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ABSTRACT

To examine the economic efficiency of initial military specialty training, procedures were tested for estimating the effects of that training on posttraining job performance. The approach chosen was an application of human capital theory in which the costs of on-the-job training and the returns to training are measured by comparing the trainee's pay and net productivity. The key element in implementing this approach is the estimation of on-the-job productivity. The data used to explore the tradeoff among training courses of different lengths consisted of enlisted supervisors' estimates of the net productivity of trainees at different points in their first term of military service. These estimates were used to construct profiles of the time path of productivity. All the productivity curves for the six specialties examined showed a positive slope that tended to decrease over time (the rate of improvement declining with experience). Moreover, comparisons among specialties tended to conform to expectations, both when comparisons were made between specialties in the same service and when between comparable specialties across services. Although further research is required before conclusions can be drawn regarding efficient mixes between formal and on-the-job training, the results suggest that it is possible to draw meaningful conclusions from data based on the carefully constructed ratings of supervisors. (A number of productivity paths are presented to show the general character of the data collected.) (JT)

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Specialty Training and the Performance of First-Term Enlisted Personnel

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PREFACE

This report was prepared as part of Rand's DoD Training and Manpower Management Program, sponsored by the Cybernetics Technology Office of the Defense Advanced Research Projects Agency (ARPA). With manpower issues assuming an ever greater importance in defense planning and budgeting, the purpose of this research program is to develop broad strategies and specific solutions for dealing with present and future military manpower problems. This includes the development of new research methodologies for examining broad classes of manpower problems, as well as specific problem-oriented research. In addition to providing analysis of current and future manpower issues, it is hoped that this research program will contribute to a better general understanding of the manpower problems confronting the Department of Defense.

Military training has received substantial attention in recent years as one area in which improved efficiency can lead to substantial cost reductions. This report treats an aspect of training efficiency that has to date received very little attention--the question of the efficient amount of formal training. Specifically, it deals with the efficient mix between formal and on-the-job training in providing first-term enlisted personnel with the skills needed to perform effectively in their military specialties. Since formal initial specialty training for first-term enlisted personnel currently costs about $2 billion per year, increased efficiency in this area could lead to substantial, recurring savings. This report describes problems involved in analyzing tradeoffs between formal and on-the-job training, alternative solutions to these problems, and some early results of Rand research in this area.

The substance of this work was originally presented at the Rand Conference on Defense Manpower, February 4-6, 1976, and is included in the conference proceedings: *Defense Manpower Policy: Presentations from the 1976 Rand Conference on Defense Manpower*, edited by Richard V. L. Cooper, R-2396-ARPA, December 1978. The present report is being

published separately because, as one of several planned publications dealing with Rand's training and productivity research, it is expected to have an audience different from that for the conference proceedings.

SUMMARY

The U.S. military is, among other things, a very large training institution. It is estimated that the cost of formal military training during FY 1976 was about $7 billion and involved about 250,000 man-years in student time.* A substantial portion of this cost is associated with the initial specialty training given to entrants to the enlisted force. Estimates are that in FY 1976, over $2 billion and 90,000 man-years of student time were devoted to initial vocational training.

Because of its large cost a great deal of attention has been given to improving the efficiency of initial specialty training. Research in this area has focused almost exclusively on one aspect of training efficiency--technical efficiency. That is, researchers have tried to determine the mix of training inputs (curriculum choice, teaching aids, staff, etc.) that most efficiently will achieve a certain level of proficiency in graduates.

The problem of selecting courses (and corresponding levels of graduate proficienoy) involves another aspect of training efficiency--economic efficiency. To evaluate specialty training in terms of economic efficiency, one must compare the benefits of additional formal training with the costs of obtaining those benefits. This report describes early results of research that is designed to address the question of economic efficiency in initial specialty training.

To evaluate the economic efficiency of training, one must assess the on-the-job performance of graduates of alternative training programs. Because additional formal training is always more costly, it is only worthwhile if it results in sufficient improvements in on-the-job performance to offset the additional cost. The key to evaluating economic efficiency in training is therefore the development of reliable measures of on-the-job performance. These measures need to reflect net rather than gross productivity, to reflect productivity

*Estimates of training costs derived from *Military Manpower Training Report for FY 1976*, Office of the Assistant Secretary of Defense (MR&A), March 1975.

over time rather than at a single point, and to be based on the performance of specific individuals rather than on the performance of a representative individual.

Measures that have these properties can be collected by a variety of methods, including direct measurement, job-knowledge tests, and supervisory ratings. Each of these methods has advantages and disadvantages, and no one approach is preferable, prima facie, to the others.

This report provides a preliminary analysis of a data set that has been assembled to explore the tradeoff among training courses of different lengths. The data consist of enlisted supervisors' estimates of the net productivity of trainees at different points in their first term of military service. These estimates are used to construct profiles of the time path of productivity. A number of productivity paths are presented to show the general character of the data we have collected.

While our analysis is admittedly simplistic, the shapes of and relationships among the productivity profiles are quite consistent with our prior expectations. Although further research is required before conclusions can be drawn regarding efficient mixes between formal and on-the-job training, the results of this study suggest that it is possible to draw meaningful conclusions from data based on the carefully constructed ratings of supervisors.

CONTENTS

FIGURES

I. INTRODUCTION[1]

Almost all new entrants into the military attend a formal course of instruction in the skills required in their military occupational specialties. It is estimated that about 320,000 of the 350,000 enlisted personnel joining the military in FY 1976 will receive such training. Since this initial specialty training will involve about 80,000 man-years of the trainees' time and cost about $2 billion,[2] the importance of conducting it efficiently is obvious. Even small improvements in efficiency can result in substantial, recurring savings.

A great deal of research has been devoted to improving "technical efficiency." To design technically efficient training courses, it is necessary to select the least-cost mix of curriculum, instructional staff, teaching aids, etc., that will produce graduates having a given level of proficiency. There are, however, an infinite number of technically efficient courses in a given specialty, each one of which will provide its graduates with a different level of proficiency. The problem of selecting among these courses (and corresponding levels of proficiency) involves another aspect of training efficiency--economic efficiency. Since almost any set of job skills *could* be taught entirely on the job, formal specialty training could be totally discontinued without losing the ability to maintain an effective military force. The reasons for having formal specialty training are economic rather than technological. To evaluate the optimal amount of formal training, one must compare the benefits of additional training with its costs. The costs of formal training (faculty and student salaries, supplies, etc.) are obvious. The returns are less obvious because they take the form of improvements in trainees' on-the-job performance. Economic efficiency in formal training is attained when the last dollar

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[1]This report was presented at the Rand Conference on Defense Manpower, February 4-6, 1976.

[2]These estimates are derived from *Military Manpower Training Report for FY 1976*, Office of the Assistant Secretary of Defense (Manpower and Reserve Affairs), March 1975.

spent on increasing the amount of formal training increases the benefits received after training by one dollar.

Rand is currently conducting research to evaluate the cost-effectiveness of different amounts of formal initial specialty training. Since more initial training is always more costly than less, longer courses are only cost-effective if they produce better-qualified graduates. The key question, therefore, is how can the quality of graduates be judged? One way is to compare the first-term productivity of graduates of different courses. At a minimum, longer courses must make graduates sufficiently more productive during their first term to compensate for the time spent in school. If, for example, graduates of a course that lasted an additional 2 months were no more productive than graduates of a shorter course, the shorter course would clearly be preferable because its graduates would be in the military labor force 2 months longer during their enlistment.

The value of such productivity comparisons is, however, limited. Suppose, to continue the previous example, that graudates of the longer course proved to be 5 percent more productive after completing the course than graduates of the shorter one, even after allowing for the fact that they had 2 months less on the job. How is one to judge whether the increase in productivity is worth the extra cost of the longer course?

To analyze such tradeoffs, one must be able to measure both the costs and the benefits of longer courses in the same terms, and the common denominator with the most general applicability is dollars. If the analysis is conducted in these terms, one can not only compare the efficiency of courses of different lengths, but can also consider other margins of substitution. For example, total first-term training costs can be reduced by reducing the number of new entrants each year--perhaps by substituting career personnel or capital goods for first-termers--as well as by choosing more efficient course lengths.

