THE CAREER MOBILITY OF U.S. ENGINEERS: STABILITY AND CHANGE DURING THE 1970s AND 1980s

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ABSTRACT

This study investigates the career mobility of engineers in the era of restructuring and downsizing. Drawing on two longitudinal surveys, we employ an increment-decrement life table approach to examine the age-specific patterns of movement from engineering into three occupational statuses. Estimates of engineers' working-life expectancy in these statuses have remained fairly constant in the past two decades. What distinguishes these two decades is that there was substantially more mobility in the 1980s than in the 1970s. There is support for (a) the existence of a "dual ladder" in engineering and (b) the prevalence of "zig-zag" mobility during the 1980s.

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Engineering in the United States is a high-paying, high-status profession. Between 1940 and 1980, the engineering workforce increased sixfold (Zussman 1985, p. 97). The United States has become the largest employer of engineers among industrialized nations. During the 1980s, the United States employed more than 2.20 million nonacademic engineers, compared to 1.12 million in Japan, 0.51 million in West Germany, 0.36 million in Britain, and 0.27 million in France (National Science Board 1991, p. 298). Engineers represent a larger fraction of the labor force in the United States than in most comparison countries.[1] Technical professions such as engineering are vital to the continued prosperity of affluent countries such as ours. Despite a declining interest in engineering education among college students, the United States remains one of the most technologically advanced countries. Hence, our lead in technology largely depends on how well we utilize the nation's engineering workforce.

To stay competitive in the global markets, U.S. industry needs a plentiful supply of workers with advanced skills and specialized training (Hunt 1995; Reich 1992). Traditionally, policy analysts have focused on engineering enrollment and employment, and most policy-oriented studies have been based on aggregated data. Consequently, we know more about recent trends of gender and racial composition in engineering training and employment than the career processes of engineers (Dix 1987a, 1987b; Fox 1995; Pearson and Fechter 1994).

On the other hand, social scientists have shown a growing interest in the career achievement and advancement of engineers (e.g., McIlwee and Robinson 1992; Meiksins and Smith 1996; Tang 2000). These studies reveal an interesting and important connection between institutions and salaried professionals. For example, Kunda's (1992) ethnographic study of engineers in a high-tech company reveals how formal and informal institutional policies change the commitment and career goals of engineers. There is additional evidence that careers of a variety of salaried professionals in organizational settings are intimately tied to economic and structural changes (Barley and Orr 1997; Cappelli et al. 1997; Osterman 1996). All this affirms the importance of what organizational theorists called the interdependence of institutions and actors (Barley and Tolbert 1997; Hirsch 1997). For researchers who are interested in organizational careers, engineering can be a window to the plight of salaried and technical professionals.

WHY STUDY CAREER MOBILITY?

Engineering careers have been a particular concern for sociologists of work and occupations for three reasons. First, engineering is an important occupation in industrial nations. Although engineering does not have all of the defining attributes of the highest status professions, it is a major occupational field with a sizable U.S. workforce. Its sheer size makes engineers a force to be reckoned with in labor market studies.

Second, engineering careers are characterized by complex mobility structures and strategies. Recent structural changes in business and industry have further complicated the process of mobility for engineers (Brint 1994; Thomas 1994).

Third, the career dynamics of engineers take on additional interest in light of recent political and industrial changes. The U.S. engineering profession has close ties with the military and industry (Layton 1986; Reynolds 1991). Engineers were a major beneficiary when defense-related industries flourished during the cold war era. However, the collapse of communism in Europe, along with the disintegration of the former Soviet Union, has shifted our technological focus from national security to civilian issues. A reduction in military spending clearly affects the employment prospects of engineers.

To set the context for discussing the trends and patterns of mobility, we first review the literature on the engineering profession. Specifically, we underscore the career goals of engineers as well as the relationship between engineering and management. This is followed by a discussion of three propositions relevant to career mobility in engineering. The focus is on how recent economic and industrial changes affect engineers' career trajectories. Each of these claims, derived from the research on labor markets, is useful for understanding different mobility patterns of engineers. We then analyze two panel data sets of engineers to answer the questions posed below. Finally, we address the theoretical significance of these findings for the career mobility of engineers.

This study examines the career mobility of U.S. engineers during periods of industrial restructuring and corporate downsizing. Although our concern about the supply of and demand for engineers in recent years remains unabated, the question of how the nation's engineers are deployed has never been critically examined. In this study, we ask the following questions:

- What is the average working-life expectancy of engineers in technical engineering work?
- How often do engineers move out of and back into technical employment?
- How have these patterns changed in recent decades?

Answers to these questions would have implications for research on work and occupations as well as for policy making.

Results of the study would contribute to the literature on mobility and organizational careers. Using engineers as a case study, we can improve our sociological understanding of the relationships between structural and historical developments, and, in turn, of how they impact careers of salaried professionals in organizational settings. The findings may allow organizational theorists to gain specific insights into processes and patterns of organizational careers, and perhaps to make generalizations about career mobility of other salaried professionals.

Examining the trends and patterns of mobility not only helps policy makers make accurate projections of the size of the engineering labor force, but the results

Table 1. Summary of Hypotheses, Predictions, and Methodological Issues

HYPOTHESES	PREDICTIONS		METHODOLOGICAL ISSUES		EVIDENCE FROM THIS STUDY
1. Dual Ladder	[1.1]	More movement from technical engineering to management (track switching)	1.1	How many times can an engineer be expected to move between technical engineering and management work?	Yes
	[1.2]	More return from management to technical engineering (back tracking)			No
2. Engineering Shortage	[2.1]	A longer stay in technical engineering	2.1	How long can someone be expected to be employed as an engineer, a manager, a worker in non-engineering occupations, or a non-worker?	No
	[2.2]	Fewer movement from technical engineering to management	2.2	How many times can an engineer be expected to move between technical engineering and management work?	No
	[2.3]	Increased rates of return movement from other occupations to engineering	2.3	How many times can an engineer be expected to switch back to engineering from other occupations	Yes
3. Downsizing	[3.1]	Increased rates of exits from management	3.1	How long can someone be expected to be employed as a manager?	No
	[3.2]	Increased rates of out-migration from engineering to other occupations	3.2	How many times can an engineer be expected to move out of engineering to other occupations?	Yes
	[3.3]	Engineers were spending less time in management	3.3	For an engineer of a given age, how many years can s/he be expected to remain on management track?	No

also reveal how well engineers as a group have adapted to changing labor market forces.

