, 79
Legal Services	81
Museums, Art Galleries, & Zoos	84
Religious Organizations	866

Appendix 4

FIRM DECISION MODELS

The three papers in this appendix address the problem of firm behavior in the face of worker turnover. The review begins with Walter Oi's paper on labor as a quasi-fixed factor, a paper which was one of the first to discuss firm behavior in the face of fixed labor costs. The other two papers provide analyses of firms as joint producers of goods and services and training and model constrained firm decision making.

Oi's [1962] paper can be seen as a sort of mirror image of Becker's in that he examines the firm side of the fixed training costs story. He proposes a short-run theory of employment based on the concept that labor is a quasi-fixed factor of production. The classical factor demand adjustment process includes a response to changes in the rate of output and the substitution effect. But, Oi argues that labor has become a quasi-fixed factor, where the total cost of employment is partially fixed and partly variable. Among other things, training costs are part of the fixed component and so represent an investment by the firm in its labor force.

The total discounted cost of hiring an additional worker is:

$$C = W_t(1+r)^{-t} + H + K$$
 where W_t is the expected wage in the t th period, T is the expected period of employment, H is hiring costs, and K is training costs. Profits are maximized when $C = Y$, where Y is

discounted revenue. The net value of training to the firm is the present value of the expected increment in the marginal value product due to training, dM_t : $V = dM_t(1+r)^{-t}$. Training is profitable if V is greater than K .

The degree of fixity of a factor, f , is the ratio of fixed costs to total employment costs. Fixed costs drive a wedge between wages and marginal product, the size of the wedge being measured by f . There will be some critical product price where long-run marginal product will fall below long-run wages, resulting in layoffs for workers with a positive f . So, expected product price becomes part of the wage setting decision made by firms.

Although Oi's theory primarily describes firm behavior, his empirical work and policy conclusions concentrate on fluctuations in unemployment.

Pencavel [1972] examines the effect of the presence of specific training on firm wage and turnover strategies. In his model, firms must simultaneously select a wage rate and some tolerable level of turnover given the effect that turnover has on their level of production. In this model, the number of workers and the level of specific training required to produce are exogeneously determined by the firm production process, and firms incorporate the quit rate into their wage strategy.

He hypothesizes a wage-turnover trade-off, where the optimal wage level and quit rate depend on the ratio of specific to general training, the efficiency of the firm labor force, and hiring and training costs. Firms have a production function: $X = X[a(Q)L]$, where

$da/dQ < 0$, X is output, a is an efficiency index, Q the quit rate, and L is person hours of labor. The firm seeks to maximize profits subject to the constraints, $dL/dt = A - QL > 0$, where A is the number of accessions, and positive training costs, $H = sg(A)$, where s is the ratio of specific to general human capital.

He derives the efficiency condition that the optimal quit rate is that where the marginal negative effects on productivity are equal to the hiring and training costs associated with turnover, or $Q = Q(x)$, where $x = x(da/dQ, sdg/dA)$.

Using two-stage-least-squares, he estimates his quit and wage equations simultaneously for nineteen two digit manufacturing industries. One difficulty with his model is that he hypothesizes that the ratio of specific to general human capital, s , is: $s = s(W, E, \dots)$, where E is the level of education and \dots is a vector of other characteristics affecting the level of specific training. He then assumes that $ds/dw > 0$, and that $ds/dE < 0$. This latter assumption, that investment in firm specific skills is negatively related to the level of formal education, is not supported elsewhere in the literature. In addition, his use of quit and wage data by industry requires the overly strong assumption that workers are homogeneous with respect to the level of specific human capital investment within industrial categories.

Parsons [1972] proposes a similarly complex system. His objective is to develop a model of optimal sharing of specific training costs between workers and firms and examine the implications of these shares for quit and layoff rates. His hypothesis is that

quits are negatively related to "worker-owned" human capital and layoffs are inversely related to "firm-owned" human capital. Firms have to choose the optimal level of human capital per worker and whether to buy (firm-owned) or rent (worker-owned) specific human capital.

The firm is hypothesized to have a production function:

$Q_t = Q(S_{1t})$, where S_1 is specifically trained workers, and S_2 are new entrants who become trained after one period. The cost of training is the foregone productivity of S_2 in period one. The supply function for trained workers is $S_{1t} = S_{1t-1} + S_{2t-1} - q_t - ly_t + R_t$, where q_t is the number of quits, ly_t is the number of layoffs, and R_t is the number of rehires.

To maximize profits, firms can manipulate the wage rates of the two types of workers and the layoff rate to employ the optimal number of experienced workers, given the worker quit function. The worker quit function depends on relative wages and the layoff propensity of the firm. He derives efficiency wage and training conditions and layoff conditions which together determine what share of specific human capital the firm should optimally buy.

He then tests the hypothesis that quits are negatively related to the share of worker financed human capital and layoffs are negatively related to the firm share. To determine a direct measure of specific human capital, he assumes that $G = T - S$ (that is, that general human capital embodied in the worker is equal to total investment minus specific human capital) and provides general functional relations for S and T . Using the predicted signs of the coefficients for the

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exogenous variables in the specific and total human capital investment equations and the chain rule, he derives expected signs for the coefficients for the predictors of quits and layoffs. The difficulty with this is that, particularly in the case of quits, the hypothesized signs are often ambiguous. Despite this problem, his results generally support his hypothesis. However, he does not provide any goodness of fit statistics.

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