We have adopted an approach to this problem that is an application of contemporary human capital theory. Basic to this apprach is the notion that the costs of and returns to training can be measured by comparing an individual's pay and allowances with his net productivity. In the representative case, the first term of service can

be thought of as having three distinct phases: first, a period of basic military training and initial technical training; second, a period of on-the-job training when the value of the individual's productivity is less than the pay and allowances he receives;[3] and third, a period during which the military earns returns on its investments in training because the person's productivity is greater than his pay and allowances. These three periods are illustrated in Fig. 1, where the time t_1 represents the end of formal training, the time t_2 the end of the period of investment in on-the-job training, and t_3 the end of the first term of service.

During formal training, the individual's *direct* contribution to military capability is by definition zero. (Since he is not assigned to an operating unit, he could not possibly be contributing to current military effectiveness.) His *net* contribution, however, is negative, because training requires resources (instructional staff, classroom space, etc.) that could otherwise be contributing to current military capability. Therefore, the full cost of a person's formal training, say at time $\hat{t}$, includes both the pay and allowances he receives (given by the distance AB) and the opportunity cost of the other resources devoted to his training (BC). After he completes formal training, his *net* contribution to military capability can be measured as the difference between his direct contribution and the opportunity cost of resources (such as the supervisors' time) devoted to his on-the-job training. The cost of on-the-job training at a point such as $\tilde{t}$ can be measured by the difference between the individual's pay and allowances and his net productivity at that time (in this case the distance DE).[4] The total cost of on-the-job training (OJT) is approximately

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[3] More precisely, this period is one of military investment in on-the-job training, since on-the-job training in the sense of improvement in job-relevant skills continues as long as one's productivity is increasing.

[4] In Fig. 1, the trainee's net productivity is shown as being negative immediately after he completes his formal training. Negative productivity would occur if the forgone productivity of the tainee's supervisors exceeds the trainee's direct productivity. Although this is not necessarily the case, it does appear to be common.

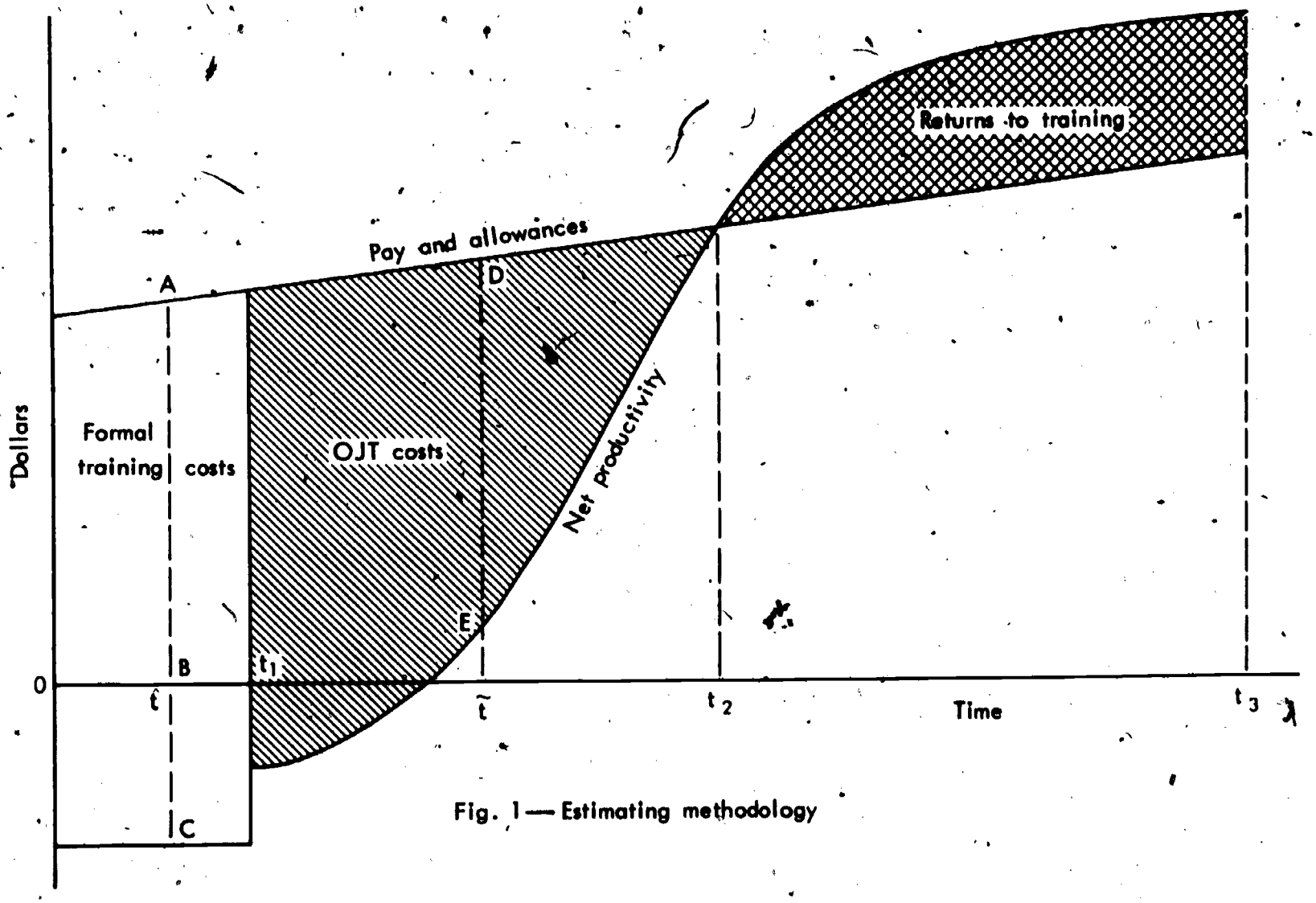

Fig. 1 — Estimating methodology

the shaded area in Fig. 1.[5] Finally, there are returns to training whenever the individual's net productivity exceeds his pay and allowances. These can be measured in the same fashion as the costs of on-the-job training and are represented by the cross-hatched area in Fig. 1.

The difference between the present value of the total cost and the returns to training constitutes the military's net investment in an individual's first-term training. Naturally, the value of the net investment will change with changes in the length of formal training.[6] For example, longer courses will increase the cost of formal training. The returns from these investments are in the form of decreases in the cost of on-the-job training and increases in the returns to training resulting from enhanced on-the-job performance. The relative magnitudes of the two effects determine whether the change in the amount of training is cost-effective.

In general, we expect the relationship between length of formal training and net investment in training to be like that shown in Fig. 2. This relationship is consistent with the view that, initially, additional amounts of formal training will reduce total training costs, but that at some point, the gains, in terms of enhanced on-the-job performance, will not outweigh the costs of the additional formal training and, hence, net costs will not be reduced. In fact, at some point, it is reasonable to assume that additional amounts of formal training will cause net costs to rise. The potential number of such tradeoffs is, of course, quite large, and the current research program could not attempt to explore all the possible alternatives. Our approach to the problem is to use existing natural experiments in training lengths in

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[5] The shaded area in Fig. 1 represents the undiscounted sum of on-the-job training costs. Because these costs are incurred at different points, they should be measured as a discounted sum. Similarly, formal training costs and the returns to training should be measured as present values, although, as a practical matter, formal training periods are typically so short that discounted and undiscounted values are virtually identical.

[6] Assuming that we are choosing from among the set of technically efficient courses.