Finally, the study allows us to evaluate several prevailing claims about the engineering profession and its practitioners. These propositions highlight the relationships between structural and historical changes. Because the focus of our analysis is on career mobility of engineers in recent decades, we generate three engineering-specific hypotheses. These hypotheses are formulated based on several structural and historical changes that have a strong bearing on engineering careers:

1. the career ladders in engineering,
2. the supply of and demand for engineers, and
3. the trends of downsizing.

Engineers cannot be assumed to remain in the same jobs throughout their careers (Perrucci and Gerstl 1969; Ritti 1971; Saxenian 1994). Skill obsolescence and economic fluctuations make some degree of career mobility inevitable. Thus, engineers' career mobility patterns are inextricably linked to the structure of the profession and its labor markets. Each of the following three propositions yields different predictions of mobility patterns in engineering. Table 1 provides a summary of predictions of these hypotheses as well as the key methodological issues.

Dual Ladder: Professional and Managerial Careers

Social scientists who study engineers have suggested that successful engineers tend to move from technical work to management (Meiksins 1996). In the United States, the typical career path for upwardly mobile engineers is to garner a promotion out of technical work into management. This move is often seen as the ultimate career goal of most engineers. Technical engineering is generally considered a springboard to more prestigious managerial positions (Perlow and Bailyn 1997; Zussman 1985).

However, not all ambitious engineers can join the managerial ranks. For many engineers, moving into management permanently is more likely to be an illusion than a reality. One reason is that competition for promotions among engineers was particularly intense during the 1980s when opportunities for management were declining (Bell 1994). Corporate downsizing has led to the thinning of managerial ranks and further limited engineers' access to management opportunities. These structural changes may have changed the way engineers view and measure success in engineering. For the most part, engineering careers are closely tied with institutional policies. As a result, organizational changes have a pivotal role in altering the career mobility of engineers.

So what happens to those who do not achieve this career goal? How do employers sustain the motivation of engineers who cannot move into management? According to organizational theorists, one of the logical responses from employers is to create alternate career paths for these technical professionals. Goldner and Ritti (1967) contend that employers create professional (technical) ladders for engineers who do not move into management. These professional career ladders have become "consolation prizes" for those who fail to move up in the occupational hierarchy. To temper the ambitions of aspiring engineers in recent decades of downsizing, some companies have adopted or expanded these university-like technical tracks for engineers. Engineers on technical tracks can advance themselves from associate fellow to fellow, senior fellow, and even to distinguished fellow (Kilborn 1990). This practice ensures that engineers on technical ladders would be able to move from lower to higher ranks with more responsibilities, higher compensation, and additional recognition, without managerial authority.

Further, companies can employ the dual ladder to mask the zig-zag mobility of engineers. Goldner (1965) observes that in order to make demotions socially acceptable, personnel movement in industrial organizations often involves a series of ambiguous steps. For example, an incompetent engineer can first be "promoted" to quasi-management positions such as "project manager" or "project director," and later moved laterally to technical work. Thus, demotions might occur more often than we observe.

All this suggests that the existence of both professional and managerial careers has become a distinct feature of the engineering profession. The dual ladder is instrumental in tempering the career ambitions of aspiring engineers. It can serve as a safety valve during periods of economic instability. Thus, frequent movements between technical work and management are "natural" phenomena in the engineering profession. Based on the dual ladder thesis, the picture for the 1980s would be very different than that for the 1970s. To provide support for the dual ladder thesis, we should expect to observe more "track switching" and "back tracking" among engineers in the 1980s, compared to the 1970s:

Hypothesis 1. *The Emerging Dual Ladder*: There would be (a) more movement from technical engineering to management (track switching) and (b) more return from management to technical engineering (back tracking) in 1980s than in 1970s.

Engineering Shortage

In addition to organizational influence, career mobility in engineering can be market driven. Career changes depend on organizational growth and decline (Baron 1984; Rosenbaum 1984); in our specific case, on whether shortages or surpluses exist in engineering, management, or both. Those who subscribe to the "engineering shortage" thesis argue that a shrinking engineering labor pool has altered the mobility patterns of engineers. Engineering shortages may have led to longer stays in technical work and fewer movements into management.

The entry and persistence rates in engineering are no doubt sensitive to changes in the supply of and demand for technical personnel. During the late 1980s, several studies projected a serious gap in engineering employment by the year 2000 (Atkinson 1990; Grogan 1990). One study projected a 35 percent increase in the number of engineering jobs between 1994 and 2005 (National Science Board 1996, p. 3-20).

Three historical developments have contributed to the alleged engineering shortage. First, interest in engineering among U.S.-born college students had declined steadily during the 1980s. Throughout the 1980s, engineering majors comprised less than 10 percent of graduates at all levels of higher education, with foreign students representing a growing fraction of this group, especially at the master's and doctoral levels (U.S. Department of Education 1996, p. 132). Additionally, nearly 20 percent of engineering graduates do not pursue engineering careers or advanced training in the field (Basta 1985). All this suggests a relatively low supply of engineers.

Second, a rising demand for engineers has further expanded the gap in labor shortages. The demand for engineers remained unabated during the 1980s, despite a shift in emphasis from the military to the civilian sector. The number of employed engineers increased from 1,102,000 in 1972 to 1,960,000 in 1996, expanding by 78 percent in a quarter of the century (U.S. Bureau of the Census 1980, p. 418; U.S. Bureau of the Census 1997, p. 410). The relatively high full-time employment rate enjoyed by engineers suggests that there is indeed a tight labor market for those with engineering skills.

Third, staffing problems are further complicated by rapid skill obsolescence and limited transferability of engineering skills. It has been suggested that the average half-life of technical training is five years (National Research Council 1988). Field transfer, cross-training, and self-employment is less common in engineering than in other professions. To circumvent this problem, engineers engaging in technical work are expected to keep up with developments in their field, or to move out of engineering into managerial work.

