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STOCHASTIC ANALYSIS OF AIR FORCE MANPOWER: A RESEARCH PROSPECTUS

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AIR FORCE SYSTEMS COMMAND
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This technical report has been reviewed and is approved for publication.

RAYMOND E. CHRISTAL, Technical Director
Occupation and Manpower Research Division

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This report describes an approach to analyzing the military/civilian manpower markets and their interface which explicitly includes stochastic elements and characterizes their impact on military manpower supply.

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PREFACE

The work reported in this study was funded by the Air Force Office of Scientific Research. The objective was to formulate a suitable theoretical structure for the study of the relationship between the national labor market and the internal labor market of the Air Force personnel system. Management of this effort was under the Scientific Services Program and administered by the Battelle Columbus Laboratories. Dr. Arthur S. De Vany was the principal investigator and Captain Jon Knight served as the Contracting Officer's Technical Representative.

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I. INTRODUCTION

The prospect of an all-volunteer force prompted an outpouring of research on the relation between military pay, recruiting effort, general business conditions, and the accession and retention rates of the various military services. This research effort was further escalated when the all-volunteer force became a reality in 1973. The results of these efforts and subsequent experience with the all-volunteer force have improved our understanding of the economic factors which influence the attractiveness of the military as a career choice. In particular, considerable work has been directed toward understanding the impact upon retention of various bonus options for enlisted personnel and continuation pay for officers at selected career decision points. As a result, there is a better understanding of the impact of relative wages on the attractiveness of the military as a career choice. This understanding is far from complete, however, and experience with the voluntary force has highlighted the importance of many factors other than relative wages as determinants of the accession and retention rates of the armed forces and has made apparent some difficulties in maintaining a voluntary armed force that were not anticipated in this earlier research. Further, experience has underlined the importance of imperfect information and uncertainty as decisive factors in shaping career choices, as well as the manpower management policies of the Armed Forces.

Decisions made on both sides of the labor market are characterized by uncertainty and incomplete information. Prospective enlistees do not know their civilian and military employment options perfectly and search to acquire knowledge. The military services, on the other hand, do not know the precise supply of applicants that will present themselves at any given time nor how their qualifications will be distributed. As a consequence, there is search and information-gathering activity on both sides of the market and uncertainty is a central element of the military manpower market.

These elements have not been given proper attention in the literature on military manpower. Ad hoc attempts to include the unemployment rate in military manpower supply functions comprises the bulk of the attention given to uncertainty, and this work has generally lacked a sound theoretical underpinning. Yet it is clear that the central empirical features of the military manpower scene cannot be explained except by models that accord a central role to uncertainty. The traditional certainty approach cannot explain fluctuations in accessions, retentions or strength levels, it cannot explain lateral career conversions within the military, changing "critical" skill areas or varying retention experience. There is no role for recruiting that can be explicated within the certainty framework. Career choices made in the certainty framework are generally irreversible; for example, an electronics specialist would never leave the Air Force because all changes in his civilian employment opportunities are assumed to have been anticipated at the time of the enlistment decision and, therefore, have no effect (ignoring those who choose military training for civilian careers). Yet, it is known that retention experience is influenced by the opportunities afforded in the civilian labor market, and that these opportunities change, often in ways that could not have been anticipated.

It is the purpose of this report to suggest an approach to the analysis of military manpower problems which explicitly considers the uncertainty and imperfect information which characterize the labor market in general and the interface between the civilian and military manpower markets in particular. The discussion largely concerns the problem of Air Force enlisted personnel although the approaches and issues readily generalize to other personnel or services. This report is the result of a small-scale effort, and for the most part, is a personal view which resulted from a relatively brief review of the issues. The following sections discuss the theoretical issues involved in incorporating uncertainty into military manpower analysis (Section II), some of the major empirical problems with civilian and military variables for estimation of an operational model (Section III) and some conclusions (Section IV).

II. BASIC CONSIDERATIONS

The objectives of the research shape the theory. Here, the objectives are to explain the supply of enlisted men to the Air Force. Basically, all points of entry and exit to the Air Force are pertinent and the supply features to be modeled are the steady-state quantities of manpower in certain specialties by years of experience. This is a "stock" concept of supply in the sense that the inventory of personnel in specific categories is the variable of interest. Flows through the system are of interest because of their influence on the manpower inventories in the given categories. While the traditional work on military manpower has split accession and retention into separate fields of study, a "stock" view of the problem, such as taken here, must treat these issues together in a simultaneous framework. In addition, the manpower stock point of view must also explicitly reat the internal Air Force labor market because ateral conversion of specialties within the Air Force is possible and, more importantly, the inventory of active personnel between assignments is generally positive.

