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TRAINING AND RETENTION OF
AIR FORCE AIRMEN: AN
ECONOMIC ANALYSIS

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PREFACE

This Memorandum is part of a continuing RAND study of Air Force manpower and personnel policies. The study investigates several aspects of the training and retention of Air Force airmen who are electronic specialists. The primary objective is to measure the responsiveness of the reenlistment rate to changes in Air Force remuneration. An attempt is also made to evaluate the degree to which Air Force training is transferable to the civilian economy.

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SUMMARY

This Memorandum examines several aspects of the training and retention of Air Force electronic specialists. The major goal of the study is to investigate the responsiveness of the reenlistment rate to changes in Air Force remuneration. An attempt is also made to measure the degree to which Air Force training is transferable to the civilian economy.

The study is based on data obtained from the Personnel Research Laboratory at Lackland Air Force Base. Both biographical and earnings information were available for a group of 505 electronic specialists who left the Air Force in 1962 after their first tour of duty and who reported their civilian earnings in 1964. Biographical data were also obtained for a control group of 393 electronic specialists who chose to reenlist in 1962 after their first tour of duty.

For this sample of airmen the reenlistment rate is very sensitive to differences between civilian and Air Force earnings opportunities. Our results imply, for example, that if the initial reenlistment rate were 50 percent and if Air Force remuneration were increased by $1,000 per year, then the reenlistment rate would rise to about 70 percent. The actual reenlistment rate for electronic specialists was 35 percent in 1962. The current reenlistment rate has declined to approximately 15 percent. Our results can also be used to evaluate the effects of alternative changes in remuneration on different initial reenlistment rates. The relation between reenlistment and remuneration undoubtedly varies among skill groups and over time. However, only further testing on data similar to that analyzed here can determine the magnitude of these differences.

Approximately 67 percent of those who left the Air Force and entered the labor force reported that they used Air Force training; approximately 16 percent of those who left returned to school and did not enter the labor force. The median income for the group who used their training is $6,000, whereas the corresponding measure for the group who did not use their training is $5,200. The average premium for using Air Force training, holding other influences on earnings
constant, is estimated to be $637. In assessing this differential, it
must be emphasized that these earnings are only for a single year.
Clearly, a 5- or 10-year average would be much more informative. On
the basis of these data we can, however, tentatively conclude that a
large percentage of electronic specialists use their Air Force training
in the civilian sector, and that the advantage of using such training,
measured in earning power, is significant. This helps explain the
tendency for the supply of reenlistees to vary inversely with skill
level attained in the Air Force.

Air Force earnings including fringe benefits are estimated for
the airmen who reenlisted after their first tour of duty. Since the
ex-airmen reported civilian earnings for 1964, this was the date of
the estimate of Air Force earnings. Assuming that most of these airmen
would have attained a rank of E5, Air Force earnings would be about
$5,600, where this includes pay, allowances, retirement, and the value
of services and items provided without charge. If the lower effective
tax rate is also taken into account, it appears that Air Force compen-
sation is at least as high as the average alternative civilian earnings.
ACKNOWLEDGMENTS

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I. INTRODUCTION

The management of military personnel is in many ways similar to the management of human resources within any large organization. Attracting competent new people, providing the training necessary to efficiently operate the organization, and guarding against the loss of skilled personnel are problems that arise in both military and civilian organizations. The methods the military uses to resolve these human resource problems, however, differ from those that non-military organizations use. As will be evident, some of these differences inhibit the efficient operation of the Air Force Personnel system. In this study our attention is restricted to the management of Air Force airmen.

The recruitment of competent airmen can be accomplished by altering several basic variables. These include: compensation; threat of induction into the Army; amount of general training offered, i.e., training that is not specific to the Air Force but is transferable to the civilian economy; required performance on Armed Forces Qualifying Exams; restrictions on minimum educational attainment, e.g., high school graduate; and, finally, the length of the enlistment period.

The military has always relied heavily on its own training organization to provide the necessary skills. Air Force airmen recruits are usually recent high school graduates possessing little, if any, of the technical training that is essential for their effective utilization. Consequently, the Air Force is one of the largest training institutions in the world. The initial reason for generating skills internally was that, with the exception of local police forces, no civilian organization existed for providing combat training. Today, a much smaller percentage of the total military force engages in actual combat. This is certainly true of the Air Force. Nevertheless, the complexity and novelty of many weapon systems has still made it impractical for the military to rely on the civilian sector to provide the necessary skills. There is, of course, a wide range of skills between combat readiness and highly skilled maintenance
requirements. The military is beginning to rely on civilian trained personnel to satisfy these intermediate personnel requirements. Even in this area, however, most skills are acquired in the military organization.

The personnel problem that has probably received the most attention and the one we focus on in this study is the retention of trained personnel. In general, the skills that are most valuable when transferred to the civilian sector are those that are most costly for the Air Force to acquire in terms of recruit training; and while there is some correlation between skill level and rate of promotion in the Air Force, the difference in salaries between high and low skill airmen seems to be much smaller than that existing in the civilian sector. Consequently, retention of airmen tends to be negatively correlated with skill level.

Among technically trained airmen, electronic specialists stand out as the group for whom there seems to be the greatest disparity between the supply of reenlistees and the number the Air Force would like to retain. Electronic specialists perform a variety of maintenance tasks, after receiving about a year of fairly general training and then on-the-job training. They comprise about 20 percent of all airmen. Roughly two out of every three electronic specialists were leaving the Air Force in 1965 rather than reenlisting, and today (mid-1967) the situation is more serious -- less than 15 percent are reenlisting after their first term. The departure of these highly skilled airmen is very costly, and, consequently, many proposals have been made to increase the retention of these men. The Cordiner Committee in 1957 recommended a system of proficiency pay that would reward the highly skilled. However, the implementation of this proposal did not seem to be very effective, possibly because the dollar amounts were small and because the timing was such that it had little impact on the reenlistment decision. The recently inaugurated reenlistment bonus program seems to overcome these deficiencies. The bonuses are relatively large and they are awarded when the airmen makes his reenlistment decision.

The effectiveness of such proposals for increasing the reenlistment rate of skilled airmen depends on the responsiveness of airmen
to increases in salary. That is, the elasticity of the supply of technically trained airmen is a crucial parameter in all of these retention proposals. If the supply curve is very inelastic, so that the reenlistment rate is increased only slightly by relatively large pay increases, then it might be more economical to keep the reenlistment rate low and to continue to incur high training costs. On the other hand, if the supply curve is relatively elastic, relatively small increases in pay will cause large increases in the reenlistment rate and reduce the total cost of the services of skilled airmen. Information about supply elasticities is needed before optimal retention policies can be designed. We address the problem of measuring the supply response to changes in pay in Sec. II.

It is important to recognize the intimate interrelations among these three personnel problems. Recruiting policies have a direct impact on both training and retention. An influx of highly skilled personnel would reduce training requirements and would, undoubtedly, necessitate revisions in the retention policy. The provision of general training facilitates recruitment while making retention more difficult, whereas the provision of specific training (not transferable to the civilian sector) has the opposite effect. Finally, a successful retention policy lowers both recruitment and training requirements. Appendix A investigates some of these interrelations and shows how a supply curve of reenlistees fits into a framework for determining an optimal Air Force retention policy.†

The criterion used in Appendix A is the minimization of dollar cost. From society's viewpoint, however, this may not be the right criterion. For example, if the Air Force undertakes a policy that leads to higher retention rates, this and the accompanying decline in recruitment means that over time fewer civilians in any cohort group will have had a tour of duty in the Air Force. Whether this would be a source of social gain or loss is a very complicated issue that to some extent depends on one's values. One could, however, go a long way toward arriving at an agreed upon measure of the social gain or loss involved if one could determine

†Appendix A takes skill requirements as given. In general, the mix of skill requirements should be made dependent upon the costs of acquiring the mix of skills.
whether ex-airmen are more productive as civilians than comparable people who have not experienced a tour of duty in the Air Force. Our work provides a measure of the productivity of ex-airmen, but we have not been able to obtain a similar measurement for comparable men who have not been in the military.