Based on these historical shifts, we must take into account the balance of supply and demand of technical personnel in the analysis of engineers' career mobility. The alleged engineering shortages imply that employers experienced difficulty in filling new and replacement needs in the 1980s. Thus, engineers would have a higher persistence rate in technical work in the 1980s than in the 1970s. If the prediction of the "engineering shortage" thesis is correct, there should be relatively little lateral and vertical mobility out of engineering, coupled with more transfer back to engineering from nonengineering occupations.

Hypothesis 2. *The Engineering Shortage*: Compared to the 1970s, there should be: (a) longer spells in technical engineering work, (b) less movement from technical engineering into management, and (c) increased rates of return movement from other occupations to engineering.

Downsizing

Another structural force that shapes engineers' career mobility is the spread of organizational downsizing in business and industry. To improve their global competitiveness, U.S. industry has engaged in restructuring or merger in recent decades. This corporate strategy has resulted in layoffs of white-collar and professional workers as well as a shrinkage of management, especially at the middle levels (Cappelli et al. 1997; Lublin 1994).

Like other salaried professionals in organizational settings, engineers are one of the hardest-hit groups in the midst of downsizing. For example, a recent study found that 60 percent of the members of 22 engineering societies had experienced at least one major reorganization between 1987 and 1992, which is three times the rate reported for the employed U.S. population in 1991 (Society of Women Engineers 1993, p. 25). A substantial growth in demand for engineers since World War II was followed by the onset of uncertainties in engineering (Levin 1994; Pearlstein 1994). The combined decades of the 70s and 80s might be a critical transition period for the U.S. engineering labor force.

Downsizing has altered the conventional career paths of technical professionals (Cappelli et al. 1997; Osterman 1996). Organizational changes in recent decades constitute powerful incentives for engineers to contemplate occupational changes. For example, some have suggested that restructuring has stimulated the out-migration of engineers to other occupations (Bell 1994). Those who seek occupational changes can sometimes apply their technical skills in neighboring scientific fields (such as computer science) or nonengineering, nonmanagerial occupations (such as business consultation and financial services) (Adams 1991, pp. 58–59). However, because of their specialized training, very few technical professionals enjoy unlimited job opportunities outside of engineering (Meiksins 1996, p. 91). These occupational constraints have undermined engineers' ability to select and switch occupations.

Others may be highly skeptical of the widespread negative impact of downsizing on career mobility of engineers. Critics have noted the countervailing forces that may result in negligible change in engineers' mobility rates. For one, expansion in high-technology industries has opened up a wide array of new career directions for engineers. It may be that some, if not all, of those who depart from engineering (or the engineering labor force) may reenter technical engineering work. For example, the rapid development in electronic and information technology industries has created a new set of job opportunities for engineers. As a result, engineers can pursue their technical careers in these "sunrise" industries to the extent that their skills are transferable.

All in all, the "downsizing" theorists argue that there were specific changes in the relationship between engineering and management during the 1980s. First, downsizing had sent large numbers of managers back into the ranks of engineering work. Second, blocked mobility and development of new industries had fostered out-migration from engineering to other occupations. Third, the age trajectory of movement into management had shifted. Downsizing has intensified the competition for management jobs, and has dimmed the prospects of many engineers to become managers. Hence, it would take a considerably longer period of time to climb the occupational ladder in engineering into the rungs of management.

Hypothesis 3. *Downsizing*: During the 1980s, (a) there were increased rates of (i) exits from management as well as (ii) out-migration from engineering to other occupations, and (b) engineers were waiting longer to be promoted into the ranks of management than was previously the case.

In sum, the decades of the 1970s and 1980s might be a critical transition period for the U.S. engineering labor force. Organizational changes have strengthened the dual ladder structure in engineering. The career dynamics of engineers might also have changed due to engineering shortages. Waves of corporate downsizing could have altered the conventional career paths of engineers.

DATA AND METHODS

To test the hypotheses posed in preceding section, we explore trends of career and occupational field mobility of U.S. engineers. This study analyzes two sets of panel data, the 1970s and 1980s administration of the *Survey of Natural and Social Scientists and Engineers* (SSE). These data sets were compiled by the National Science Foundation (NSF) to estimate the size and demographic and employment profile of the science and engineering population in the United States. The first SSE interviewed respondents in 1972, 1974, 1976, and 1978. This panel began with 50,093 individuals (about 27,000 of whom were engineers) drawn from the 1970 census. The second SSE administered interviews in 1982, 1984, 1986, and 1989. It followed 88,363 individuals (some 34,300 of whom were engineers) based on a 5 percent sample taken from the 1980 census (U.S. Department of Commerce 1990). Both panels[2] were stratified (therefore all results are weighted unless otherwise noted). These large data sets allow for the possibility of preparing increment-decrement life table (IDLT) estimates for engineers.[3]

As shown in Table 2, to critically examine the propositions for each thesis, we address issues revolving around the working-life expectancies of engineers in different statuses, as well as their movement between these statuses, during the past two decades. All in all, our analysis focuses on four exhaustive and mutually exclusive statuses. The first and largest group consists of *engineers*,[4] who account for about three quarters of the sample. The second employment status of interest is *managers*[5] (comprising about 15% of the sample), including administrators and

Table 2. Career Mobility of Engineers Aged 25–64, 1972–1974 and 1982–1984

	DESTINATIONS							
	1972–1974				1982–1984			
	(a)	(b)	(c)	(d)	(a)	(b)	(c)	(d)
ORIGINS	Engineering	Management	Other Occupations	Nonworker	Engineering	Management	Other Occupations	Nonworker
Engineering	.8420	.0756	.0537	.0286	.7758	.0951	.0807	.0484
Management	.3416	.5627	.0650	.0306	.3239	.5692	.0693	.0377
Other Occupations	.5041	.1149	.3389	.0421	.8065	.1001	.0742	.0192
Nonworker	.4068	.0503	.1396	.4033	.2971	.0584	.0804	.5640

officials (excluding agriculture). The third group in our analysis includes all *other occupations*[6] (about 6% of the sample). The fourth group is *nonworkers*[7] (about 4% of the sample).

Due to the multistate nature of career mobility, an increment-decrement life table (IDLT) with multiple destinations is an appropriate method to achieve these goals.[8] The term *decrement* refers to the attrition or out-migration of individuals from each of the four employment statuses. The term *increment* refers to the fact that individuals return to engineering as well as leave it. Hence, our analysis incorporates new additions as well as departures.