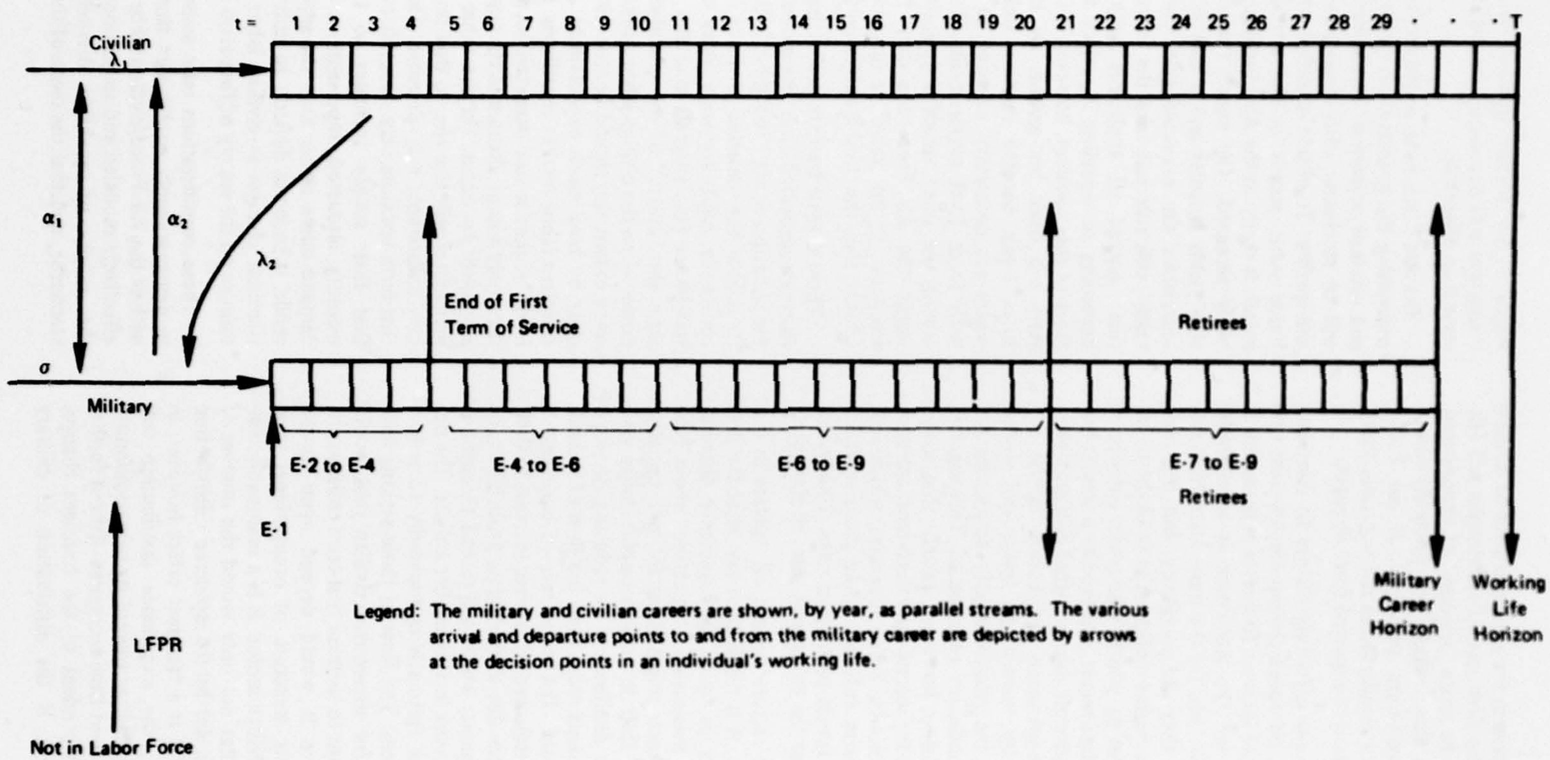
To gain an overall picture of the problem, consider Figure 1. In period zero, suppose a job seeker considers an Air Force or civilian career. Based upon considerations developed below, some proportion of employment seekers enter the Air Force, another the civilian work force, and some proportion withdraw from search for employment in favor of school or other nonlabor force activities. Each period brings a new flow of employment seekers and both the total number as well as the proportions choosing different careers will fluctuate.

Over a suitably large number of trials, if all else remains the same, transient effects will be eliminated and the various supply flows will be approximated by their mean rates. Successive cohorts will enter either military or civilian careers and will "age" in them. In either career, job holders remain active processors of information and, as formalized below, they use a statistical decision rule which tells them to switch careers whenever the current wage earned falls below their reservation wage, which equals the expected gain of seeking employment in an alternative career, net of search costs.[1] Some civilians will find that their wage falls below the reservation wage at which they would switch to the Air Force and will seek an Air Force career even though they have several years of civilian experience. Of course, their reservation wage rises with experience and first-term enlistments of experienced civilian workers become less likely the longer they remain in a nonmilitary occupation. Likewise, workers in the Air Force adopt a reservation wage based on the expected gains of seeking civilian employment and this reservation wage is such that whenever the current Air Force wage exceeds it, the worker remains in the Air Force. Fluctuations in civilian opportunities or rate of progress in the Air Force can affect supply decisions at any time during the career.

The time-path of a cohort of Air Force personnel can be described as a Markov process. The probability of progressing from the i to the $i+1$ year in the Air Force, where the $i+1$ year is a reenlistment decision, is the probability that the wage in year $i+1$ exceeds the reservation wage; this minimum supply price characterizes the expected gains of searching for civilian employment. This probability reflects the proportion in the cohort whose present wage exceeds their reservation wage. Each member of the cohort will use his rate of progress in the Air Force to revise his expectations regarding his lifetime earnings stream in both the Air Force and in civilian employment. For some, a slower than expected progression will cause the value of the Air Force alternative to fall below the expected value of the civilian alternative and they will leave. Others will use their experience to revise their entire career earnings projections downward and they may revise their civilian alternatives downward by even more than their Air Force alternatives and, therefore, elect to remain in the Air Force in spite of disappointed expectations. The crux of the issue is that early work experience provides evidence to revise expectations of earnings ability upward or downward. It is quite possible that some individuals who receive rapid promotion in the Air Force are more apt to leave the Air Force rather than stay if this leads them to also revise their estimated civilian opportunities upward.

Changes in civilian employment opportunities (which are recognized as permanent shifts) also cause revisions in the expected gains of searching for civilian jobs. The temporary fluctuations should not bring about more than minor revisions in the reservation wage the Air Force must meet to retain personnel. Furthermore, changes in the civilian labor market will exert a stronger effect on younger Air Force personnel and first-term enlistees than on more experienced personnel. Given

[1] In the simplest formulation of the reservation wage property, the job searcher is assumed to know the distribution of wage offers which his skills can command in the labor market. In each time period, one draw is made from the offer distribution. The amount of search undertaken depends entirely on the parameters of the wage distribution and the pecuniary and opportunity costs of canvassing potential employers. Relatively high search costs and low expected wage offers will limit the period of unemployment. Individuals with highly valued skills can afford to reject offers which fall below expectations and to search more extensively. For an excellent review see Lippman and McCall (1976).



Legend: The military and civilian careers are shown, by year, as parallel streams. The various arrival and departure points to and from the military career are depicted by arrows at the decision points in an individual's working life.

Figure 1. **Flows and inventories of man-years over military career horizon.**

an upward revision in the expected gains of civilian employment, the flow rate of enlistments will fall and there will be more "leakage" of experienced personnel, but that leakage will primarily affect first- and second-term personnel. If Air Force wages or quality standards are not adjusted, there will be a reduction in expected force strength.