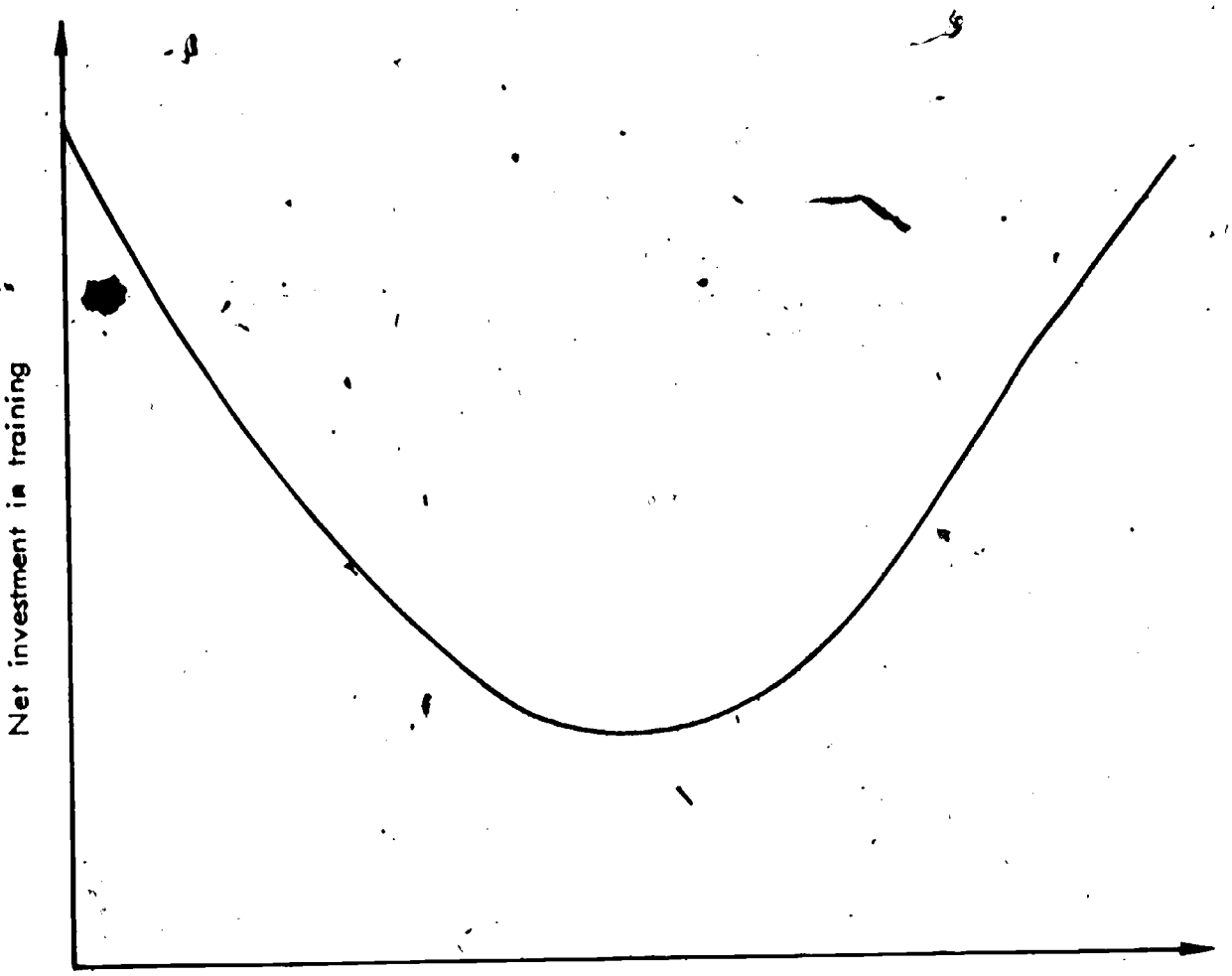

Fig. 2 — Relationship between length of formal training and net investment in training

a variety of specialties to gauge the nature of (a) the potential economies to be derived from more efficient course length and (b) the factors that influence them.

The major limitation to putting this sort of model into operation is the difficulty of estimating the time path of productivity. We have developed a method in which survey data are used to estimate productivity, and we have recently finished collecting data on members of about 50 specialties in the three major service branches. This data set consists of supervisory ratings of the net contribution to unit production of selected first-term personnel serving at their first-duty station. These ratings apply to each individual in the sample at a number of points during his first term of service. They thus permit individual productivity profiles to be constructed for an entire first

term. The technique used to elicit these ratings was that of a sequential mail survey. An initial survey questionnaire was mailed to selected first-term personnel identified by personnel records as enlistees serving at their first-duty station. This survey was designed to verify sample criteria and to identify enlisted supervisors most familiar with the sampled first-termer's work. A subsequent survey questionnaire was mailed to identified enlisted supervisors to elicit the productivity ratings previously described. In its final form, the productivity data set consists of background material on individual first-term personnel drawn from service personnel records and survey material, a set of productivity ratings from an enlisted supervisor or supervisors, and additional background material on the supervisory raters themselves. This data set, then, forms the basis for the productivity analysis of the general model.

The purpose of this report is to describe this data set and some of the results of our early analysis of it. In Section II, the kinds of productivity measurements we have used are described in terms of the reasons for choosing them rather than as alternatives. In Section III, we present estimated productivity curves for six military occupational specialties and compare them to indicate the types of curves, and the relationships among them, that resulted from our data. Section IV summarizes the findings of the study and indicates the need for and directions of further research in this area.

II. PRODUCTIVITY MEASUREMENT

The two most difficult problems associated with adequately addressing the issue of economic efficiency in military specialty training are (1) to establish an appropriate analytic framework for comparing the benefits and costs of additional amounts of training and, since the benefits of additional training take the form of increased productivity, (2) to estimate productivity. We believe that the human capital model just outlined provides an appropriate framework for analyzing the effects of different amounts of formal training. In this section, we deal with the problem of productivity estimation. The objective is to assess the advantages and disadvantages of several alternative approaches to the problem, focusing on both their conceptual appropriateness and the cost of gathering the type of productivity data needed to address the issue of economic efficiency in specialty training. The first step in this process is to determine the properties that are important in such measures.

PROPERTIES OF PRODUCTIVITY MEASURES

Three properties are crucial in any productivity measures used to evaluate alternative specialty training policies. The measures should (1) permit productivity to be estimated over time, not just at a single point, (2) measure net rather than gross productivity, and (3) be linked with the characteristics of the individual to whom they apply. First, it is important that the time path of productivity be measured, because different types of formal training may affect productivity differently during the course of a military career. For example, if one were comparing two equally costly training courses in which one course emphasized the skills needed by a mature technician and the other emphasized the skills that an enlistee would use in the early months of his first-duty assignment, a measure that captured only productivity in the early months after completion of training would favor the latter course, whereas a measure that focused on productivity later in the career would favor the former. Adequate evaluation requires comparisons of productivity at a number of points so

that comparisons can be made among courses with differential effects on productivity over time.

Second, it is important that net rather than gross productivity be measured. An individual's gross productivity is the amount he personally produces; his net productivity is the difference between the unit's production in his presence and in his absence. The two need not be at all the same, and the relationship between them can be expected to change systematically with experience. Consider, for example, a new, specialty school graduate who joins a large radio repair shop. Although he will probably be able to complete some simple types of repairs, he will almost certainly need fairly close supervision. His gross productivity in these circumstances is positive, but if the reduction in his supervisors' production exceeds the trainee's direct production, his net productivity is negative. As he acquires more experience, his gross productivity will normally increase, and the amount of supervision he requires will decrease, so that net productivity will rise more rapidly than gross productivity. At some point, supervision will become minimal, and gross and net productivity will, for all intents and purposes, be identical.[7] To the extent that the two measures differ, net productivity is clearly the appropriate concept for evaluating training because it measures the difference in military effectiveness attributable to an individual. The use of gross productivity tends to bias analyses of substitutions between formal and on-the-job training in favor of on-the-job training by overstating the trainee's productivity during his early experience when supervisory inputs are greatest.

The ability to relate productivity measures and trainee characteristics, such as aptitude, education, attitudes, etc., is essential to a detailed analysis of training alternatives. Otherwise, it is extremely difficult to control for personal characteristics in assessing the effects of alternative amounts of formal training. Lacking these relationships, one is essentially restricted to making comparisons

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[7] Of course, for those with substantial supervisory responsibilities, the relationship is reversed and net productivity exceeds gross productivity. This circumstance is not likely to be relevant during the period of interest here.

among representative individuals or to performing experiments involving matched samples. The former approach is undesirable because one can never be certain how representative the "representative individual" is. The latter approach is undesirable because it precludes the use of natural experiments and because the experiment in this case (including formal and on-the-job training) is quite lengthy. Both approaches are limited in the sense that the relationships that are estimated are conditional on a given mix of trainee attributes--they provide no information on the effects of changes in trainee attributes.

ALTERNATIVE MEASUREMENT PROCEDURES

Measures having the properties just discussed can be gathered in a number of ways. Here we describe the strengths and weaknesses of two of the major alternatives, which provides a basis for evaluating the measurement procedure we have used.