The rest of the study is divided into three parts. In Sec. II a supply function of first-term reenlistees is estimated from data on the reenlistment behavior of a group of Air Force electronic specialists. We find that the difference between civilian earnings opportunities -- as inferred from demographic attributes and measures of educational attainment -- and opportunities within the Air Force is an important determinant of reenlistment behavior. The policy implications of this finding are briefly explored.

Section III explores various hypotheses that might account for the inverse relation between skill level attained in the Air Force and the supply of reenlistees. Differences in post-Air Force civilian earnings between a group that claimed to use their Air Force electronics training in their civilian occupation and a group that claimed otherwise, as well as the sizes of the two groups suggest that potential civilian earnings for an airman are related to the amount of training he has received. Section IV contains some concluding remarks together with suggestions for future research.
II. THE SUPPLY CURVE FOR ELECTRONIC SPECIALISTS

In this section we investigate the relationship between the probability of reenlisting and remuneration. The analysis is based on cross-sectional data obtained from the Personnel Research Laboratory at Lackland Air Force Base. The data consist of information on two groups of randomly selected first-term airmen -- a group who left the Air Force after completing their first term and a group who reenlisted. After presenting the hypothesized supply curve, a method is described for estimating potential civilian earnings for airmen. The supply function is then estimated and the effect of changes in remuneration on reenlistment rates is assessed.

THE ECONOMIC MODEL

Our basic hypothesis is that for all first-term airmen the probability of reenlisting is a decreasing function of the difference between civilian earnings and Air Force remuneration. The following logit model was used to represent this relationship.†

\[
\ln\left[\frac{P_i}{1 - P_i}\right] = \alpha + \beta (E_i^* - A_i),
\]

where \(P_i\) is the probability that the \(i\)th airmen reenlists, \(E_i^*\) is his potential earnings as a civilian, and \(A_i\) is his prospective Air Force earnings if he reenlists.

We further assume that \(A_i\) depends only on the airman's rank at the end of his first term and possibly on his skill category. Since we are investigating the reenlistment behavior of a group of electronic specialists, we initially assume that for this group \(A_i\) depends only on the airman's rank.

This allows us to rewrite the function as

\[
\ln\left[\frac{P_i}{1 - P_i}\right] = \alpha - \beta A_r + \beta E_i^*
\]

or as

†For a discussion of the logit model, see Zellner and Lee [9].
\[
\ln \left( \frac{P_i}{1 - P_i} \right) = \alpha + \beta E_i^*,
\]

where \(\alpha\) is a constant that depends only on the ith airman's rank. Thus, in estimating this function, we will not require information on earnings in the Air Force, but will simply allow the constant term to depend on rank by using dummy variables to represent rank.

This function asserts: (1) that the change in the probability of reenlisting \(dP_i\), induced by a change in potential civilian earnings \(dE_i^*\), is

\[
dP_i = \beta P_i (1 - P_i) dE_i^*,
\]

and (2) that the effect of a change in Air Force remuneration \(dA\) is

\[
dP_i = -\beta P_i (1 - P_i) dA,
\]

where these are valid only for small changes in pay, and where \(P_i\) is the initial probability of reenlisting. We, of course, hypothesize that \(\beta\) is negative.

These equations assert that as \(P_i\) approaches either 1 or 0, the response to a change in the pay differential approaches zero. For first-term airmen, the shape of the hypothesized relationship between the pay differential \(E^* - A\), and \(P\) is shown in Fig. 1, where the graph of the equation -- the solution of equation (1) --

\[
P = \frac{1}{1 + e^{-\alpha - \beta (E^* - A)}}
\]

is plotted for \(\alpha = 0, \beta = -1\); and for \(\alpha = \beta = -1\). The first approximates the estimated supply function for airmen of rank E4 at the end of the first term, while the second approximates that estimated for airmen of rank E3 at the end of the first term.\(^\dagger\)

\(^\dagger\) The results given below are not presented in this form, because an estimate of prospective Air Force pay is required in order to do so, and a good deal of uncertainty is attached to any such estimate. See the discussion of Air Force pay, p. 11.
Fig. 1—Relation between $P$, the probability of reenlisting, and $E^*-A$, the pay differential.
The first step in estimating this supply function is to obtain an estimate of potential earnings for each airman in the sample. This is accomplished in the following subsection. Then airmen are classified into n groups by their estimated potential earnings and the proportion who reenlist is calculated for each group. Finally, the logit of the proportion in each group that reenlists, \( \ln[p_j | 1 - p_j] \), is regressed on average potential earnings \( E_j^* \), and averages of the dummy variables that represent the constant term \( \alpha_r \), where these averages are calculated for each of the n groups, i.e., \( j = 1, 2, \ldots, n \).

THE DETERMINATION OF POTENTIAL EARNINGS

Estimated potential civilian earnings for each airman \( \hat{E}_i \) are inferred from the airman's years of schooling prior to enlistment; his high school average as he reported it; his scores on a set of Air Force administered tests; and the region in the country from which he entered the Air Force. This is done via a relationship of the form

\[
\log_{10} \hat{E} = \gamma_0 + \sum_{j=1}^{6} \gamma_j x_j,
\]

where \( x_1 \) is 1 if the airman is from North-urban and 0 otherwise; \( x_2 \) is 1 if the airman is from North-rural and 0 otherwise; \( x_3 \) is 1 if the airman is from South-urban and 0 otherwise; \( x_4 \) denotes years of schooling upon entering the Air Force; \( x_5 \) denotes high school average; and \( x_6 \) is the average score on Air Force tests.\(^{\dagger\dagger}\)

\(^{\dagger}\) The South by our definition consists of the following 12 states: Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee, Texas, and Virginia. The rest of the country is defined as the North.

A rural community is one with a population less than 10,000. All others are urban communities.

\(^{\dagger\dagger}\) \( x_6 \) is the sum of the score on the Armed Forces Qualifying Test and of the average score on other Air Force tests. The Armed Forces Qualifying Test has been used since 1951 for classifying Selective Service registrants and enlistees into the four services. The purpose of the test is
We estimate the $\gamma$'s in this relationship by using observations on the $x$'s and on reported post-Air Force civilian earnings of a group of 397 airmen who did not reenlist after their first tour of duty. Denoting these reported earnings by $E_m$, our hypothesis is that

$$\log E_m = \log \hat{E} + z,$$

where $z$ is a random component of reported earnings that has mean zero and is distributed independently of $\log \hat{E}$. It follows that a regression, hereafter called the earnings regression, of $\log E_m$ on the $x$'s yields estimates of the $\gamma$'s.