There are some offsetting factors to consider, however. First, improved civilian employment opportunities could increase first-term enlistments if enlistees now see the Air Force as a relatively better means to train for the more attractive civilian jobs than they did previously. But this possible avenue to higher enlistments is likely to be more than offset by youths who prefer entry-level jobs in the civilian sector, matched by a similar fall in second enlistments due to higher civilian wages. Whether the experience distribution in the Air Force would tip toward the lower end would depend upon the relative supply elasticities for first- and second-term enlistments. This suggests another possibility however, namely that lower retention rates for second- and third-term enlistees create additional Air Force vacancies, which prospective first-term enlistees could perceive as increasing their future promotion rates. This would tend to increase the enlistment rate, all else equal.

Since these factors do not all operate in the same direction, it is difficult to say what the precise effect may be upon the experience distribution, but a reasonable conjecture about the sequence of events might be as follows: initially, the rightward shift in civilian opportunities ages the experience distribution by reducing the flow of new enlistments more than the flow of second-term enlistments. The lower rate of experienced enlistments is followed by a small increase in first-term enlistments due to the higher probabilities of early advancement, which will prevail throughout the careers of men in this smaller cohort. The net effect of these factors is undoubtedly to reduce total enlistments. The flow of those seeking military training for subsequent civilian jobs would not be sufficient to increase first-term enlistments, especially since it would depend upon special "twists" in the structure of occupational wage rates in the civilian sector. It is a reasonable conjecture then that not only would the number of personnel fall but also that the experience distribution would age. This is a transient effect however. In the long run, the experience distribution will asymptotically decline toward its new equilibrium which, if sufficient time transpires without further shocks, is independent of the transient changes which occurred. If the distribution of military wages is not revised upward however, military manpower will necessarily be smaller in the steady state than otherwise.

The Air Force as an employer faces uncertainty concerning the quantity and quality of applicants and retained personnel. The stream of applicants will be stochastic with respect to both quantity and quality. To obtain qualified personnel the Air Force must search in the arrival stream. This search is costly to the Air Force, and to the people being screened. The search for quality enlistees also yields benefits and a rule is devised which maximizes the expected gain from search. Formally, this rule can take the form of a stopping rule: Accept all applicants with qualifications exceeding or equaling X, reject all others. One facet of this problem, however, is that if qualifications are fixed but arrivals are stochastic, then force levels become random unless Air Force wages are constantly adjusted to equate supply with force level requirements. In other words, among the three variables—quantity, quality and wages—the Air Force has only two degrees of freedom: if the value of any two variables is chosen, then the third is determined.

There is little harm in permitting force levels to fluctuate provided that the system is stable and the variation is not "too great." The alternative is to reduce the variation in force levels by either constantly adjusting wage rates or qualification standards. This suggests that the Air Force can skim the "cream" of the qualified pool of manpower when the civilian labor market is soft and to some extent this should be true. However, it is not clear by how much expectations are affected by transient labor market conditions. If a soft civilian labor market is not expected to persist for long, then only minor changes in the supply of enlistees are likely to occur. On the other hand, reenlistment rates will also rise, so that the desired rate of new enlistments may decrease. Thus, demand for first-term enlistees may diminish at the same time that their supply increases so that the actual quantity inducted represents a point on the demand curve rather than the supply curve. As a result, it becomes difficult to isolate the effect of transient changes in civilian labor market opportunities on the supply of first-term enlistees.

These considerations raise some general issues in demand/supply equilibrium that must be dealt with if the Air Force/civilian labor market is to be effectively modeled and understood. Suppose that the supply of qualified first-term enlistees is stochastic, and that the mean of the distribution is a positive function of the Air Force wage. One of these distributions is illustrated in Figure 2 at wage w_0. Given that the Air Force offers w_0, the monthly supply of enlistees will fluctuate randomly with probabilities illustrated by the distribution f(x). If the Air Force has an upper limit on its force structure which it may not exceed, this will limit the maximum number of enlistees it may accept in any month, *ceteris paribus*. Say that level is E^{max}. This limit placed an upper bound on the system and truncates the supply distribution from the right. Then the effective supply distribution is the left-hand portion of f(x) with mean $\bar{E} = \int_0^{E^{max}} xf(x)dx + E^{max} \int_{E^{max}}^{x} f(x)dx$. Obviously, $\bar{E} < E^{max}$, and the mean induction rate is less than the mean supply rate of enlistees, $\hat{E}$, unless E^{max} lies wholly to the right of the upper limit of the supply distribution, in which case $\bar{E} = \hat{E}$. Thus the observed mean induction rate does not estimate the mean supply rate because of the bias imparted by the limit E^{max} relative to $\hat{E}$. As an example, we can assert that this bias is larger for the Air Force than the Army.

In addition to an upper limit which is maintained because of congressional year-end strength limitations, there may also be a lower limit imposed by the Air Force national defense requirement. Certainly at the level of the local recruiting office the dominant constraint to meet the quota is of this form. But the supply distribution can only be truncated from above by refusing applicants; it cannot be truncated from below in the absence of a draft (at least, if wages and quality standards are fixed). If the Air Force personnel structure is to walk a narrow line, then E^{max} and E^{min} will contain a narrow band. To reduce the probability that enlistments fall below E^{min} the supply distribution must lie further to the right, which implies that a higher wage must be offered and also implies that a larger proportion of qualified applicants must be rejected on average. Such a situation is illustrated in Figure 3. The supply curve indicates the mean of the supply distribution as a function of the wage offered. In order to contain enlistments within the E^{max} E^{min} band with high probability, the wage offer must be high enough to shift the supply distribution to the right. This implies a high rejection rate with mean enlistments lying between E^{max} and E^{min}, but far below the mean of the supply distribution.

Conventional supply analysis done in a certainty framework is incapable of handling these problems. If upper and lower limits are not placed on E, then a mean enlistment rate equal to that achieved with the high wage and high rejection case could be achieved at a lower wage, w_1, in Figure 3. Clearly, there is a trade-off between cost and the variance of the enlistment rate for any given mean enlistment rate, and the cost of walking a narrow line on force structure may be very high.