Since there are four different destination states, our analysis would be somewhat more complicated than the situation in which there is only one exit route.[9] We calculate a range of useful measures, including the expected number of years in each state, the number of expected moves between states, and the average length of spell in each state. We also present selected results based solely on single decrement life table (SDLT) estimates (that includes all types of exits in a single destination) in order to show the importance of examining both increments (mobility back into engineering) as well as decrements (exits from engineering).

The age (at last birthday) of SSE respondents in the 1972 survey ranged from 18 to 98, and from 17 to 87 in the 1982 SSE. Because of the small sample sizes under age 25 and above age 64 in some of the occupational categories in both panels, we confine our analyses to respondents aged 25–64. Therefore, only truncated IDLTs within this age boundary are presented.

Sample attrition in the SSE panels is significant, and is somewhat higher than in studies such as the *Panel Study of Income Dynamics* and the *National Longitudinal Surveys*. Approximately 70 percent of the 1972 panel remained in the 1978 sample, while only half of the 1982 sample remained in 1989.[10] After presenting the results, we discuss how the problem of attrition affects our interpretations. We begin by presenting results for 1982–1984 and 1972–1974. This enables us to avoid the years with the worst sample attrition.

RESULTS

Career Mobility

Table 2 documents the transition probabilities among four statuses for the 1972–1974 and 1982–1984 periods: engineering, management, other (nonengineering) occupations, and nonworker. Several results are clear from the analysis. First, engineers were a bit more mobile in the 1982–1984 period than in the 1972–1974 period. For a sizable portion of the engineering workforce, employment in engineering is not a static state in which individuals remain without movement for the majority of their working lives, but rather is a dynamic context wherein moves are not uncommon. During the 1982–1984 period, 9.5 percent of engineers moved to management, 8.1 percent moved to nonengineering occupations, and 4.8 percent became nonworkers, compared to 7.6 percent, 5.4 percent, and 2.9 percent, respectively, a decade earlier. The results provide support for the dual ladder hypothesis predicting more movement from technical engineering to management during 1982–1984 than during 1972–1974 [1.1]. They directly contradict the engineering shortage hypothesis of fewer movements from technical engineering to management [2.2]. Further, the downsizing thesis predicting increased rates of out-migration from engineering to other occupations receives support [3.2].

A second striking finding in Table 2 is that persistence in management stayed roughly constant, with just over half of the managers remaining in this status for the 1972–1974 and 1982–1984 periods. Return mobility from management to engineering also remained roughly constant, with approximately one-third of managers returning to engineering. These findings run counter to the dual ladder thesis predicting more return from management to technical engineering in the 1980s than in the 1970s [1.2]. They also challenge the downsizing hypothesis of increased rates of exits from management [3.1]. If restructuring and mergers in the past two decades had indeed resulted in increased exits from management among salaried professionals, we fail to observe this phenomenon in the engineering workforce. The findings of career mobility of managers in the past two decades have both substantive and methodological implications for research on work and organizations.

Substantively, they suggest that management is not a sinecure in our competitive and turbulent economy. Management is not a permanent destination for many engineers. In the language of mobility tables, management is not an absorbing state. Another interpretation is that the line between management and technical work is blurred in engineering, which results in comparable proportions of individuals remaining in management and returning to engineering in the 1970s and 1980s. It is quite possible that many who report the title of "manager" are in fact "project managers," who return to a technical position after the project is completed.

Methodologically, the results imply that we must include return moves from management to engineering in our analysis. Otherwise, as we will see, the working-life expectancy in engineering will be dramatically underestimated. A more systematic exploration of these data with life-table techniques will enable us to examine these changes more carefully.

A third striking feature in Table 2 is that transition probabilities for those in other occupations have increased between the 1970s and 1980s. As noted earlier, persistence in engineering declined. The lower persistence rate resulted from increased moves to all other destinations. However, return movement to engineering from other occupations increased from 50.4 percent during 1972–1974 to 80.7 percent during 1982–1984, a finding that fits the engineering shortage thesis predicting increased rates of return movement from other occupations to engineering

[2.3]. The result reveals more turbulence in the careers of engineers during the 1980s compared to the 1970s.

Working-Life Expectancy for Engineers

Table 3 presents some summary statistics from multiple increment-decrement life table for engineers. What do we learn about the occupational mobility of engineers in recent decades? Did the working-life expectancies of engineers differ between the 1970s and 1980s? During the period 1972–1974, the remaining working-life expectancy at age 25 in engineering, management, other occupations, and nonworkers are 26.93, 4.70, 2.71, and 2.02 years, respectively, with the total equal to 36.36. The percentage distribution of the remaining working-life expectancy is 74.1, 12.9, 7.5, and 5.6, which is also very close to the comparable figures for the 1982–1984 period (75.2, 15.0, 5.8, and 4.0, respectively). Compared to the 1982–1984 results, the remaining working-life expectancy at age 25 in engineering field is almost identical (26.93 to 26.76). This observation runs counter to the engineering shortage hypothesis predicting a longer stay in technical engineering [2.1]. But in management, the expected duration is shorter by one year (4.70 to 5.81) or 19.1 percent. This finding fits the downsizing thesis that engineers were spending less time in management in the 1980s than in the 1970s [3.3]. As a result of waves of consolidation and merger, engineers enjoyed relatively shorter tenures in management.

It is also shorter in nonworkers by 0.32 years (2.02 to 2.34) or 14.5 percent, while it is longer in other occupations by 0.46 years (2.71 to 2.25) or 15.8 percent. Nevertheless, these differences are small. Consequently, the expected percentage of total working-life expectancy (36.36 years spent) in each occupational state (or the occupational distribution of engineering population) is very close to each other—this measure excludes the effect of gain in total working-life expectancy, which is 0.79 years. The pattern of changes across ages is also very similar.