The earnings data were obtained from questionnaires sent by the Personnel Research Laboratory at Lackland Air Force Base in 1964 to 800 ex-airmen who had all been electronic specialists during their first term and who had been in the Air Force from about 1958 to 1962. Aside from the restriction to electronic specialists and to the 1958-1962 period, the 800 men are a random sample of airmen who did not reenlist after their first tour of duty. Among the information requested was current salary; years of schooling before, during, and since the Air Force tour of duty; and whether Air Force experience was being used on the job held since leaving the Air Force. For the 568 from whom responses were obtained, additional biographical information, information on the $x$'s, was sought from Air Force records. We were able to obtain the additional information for 505, of whom 397 had reported full-time civilian earnings. The difference is accounted for by 80 who reported spending a significant portion of their time in school and by 28 who did not report earnings.

The fact that the sample size for the earnings regression is only 397 out of a potential 800 is of no special concern, since there is no to measure an individual's potential with regard to military training. The test consists of 100 questions equally divided among the following four areas: vocabulary, arithmetic, spatial relations, and mechanical ability. The other tests include the Airman Qualifying Exams and other Air Force aptitude tests. These tests are used to measure aptitudes in the areas of mechanics, administration, general and electronics.
reason to expect the estimated \( Y \)'s of the earnings regression to be systematically affected by this diminution in sample size. The estimated \( Y \)'s would be so affected only if the relationship between civilian earnings and the \( x \)'s were different for the 397 airmen for whom we have observations from that for the remaining airmen, but there is no reason why this should be.

Some aspects of the reported civilian earnings are worth noting. Reported full-time annual earnings ranged from $528 to $25,000. Average and median annual earnings were, respectively, $5,920 and $5,760. It is interesting that the Air Force earnings of these men had they reenlisted would have been approximately the same as their reported median earnings as civilians. It is fair to assume that in 1964, the time at which the ex-airmen reported earnings and two years after the reenlistment decision, most of the ex-airmen would have attained the E5 rank. On average, an E5 would earn about $5,600, where this includes pay, allowances, and the value of services and items provided without charge. It includes an estimate of the value of the retirement benefits and of medical services provided to servicemen.

It may be claimed that this estimate is not comparable to the earnings examined above because those earnings do not include fringe benefits. We would argue that civilian fringe benefits are likely to be almost insignificant for workers who have held jobs for a maximum of two years. For example, the high value of the armed services retirement benefit ($729 for an E5) results from benefits after only twenty years of service equal to half of base pay at the time of retirement. Only certain civil service jobs have benefits at all comparable to these. Furthermore, a comparison of Air Force earnings with reported civilian earnings does not take account of the inclusion in the latter of earnings from overtime, and does not take account of the lower effective rate at which Air Force earnings are taxed. Pay comprises less than $3,000 of the estimated Air Force earnings of $5,600 and only this part is subject to tax. Finally, the comparison does not make any adjustment for possible unemployment in the civilian economy. Thus, it seems as if remuneration in the Air Force is at least as high as average remuneration in the civilian economy for those ex-airmen who report being in the labor force about two years after leaving the Air
Force, and this consists of more than 80 percent of those who failed to reenlist. If anything, this suggests that a large number of men are either willing to suffer a decrease in earnings in order to be civilians, or are optimistic about their opportunities as civilians at the time they make the reenlistment decision.

The estimated regression of the $\log_{10}$ of reported earnings on the six biographical variables is

$$\log_{10} \hat{E} = 3.62387 + 0.05645(x_1) + 0.01008(x_2) - 0.01145(x_3)$$

(0.0246)        (0.0264)        (0.0295)

$$+ 0.00289(x_4) - 0.01122(x_5) + 0.00059(x_6)$$

(0.0072)        (0.0133)        (0.0003)

The coefficient of determination is 0.061 and the $F$-ratio is $F(6,390) = 4.24$.

The estimated coefficients suggest that potential earnings are greater if the airman is from the North than from the South, and are greater if he is from a Northern urban area rather than from a Northern rural area. If he is from the South, however, the regression suggests that potential earnings are greater if he is from a rural area, a puzzling result. In addition, the regression suggests that potential earnings are greater the greater the airman's years of schooling prior to entering the Air Force, $x_4$; the higher his reported high school average, $x_5$ (ranges from a possible high of 1 to a possible low of 4); and the higher his scores on Air Force administered tests, $x_6$ (ranges from a possible low of 0 to a possible high of 200). We will have more to say about the magnitudes of such coefficients in Sec. III.

The low degree of explanatory power of this regression may lead the reader to question whether $\hat{E}_i$ as estimated from it is a good estimate of $E_i^*$, the relevant earnings concept for the supply function. There is certainly a possibility that this earnings regression does not include all the variables that determine $E_i^*$, either because these could not be measured for all the airmen, or because we could not identify all the variables that influence $E_i^*$. It turns out that such

$\dagger$ The numbers in parenthesis are standard errors of the regression coefficients.
omission does not prevent us from obtaining a consistent estimate of the supply function parameter, \( \beta \), although the omission may produce an earnings regression in which the coefficients of some of the included variables contain the influence of some of the omitted variables. The reader may also wonder why \( \hat{E}_i \) is used below instead of reported earnings, \( E_m \), for the 397 who reported civilian earnings. The answer is that the use of \( E_m \) would lead to an inconsistent estimator of \( \beta \). A technical discussion of both of these points is contained in Appendix B.

A separate word may be in order for why race is not included as a determinant of estimated potential civilian earnings. Of the 505 men who did not reenlist only two were Negroes.\(^\dagger\) Thus, had we wanted to estimate the effect of race on \( \hat{E}_i \), it would have to have been inferred from the reported earnings of the two Negroes who did not reenlist, and this seemed too small a sample from which to draw inferences.

For use in the supply function we calculate \( \hat{E}_i \), the estimated potential civilian earnings, from the earnings regression for each of the 505 airmen who did not reenlist and for each of a random sample of 393 airmen (also first-term electronics specialists during 1958-1962) who did reenlist. Since any differences in potential earnings between airmen in the two groups must result from differences in the values of the \( x \)'s for the two groups, we first examine in Table 1 the average values of the biographical variables of the two groups.

The unavailability of measures of the \( x \)'s for all 800 of the original sample of those who did not reenlist may be a source of bias in Table 1 and in the supply function estimated below. The bias may arise because of the initial diminution of the sample from 800 to 568. This diminution resulted because the addresses of 232 of the original sample could not be traced. Bias may arise because the \( x \) values for these men may not be a random sample of the \( x \) values for the original 800 men.\(^\dagger\dagger\)

The further diminution from 568 to 505 can be assumed to occur in a

\(^\dagger\) However, in the random sample of 393 men who reenlisted there were 22 Negroes. The proportion of Negroes in the group that did not reenlist was 0.004 whereas the proportion in the group that reenlisted was 0.04. These two proportions are significantly different at the 0.1-percent level.

\(^\dagger\dagger\) Unfortunately, we have not been able to obtain Air Force records for these men.
random way with respect to values of the x's, since it occurs because of missing information on Air Force records for some of these men.

Subject to this possible source of bias, Table 1 shows that those who reenlist have fewer years of schooling, have a slightly lower reported high school average, and perform less well on Air Force tests. In addition, those who come from the South reenlist more frequently than those who come from the North. When these average values are inserted into the earnings regression they imply average potential earnings for the 505 men who did not reenlist equal to $6,053 and average potential earnings for the 393 who reenlisted equal to $5,768.