Substitution Measurement

The general character of the productivity measures one would collect with unlimited resources is fairly straightforward. Such measures would involve estimating an individual's net productivity by measuring a unit's output in his presence and in his absence. In our example of the radio repair shop, the shop's output could be measured with its full complement of personnel and then with various combinations of n - 1 personnel. The difference between the output of repairs with and without a given person is a measure of his net productivity. A time path of net productivity could be estimated either cross-sectionally or longitudinally.

One substantial difficulty in implementing this approach is the measurement of unit output. The problem arises primarily because there are many different types of output in a given specialty. To return to the radio shop example: Within a given shop, several types of radios will be maintained and many types of failures will occur. If there are substantial variations in the difficulty of repairing different types of failures and in the mix of failures over time, the number of "repaired radios" that can be turned out in a given number of man-hours

will differ considerably. To take these variations into account, weights must be developed for different types of repairs, and output must be measured as a weighted sum of repairs. When the context is broadened to include multiple shops, the development of appropriate weights is even more important, because differences in equipment mixes among shops can introduce substantial differences in measured productivity if inappropriate weights are selected.

At first glance it may seem that once an unambiguous definition of output is developed, a small number of observations will be sufficient to evaluate two alternative training strategies because the productivity measurements can presumably be made quite precisely. This is not true, however, because of the large number of factors besides military training that influence a person's contribution to unit performance. These include (a) his motivation, ability, previous education, etc.; (b) the number, experience level, motivation, ability, and previous education of other personnel in the unit; (c) the group's experience in working together; (d) the stock of capital equipment; and (e) the demand for service that the shop faces. To control for these factors, a large number of observations are necessary.

It should be apparent from the preceding discussion that the "ideal" sort of productivity measures would be quite costly to assemble and would, in spite of the cost, be less than perfect. This suggests that it is worthwhile to consider other alternatives. If suitable less costly alternatives can be found, they would be preferable if only because of the limited amount of previous research in this area. Since the information available is so limited, it is probably better to obtain a first approximation of productivity and economic efficiency of training for a number of specialties than to devote the same amount of resources to a detailed analysis of one or two specialities.

Job-Performance Tests

One approach that retains the characteristic of direct measurement but involves measures that are simpler to develop and administer is the use of job-performance tests. This approach involves testing individuals on a specific set of skills used in their specialty. By

testing people with different amounts of on-the-job experience, or one person at several times, the relationship between productivity and experience can be established; and by linking these measurements to those of formal technical training, background, ability, etc., one can estimate the effects of different initial training (controlling for personal characteristics).

There are several major limitations to this approach, however. Most importantly, it involves measurement of gross, rather than net, productivity. The on-the-job training process in the military generally involves substantial inputs of supervisory resources, and therefore differences between net and gross productivity are likely to be large, especially early in the on-the-job training process. Use of gross productivity will result in downward-biased estimates of on-the-job training costs and, therefore (because the returns to formal training are understated), will lead to policies that entail less-than-efficient amounts of formal training. A more subtle bias occurs because of differentials in supervision across individuals. One would expect the level of supervisory inputs to the on-the-job training process to vary with the trainee's amount of formal training and his personal attributes. If, for example, better trained, more able personnel require less supervision, gross productivity measures understate the differential in performance between the better-trained, more able individuals and those with less ability and training. This implies that gross productivity measures will fail to capture part of the returns to additional formal training and also that the relationships between personal characteristics and productivity estimated from gross productivity data will be biased. Finally, there are real questions of how well job-performance tests measure actual gross productivity. Even if the chosen job tasks accurately reflect the duties in a particular specialty, they may not accurately represent a particular individual's actual duties. Further, job tests measure a person's *capability* to perform those tasks, not his actual performance of them. The difference in the observed performance of two similar persons with, for example, different levels of motivation is likely to be much smaller during a short test than over the course of several days or weeks on the job.

Rand Method

The approach we have chosen uses supervisors' ratings of net productivity rather than direct measurement. This approach has the disadvantage of being a subjective measure, but it also has many advantages, especially since there has been so little previous analysis of the relationship between formal specialty training and productivity. In the following discussion, we will describe the productivity measurements that have been gathered and examine the strong and weak points of the approach.

We have used a self-administered mail questionnaire to obtain supervisors' ratings of the net productivity[8] of specific trainees at several points during their first term of service. Specifically, supervisors were asked to rate each trainee's productivity (1) during his first month with the unit, (2) at the time that the rating was completed, (3) 1 year from the *time of rating*, and (4) after completion of 4 years of service. In each instance, the supervisor was asked to rate the individual's net productivity ralative to that of the typical specialist with 4 years of experience. Together, these points trace out an estimated time path of relative net productivity that can be related to the attributes of the person being rated.

This method of estimating productivity is attractive for four reasons. First, it measures net rather than gross productivity. Second, it does permit one to control for personal characteristics in comparing training alternatives. Third, the cost of data collection is relatively low, which means that for a given budget many more specialties can be analyzed than would be possible using, for example, substitution measures. Although substitution measures would presumably lead to more precise estimates, it appears more valuable, at the present stage of research in this area, to explore the general magnitude amd pattern of training effects across a number of specialties than to analyze a small number of specialties in great detail. Fourth, because of the general nature of the measures that are obtained, comparisons across specialties are feasible both within a given service and

[8]Net productivity is defined as the difference between a trainee's gross productivity and the forgone productivity of supervisors who work with him.

across services. This feature is also important in obtaining a broad overview of the effects of training on productivity.

Two important limitations to our approach should be considered. First, the concept of net productivity is fairly sophisticated, and it is not one that enlisted supervisors are likely to have been familiar with before receiving the questionnaire. Thus it is possible that some survey responses will be invalid because supervisors did not understand what they were being asked to do. Because of this possibility, we spent a great deal of time and effort in the survey design stage to develop and field test a clear explanation of the concept of net productivity. Of course, no such explanation could be clear to all recipients of the questionnaire, so a simple test of comprehension was included in the survey instrument. In addition to their questionnaire responses, supervisors were asked to rate both a "typical" technical school graduate and a directed duty assignment trainee;[9] this rating was intended to provide some insight into the supervisor's comprehension of the concept. Clearly, some responses will still be unusable because of the rater's inability to comprehend the concept of net productivity, but a preliminary analysis of the data does not indicate that this is a serious problem.

Another potential limitation is the possibility of important differences among raters in their rating systems--some tend to rate easy and others hard; some tend to see people as very similar and some as very dissimilar. These differences have the potential of producing substantial noise in the data, and a pilot study of our approach[10] suggested that they were indeed a serious consideration. An econometric model for dealing with this source of distortion by estimating parameters of the supervisor's rating system was developed in conjunction with the pilot study, and has been expanded and tested through

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[9] A directed duty assignment trainee is one who goes directly from basic military training to an operating unit without attending a formal specialty training school.

[10] R. M. Gay, *Estimating the Cost of On-the-Job Training in Military Occupations: A Methodology and Pilot Study*, The Rand Corporation, R-1351-ARPA, April 1974.

Monte Carlo simulation.[11] It provides a means for controlling for supervisor-rating effects. The ratings of a typical trainee provide another method of determining distortion, since one would expect, for example, the supervisor who is a harder-than-average rater to give both the "typical trainee" and individual trainees low ratings. A preliminary analysis of our data suggests that a good deal of the noise in the supervisor ratings is, in fact, eliminated by controlling for the supervisor's rating of the typical trainee.

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[11] Richard V.L. Cooper and Gary R. Nelson, *Analytic Methods for Adjusting Subjective Rating Schemes*, The Rand Corporation, R-1685-ARPA, June 1976.

III. PRODUCTIVITY RELATIONSHIPS

The data base assembled at Rand to provide a vehicle for analyzing the effects of different amounts of first-term specialty training is very large and, in many respects, unique. It includes information on individuals in more than 50 specialties in the three major service branches. When preliminary data processing is completed, an observation will include (a) the supervisor's rating of a trainee, (b) background information from service personnel records on both the trainee and the supervisor, and (c) additional background information on the trainee obtained from a survey he had completed. The survey data were collected through sequential mail surveys of about 30,000 first-term enlisted personnel and an approximately equal number of enlisted supervisors. This section presents the findings of a very preliminary analysis of these data. Because we are at a very early stage in our work, we have adopted a rather elementary form of analysis--comparisons of estimated productivity functions over time in several specialties. In presenting these results, we intend to suggest a broad consistency between the observed patterns of productivity and those one would have expected a priori.