Several additional considerations also apply. The arrival distribution may not remain in its initial position because the rejection rate reduces the expected gain of searching and testing for the Air Force as a prospective employer. That is, higher expected rejection rates shift the arrival distribution to the left. Furthermore, rejection is selective in terms of qualifications and this would influence the skill distribution of applicants by shifting it toward higher qualifications since fewer of those with lower qualifications will receive offers. Nonetheless, if a minimum enlistment rate is to be met with high probability, then the standards must be flexible enough to accommodate months when few applicants present themselves. If Air Force wages are raised within this regime, with no change in E^{max} or E^{min}, mean enlistments will move closer to E^{max}, the rejection rate will rise, enlistments will fall below E^{min} less often, and the mean qualifications of Air Force personnel will rise. There will be unfilled vacancies on average in the sense that E^{max} could be hired if they present themselves, but fewer than that number will show up in most months, and in some months fewer than E^{min} apply for induction.

Another factor to consider is that it may be possible to hoard or inventory qualified applicants, that is, carry them over to later months when their enlistments are accepted. In this manner variations in the application rate of enlistees may be smoothed over time, reducing effective dispersion in f(x). This practice, however, requires that the potential enlistee be willing to wait to begin his tour. Waiting has its costs and these opportunity costs limit the number willing to wait for later induction as well as limiting the length of wait. Of course, the higher expected earnings are in the Air Force relative to civilian earnings the longer qualified applicants are willing to wait to begin service. There will be times when the queue of enlistees is so long that the wait becomes intolerable to later applicants and they go on to search further. (It is notable that the individuals in the queue awaiting induction are counted among the unemployed, in addition to active searchers who continue looking for employment.) Thus, the ability of accession smoothing to dampen monthly variations in enlistments depends on the willingness of applicants to

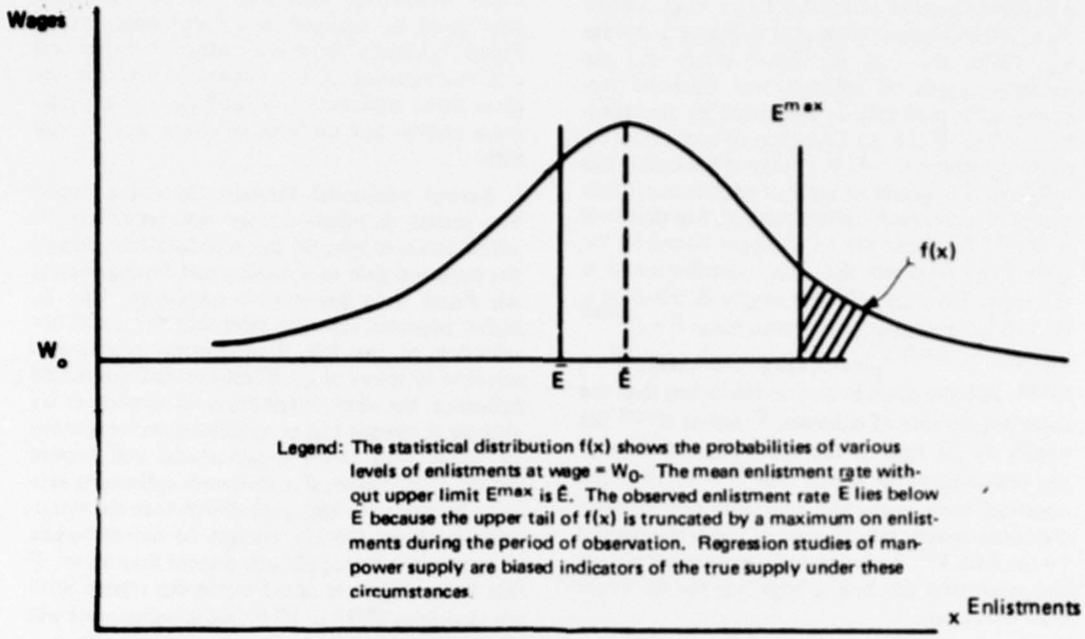


Figure 2. **Random enlistments with an upper limit.**

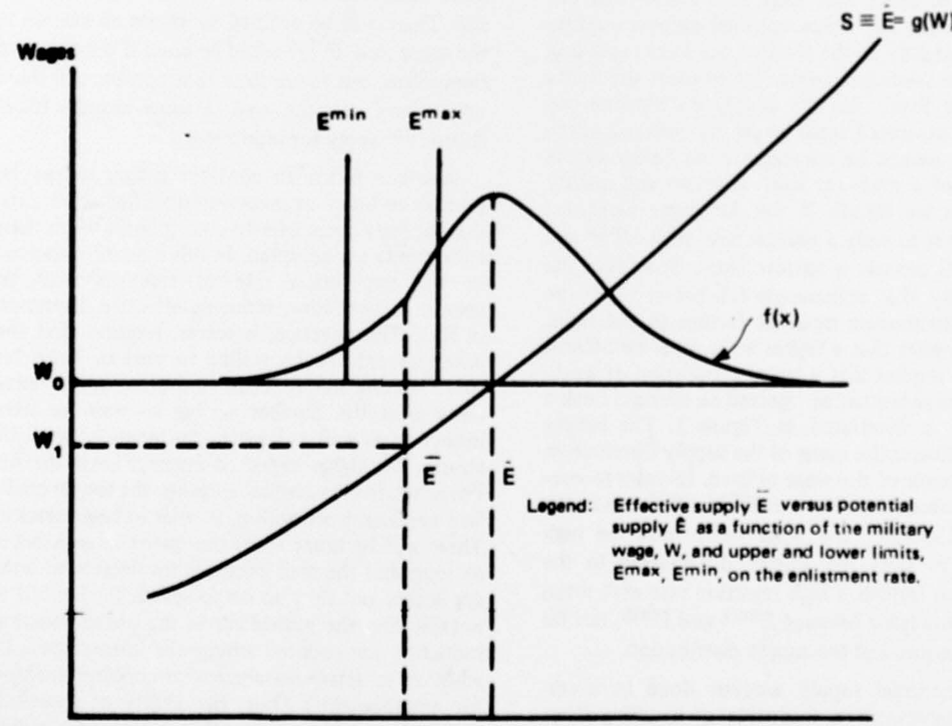


Figure 3. **Random enlistments with upper and lower bounds.**

wait for induction.