Table 1

<table>
<thead>
<tr>
<th>Group</th>
<th>NU</th>
<th>NR</th>
<th>SU</th>
<th>SR</th>
<th>Years Schooling Before AF</th>
<th>High School Average</th>
<th>AFQT Score</th>
<th>Other AF Tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>505 ex-airmen</td>
<td>.416</td>
<td>.372</td>
<td>.101</td>
<td>.111</td>
<td>12.3</td>
<td>2.38</td>
<td>85.0</td>
<td>67.0</td>
</tr>
<tr>
<td>393 reenlistees</td>
<td>.382</td>
<td>.241</td>
<td>.155</td>
<td>.122</td>
<td>11.9</td>
<td>2.45</td>
<td>81.4</td>
<td>64.6</td>
</tr>
</tbody>
</table>

THE ESTIMATED SUPPLY FUNCTION

As noted, the earnings regression supplies estimates of potential civilian earnings for the 898 airmen in the sample, 393 who reenlisted and 505 who did not. In addition, we form the following dummy variables for each airman:

\[
Y_1 = \begin{cases} 
1 & \text{if E1 or E2 at end of first term} \\
0 & \text{otherwise} 
\end{cases}
\]

\[
Y_2 = \begin{cases} 
1 & \text{if E4 at end of first term} \\
0 & \text{otherwise} 
\end{cases}
\]

\[
Y_3 = \begin{cases} 
1 & \text{if E5 at end of first term} \\
0 & \text{otherwise} 
\end{cases}
\]

Most of the airmen had rank E3 or E4 at the end of the first term; only four were E1 or E2, and only 12 were E5. Finally, each of the 393 men who reenlisted is assigned a probability of reenlisting equal to 1, while each of the 505 men who did not is assigned a probability equal to 0.

The logit function given above cannot be estimated from these individual observations, because one cannot form the logit of p, \( \ln[p/(1 - p)] \), if p takes the value zero or one. This suggests that observations be
grouped. We have done this by ranking the observations by \( \hat{E} \), and by forming 44 groups of size 20 and one group of size 18, thus exhausting the 898 observations. Then for each group the average values of the variables are computed. These average values are the data used to compute the logit supply function.

Our hypothesis is that

\[
p_j = \hat{P}_j + u_j,
\]

where \( p_j \) is the observed proportion who reenlist in the \( j \)th group of size \( n_j \), \( P_j \) is the true proportion, and \( u_j \) is a random variable, binomially distributed with mean zero and variance \( P_j(1 - P_j)/n_j \). This hypothesis together with the hypothesized logit relation between \( P_j \) and \( \hat{E}_j \) and the \( Y_j \)'s implies a model of the form

\[
\ln[p_j/(1 - p_j)] = \alpha_o + \hat{E}_j + \alpha_1 Y_{1j} + \alpha_2 Y_{2j} + \alpha_3 Y_{3j} + z_j,
\]

where \( z_j = u_j/[P_j(1 - P_j)] \), which has mean 0 and variance \( 1/[n_j P_j(1 - P_j)] \).

Since the variance of the disturbance \( z_j \) varies across observations and depends on unknown true parameters, we adopt a two-stage procedure. First we regress \( \ln[p_j/(1 - p_j)] \) on \( \hat{E}_j \) and the \( Y_j \)'s. Then using the estimated values of \( \beta \) and the \( \alpha \)'s, we compute estimated \( P_j \)'s and construct the weights

\[
w_j = \left[ n_j \hat{P}_j(1 - \hat{P}_j) \right]^{1/2}.
\]

We then regress \( w_j \ln[p_j/(1 - p_j)] \) on \( \hat{E}_j \) and the \( w_j Y_j \)'s and \( w_j \), the last replacing what had been a constant in the unweighted regression.

Since the weighted regression is virtually identical to the unweighted one, we relegate the weighted regression to a footnote. In the regressions, \( \hat{E}_j \) is measured in thousands of dollars.

The unweighted logit is

\[
\ln[p/(1 - p)] = 4.430 - 1.154 \hat{E} - 5.12 Y_1 + 2.12 Y_2 + 8.37 Y_3.
\]

\[(0.199) \quad (6.02) \quad (1.07) \quad (3.86)\]

The corresponding weighted logit is

\[
w_i \ln(p_i/(1 - p_i)) = 4.406 w_i - 1.170 w_i \hat{E}_i - 5.84 w_i Y_{1i} + 2.264 w_i Y_{2i} + 8.625 w_i Y_{3i}
\]

\[(1.242) \quad (0.203) \quad (6.045) \quad (1.076) \quad (3.829)\]

where

\[w_i = \left[ n_i \hat{P}_i(1 - \hat{P}_i) \right].\]
The F-ratio is 9.3, and the coefficient of determination is 0.48.

Loosely speaking, the coefficient of \( \hat{E} \) implies that if the reenlistment rate is initially 0.5, an annual across-the-board 100-dollar raise in Air Force pay would increase the reenlistment rate from 0.5 to 0.5 + 0.25(0.1154), which is approximately 0.53. Before proceeding to a more detailed discussion of this estimated function and its uses, we present a linear regression of \( p_1 \) on \( \hat{E}_1 \) and the \( Y_1 \)'s. Here \( p_1 \) is either 0 or 1, and the regression is computed across the 898 individual observations. We do this to check on the estimated logit function which was estimated from data that were grouped in a somewhat arbitrary way. The estimated regression is

\[
\hat{p}_1 = 1.60294 - 0.246 \hat{E} + 0.0152 Y_1 + 0.265 Y_2 + 0.367 Y_3
\]

\[
(0.037) \quad (0.240) \quad (0.040) \quad (0.142)
\]

The F-ratio and coefficient of determination are, respectively, 21.33 and 0.295. It is satisfying to note that the implied response to a change in the pay differential is consistent with that implied by the logit function.

**THE EFFECT OF CHANGES IN AIR FORCE REMUNERATION**

Although the supply function has been estimated from a particular set of data--data generated by the reenlistment behavior of a group of first-term electronic specialists who completed their first term during 1962--the estimated slope of the supply function may accurately measure the response of reenlistments to changes in pay differentials independent of the time the change occurs and independent of the skill class of the airmen for whom the change in pay is to occur. (Below, we describe how we could test this possibility.) For the moment, let us accept the supply function and show how it could be used to predict the effect of a change in annual Air Force pay.

Given a group of airmen for whom a change in Air Force pay is being considered, and given the initial reenlistment rate for them \( p^0 \), an estimate of the reenlistment rate \( p^1 \) that will result if the change in pay is put into effect is found as follows:
\[
\ln[p^o/(1 - p^o)] = \alpha + \beta(E_o - A_o)
\]

and

\[
\ln[p^1/(1 - p^1)] = \alpha + \beta(E_o - A_1),
\]

where

\[
\Delta A = A_1 - A_o
\]

is the contemplated change in pay. Then

\[
\ln[p^1/(1 - p^1)] - \ln[p^o/(1 - p^o)] = -\beta(\Delta A),
\]

so

\[
\ln[p^1/(1 - p^1)] = -\beta \Delta A + \ln[p^o/(1 - p^o)]
\]

and

\[
p^1/(1 - p^1) = e^{-\beta \Delta A} [p^o/(1 - p^o)],
\]

so

\[
p^1 = \left[1 + e^{\beta \Delta A} (1-p^o)/p^o\right]^{-1}.
\]

Then if \(\beta = 1.154\) and \(p_o = 1/2\) and \(\Delta A = 1\) (thousand dollars),

\[
p = \frac{1}{1 + e^{-1.154}} \approx 0.76
\]

This calculation is strictly correct only if the group for whom it is made is homogeneous in the sense of being composed of individuals who all initially reenlist with probability 1/2.