This section is divided into three parts. First, we describe the data used in the present analysis. Second, we present a comparison of estimated productivity curves for six military occupational specialties. Third, by analyzing estimated productivity curves for the "typical" technical school graduate and directed duty assignment trainee, we illustrate both the potential for and the pitfalls of using these sorts of data to analyze effects of training on productivity.

DATA CHARACTERISTICS

As mentioned previously, our productivity data consist of responses to questionnaires administered by mail to supervisors in a selected set of military occupational specialties. Supervisors were requested to provide three types of estimates of net productivity over time. First, and most important, we asked for estimates of specific

individuals' net contribution to unit productivity at four points during their first term of service: (1) during the first month on the job, (2) at the time that the rating was completed (which will, of course, imply different amounts of on-the-job experience for different individuals), (3) 1 year from the time of the rating, and (4) after 4 years of service. Second, we asked for estimates of the typical technical school graduate's net contribution to unit production during his first month on the job, after 1 year on the job, after 2 years on the job, and after 4 years of service. Third, we asked for estimates of the typical directed duty assignment trainee's net contribution to unit production after 1 month, 1 year, and 2 years on the job and after 4 years of service.

For purposes of the present analysis, we have selected a subsample of 6 of the more than 50 military occupational specialties for which data have been collected. The subsample covers a range of job tasks and includes a set of comparable specialties in different services. We have selected the light weapons infantry specialists (11B) and the hospital corpsmen (91B) in the Army; radio repair specialists (ETN) and hospital corpsmen (HM) in the Navy; radio repair specialists (304X4) and hospital corpsmen (902X0) in the Air Force. Observations for an individual were included only if a complete set of four productivity estimates was available, and if the trainee (a) was serving at his first-duty station, (b) had attended technical school training, and (3) was serving in the specialty in which he was trained. Further, to eliminate responses clearly indicating that the supervisor's comprehension of the concepts was poor, we deleted cases in which the supervisor rated the typical technical school graduate's productivity at 100 percent or more during his first month on the job or at zero or less after 4 years of service.[12]

COMPARISON OF PRODUCTIVITY CURVES FOR SIX SPECIALTIES

Representative productivity curves for members of a given specialty can be estimated by using ratings of the productivity of specific

[12]Using these criteria, the number of cases in each specialty were 11B, 96; 91B, 197; ETN, 252; HM, 85; 304X4, 689; and 902X0, 363.

individuals, as illustrated for two Navy occupational specialties (radio repairmen and hospital corpsmen) in Fig. 3. Average productivity during the first month on the job and after 4 years of service (points 1 and 8 in Fig. 3) can be estimated by taking the average value of the responses for all individuals in the sample.[13] Intermediate points are estimated by taking the average estimate of productivity at the present time and 1 year from now for groups of individuals in different experience categories. Specifically, we have grouped individuals into three experience categories: 5-9, 10-14, and 15-19 months of job experience. Points 2-4 in Fig. 3 represent the mean values of the estimates of productivity at the time of the rating for those in each of the categories (plotted at the midpoints of the intervals). Points 5-7 represent the average values of estimated productivity a year from the time of the rating for people in the same experience categories.[14]

On average, these estimates of relative productivity for both the radio repairmen and hospital corpsmen conform to our expectations. The curves have positive slopes, reflecting an increase in productivity as a function of experience. Further, estimated relative productivity after 4 years of experience approaches 100 percent in both specialties. Since productivity is being measured relative to the average specialist with 4 years of experience, average productivity at this point would, in the absence of bias, be 100 percent.[15] The averaged ratings of the radio repairmen are consistently below those for the hopsital corpsmen, which is to be expected because radio repair is more technically demanding and requires more experience before one can attain proficiency. Figure 4 shows similar comparisons for the Air Force hospital corpsmen and radio repairmen, whose productivity patterns are similar to those of the Navy specialists. Initial net productivity is negative for radio repairmen and positive for hospital corpsmen, and the differences in

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[13]Since the horizontal axis of Fig. 3 measures on-the-job experience and point 8 corresponds to productivity after 4 years of *service*, the position of point 8 in a given specialty depends on the length of formal technical training in that specialty.

[14]Cells with fewer than 10 observations were not included in the plots.

[15]This at least partly explains why the difference between the two curves diminishes over time.

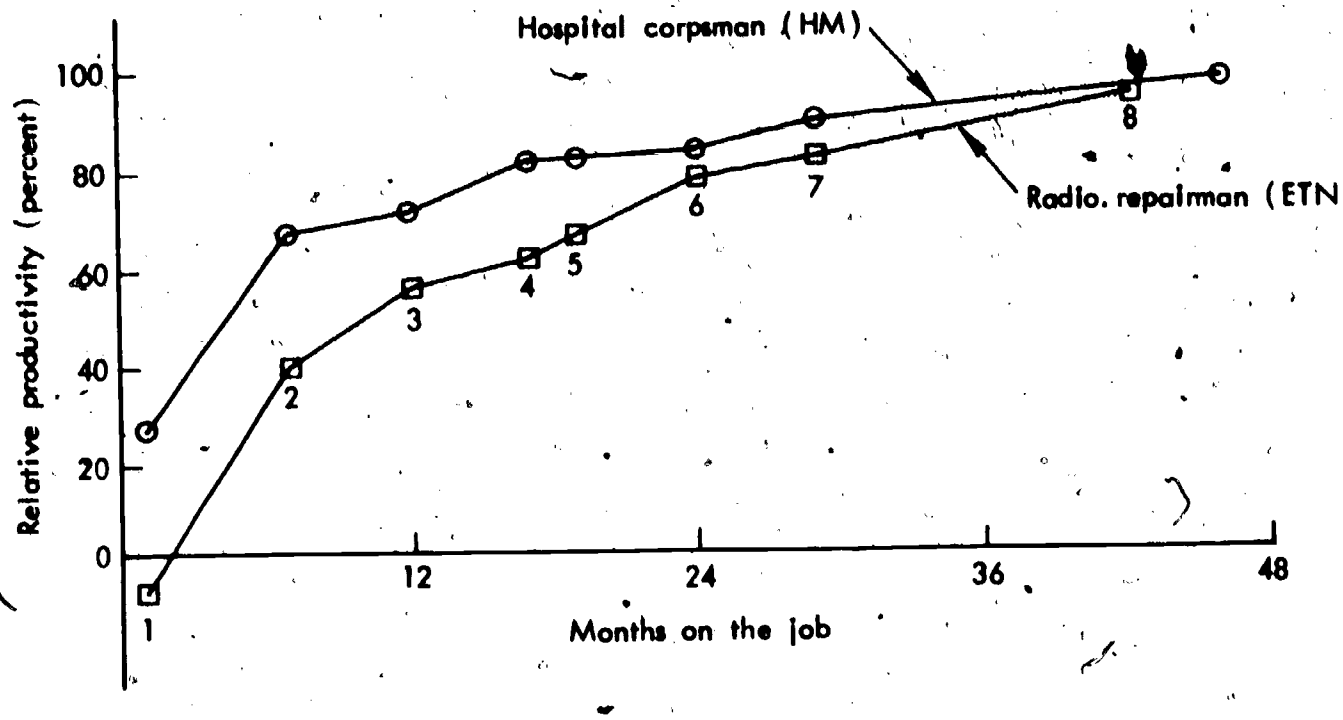

Fig. 3 — Comparison of productivity profiles in two Navy specialties: hospital corpsman (HM) and radio repairman (ETN)