The discussion to this point has emphasized the supply side of the military manpower market, but the stochastic approach allows for the joint determination of observed enlistments by demand and supply. Given the stochastic nature of the market, observed enlistments fluctuate and may be either points on the supply curve or the demand curve, depending on the draw for that observation. According to this approach, studies of enlistments or retention must accord equal importance to the demand and supply sides of the market.

A natural approach to the demand side is an inventory theoretic extension of the demand policies already discussed. Manpower inventory targets can be specified in terms of means, lower bounds, upper bounds, or other parameters of distributions. With randomness in the system it is impossible to maintain manpower inventories at precise levels each period, but policies can be devised which limit random variations or specify the nature and parameters of the underlying distributions in the manner illustrated in Figure 3. This would require that optimal values of E^{max}, E^{min} and $\bar{E}$ be determined along with the wage and qualifications standards that are consistent with those values. On the other hand, during periods when demand exceeds supply the reservation quality must be lowered if strength is to be maintained (at given wages). The queue on the supply side results in potential employees waiting for jobs and such waits will affect the arrival distribution; a phenomenon known as "balking" in the queueing literature.[2] Thus, the existence of queues will affect the level of search and ultimately the equilibrium arrival rate of searchers.

III. EMPIRICAL ISSUES: MILITARY AND CIVILIAN DATA

In order to develop a general model which can explain the age and skill distribution of the enlisted force, it is necessary to estimate parameters which describe the search behavior of both employers and potential employees. Two phases of military service are of special importance: the initial enlistment point and subsequent periods in which retention decisions are made. Individuals initially entering the labor force invest resources in obtaining information about wage offers and job opportunities in a variety of occupations. The decision to accept employment involves both choice of occupation and whether to pursue that career in either a military or civilian context. In subsequent time periods, employees may revise their initial decision by either continuing their present career, switching career paths (from military to civilian or the reverse), or dropping out of the labor force entirely. Military data requirements fall into six categories within this general framework: enlistment data, inventories, retention data, individual characteristics, civilian wages, and unemployment rates.

A. *Enlistment Data*—The individuals who are potential military employees are a subset of the total civilian, noninstitutionalized population. Age, health, education, and test-score; e.g., the Armed Forces Qualification Test (AFQT) or the Armed Services Vocational Aptitude Battery (ASVAB) requirements disqualify some proportion of labor force participants from employment in the military sector. As a consequence, recruiting resources are generally allocated on the basis of estimates of qualified military available (QMA) in particular geographic areas.

The relevant pool from which military employees are drawn is the number of individuals in the civilian, noninstitutionalized population between the ages of primarily 17 to 21 years. Labor force participation rates (LFPR) of this group, which depend on parameters such as the absolute level of wages and nonlabor income, can be taken as given or incorporated into the model as an endogenous variable. Once individuals enter the labor force, they search over potential employers and must decide whether to accept a job in either the military or civilian sectors. Let σ be the main arrival rate of searchers at military employers and λ_1 the mean arrival rate for searchers in the civilian sector, as in Figure 1. *The parameters σ and λ_1 refer only to the flow of individuals with no significant previous employment.* When supply exceeds demand, queues of job applicants form in both the civilian and military sectors. The lengths of these queues depend primarily on arrival rates and the rate at which applicants are processed through pre-employment screening and placed into jobs. The time which individuals must spend waiting in the queues in turn induces other behavior such as balking (refusing to join the queue), jockeying (switching queues), and reneging (leaving the queue after already having begun processing). Let α_1 be the mean rate at which individuals leave or refuse to join the civilian queue because of these considerations and α_2 be the mean rate at which individuals leave or refuse to join the military queue. Searchers may also

[2] Some potential employees, perceiving the expected wait to be intolerable, "balk" by refusing to join the queue.

arrive at military employers because they have either quit or been fired from a civilian job. λ_2 represents the mean arrival rate of individuals with previous (full-time) civilian job experience in Figure 1.

In past studies of the interaction between the military services and the civilian sector, regression equations of the following general form have been estimated:

$$\frac{E}{QMA} = f(\frac{W_m}{W_c}, U, R, Z) + v \quad (1)$$

where E = volunteer enlistments (first-term), QMA = population of qualified military availables, U = unemployment rate, R = recruiting resources spent by the military, Z = miscellaneous control variables, W_m, W_c = military or civilian wage, and v = error term.

The dependent variable has usually been specified as the enlistment rate rather than enlistments because it must be standardized for differences in the pool of potential enlistees over time or across states. Early studies such as Fisher (1969) used the Current Population Reports (CPR)[3] annual estimate of the population of male civilians, ages 17 to 20. Quarterly observations were obtained by linear interpolation and his time series ran from 1957 III to 1965 IV.

Subsequent studies have usually adjusted the data on the population of male civilians obtained from the Bureau of the Census in various ways to reduce it to a smaller number which is supposed to measure the pool of potential enlistees that are qualified. Hause (1973) specified QMA as the entire 18- to 19-year-old male civilian population not enrolled in school in October on a quarterly basis from 1957 to 1963. In other words, Hause deflated the population base by removing the males who were enrolled in school, although no statistical source was cited for data on school enrollments.

More ambitious adjustments are now common. Bennett, Haber, and Kinn (1972) obtained preliminary data from the 1970 Census of Population to measure the male population but then used unpublished data from the Office of the Surgeon General to construct a ratio of military examinees found acceptable for induction to the total number examined. This proportion times the total male population ages 17 to 21 defined the number of QMAs.[4] A more recent example of estimated QMAs is Goldberg (1975). The data for calender 1973 by state and QMAs were defined as 17 to 21-year-old residents in Mental groups I through IV who were high school graduates not enrolled in school. He argued that relatively few college students enlist in the services and should, therefore, be eliminated from the pool. The basic source was the CPS and the percent of civilian males ages 17 to 21 enrolled in college and other post-secondary schools was obtained from the *Digest of Educational Statistics*, 1973.

Abellera (1976) derived detailed projections of QMAs age 18 for the period 1976–1985. He relied upon Burueau of the Census projections for the population base, which have proved relatively accurate in the past because they simply "age" the current population of 8-year-olds by expected mortality experience over the next 10 years and expected net migration to arrive at the future stock of 18-year-olds. A number of subtractions were performed to arrive at QMAs. Recent census figures on school enrollment were used to project the proportion of youths continuing their education beyond high school. Youths with civilian employment were also subtracted. They were estimated from U.S. Department of Labor (1975) data. Also subtracted were youths currently in the military service (about 2.0 percent) and an estimated 1.5 percent of 18-year-olds who are institutionalized in any year. These four subtractions reduced the number of QMAs to 14 percent of the initial pool. Slightly more than one-half of this available pool applied for enlistment from FY 1972 to FY 1974.