To illustrate this, suppose it is instead composed of two groups of equal size, the first of men who all initially reenlist with probability 0.1; the second of men who all initially reenlist with probability 0.9. If for each of these subgroups we separately compute the effect of the pay change, we find that for the first group the proportion rises from 0.1 to about 0.26, while for the second group it rises from 0.9 to about 0.97. The combined result is a rise in the proportion who reenlist from 0.5 to 0.62, a change less than half as large as that found under the assumption that the whole group was homogeneous.†

†Given the assumed shape of the supply function, the response to a pay raise half as large would be more than half as large, while the response to a pay raise twice as large would be less than twice as large.
This, of course, is an extreme example that is unlikely to be encountered. Nevertheless, if the data are available, splitting a group for whom a prediction is desired into homogeneous subgroups will help.

RANK AND REENLISTMENT RATES

Our result suggests that rank has a substantial effect on reenlistment rates. Table 2 indicates the simple relation between the two.

Table 2

<table>
<thead>
<tr>
<th>Rank</th>
<th>Number</th>
<th>Proportion Who Reenlist</th>
</tr>
</thead>
<tbody>
<tr>
<td>E1 or E2</td>
<td>4</td>
<td>0.250</td>
</tr>
<tr>
<td>E3</td>
<td>175</td>
<td>0.353</td>
</tr>
<tr>
<td>E4</td>
<td>707</td>
<td>0.486</td>
</tr>
<tr>
<td>E5</td>
<td>12</td>
<td>0.583</td>
</tr>
</tbody>
</table>

Behind differences in rank lie differences in prospective Air Force pay, and differences in the amenities of Air Force life. Thus, we would not expect the pay differences between ranks to completely explain the size of the rank dummy coefficients. This certainly seems the case. For example, if an E3 and an E4 both have civilian potential earnings equal to $6,000, the E3 according to the unweighted logit supply function reenlists with probability about 0.07, while the E4 with probability about 0.40. It would take an Air Force pay raise of approximately $2,400 per year to the E3 to get his probability of reenlisting up to 0.40. The actual or prospective pay differences between the two ranks is not this large.

REENLISTMENT RATES OVER TIME

While our supply function may provide an accurate measure of the response of reenlistment rates to changes in pay differentials at a point in time, it cannot, by itself, be used to predict the course of reenlistment rates over time. This is so because we have provided
no way to estimate how potential civilian earnings vary over time, nor have we provided a way to take account of the abrupt changes in the nonpecuniary attractiveness of reenlisting in the Air Force that occur when the country passes from peacetime to wartime or vice versa.

In order to study how potential civilian earnings change over time, one would want to gather data continuously on the earnings of ex-airmen. We would expect to find that these depend on, among other things, the general state of the economy, the state of those industries in which Air Force training is likely to be most valuable, and the characteristics of the airmen themselves.
III. AIR FORCE TRAINING AND RETENTION

The most often remarked phenomenon about reenlistment rates is the tendency toward an inverse relation between them and the amount of technical training received in the Air Force. Indeed, our study utilizes data for electronic specialists because the Air Force has been concerned with reenlistment rates for this technically trained group. Our supply function and additional material now to be presented may explain the relatively low reenlistment rates for technically trained people.

First of all, there exists the possibility that this low rate is to be explained solely on the basis of differences in ability and pre-Air Force education. Since pay and other rewards in the Air Force do not vary with ability as much as they do in the civilian sector, and since the Air Force chooses for its technical training the most able airmen, we might expect lower reenlistment rates for the technically trained.

Using our supply function to test this explanation we would use biographical information and rank for other skill categories for randomly selected groups of airmen who first enlisted at the same time as the men in our original sample. Then using the earnings regression described above, we would find average estimated potential civilian earnings for each group, call it $\bar{E}_L$, and would then calculate a predicted supply of reenlistees rate, $\bar{p}_L$, from the estimated supply function as follows:

$$\ln\left[\frac{\bar{p}_L}{(1 - \bar{p}_L)}\right] = 4.430 - 1.154(\bar{E}_L - \Delta A_i) - 5.12(\text{fraction E1 or E2}),$$

$$+ 2.12(\text{fraction E4}) + 8.37(\text{fraction E5})$$

where $\Delta A_i$ is the Air Force pay of the airmen in the $i$th randomly selected group minus the Air Force pay of the original electronics specialists, all of the same rank. For example, $\Delta A_i$ might be equal to minus proficiency pay if the electronics specialists received such pay and the $i$th group did not.
Such an explanation would probably not account for the large differences in the supply of reenlistees across skill classes. It has been suggested that the technical training received in the Air Force is much more valuable in the civilian sector than is other Air Force training. If this is so, it would help explain the low reenlistment rates for people who have received technical training. Our data on the post-Air Force civilian earnings of electronic specialists seem to support this view, since they show that the use of technical training raises civilian earnings by a substantial amount.

DIFFERENCES BETWEEN THOSE WHO USE THEIR AIR FORCE TRAINING AND THOSE WHO DO NOT

Of the 397 ex-airmen who report being in the labor force, 267 or slightly more than two-thirds reported to be using their Air Force training. Table 3 shows that the men who claim to be using their training earn more than those who claim not to be. The differences between both the medians and the means of those who use and those who do not use Air Force training are statistically significant.†

Table 3

<table>
<thead>
<tr>
<th>Group</th>
<th>Median</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Everyone</td>
<td>$5,760</td>
<td>$5,920</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(1,892)</td>
</tr>
<tr>
<td>267 who use AF training</td>
<td>$6,000</td>
<td>$6,079</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(1,582)</td>
</tr>
<tr>
<td>130 who do not use AF training</td>
<td>$5,200</td>
<td>$5,593</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(2,368)</td>
</tr>
</tbody>
</table>

*aThe numbers in parentheses are standard errors of earnings, not standard errors of mean earnings.

†A test comparing the medians yields a chi square statistic with one degree of freedom equal to 9.63. Therefore, the probability that the medians are from the same population is less than 0.005. Scheffé's
These earnings differentials may, however, be the result of things like ability and education. Table 4 compares the two groups with respect to total years of schooling as of the time of responding to the questionnaire, and two measures of ability—high school average and an average of Air Force administered tests. On the basis of these comparisons, the group who reports using Air Force training appears more able than the one who reports otherwise.†

Table 4

SELECTED CHARACTERISTICS OF EX-AIRMEN

<table>
<thead>
<tr>
<th>Group</th>
<th>Total Years of Schooling</th>
<th>High School Average</th>
<th>AF Test Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>267 who use AF training</td>
<td>12.7</td>
<td>2.39</td>
<td>153</td>
</tr>
<tr>
<td>130 who do not use AF training</td>
<td>12.7</td>
<td>2.42</td>
<td>147</td>
</tr>
</tbody>
</table>

NOTE: Air Force test score is the sum of the score on the Armed Services Qualifying Exam and an average of the scores of between 14 and 21 tests that examine proficiency in various occupations.

†The distribution of ex-airmen among Air Force Specialty Codes was as follows: radio-radar systems, 371; missile electronic maintenance, 36; armament systems maintenance, 20; nuclear weapons, 11; training devices, 28; wire maintenance, 32; and miscellaneous, 7.

test for a comparison of means from normal distributions with unknown and unequal variances yields a statistic with 129 degrees of freedom equal to -2.16. The probability that the means are drawn from normal distributions with the same mean is, therefore, less than 0.02.