What distinguishes this period from 10 years later is the remaining expected number of moves between various occupational states. The total number of expected number of moves between age 25 and 65 for 1972–1974 is 5.15, while it is 6.84 for 1982–1984, an increase of one-third. Respectively, the remaining expected number of moves at age 25 to engineering, managerial field, other occupations, and nonworker states are 2.07, 1.26, 1.06, and 0.76, all are smaller than those for 1982–1984 (2.90, 1.55, 1.57, and 0.82). The biggest difference occurs in the remaining number of moves to other occupations at age 25, where the change is 48 percent. While this indicates that, compared to 1972–1974, the chance of entering other occupations in 1982–1984 increases by about 50 percent, the chance of moving to engineering also increases by 40 percent (2.90/2.07). These results suggest that engineers were more likely to move back and forth in 1982–1984 than in 1972–1974, although the expected lengths of stay in various occupational states changed little. As a whole, the data suggest that engineers were more

Table 3. Truncated Working Life Expectancy (Aged 25-64) and Expected Number of Occupational Moves of Engineers

Age	(1) WORKING LIFE EXPECTANCY IN (a) Engineering	(b) Management	(c) Other Occupations	(d) Nonworker	(2) EXPECTED PERCENT SPENT IN (a) Engineering	(b) Management	(c) Other Occupations	(d) Nonworker	(3) EXPECTED NUMBER OF ENTRIES TO (a) Engineering	(b) Management	(c) Other Occupations	(d) Nonworker
1 9 7 2 - 7 4:												
25	26.93	4.70	2.71	2.02	74.0	12.9	7.5	5.6	2.07	1.26	1.06	0.76
30	23.34	4.33	2.14	1.91	73.6	13.7	6.7	6.0	1.73	1.08	0.85	0.73
35	19.70	3.77	1.70	1.87	72.9	14.0	6.3	6.9	1.45	0.90	0.70	0.70
40	16.13	3.09	1.35	1.85	71.9	13.8	6.0	8.2	1.19	0.71	0.56	0.68
45	12.60	2.36	1.06	1.86	70.5	13.2	5.9	10.3	0.93	0.55	0.45	0.68
50	9.10	1.66	0.84	1.86	67.6	12.3	6.2	13.8	0.69	0.38	0.35	0.67
55	5.69	0.98	0.59	1.83	62.7	10.7	6.4	20.1	0.45	0.23	0.23	0.63
60	2.49	0.39	0.26	1.55	53.1	8.4	5.6	32.9	0.21	0.09	0.09	0.48
1 9 8 2 - 8 4:												
25	26.76	5.81	2.25	2.34	72.0	15.6	6.1	6.3	2.90	1.55	1.57	0.82
30	23.03	5.56	1.74	2.15	70.9	17.1	5.4	6.6	2.35	1.40	1.23	0.76
35	19.25	4.93	1.48	2.10	69.3	17.8	5.3	7.6	1.99	1.17	1.04	0.73
40	15.67	4.10	1.20	2.07	68.0	17.8	5.2	9.0	1.61	0.93	0.81	0.70
45	12.19	3.20	0.94	2.05	66.3	17.4	5.1	11.2	1.27	0.72	0.62	0.69
50	8.77	2.30	0.71	2.01	63.6	16.7	5.1	14.6	0.95	0.53	0.46	0.66
55	5.44	1.46	0.47	1.92	58.6	15.7	5.0	20.6	0.64	0.35	0.29	0.60
60	2.37	0.65	0.23	1.51	49.9	13.7	4.8	31.7	0.31	0.14	0.14	0.41

mobile in the 1980s than in the 1970s. Additionally, there is indication that engineers are increasingly likely to experience "zig zag" mobility.

The average length per move made at various ages also confirms this assertion. Based on 1972–1974 transition probabilities, the average length of an employment spell is 7.1 years (36.36/5.15), compared to 5.4 years for 1982–1984. The average lengths per spell in engineering, managerial field, other occupations, and nonworker states are 13.0, 3.7, 2.6, and 2.7 years, respectively, compared to 9.3, 3.7, 1.4, and 2.9 years in 1982–1984. We see that both of the spell lengths in engineering and other occupation are significantly longer in 1972–1974 than in 1982–1984, while the other two are pretty much the same.

There is another noteworthy finding. Individuals in 1982–1984 had a slightly greater chance of holding managerial positions. This observation is inconsistent with the assumptions of the downsizing thesis. The percentage of the remaining working-life expectancy spent in management fields in 1982–1984 is consistently greater by 3 to 4 percentage points than in 1972–1974 across all ages.

For the period of 1972–1974, working-life expectancy in engineering fields at age 25 based on single decrement analysis only is 10.72 years. This is only 30 percent of the total based on the increment-decrement model, which implies that 70 percent of remaining working-life expectancy in engineering is "lived" by those who switched back into technical engineering (71% in 1982–1984). This implies that the median length of a spell in engineering is fairly short, as shown in Figure 1.

The median length of a spell in engineering (or management) at various ages for the 1972–1974 and 1982–1984 periods is presented in Figures 1 and 2. Estimated from the single decrement life table, this indicator measures the number of years it will take before half of the engineers will have left engineering at least once (although they may come back later). We see in Figure 1 that it starts at 7.3 years at age 25, reaches a plateau between 8.0 to 8.9 years which last up to age 46, then declines steadily to 2.6 years at age 62 (we cannot calculate further). Compared to 27 years of working-life expectancy at age 25, individual spells in engineering last only one-quarter as long as the total. So while remaining working-life expectancy in engineering accounts for three quarters of the total working-life, engineers are also moving out extensively, although most of them return later. The age pattern of the median length of a spell in engineering is similar to 1982–1984, but the level for 1972–1974 is greater by 1 to 3 years from age 25 to 50, and they do not cross over until after age 61. This difference implies that there was less occupational mobility during 1972–1974 than in the 1982–1984 period. The proportion of moves made to managerial positions also has similar pattern in this period compared to 1982–1984. But in the age range of 30 to 50, nearly 60 percent of moves during the period 1972–1974 were moves into management.