The most extensive attempt to estimate QMAs is currently being done by General Research Corporation (1975). They claimed to have acquired the Public Use Sample of the decennial census and intend to update (age) it on an annual basis. Adjustments would be done to account for mortality, geographic migration, education, veterans, in-service, institutionalized, and use of DOD rejection/acceptance rates to arrive at an annual QMA profile.

Obviously, the CPS has provided the popular means for estimation of the initial pool of male youths. It is available for an extensive time period and is detailed with respect to location. It can also be checked for consistency with the decennial census. The difficulties involve reducing the initial pool to an estimate of the smaller pool of QMAs. This is not a trivial issue because the magnitude of QMA affects the absolute size of the coefficients in the linear regression by a constant factor. To show this, suppose that the true number of QMAs were less than the measured number:

[3] Now known as the Current Population Survey (CPS).

[4] This study also estimated the QMAs for each mental group by a similar procedure; that is, the ratio of the number of acceptables in mental group i to the total number of acceptables formed a proportion which could be multiplied by the number of military available.

$$\frac{E}{QMA^*} \equiv \frac{E}{\lambda QMA} \qquad (2)$$

where QMA* is the "true" pool of QMAs, QMA is the measured number of QMAs, and λ is a constant, $0 < \lambda < 1$.

The empirical dependent variable is $\frac{E}{QMA}$ which equals $\lambda E/QMA^*$. Substituting the last expression into a linear version of equation (1) and dividing through by λ we have

$$\frac{E}{QMA^*} = \frac{1}{\lambda} b_0 + \frac{1}{\lambda} b_1 \left(\frac{W_m}{W_c}\right) + \frac{1}{\lambda} b_2 U \frac{1}{\lambda} b_3 R + \frac{1}{\lambda} b_4 Z + \frac{1}{\lambda} v \qquad (3)$$

The true coefficients are a multiple ($\frac{1}{\lambda} > 1$) of the estimated coefficients.

Estimating the true number of QMAs is relatively difficult however. For example, use of DOD rejection/acceptance rates to measure the proportion of physically and mentally unfit in the pool may not provide accurate estimates because military applicants are not a random sample from the population. In terms of estimating the proportion of youths who are physically unqualified over time or across states, it would seem to be a wise policy to check DOD rejection rates for correlation with other civilian health and mortality indexes.

The distribution of QMAs by other characteristics is accomplished relatively easily although difficulties might occur in terms of estimating the many joint distributions which are generated as the number of variables increases. The educational distribution of male youths is widely available in Census Bureau and Health, Education and Welfare publications. Distributions by sex, race, and age are also abundantly available from the Census Bureau and the Bureau of Labor Statistics (BLS). The distribution by test scores, at least among applicants and draftees, should be available from DOD sources. Existing studies assumed that the distribution of mental abilities has remained relatively stable over time. This is consistent with the empirical research which has shown that the fear of a decline in national intelligence due to dysgenic selection pressures was unfounded (Carter, 1966; Gottesman, 1968). However, if cross-sectional data are used, an adjustment for test score distributions might be included because intelligence quotient (IQ) (and presumably test score) distributions are significantly lower in southern states.

In the final analysis though, adjustments of population figures to arrive at estimates of the number of individuals who are deemed qualified for military service are inherently arbitrary. Moreover, the elimination of various categories of labor imposes demand-related requirements in an area which is more properly treated under the topic of supply. If quality is to be used productively as a policy tool (in addition to quantity and wage rates), then *a priori* adjustments for the pool of potential enlistees should properly be kept to a minimum.

Given the resource pool, the number of contacts which are made by recruiters yields estimates of the mean arrival rate of job searchers in the military sector. Enlistment rates provide information on the number of job acceptors and allow us to infer the rate at which individuals balk or renege with respect to the queue in the military sector. The rate of job acceptance (enlistment) in the military depends on the relative present values of civilian and military income streams. Currently about 13 percent of all applicants are disqualified for failure to meet physical standards and 13 percent of applicants are disqualified by the mental and educational standards. In FY 1964, there were 161,000 enlistment applicants but only 100,000 accessions (because the applicant did not meet standards or decided not to accept a military contract). An estimated 12.5 percent of all qualified applicants in FY 1974 rejected service enlistment offers, according to Abellera (1976).

With respect to the related issue of the quality composition of enlistments, Abellera (1976) found that the AFQT distribution of applicants does not tend to shift as the labor market conditions change. This seems to be an unsettled issue, however. For example, Lightman (1975) found that sensitivity to the state of the civilian economy was greatest for the Canadian Air Force, the service branch with the highest average quality of applicants. The U.S. studies summarized by Grissmer, Amey, and Arma (1974) did not show any strong tendency for Air Force enlistments to be especially sensitive. Another point is that Hause (1973) warned that a new AFQT test introduced in late summer 1960 apparently shifted class boundaries between mental categories by an unknown amount.

B. *Inventories*—The overall objective is to obtain estimates of the stock of enlisted personnel available by pay grade and length of service. This information can be generated from the uniform airman record (UAR) on a semiannual basis. Inventories should be developed for each primary Air Force specialty code (PAFSC) and for the total enlisted force. Two sets of inventories should be generated: one based on total active federal military service date (TAFMSD) and one based on pay date.

C. *Retention Data*—After individuals have begun their military careers, the services experience losses in manpower, particularly at the end of the first enlistment (generally after four years of service, but this may vary from two to six years). Losses can be placed into two categories: quits or fires. Individuals again compare the relative present values of continuing their military career (reenlisting) or switching to the civilian sector. Losses also occur because the services may "fire" individuals by either declaring them not eligible to reenlist or by discharging them under less than honorable conditions. Finally, actuarial losses occur because of death or disability. The Air Force may also experience some gains in manpower from broken-service reenlistments.