†It seems reasonable to expect that the 80 ex-airmen who returned to school would be more able by these measures than either of these groups. Their high school average and Air Force test score was higher, 2.26 and 155, respectively, although the differences are statistically insignificant. The direction is consistent with Gary Becker's hypothesis that those who are more talented will have a stronger tendency to invest in their own human capital.
To isolate the effect on earnings of the use of Air Force training, we computed a multiple regression of the logarithm (to the base 10) of annual earnings on total years of schooling, high school average, Air Force test score, and seven dummy variables. The dummy variables allow us to estimate the effect of any combination of three dichotomies: North-South, urban-rural, and use Air Force training/do not use Air Force training. Region is defined as in Sec. II, but here it is the location from which the airman reported civilian earnings--his post-Air Force location. There are eight possible combinations of these dichotomies. The effect of the combination not explicitly included as a dummy variable--in our case, South-rural, do not use Air Force training--is given by the constant term in the regression. The regression allows us to answer the following kind of question: Holding constant our two measures of ability, years of schooling and region, what is the earnings differential attributable to whether or not an ex-airman reports using his Air Force training? Table 5 describes the estimated regression.

One noteworthy finding is that the coefficient of years of schooling, while having the right sign, is statistically insignificant and is very small in absolute value. Its magnitude implies that an additional year of schooling raises earnings by less than one-half of one percent per year. Two things may account for this finding. First, two measures of ability are held constant in the regression. Other investigators of the effect that earnings have on years of schooling are rarely able to do this. Second, it would not be too surprising if the common Air Force experience of these men washed out the effects of small differences in pre-Air Force years of schooling.

A test of the hypothesis that earnings do not depend on whether Air Force training is used is easily constructed. If Air Force training does not affect earnings, then the following set of equalities hold.

\[ \beta_1 = \beta_5 \]
\[ \beta_2 = \beta_6 \]
\[ \beta_3 = \beta_7 \]
\[ \beta_4 = 0 \]
Table 5
EARNINGS REGRESSION FOR 397 EX-AIRMEN WHO ENTERED THE LABOR FORCE, BY POST-AIR FORCE LOCATIONa

<table>
<thead>
<tr>
<th>Post-AF Location</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Regression Coefficient</th>
<th>Standard Error of Regression Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uses training</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>North-urban</td>
<td>0.385</td>
<td>0.487</td>
<td>0.097</td>
<td>0.037</td>
</tr>
<tr>
<td>North-rural</td>
<td>0.151</td>
<td>0.359</td>
<td>0.062</td>
<td>0.039</td>
</tr>
<tr>
<td>South-urban</td>
<td>0.088</td>
<td>0.284</td>
<td>0.075</td>
<td>0.041</td>
</tr>
<tr>
<td>South-rural</td>
<td>0.048</td>
<td>0.214</td>
<td>0.054</td>
<td>0.045</td>
</tr>
<tr>
<td>Do not use training</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>North-urban</td>
<td>0.174</td>
<td>0.379</td>
<td>0.073</td>
<td>0.038</td>
</tr>
<tr>
<td>North-rural</td>
<td>0.088</td>
<td>0.284</td>
<td>0.013</td>
<td>0.041</td>
</tr>
<tr>
<td>South-urban</td>
<td>0.033</td>
<td>0.178</td>
<td>-0.124</td>
<td>0.050</td>
</tr>
<tr>
<td>South-rural</td>
<td>0.033</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High school average</td>
<td>2.40</td>
<td>0.512</td>
<td>-0.014</td>
<td>0.013</td>
</tr>
<tr>
<td>Total years schooling</td>
<td>12.72</td>
<td>1.512</td>
<td>0.004</td>
<td>0.004</td>
</tr>
<tr>
<td>AF test score</td>
<td>151.05</td>
<td>22.60</td>
<td>0.0005</td>
<td>0.0003</td>
</tr>
<tr>
<td>Log_{10} earnings</td>
<td>3.7535</td>
<td>0.1310</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\[ F(10,386) = 5.92 \]
\[ R^2 = 0.133 \]
\[ \hat{\delta}_0 = 3.595 \]

aLocation from which earnings are reported.

That is, the null hypothesis is

\[ \beta_1 + \beta_2 + \beta_3 + \beta_4 - \beta_5 - \beta_6 - \beta_7 = C = 0. \]

Under the null hypothesis, the quantity \( \hat{\delta}/s_C \) has the t distribution with N-11 or 386 degrees of freedom, where \( \hat{\delta} \) is the estimated value of C, and

\[ s_C^2 = s^2 \delta'(X'X)^{-1} \delta. \]

\( s^2 \) is the estimated residual variance, \( (X'X)^{-1} \) is the 11 x 11 matrix of cross products of the independent variables (including the constant term), and
\[ \delta' = (0, 1, 1, 1, -1, -1, 0, 0). \]

Since \( \hat{C}/s_C = 4.8 \), we can reject the null hypothesis that earnings do not depend on whether Air Force training is utilized at the 0.001-percent level.

The effects of the dichotomous variables may be summarized in tabular form. Table 6 shows predicted earnings as a function of location and whether or not Air Force training was used. The measures of ability and total years of schooling are held constant at their average values across all 397 observations. The puzzling aspect of Table 6 is the relation between South-urban and South-rural mean earnings if Air Force training is not used. The magnitude of the difference is very large and its sign is unexpected. The only explanation we can offer is that both of these cells contain only a few observations—thirteen in each.

Table 6

<table>
<thead>
<tr>
<th>Group</th>
<th>North Urban</th>
<th>North Rural</th>
<th>South Urban</th>
<th>South Rural</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use AF training</td>
<td>$6,100</td>
<td>$5,620</td>
<td>$5,795</td>
<td>$5,526</td>
</tr>
<tr>
<td></td>
<td>(0.385)</td>
<td>(0.151)</td>
<td>(0.088)</td>
<td>(0.048)</td>
</tr>
<tr>
<td>Do not use AF training</td>
<td>$5,768</td>
<td>$5,023</td>
<td>$3,664</td>
<td>$4,875</td>
</tr>
<tr>
<td></td>
<td>(0.174)</td>
<td>(0.088)</td>
<td>(0.033)</td>
<td>(0.033)</td>
</tr>
<tr>
<td>Difference</td>
<td>$332</td>
<td>$597</td>
<td>$2,131</td>
<td>$651</td>
</tr>
</tbody>
</table>

*The numbers in parentheses represent the proportion of the 397 airmen in each of the eight categories.*

In each region those who report using Air Force training earn more than those who do not. A summary measure of the difference is obtained by weighting the differences in the third row of Table 6 by the proportion of the airmen in that region and summing. The result is $637.

\[ 0.56(\$332) + 0.24(\$597) + 0.12(\$2,131) + 0.08(\$651) = \$637 \]
This is a large premium and it is quite likely that it exceeds the value of non-technical Air Force training. If so, it would help explain why there tends to be a relatively small supply of reenlistees among those who receive technical training. Of course, to say anything definite about the value of technical versus non-technical training would require estimates of the latter, which we cannot supply at this time.

Before turning from Table 6, it is interesting to note that earnings across regions for those who report using Air Force training are more uniform than for those who report that they do not use Air Force training in their civilian occupations.