In short, based on the occupational mobility estimates of engineers in two time periods, we identify two emerging career patterns: (1) an increasingly mobile

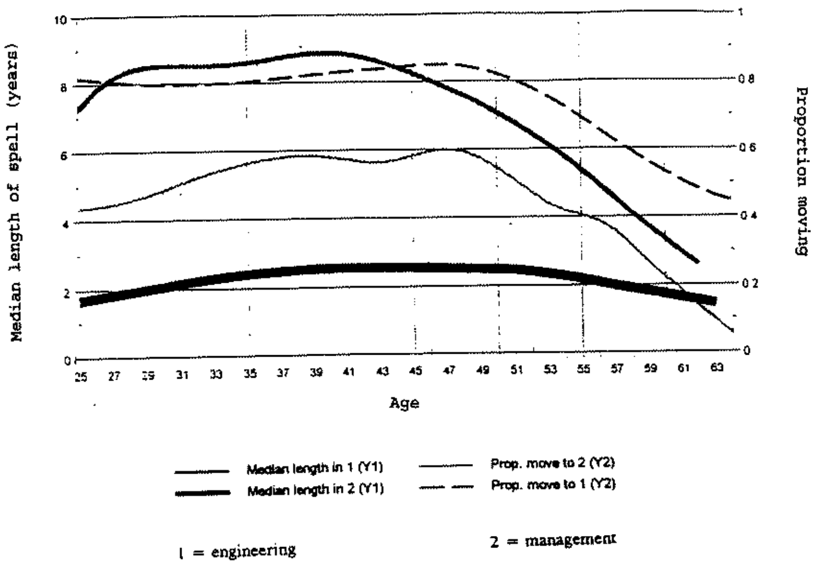

Figure 1. Median Spell Length and Proportion Moving to Engineering or Management, 1972–1974

engineering workforce and (2) the prevalence of zig zag mobility among engineers. After addressing how the problem of attrition affects our interpretations of the results, we discuss the theoretical and research implications of the findings.

Sample Attrition

Thus far, we have analyzed transitions between the first and second waves of the SSE data sets (1972–1974 and 1982–1984). We now investigate the effect of sample attrition on estimates that include all years in the analysis. The results indicate that these two time periods are each representative of their decades. We also found that the first years of these panel studies are most reliable, and subsequent years suffer from biases resulting from sample attrition. Figure 3 shows the remaining working-life expectancies in various occupational states for engineers at age 25. These results confirm that the life-expectancy in engineering was quite similar for these two decades. Thus, using the full data sets confirms the basic results obtained when we examined the first transition period.

There is a troubling result in these data as well: working-life expectancy in engineering declines throughout each decade. This result is obtained for both decades. We see that the working-life expectancy in engineering decreases over

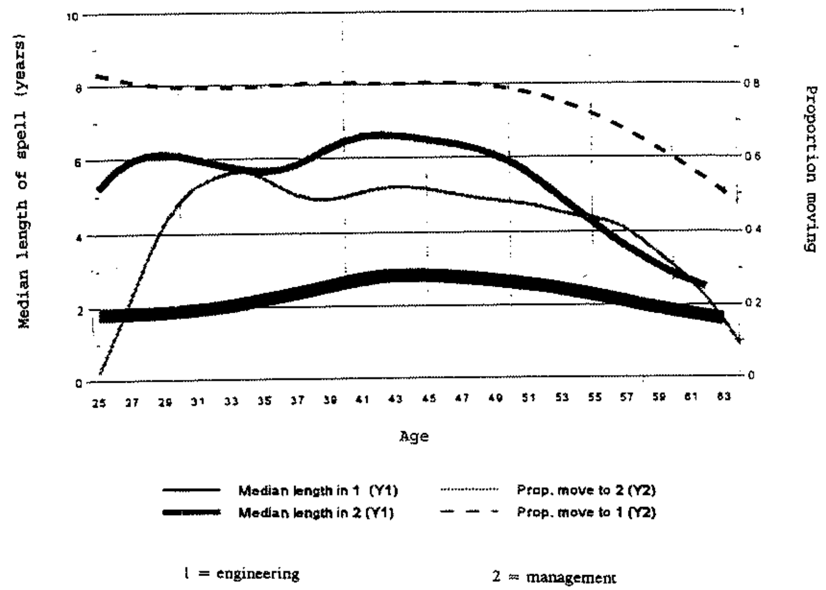

Figure 2. Median Spell Length and Proportion Moving to Engineering or Managment, 1982–1984

the three periods. This result is partly due to the aging of these cohorts. As engineers grow older, more of their time is spent in management, other occupations, and nonemployment. Consequently, this observation should not be viewed as a substantive finding about the engineering profession, but is an artifact of a study design that follows a cohort over time. However, we were also concerned about whether data quality problems could be contributing to this result.

Our principal suspect was sample attrition, which is perhaps the most common and threatening problem with panel data. Both SSE data sets (1972–1978 and 1982–1989) experienced high rates of attrition; this is especially true of the 1982–1989 panel (50 percent attrition). Thus, it is quite possible that the results tells only half of the story of the 1980s. For example, when confronted with downsizing and/or engineering surpluses, younger engineers were less likely to climb the occupational ladder successfully. As a result, they did not report career movements. Further, individuals in engineering or management might have remained in entry-level jobs, and some might have moved out entirely.

To test these propositions, we conducted analysis to determine whether attrition was dependent on age and previous occupation. The results[11] (not shown here) indicate that age is a predictor of attrition: compared to age group 25–29, individ-

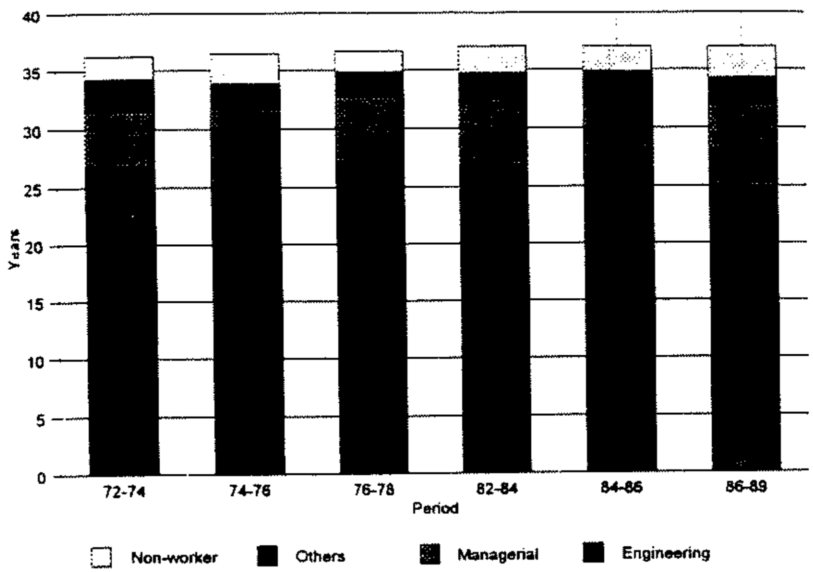

Figure 3. Working Life Expectancy in Various Occupational States at Age 25

uals at higher ages are significantly less likely to drop out. The younger the respondent, the greater the odds of attrition.[12]

Occupation is also a significant predictor of attrition during the 1980s. It becomes a significant predictor of attrition as the 1970s panel matures. However, this finding does not pose a fundamental problem for our analysis, since it would only result in a shift toward a greater share of managers in the sample relative to engineers. By itself it need not bias the estimates of transition probabilities.