After twenty years of service, most individuals retire from the military, although some enlisted personnel remain for up to thirty years. Retirees may either enter second careers in the civilian sector or drop out of the labor force entirely.

The age and skill distribution of the enlisted force is determined by the factors which influence the quality and quantity of enlistees and reenlistees. Each year of service in an enlisted career can be viewed as a step in a serial queue. The present value of each individual's military income stream is jointly determined by existing wage structures and the conditional probabilities P_{ijt}, where the notation refers to the probability that the *i th* individual is in pay grade E_j at time t (j = 1, 2, . . ., 9; t = 1, 2, 3, . . ., T). T represents the military career horizon. The rates at which individuals move through the serial queue depend on supply and demand considerations.

The general objective of the retention data is to determine, by AFSC, the break-down of positive and negative continuation decisions of enlisted personnel.

D. *Individual Characteristics*—For each searcher, career decisions and relative wage offers will depend on a vector of individual characteristics. Data requirements for this category will be used to determine the demographic composition of each AFSC. It would be valuable to know the nonmilitary experience of the enlisted personnel both prior to and after leaving the Air Force. In general, it is important whether individuals were employed, unemployed, or in school before enlisting and which of these states they entered upon separation. Table 1 summarizes sources of specific military data needed to examine the issues discussed in this report.

To complete our discussion of data, two additional civilian variables must receive careful attention, namely, civilian wages and unemployment.

E. *Civilian Wages*—Obviously a measure of the distribution of civilian wages available to potential enlistees is crucial to any study of this kind. Fisher (1969) assumed that civilian earnings were distributed lognormally with a constant variance over the period of empirical analysis so that an index of median civilian earnings would completely reflect variation in nonmilitary opportunities. The empirical measure was the median income of year-round, full-time male workers, ages 14 to 19 and 20 to 24. The source was the CPR and a weight of 2/3 was given to ages 14 to 19 and 1/3 to ages 20 to 24 in constructing each observation on W_c because the typical enlistee was 18 and would forego two years of civilian earnings before 20 and a year of civilian earnings after age 20. Hause (1973), on the other hand, did not include a relative wage variable.

Bennett, Haber, and Kinn (1972) used the estimated annual wage of production workers in manufacturing in their cross-sectional analysis for 1970. Of course, this could easily be interpreted as a measure of the differences in labor force skills across states rather that an index of military-civilian wages. Nevertheless, the wage coefficients were significantly positive in the Air Force regressions.[5] Lightman (1975) also used the average weekly industrial wage in his Canadian data, which consisted of pooled time series and cross-sectional data. He pointed out that the average wage may not be received by new employees, and that the earnings profile over the first few years is steeper in the military, but still believed that average wages were a reasonable estimate of civilian alternatives.

The most elaborate index was constructed by Grissmer et. al. (1974) for a cross-sectional analysis by state. They used the average incomes for individuals ages 16 to 19 and 20 to 24 as reported in the *Consumer Income Series* P-60, No. 85, December 1972, U.S. Dept. of Commerce. To quote Grissmer et al. (p. 184):

> A non-linear interpolation method was used to estimate the average incomes for 17 to 18 year olds and 19 to 21 year olds over a 3-year time horizon. The civilian pay also was discounted at 30 percent. The actual civilian wage used for each RMS was weighted by the relative pay received by individuals on manufacturing payrolls in the area. This method assumes that the income of 17 to 21 year olds is directly correlated with the manufacturing wage in each state.

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[5] The failure to adjust for lower AFQT distributions in southern states means that the relative number of QMAs is overstated, which implies that enlistment rates are understated in the South. Since the South is the low wage region in the United States, much of the cross-sectional variation in military-civilian wages is due to the southern data. Since the data understate southern enlistment rates, wage elasticities are probably underestimated.

Table 1. **Summary of Military Data Requirements**

Data	Source	Format	Comments
A. Enlistment Data		listing	
1. number of contacts	*		
2. number of enlistments	PACE		Available monthly since March 1966
B. Inventories	UAR	9x30 matrix	Available semiannually since June 1966; based on both TAFMSD and pay date
1. total enlisted force			
2. AFSC			
C. Retention Data		table	
1. first-term reenlistment rates	ARL		Available monthly since 1954; break out by AFSC
2. second-term reenlistment rates			
3. number of less than honorable discharges			
4. number of disability discharges and deaths			
5. number of broken-service reenlistments			
6. lengths of reenlistment/extension			
7. number declared not eligible to reenlist	*		
D. Individual Characteristics		table	
1. age			Break out by AFSC
2. race			
3. sex			
4. educational level attained			
5. health (PULHEN)			
6. number of dependents			
7. AFQT			
8. prior-service civilian experience	*		
9. post-service civilian experience	*		
E. Other			
1. Wages			
a. basic pay tables			
b. AFSC eligible for enlistment/reenlistment bonuses			
c. AFSC eligible for proficiency pay			
2. Quality			
a. AFQT and other test-score criteria by AFSC			
b. length and cost of military technical training by AFSC			
3. Quantity: end strength requirements by fiscal year			

*Availability and source to be determined by Air Force Human Resources Laboratory.
PACE – Processing and Classification of Enlistees
ARL – Airman Reenlistment and Loss Record
PULHEN – Physical Profile

There was no further rationale offered.

Civilian earnings data over time, space, occupation, and industry are relatively easy to acquire from Census Bureau and BLS publications. The important problem is to specify the theoretical variable carefully and choose empirical data which are the closest approximations, consistent with matching observations on other variables. For instance, the civilian data should be for year-round, full-time workers only, since military service is obviously full-time employment.

Other issues must be considered. If the distribution of earnings were relatively constant over time and space, nearly any statistic would suffice–average, median, earnings at the 25th percentile, etc. However, Henle (1972) found that there was a slight, but persistent, trend toward greater inequality of earnings from 1958 to 1970. The trend was common across industries and occupations and was most evident among manual and low-skilled white collar workers. In cross-sectional data by states, there are also well-known differences in the degree of inequality because southern states have higher dispersion in the distribution of income.

Another consideration is whether the use of wage data based upon young males as independent variables might lead to problems in obtaining consistent estimates of the direct effect of civilian wages on enlistments. A change in enlistments would have a negligible effect on overall civilian wages but might have a larger effect upon the supply of young male labor and, therefore, upon wages for this class of labor. In such cases of a two-way dependence an estimation procedure appropriate for simultaneous equations would be appropriate.