THE SOCIAL BENEFITS OF AIR FORCE TRAINING

The data just examined provide a measure of the civilian productivity of technically trained ex-airmen. Whether there is a pecuniary social gain attached to having more technically trained ex-airmen in any civilian cohort group depends on how well these men would have done had they not entered the Air Force.† As noted above, we cannot answer this question with the data now available to us.

One aspect of the behavior of ex-airmen that is related to their civilian productivity is their migratory behavior. Table 7 presents the net migration of the 397 ex-airmen among regions. The table shows that there is a strong inclination for airmen whose pre-Air Force location was North-rural or South-rural to move to urban centers.†† On net, 18 percent moved from rural to urban areas. On the other hand, there was virtually no net migration from South to North. The percentage of airmen who came from the South was 20.5, while the percentage who returned to the South was 20.2.

†The answer to this question is highly dependent on the character of the draft. Even if these men would have escaped induction had they not entered the Air Force, until the age of 23 they would have had great difficulty finding good civilian jobs because of the threat of induction. (This assumes that these men would not have gone to college.) The present proposal to draft at age 19 would change this and would adversely affect the supply of recruits to the Air Force.

†† Areas are defined as above. Definitions are contained in Sec. II.
Table 7

<table>
<thead>
<tr>
<th>Region</th>
<th>Proportion Coming From</th>
<th>Proportion Coming To</th>
<th>Net Migration</th>
</tr>
</thead>
<tbody>
<tr>
<td>North-urban</td>
<td>0.408</td>
<td>0.559</td>
<td>+0.151</td>
</tr>
<tr>
<td>North-rural</td>
<td>0.383</td>
<td>0.239</td>
<td>-0.144</td>
</tr>
<tr>
<td>South-urban</td>
<td>0.093</td>
<td>0.121</td>
<td>+0.028</td>
</tr>
<tr>
<td>South-rural</td>
<td>0.112</td>
<td>0.081</td>
<td>-0.030</td>
</tr>
</tbody>
</table>

To assess whether Air Force experience significantly affects the migratory behavior of ex-airmen, the migratory behavior of a control group would have to be studied. As with earnings, we cannot supply this information at this time.
IV. CONCLUSIONS

This study has investigated several aspects of the training and retention of Air Force airmen, in particular, electronic specialists. Primary attention has been given to drawing inferences about the responsiveness of the reenlistment rate to changes in Air Force remuneration. An attempt was also made to measure the degree to which Air Force training is transferable to the civilian economy. In the course of the study several other results were discovered which, while not directly important to our study, are interesting in their own right.

The study was based on data obtained from the Personnel Research Laboratory at Lackland Air Force Base. Both biographical and earnings information were available for a group of 505 electronic specialists who left the Air Force in 1962 after their first tour of duty and who reported their civilian earnings in 1964. Biographical data were obtained for a control group of 393 electronic specialists who chose to reenlist in 1962 after their first tour of duty.

Analysis of these data has led to the following conclusions. For this group of airmen the reenlistment rate was quite sensitive to differences between civilian and Air Force earnings opportunities. This implies, for example, that if the initial reenlistment rate were 50 percent and if Air Force remuneration were increased by $1,000 per year, then the reenlistment rate would increase to about 70 percent. The relation between reenlistment and remuneration may, of course, vary among skill groups and over time. However, only further testing on data similar to that analyzed here can determine whether this is the case. If the Air Force knew the response of reenlistments to changes in remuneration for each skill group, it could utilize the procedure outlined in Appendix A to determine the best mix of reenlistment rates.

Approximately 67 percent of those who left the Air Force and entered the labor force reported that they used Air Force training; approximately 16 percent of those who left returned to school and did not enter the labor force. The median income for the group who used their training was $6,000, whereas the corresponding measure for the
group who did not use their training was $5,200. The average premium for using technical Air Force training, holding other influences on earnings constant, was estimated to be $637. In assessing this differential, it must be emphasized that these earnings are only for a single year. Clearly, a 5- or 10-year average would be much more informative. On the basis of these data we can, however, tentatively conclude that a large percentage of electronic specialists use their Air Force training in the civilian sector, and that the advantage of using such training, measured in earning power, is significant. This helps explain the tendency for the supply of reenlistees to vary inversely with skill level attained in the Air Force.

Air Force earnings including fringe benefits were estimated for the airmen who reenlisted after their first tour of duty. Since the ex-airmen reported civilian earnings for 1964, this was the date of the estimate of Air Force earnings. Assuming that most of these airmen would have attained a rank of E5, Air Force earnings would be about $5,600, where this includes pay, allowances, retirement, and the value of services and items provided without charge. If the lower effective tax rate is also taken into account, it appears that Air Force compensation is at least as high as the average alternative civilian earnings.

This study suggests several topics for additional research. Analysis of the temporal behavior of the supply of reenlistees is the most obvious. This would require the collection through time of data on the earnings of ex-airmen. These earnings would depend on the general state of the economy, on the economic health of those industries in which Air Force training is likely to be used, and on the characteristics of the airmen themselves, particularly, as we have suggested, skill level attained in the Air Force. Such data would help in predicting the supply of reenlistees over time and would make possible further testing of the effect of changes in Air Force remuneration.

The question raised here about the social benefits or costs of Air Force training could be asked about a variety of programs whose aim is to provide training that will enhance earning power. It might be possible to compare the efficiency of a number of such programs. For example, the efficiency of Project 100,000 could be compared to some nonmilitary program like Job Corps.
Finally, the supply curve analysis used here is germane to broader issues involved in comparing the draft with an all volunteer military force. Since the reenlistment decision, as contrasted with the initial enlistment decision, is not influenced by the presence of the draft, it is determined by the same considerations that would determine the supply of recruits in the absence of the draft.
Appendix A

OPTIMAL RETENTION POLICIES FOR DIFFERENT SKILL CATEGORIES

The relationship between remuneration and the reenlistment rate undoubtedly varies among skill categories. The main reason for this variability is that civilian job opportunities differ across skill categories. Training costs also differ from one skill category to another. These factors suggest that both remuneration and retention should vary across skill categories. This appendix outlines a procedure that can be used to determine the best mix of reenlistment rates.

Let $c_i$ and $k_i$ denote, respectively, average training cost and average training time for the $i$th skill category; also let $P_i(x)$ denote the probability of a first term reenlistment in the $i$th skill category when annual remuneration is $x$ dollars. This is the function that is estimated in Sec. II for electronic specialists and is assumed to have the following form:

$$P_i(x) = \frac{e^{\alpha - \beta x}}{1 + e^{\alpha - \beta x}},$$

where $\alpha$ and $\beta$ are the parameters to be estimated. Neglecting discounting considerations, assume that the Air Force wishes to choose $x$ to maximize the output to cost ratio for specialty $i$ over the next four years.† If the airman reenlists, the output from job $i$ over the next four years is $t_4$, which represents the total time spent on job $i$ over the four-year period. On the other hand, if the airman does not reenlist, four-year output from job $i$ is $t_4 - k_i$. If the airman reenlists, the cost of the four-year output is $w_i$, where $w_i$ is the airman’s four-year salary for performing job $i$. If the airman does

†Discounting factors are probably of considerable importance, which implies that the time profile of remuneration is a key variable. In particular, reenlistment bonuses may have a greater influence on retention than comparable increases in remuneration. The composition of remuneration (cash versus fringe benefits) will also affect the retention decision. Finally, other criteria may be more appropriate like maximizing total discounted net benefits accruing to the Air Force.
not reenlist, the cost of the four-year output is $c_i + w'_i$, where $w'_i$ is the four-year salary of a new recruit. It follows then that the expected four-year output from job $i$ and the expected cost of job $i$ are, respectively,

$$E(Q) = t_i p_i(x) + (t_i - k_i)(1 - p_i(x))$$

and

$$E(C) = (w_i) p_i(x) + (c_i + w'_i)(1 - p_i(x)).$$

The Air Force chooses $x$ to maximize the ratio.