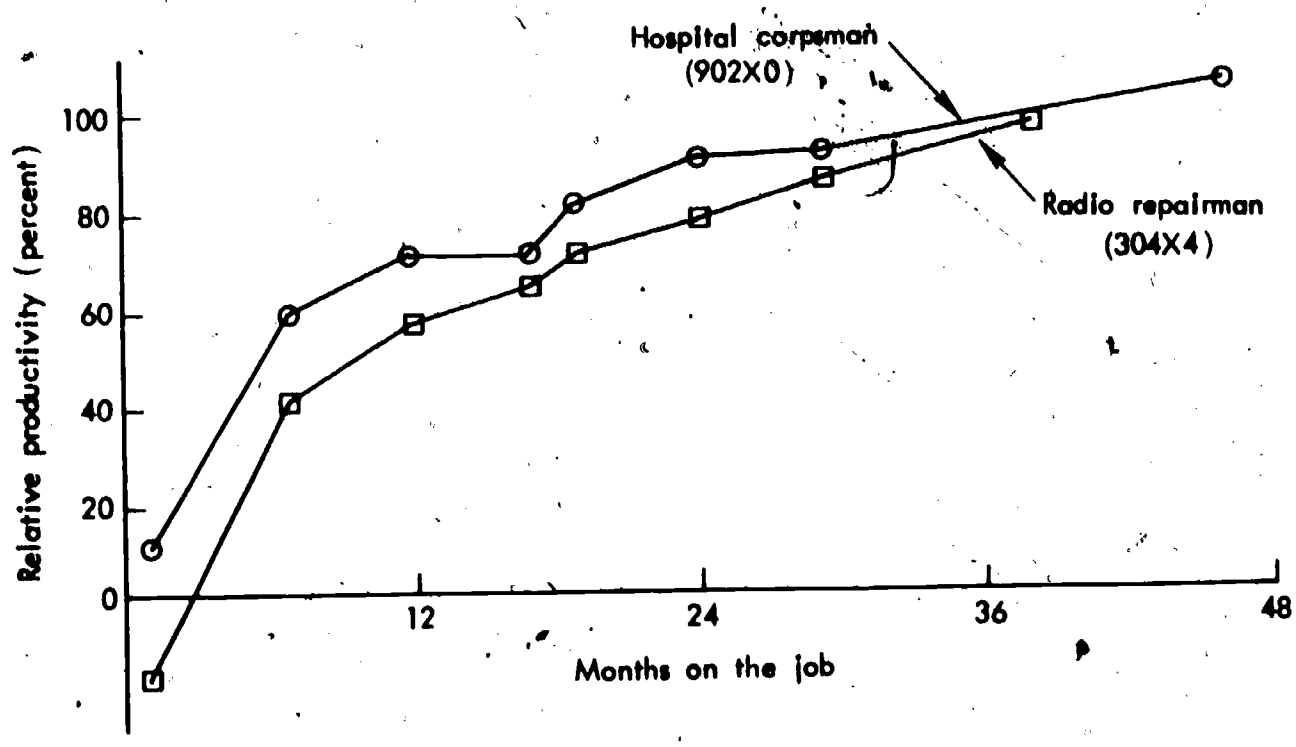

Fig. 4 — Comparison of productivity profiles in two Air Force specialties: hospital corpsman (902X0) and radio repairman (304X4)

relative productivity diminish with experience. The curves for the two Army specialties (hospital corpsmen and light weapons infantrymen) shown in Fig. 5 are less clear-cut. Here it is not so obvious which is the more technically demanding specialty; moreover, the differential in productivity does not decline over time as expected.

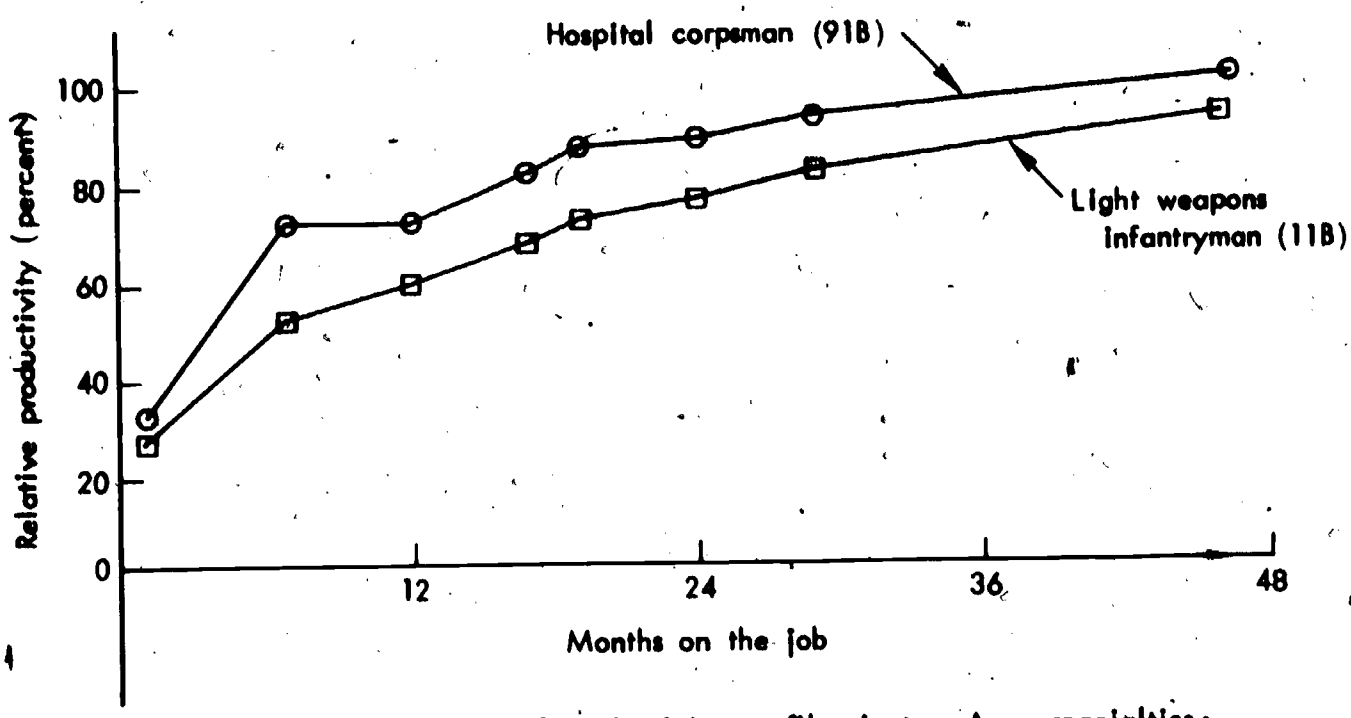

Fig. 5 — Comparison of productivity profiles in two Army specialties: hospital corpsman (91B) and light weapons infantryman (11B)

Another way of exploring the consistency of our estimates is by comparing estimates of similar specialties in different services. The two curves in Fig. 6 show the productivity profiles in two radio repair specialties, Navy ETN and Air Force AFSC 304X4. Here a striking similarity can be observed in both initial and final productivity and rate of progress. The curves suggest that there is a high degree of comparability between the two services in this occupational specialty.

Figure 7 makes a similar comparison of the productivity ratings for hospital corpsmen in the three services. Again the consonance among the curves is striking in terms of both slopes and intercepts. However, the average productivity curve for the Air Force corpsmen has a slightly lower initial value than the curves for the Army and Navy