However, the most revealing finding is that the population most likely to make a return move into engineering is most likely to be lost in subsequent surveys. Consequently, with each wave of the survey, life expectancy in engineering declines because the extent of return movement into engineering is increasingly understated. In the later waves of the panel, the proportions of remaining working-life expectancies in all states "lived" by returning engineers will decline. The employment status most affected by this is engineering. The reason is that of the 27 years of working-life expectancy in engineering, 70 percent is lived by those who switched back into engineering.

Finally, we found that "movers" (who are defined as those who were not in the same occupational state over the previous surveys) have a significantly higher attrition rate than "stayers" (defined otherwise). This observation suggests that attrition procedure tends to filter out movers rather than stayers, making the sample increasingly less mobile. Hence, this study may underestimate career changes for engineers. As indicated above, respondents who dropped out of the SSE sample might have certain characteristics that set themselves apart from those who remained in the study. Therefore, we can apply our analysis of interdecade mobility patterns and rates only to a certain segment of the engineering population.

DISCUSSIONS

This chapter presents a dynamic, multistate analysis of the career mobility of engineers during the past two decades by estimating a set of increment-decrement life tables. Our analyses focus on periods 1972–1974 and 1982–1984, which represent the level of remaining working-life expectancies in various occupational states studied for each decade. This section discusses the implications of key findings for (1) labor market studies, (2) technical professionals, and (3) public policy making. We conclude the chapter with a brief discussion of methodological issues for future research on career mobility of salaried professionals.

Results of interdecade differences in mobility rates challenge organizational theorists to adopt a more dynamic approach to studying career mobility of salaried professionals. As we have seen, each of three proposed hypotheses receives mixed support. Claims such as dual ladder, engineering shortage, and downsizing cannot fully capture the dynamics of engineering careers. During the past two decades, the career mobility of technical professionals in organizational settings was not entirely driven by market or organizational forces. Instead, we should view the diverse career paths for engineers as an outcome of a convergence of institutional, occupational, and economic forces.

Contrary to the prevailing view shared by researchers on work and occupation, engineering is more than an organizational career. It is true that institutional changes have a strong bearing on career mobility of engineers. However, unlike other professionals, engineers enjoy certain degree of flexibility to adapt to organizational or labor market changes. This proposition is supported by the finding that estimates of working-life expectancy in the four occupational states studied for the two decades have remained fairly constant. Roughly speaking, for an average engineer whose total working-life expectancy is 37 years within the age range 25 to 65 studied, about 75 percent of his or her life is spent in engineering, 15 percent in management, 6 percent in other occupations, and 4 percent in not working.

What do these results mean to technical professionals? The typical career of engineers allows for a great deal of commitment to this occupation. We have seen that very few engineers are drawn into the ranks of management after only a few years. But that does not necessarily mean that engineers have weak organizational commitment. Quite the contrary, further analysis of mobility rates suggests a unique relationship between engineering careers and organizations. An interplay of institutional, occupational, and economic forces does not make engineers more or less dependent on employers or labor market forces. Instead, we argue that these forces might have become an impetus behind the emerging diverse career paths for salaried professionals. This is evident in the differential interdecade mobility rates among engineers.

There was substantially more mobility in the 1980s than in the 1970s. As a whole, the remaining number of moves to each field at age 25 becomes greater in 1980s, from 5.15 to 6.85 times (a one-third increase), while the average spell becomes shorter from 7.06 to 5.42 years (a 23% decline). The one exception to this pattern is the nonworker state, where the expected duration increased. These patterns resemble Jacobs' "revolving door" analysis of women's career mobility into male-dominated fields, although the substantive story here is quite different (Jacobs 1989). In this case, management appears to be a relatively transient state, and the revolving door between engineering and management is moving faster and faster while the levels in each status remain relatively intact. It seems likely that most moves into management are to the position of project manager, a title and status that evaporates rapidly as the project in question is completed.

Further, the analysis suggests that zig-zag mobility among engineers has become increasingly common. The results imply increased rates of "demotion" in the engineering labor markets during recent periods of downsizing. This may be one of the reasons why we observed more movement into management in the past decade. The data also reflect a rather lengthy process of demotion among engineers. Offering monetary incentives to early retirement is one way of reducing the size of the engineering workforce. Expanding the number of steps of promotions out of technical engineering work into temporary managerial assignments may constitute a face-saving, less costly way to downsize the workforce. This gradual approach gives employers the flexibility of streamlining the size of the engineering workforce.

An optimistic reading of these findings is that career paths for engineers have become more diverse. According to the dual ladder approach, engineers traditionally are on the technical *or* managerial track. Our analysis indicates that engineering work should be defined more broadly. Whether one stays on the technical track or moves into management is no longer an either/or option. The findings bolster the assertion that engineering has become the hybrid career (Perlow and Bailyn 1997, pp. 241–243). Increasing numbers of engineers can be expected to move back and forth between technical and managerial work. We believe this may reflect a blurring of lines between management and technical work as hierarchies flatten. For an engineer, career success may be defined as having the capacity to perform all of these roles competently throughout their career.

Finally, the results present good and bad news for policy making. The good news is that engineers still spend most of their career (more than 70%) in the technical fields for which their lengthy education prepares them. The percentage of life spent in nonworker states increased only by

0.7 percentage point at age 25 from 1972–1974 to 1982–1984, suggesting that despite structural changes in the economy, this skilled labor force group is still well utilized.

The bad news is that engineers are being shaken up in the sense that they have to move more frequently among various occupational states to adapt to the new market environment, resulting in an increase in the amount of movement between different occupational states. Although this does not necessarily change the number of years they can expect to remain in various occupational states, it could make engineers feel more uncertain about their job security than before. The results support a pessimistic view of less stability and security in engineering careers. This may be one of the reasons behind a continuous declining interest in engineering among college students.