$$\frac{E(Q)}{E(C)}.$$

A more complete model could also take account of second and third reenlistments. Using methods of Markov chains, the age distribution of the force could be predicted and, depending upon the assumptions made with regard to productivity and age, this distribution could be altered (in the appropriate way) by changing remuneration. For an analysis of the problem of differential pay see Smith [6].
Appendix B

ON THE RELATION BETWEEN ESTIMATED POTENTIAL CIVILIAN EARNINGS AND THE ESTIMATED SUPPLY FUNCTION

The earnings regression, whose predictions are used as estimates of potential civilian earnings, explains only about 6 percent of the variance of the logarithm of post-Air Force reported civilian earnings. For this and other reasons, it is quite likely that predictions from this regression constitute only part of the potential civilian earnings variable that is relevant to the reenlistment decision. The purpose of this appendix is to explore the implications of this possibility for the estimated supply function.

We write

$$E_m = \hat{E} + u + z,$$

and

$$E^* = \hat{E} + u + v,$$

where $E_m$ is reported post-Air Force civilian earnings; $E^*$ is the earnings variable relevant to the reenlistment decision, a variable we do not observe; $\hat{E}$ is the prediction from the earnings regression; $u$ is the unidentified part of $E^*$ that is also a component of $E_m$ and that arises because of left-out variables in the earnings regression; $z$ is a random component of $E_m$ that is not related to $E^*$ or its components; and $v$ is a random component of $E^*$ that is not related to $E_m$ or its components.

In this discussion, we use a simplified version of the supply function, one for airmen all of whom face the same Air Force opportunities. Such a "true" supply function may be written

$$Q = \sigma + \beta E^* + w,$$

where $Q$ is an increasing function of the probability of reenlisting and $w$ is a disturbance that is assumed independent of $\hat{E}, u, z$ and $v$. 

In what follows, \( q, e^*, \) and \( \hat{e} \) represent deviations from the means of \( Q, E^* \), and \( \hat{E} \), respectively, while, \( z, v, w, \) and \( u \) represent both levels and deviations because all have zero means--\( z, v, \) and \( w \) by assumption, \( u \) because \( \hat{E} \) is a prediction from a least squares regression.

The questions taken up are:

1) What is the relation between the parameter \( \beta \) and the regression coefficient of \( \hat{E} \) in a regression of \( Q \) on \( \hat{E} \)?

2) Why is not \( E_m \) used as an estimate of \( E^* \) for those airmen for whom these data are available?

To begin, suppose \( Q \) is regressed on \( \hat{E} \), instead of \( Q \) on \( E^* \). The computed coefficient is

\[
\hat{b}_{qe} = \frac{\sum q \hat{e}}{\sum \hat{e}^2} = \frac{\sum \beta (\hat{e} + u + v) + w \hat{e}}{\sum \hat{e}^2}
\]

Taking probability limits, we obtain

\[
\text{plim} \hat{b}_{qe} = \beta \left[ 1 + \frac{\text{plim} \sum \hat{e}u + \text{plim} \sum \hat{e}v}{\text{plim} \sum \hat{e}^2} \right].
\]

Thus, \( \hat{b}_{qe} \) converges in probability to \( \beta \), the true supply function parameter, if \( \sum \hat{e}u \) and \( \sum \hat{e}v \) both converge to zero.

Now, it is quite reasonable to assume, as we do, that \( v \), the component of \( E^* \) that is not part of \( E_m \), is independent of all components of \( E_m \). Thus consistency of \( \hat{b}_{qe} \) depends on \( \sum \hat{e}u \).

Since \( u \) arises because of left out variables in the earnings regression, it seems clear that it will tend to be uncorrelated with \( \hat{e} \), the prediction from that regression. This is so because the included variables in that regression pick up the effect of the excluded or left out variables to the extent that the latter are correlated with the former. This leaves for \( u \) only the effect on \( E_m \) of the part of the left out variables that is uncorrelated with the included variables, and, hence implies that \( u \) is uncorrelated with \( \hat{e} \).

Thus, regressing \( Q \) on \( \hat{E} \) instead of \( Q \) on \( E^* \) need not give rise to an inconsistent estimate of \( \beta \).
Now, for the second question. An alternative to using $\hat{E}$ as an estimate of $E^*$ is to use $E_m$ for those airmen for whom this information is available, and $\hat{E}$ for the others. This may seem a reasonable procedure, because given the relationship among $E_m$, $E^*$, and $\hat{E}$, we seem to be throwing information away by not using $E_m$ which, after all, does contain information about $u$.

To investigate this, define $E'$ as $E_m$ for those for whom we have such data and as $\hat{E}$ for everyone else. Further, let $e'$ be the deviation of $E'$ from its mean. Then, the regression coefficient obtained by regressing $Q$ on $E'$ is

$$b_{qe'} = \frac{\sum e' q}{\sum e'^2} = \frac{\sum_0 e' q + \sum_1 e' q}{\sum_0 e'^2 + \sum_1 e'^2},$$

where the subscript "0" means summation over those observations for which $E'$ equals $E_m$ and the subscript "1" means summation over all other observations.

For observations "0,"

$$e' = \hat{E} - (1/n)\Sigma e' = \hat{E} - (1/n) [\bar{E} + \bar{Z} + \bar{u} + \Sigma z] = \hat{e} - (1/n)[\bar{u} + \bar{z}],$$

while, for observations "1,"

$$e' = E_m - (1/n)\Sigma e' = \hat{E} + u + z - (1/n)\Sigma e' = \hat{e} + u + z - (1/n)[\bar{u} + \bar{z}],$$

where $n$ is the total sample size and summation without a subscript means summation over all observations.

When the probability limit of $b_{qe'}$ is taken, any term that involved $(1/n)[\bar{u} + \bar{z}]$ would be zero since both $u$ and $z$ converge to zero. Therefore, to simplify the following display, we simply drop $(1/n)[\bar{u} + \bar{z}]$ from the expressions for $e'$.

Then, $b_{qe'}$ may be written in terms of $\hat{e}$, $u$, $z$, $v$, and $w$ as

$$b_{qe'} = \frac{\sum_0 [v(\hat{e} + u + v) + w]\hat{e} + \sum_1 [v(\hat{e} + u + v) + w][\hat{e} + u + z]}{\sum_0 \hat{e}^2 + \sum_1 (\hat{e} + u + z)^2}.$$
Assuming that \( z, v, \) and \( w \) are each independent of \( \hat{e} \) and \( u \), and of each other

\[
\text{plim } b_{q\hat{e}} = \beta \frac{\text{plim}(\Sigma_{\hat{e}}^2 + \frac{2}{\beta} u + 2 v \hat{e} + u^2)}{\text{plim}(\Sigma_{\hat{e}}^2 + 2 v \hat{e} + u^2 + v^2)}
\]

The presence of \( \sum_{i=1}^{n} x_i^2 \) in the denominator implies that \( b_{q\hat{e}} \) is an inconsistent estimate of \( \beta \). For this reason we use \( b_{\hat{e}} \) as our estimate of \( \beta \).
REFERENCES