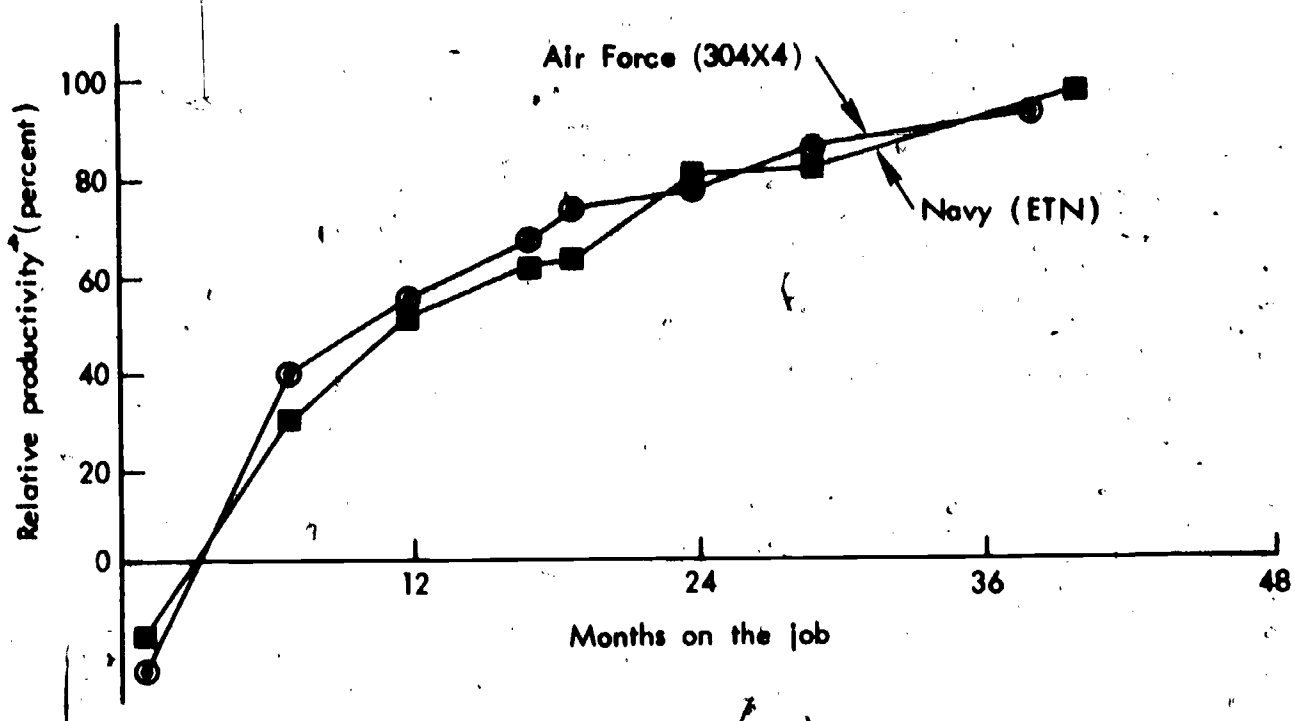

Fig. 6 — Comparison of productivity profiles in two radio repair specialties: Navy ETN and Air Force AFSC 304X4

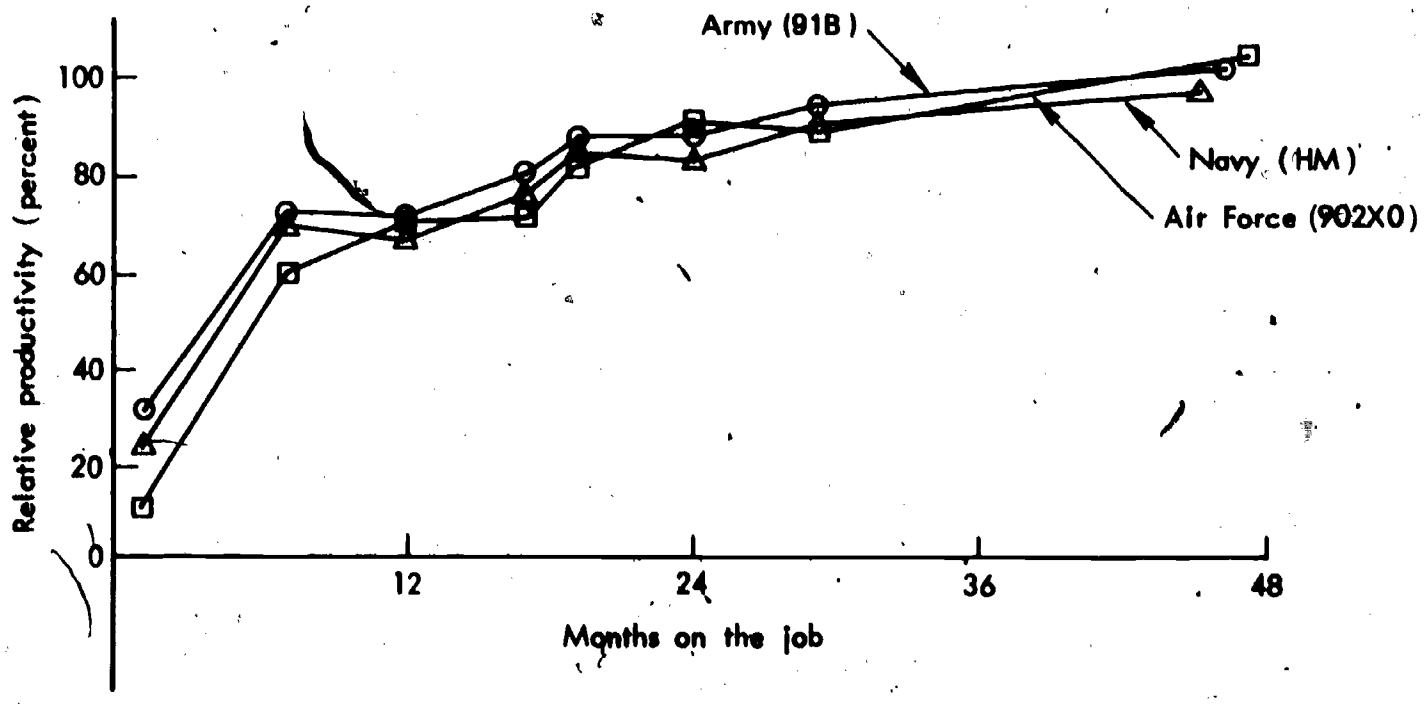

Fig. 7 — Comparison of productivity profiles in three hospital corpsman specialties: Army 91B, Navy HM, and Air Force 902X0

corpsmen. One possible explanation is that hospital corpsmen in the Air Force receive approximately 20 percent less formal schooling than those in the Army and Navy, but this hypothesis cannot be tested in the current analytic framework.

Servicewide productivity curves for both hospital corpsmen and radio repairmen are presented in Fig. 8.[16] The relationships in this instance are quite similar to those observed for the Navy and Air Force in Figs. 3 and 4.

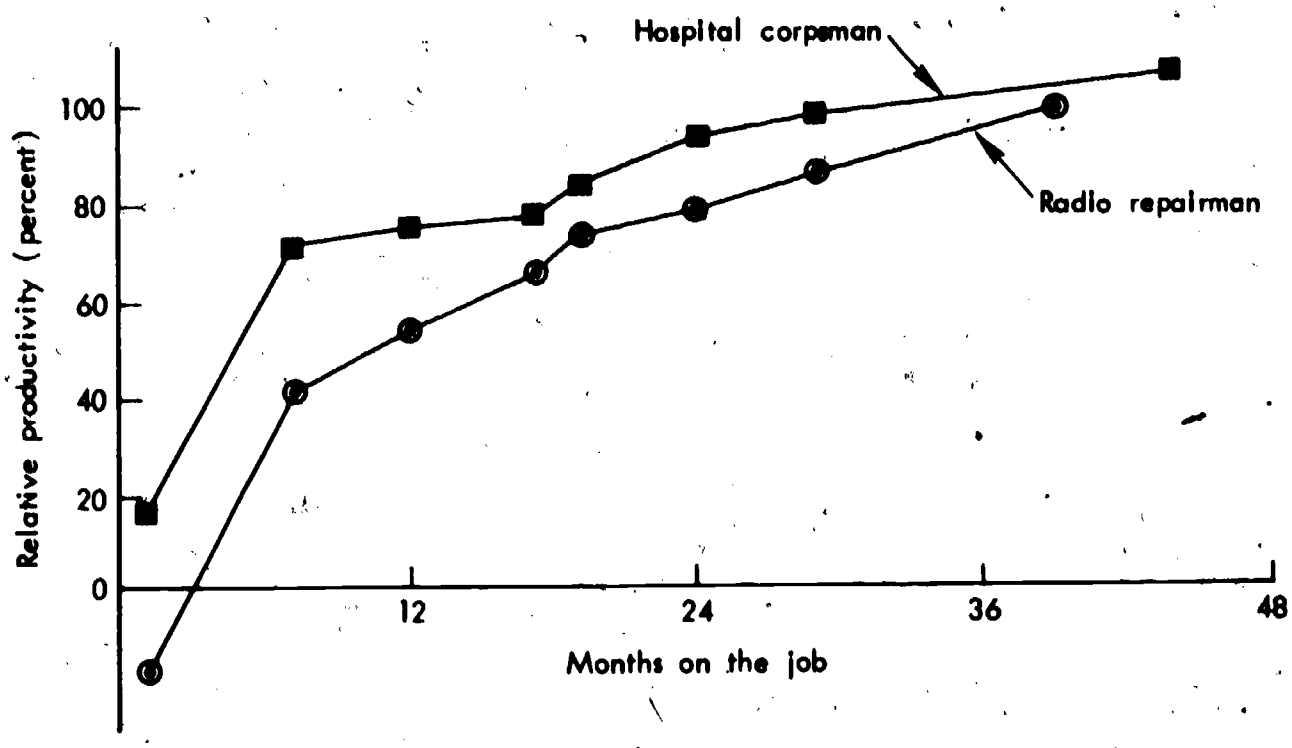

Fig. 8 — Servicewide comparison of two occupational specialties: hospital corpsman and radio repairman

As a group, these results are quite encouraging. They are consistent with expectations both in terms of the productivity patterns observed over time in a given specialty and the relationships among specialties. These findings suggest that the productivity estimates we have assembled will be useful in appraising alternative training policies.