CONCLUSION

The results point to the complexity of recent trends in the career trajectories of engineers. On the one hand, engineers have borne the brunt of corporate downsizing and restructuring because they have been concentrated in industries (such as military-related production) where these changes were prevalent. However, because of continued growth in demand, their specialized technical skills, and central role in many contemporary organizations, engineers have been and will continue to be a stabilizing workforce. Hence, there is much room for further research on career mobility of technical professionals. First, these results should be replicated during the 1990s, since this was a period of depressed employment opportunities in engineering. Unfortunately, the 1990s SSE panel was canceled due to funding cutbacks.

Second, studies should examine the relationship between industry characteristics and engineers' careers. Previous research has demonstrated the differential impact of industry- or firm-specific characteristics on career progress (Baron, Davis-Blake, and Bielby 1986; Hardy, Hazelrigg, and Quadagno 1996; Kalleberg 1996; Kalleberg, Knoke, Marsden, and Spaeth 1996; Shenhav and Haberfeld 1988). Unfortunately, the SSE data do not include information on specific firm characteristics, which consequently has blocked us from pursuing this line of investigation. It is quite possible that the degree of labor shortage varies across engineering fields. For example, with data on industry characteristics, we might be able to examine variations in the supply and demand of engineers across industries, and then to draw inferences on subfield differentials with regard to personnel shortages in engineering.

Third, future research should attempt to combine the multistate flows documented in this study with more details on individual heterogeneity. Finally, researchers should make special efforts to examine the experiences of successive entering cohorts of engineers. Because the present study is based on a panel design that did not include new entrants during the study period, the results may understate changes experienced by new entry cohorts. It may be that entering cohorts are most vulnerable to the changes in employment opportunities brought about by decreases in military spending and other structural shifts in the economy (e.g., Freeman 1994; Osterman 1996).

NOTES

1. At 1.88 percent, the share of engineers in the U.S. labor force slightly exceeds that in Japan and Germany (1.87% and 1.83%, respectively), while our leads over Britain (1.37%), France (1.13%), and Italy (.30%) are more substantial (National Science Board 1991). Data from the Current Population Survey, which uses a more restrictive definition, indicate a somewhat smaller proportion of the labor force in engineering (about 1.5%), which would leave us trailing Germany and Japan but still ahead of Britain, France, and Italy. For a discussion of definitions of engineers, see Note #3.

2. It should be noted that the 1970's SSE only includes engineers who responded to the 1970 census. Consequently, those who became engineers after 1970 are not included in this panel. Thus, these data do not represent the total engineering personnel in the 1970s. The data structure is similar for the 1980s (U.S. Department of Commerce 1990).

3. There is no consensus concerning the definition of an engineer used by different data collection agencies, such as the Bureau of Labor Statistics (BLS) and the NSF. In the SSE, respondents were defined as "engineers" if they met two of the following three "in-scope" criteria: (1) a minimum of two years of college education; (2) self-reported employment in an engineering occupation defined by NSF; and/or (3) professional identification as an engineer based on education and/or work experience. This definition is broader and more useful for understanding the nature and the scope of occupational mobility of engineering personnel than that employed by the BLS, which excludes sales engineers, engineering teachers, and individuals trained or educated in engineering who work in nonengineering fields or in management. The definitions of engineer for these two panel data are consistent over each of these SSE studies (U.S. Department of Commerce 1990).

4. Engineers in the SSE data include college professors and instructors, and engineers in the following fields: aeronautical, aerospace, astronautical, agricultural, chemical, civil or architectural, computer, electrical or electronic, environmental or sanitary, industrial, marine or naval architectural, metallurgical or material, mining or geological, nuclear, petroleum, sales, systems, and some other residual categories.

5. This group includes administrators, managers, or officials of production and operations, of scientific and technical research and development, and of others (excluding self-employed); college presidents or deans; self-employed proprietors; and urban and regional planners.

6. This residual category was defined as all employed individuals who did not fall into engineering or management employment as defined above.

7. This group is defined as including both the unemployed or those not in the labor force. Since so few engineers were unemployed or out of the labor force, we combined these two categories into one destination. We did so because age-specific transition matrices were so sparse when both states were included, which made calculations of stable estimates difficult.

8. Although the so-called working-life table has been in common use for many countries since the early 1980s, this method has been usually applied to the general or elderly labor force with only two intercommunicating states (active and inactive economically) and an absorbing state (death). Sometimes such tables have also been broken down by education, race, and gender (e.g., Land, Guralnik, and Blazer 1994; Schoen and Woodrow 1980; Smith 1982, 1986). No effort thus far has been made to estimate the working-life tables for an individual occupation based on the IDLT methodology.

9. We calculated the transition probabilities between these states for five-year age groups, starting with 25–29 and ending with 60–64. We converted the two-year transition data into single-year transition probabilities. Then, we projected the career patterns that would hold if the observed transition probabilities were to persist over the entire course of engineers' careers. This means that summarizing a set of transition probabilities is useful for assessing change over time, and is similar to the assumption made in the calculation of many demographic measures. For example, estimates of life expectancy assume that current age-specific mortality patterns will hold over the entire course of an individual's life. In the same way, we assumed that the observed transition probabilities remain fixed over time.

10. Mortality also plays a role in the attrition, and it varies widely across ages. Based on the corresponding mortality schedules weighted by sample gender composition, the probability of death for engineers age 25 in 1972 is .0042 within two years, and it is .0038 for engineers age 25 in 1982. This probability for engineers age 65 is .0636 in 1972 and .0483 in 1982. But, as a whole, mortality effect claims for only about 1.3 percent of the sample aged 25–64 for each two-year period. This is rather trivial compared to the total attrition proportions.

11. Results from logistic regression model of attrition for the 1970s and 1980s are available from the authors.

12. This result occurs despite the countervailing mortality effect, because mortality is treated as attrition, and the mortality level increases with age. If the mortality is disentangled from dropping out due to other reason, the age effect on attrition will be even greater. This effect tends to make the age structure of the sample older. However, such effect may have little impact on our estimates because they are based on age-specific transition probability, which eliminates age composition effect.

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UNUSUAL OCCUPATIONS

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