F. *Civilian Unemployment*–The usual procedure has been to introduce a measure of unemployment as another independent variable to reflect civilian employment opportunities. Goldberg (1975) used BLS data on male youth unemployment across states in 1973. Bennett, Haber, and Kinn (1972) used the BLS aggregate unemployment rate across states in 1970 as published in the Labor Department's "Area Trends in Employment and Unemployment," July 1971. Grissmer et. al. (1974) used the civilian unemployment rates for males, ages 17 to 18 and ages 19 to 21, as published monthly by the BLS in *Employment and Earnings*. Fisher (1969) used unpublished BLS figures on the unemployment rate for all males ages 18 to 19, but rather than enter unemployment rate as a separate variable, he formed an "expected" relative civilian wage, $\frac{W_m}{(1-u)W_c}$.[6]

[6] This is similar to the empirical treatment of the minimum wage effect on teenage unemployment, where the independent variable measuring the relative minimum wage is commonly the ratio of the minimum to the industrial average wage multiplied by the coverage rate.

Hause (1973) argued that this formulation was unconvincing because the earnings anticipation of an individual should depend upon his own employment status, and there is no reason why these conditional anticipations in the aggregate should equal the mathematical expectation for the group. Hause drew upon search theory to develop a simple rationale for regressing the enlistment rate on two variables–the aggregate unemployment rate and the product of average duration of unemployment and the unemployment rate. The model is derived from the premise that a large part of enlistment rate variance is due to enlistments by unemployed young males and that the conditional probability of enlistment is a positive function of the duration of unemployment. The two independent variables were collinear ($r = .77$). Hause also had some interesting remarks about the use of unemployment rates for young males. These data have two serious defects. First, the composition of young unemployeds changes significantly over the year because reported unemployment rates do not distinguish between full- and part-time workers (which has an exceptionally strong seasonal pattern for these ages), and because no adjustment is made for summer jobs sought and obtained by students. Also, there are problems of consistent estimation because of the greater likelihood of a two-way dependence between enlistments and unemployment for male youths, but not between enlistments and the aggregate unemployment rate.

Discussion of Unemployment Data

Unemployment data have been relatively abundant since 1940. The Bureau of the Census conducts a monthly survey for the BLS in approximately 47,000 households in the United States. Commonly referred to as the Current Population Survey (CPS), it is the largest monthly household survey in the world. The data from these sample interviews are inflated by independent population controls to estimate the number of persons employed, or not in the labor force. Estimates are available by a wide variety of characteristics–location, age, sex, race, marital status, and industry, with many cross-classifications also. Data are also disaggregated in terms of active job seekers versus those laid off or waiting to report to a new job, as well as duration of unemployment by weeks. In addition, the BLS has published information on labor turnover rates in manufacturing since 1963 by total separations, layoffs, quits, accessions, and new hires by 4-digit industry.

Choice of data must be dictated by the operational nature of the stochastic model which is developed but some issues can be discussed here. First, consider the use of aggregate unemployment rates versus youth unemployment rates. Sampling error is considerably higher for teenage unemployment than for aggregate unemployment. For the overall unemployment rate, chances are 9 in 10 that the true rate would fall within ± .2 percentage points of the sample rate, for example, if the published rate is 9.2, the range is 9.0 to 9.4. But the error is ± .9 percentage points for teenagers (Shiskin & Stein, 1975). However, also note that in the second quarter of 1976, youths ages 16 to 24 comprised 1/4 of the civilian labor force but almost 1/2 of the total number unemployed. School was the major activity for 46 percent of jobless teenagers in March 1975, down from about 55 percent 2 years earlier. Among unemployed teenagers, as many as 1/3 were seeking part-time work (Hedges, 1976).

Other differences between youth and overall rates are that the mean duration of unemployment is shorter for teenagers than for older workers. Among unemployed workers under age 20, only 30 percent received unemployment compensation in May 1975; but 75 percent of unemployed workers over age 25 were receiving benefits.

Recent articles (Mincer, 1976; Moore, 1971) on the unemployment effects of the minimum wage law, especially for teenagers, suggest that the unemployment rate should be included in the analysis of military supply because indexes of relative military-civilian wages are incomplete indicators of relative opportunities. In effect only a fraction of teenagers can be employed in the covered civilian sectors at any point in time, the remainder becoming unemployed (queueing up), working in uncovered sectors, dropping out of the labor force, continuing in school, or joining the military.

A final consideration is to use the ratio of employment to working age population as a substitute or complement to other measures of civilian employment opportunities. An article by Geoffrey Moore (1975) argues that the employment ratio is a much neglected but relatively objective and statistically reliable indicator of the degree of full employment in the economy. According to Moore:

> A high employment percentage demonstrates that opportunities to find work exist and that efforts to find work are likely to be successful. It is not surprising then, that more people are induced to look for work. By definition, they become unemployed. Under such circumstances a high unemployment rate is not an indication of difficulty in finding work but rather the opposite.

IV. SUMMARY

1. Uncertainty is a central feature of the market for military manpower.

2. Fluctuation in the flow of accessions and retentions, changes in overall strength levels, and experience distributions by skill class can be modeled within a simultaneous, stochastic framework of demand and supply.

3. Transient fluctuations in the flow and stock of manpower must be distinguished from steady-state (or equilibrium) values for manpower variables.

4. The level of wages, quality, and quantity of manpower are not independent; i.e., only two of these variables can be independently chosen.

5. With randomness in the system it is impossible to maintain levels and composition of manpower inventories at precise levels, but policies can be devised (at a cost) which limit variations by changing the form and/or parameters of the underlying distributions.

6. A search for data with which to estimate an operational version of the model revealed that appropriate, although imperfect, data are available.

7. Estimating the pool of qualified potential enlistees is difficult, but should be conceptually treated as a supply variable rather than imposing numerous demand-related adjustments.

8. Recruiting contacts yield estimates of arrival rates for searchers, enlistment rates measure job acceptors, and combined with rejection data allow us to infer balking and reneging rates.

9. A relatively rich data base for manpower inventories and measures of civilian opportunities is specified and can be assembled for estimation procedures.

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