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[16] These curves include all members of the respective specialties regardless of service.

COMPARISON OF PRODUCTIVITY CURVES FOR GRADUATES AND NONGRADUATES

Both the potential for and the pitfalls of using these types of data to analyze the effects of training on productivity can be illustrated by some comparisons of productivity curves estimated as averages of supervisors' ratings of the "typical" technical school graduate's performance and the performance of the "typical" directed duty assignment trainee. Unlike the curves estimated from ratings of specific individuals, these curves chart the progress of hypothetical typical trainees through the first term of service.

The four curves in Fig. 9 present such comparisons for two radio repair specialties: Navy ETN and Air Force 304X4. The curves exhibit properties consistent with the general expectations of productivity estimates and are similar to the average curves estimated for specific individuals. The curves for the Navy radio repairmen (represented by the solid lines) show substantial and persistent differences between

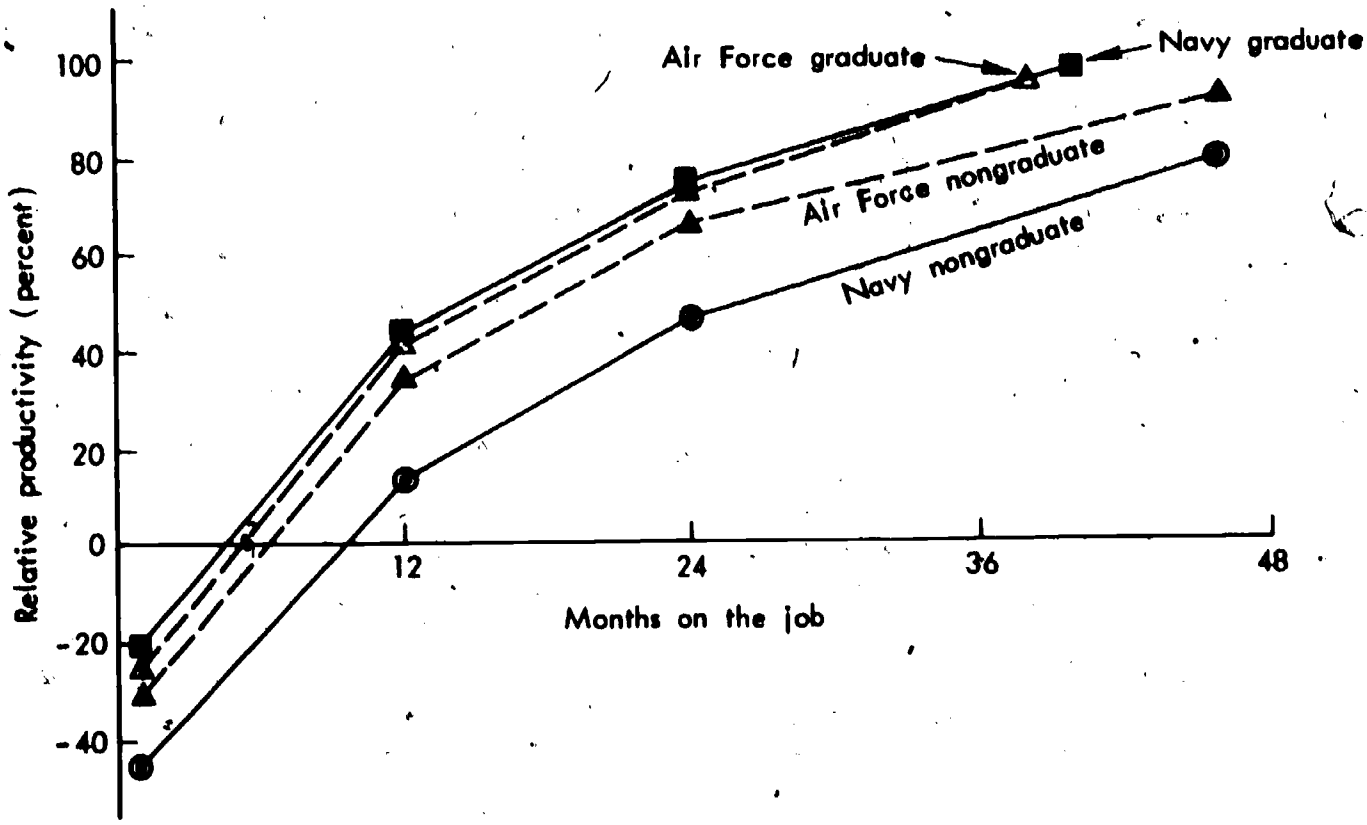

Fig. 9 — Comparison of combined productivity profiles of "typical" graduate and nongraduate trainees in two radio repair specialties: Navy ETN and Air Force 304X4

the performance of graduates and nongraduates throughout the first 4 years of service and suggest that returns to training may be substantial. The curves for the Air Force radio repairmen (represented by the dotted lines) show a similar relationship between the performance of graduates and nongraduates, but the differences appear to be much smaller than those between the two Navy curves.

Based on these two sets of curves alone, one might argue that there is a difference in training effectiveness between the Navy and Air Force, with higher returns to training occurring in the Navy. Consideration of the two sets of curves together, however, raises questions about this interpretation. The two curves for the graduate repairmen are practically identical; the differences between the services arise because Navy nongraduates do not perform as well as Air Force nongraduates. This suggests that the apparent difference in returns to training between the two services may, in fact, be due to differences in the relative quality of graduates and nongraduates rather than to differences in training effectiveness. That is, Navy and Air Force technical school graduates may be roughly comparable in terms of aptitude, education, etc., but Navy directed duty assignment trainees may be less able than their Air Force counterparts. Of course, with this sort of analysis one cannot really sort out the effects of differences in personal characteristics from differences in training effectiveness. The results do imply, however, that we are likely to observe systematic differences in the performance of graduates and nongraduates, and that in analyzing them it will be important to control for the personal characteristics of trainees.

IV. CONCLUSIONS

To determine the efficient *amount* of technical school training for military occupational specialties, the analysis must be conducted within a framework that permits the analyst to estimate the effects of that training on posttraining job performance. The approach we have chosen is an application of human capital theory in which the costs of on-the-job training and the returns to training are measured by comparing the trainee's pay and net productivity. The key element in implementing this approach is the estimation of on-the-job productivity. To construct estimates of the time path of productivity, we have used supervisors' estimates of the net productivity of trainees at various points in their first term of service. A number of estimated productivity paths were presented to show the general character of the data we have collected.

All the productivity curves for the six specialties discussed in this report showed a positive slope that tended to decrease over time (the rate of improvement declined with experience). Moreover, comparisons among specialties tended to conform to expectations, both when those comparisons were made between specialties in the same service and when they were made between comparable specialties across services.

Encouraging as these results are, they are of no direct help in solving the problem of efficient amounts of technical school training. Two steps are necessary before this problem can be addressed. First, the productivity estimates must be integrated into a broader framework so that training costs and returns to training can be estimated. Second, estimated net training costs (formal training costs plus on-the-job training costs less returns to training) must be analyzed for individuals with differing amounts of formal training. And, as the results of this study of "typical trainee" data suggest, future analyses must be done in a multivariate framework that controls for other factors that influence estimated productivity.