Variable Indirect Personnel Costs: Concepts, Methodology, and Empirical Estimates

Henry L. Eskew, Ph.D.

Consultant to

SAG Corporation
4115 Annandale Road
Annandale, VA 22003

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Naval Center for Cost Analysis
4290 Mount Vernon Drive NW
Suite 18200
Washington, DC 20393-5444

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Background

In March 1996, the Naval Sea Systems Command tasked the Naval Center for Cost Analysis (NCCA) with initiating a study relating to indirect costs of naval personnel. The Deputy Assistant Secretary of the Navy (Ships) amplified that tasking in June 1996. The study, which ultimately became known as 'Cost of a Sailor,' sought to develop a capability for improving the Navy's estimates of changes in cost—both direct and indirect—that result from changes in the numbers and types of operating force personnel.[1]

In August 1997, the Principal Deputy Assistant Secretary of the Navy (Research, Development and Acquisition) distributed the cost-estimating rates that resulted from 'Cost of a Sailor,' requesting that the full (direct plus indirect) rates be used for all future intra-Navy analytical purposes, but that direct-only rates be used in cost estimates that are to be forwarded to organizations outside the Navy. That same communication announced the forthcoming availability of a database/model to be called "Cost of Manpower Estimating Tool (COMET)," which would be the single source for estimating the cost of manpower in the Navy. A December 1997 memorandum from the Director of NCCA announced the completion and availability of COMET.

The indirect cost-estimating rates (factors) contained in COMET were those developed in the "Cost of a Sailor' study. They were generated from a database that ended in Fiscal Year 1996. Because a considerable amount of time has passed since then, and because more and better data are now available, NCCA decided that an update and, to the extent possible, an improvement in those factors was in order. This is a report on the analytical effort to update and improve the indirect cost factors.

The Concept of Variable Indirect Personnel Costs

Imagine that the Navy is considering the addition of ten attack submarines to the active fleet. A question that might naturally arise is, "What would be the impact of this action on military personnel costs?"[2] In rough terms, this decision might require some140 officers and 1200 enlisted personnel as additional crew. Converting those numbers to estimates of the *direct* cost impact could be done in several ways, each of which is relatively straightforward and likely to produce nearly the same answer. The problem with all of those answers, however, is that they almost certainly understate the true cost impact. A large number of personnel support activities reside in the Navy's shore establishment—training and base operations being perhaps the two most prominent—and those activities will undoubtedly be affected by the increase in operating personnel. We emphasize that it is the *change in the annual costs* of those activities, associated with the *change* in operating personnel that is relevant here. Virtually any support activity is characterized by some costs that are fixed and others that are variable. We have no interest in

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[1] Although in some parts of the Navy, the terms *personnel* and *manpower* have quite different connotations, they tend to be used interchangeably in the present context. For more on this, including a discussion of how the notion of *billets* enters the picture, see Henry L. Eskew, *Some New Estimates of the Navy's Indirect Manning Costs*, CNAC Research Memorandum 95-203, Dec 1995, p. 5.

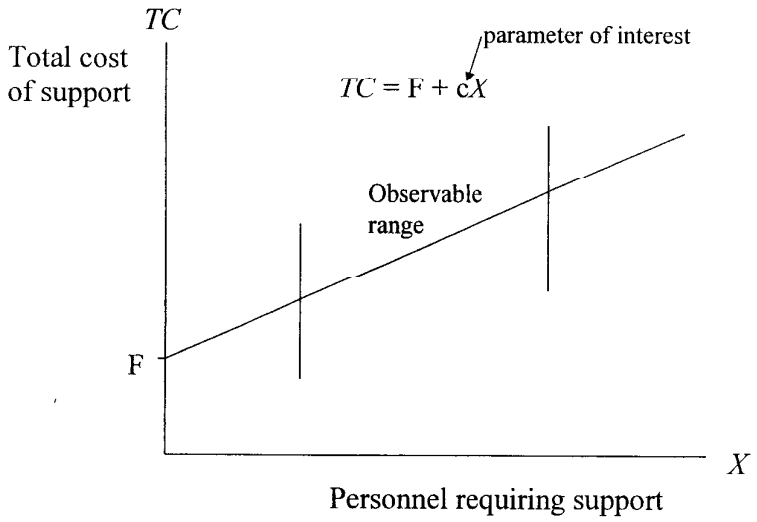
[2] This question might arise within the larger issue of annual operating and support costs resulting from this decision.

the fixed costs because they have no bearing on the decision at hand. Our interest is in identifying and measuring only those support costs that vary with the number of people requiring support.

Closely associated with the notion of variable indirect personnel costs is an "opportunity cost" concept applicable to personnel costs in general. If decrementing the existing force would reduce annual expenditures by the full (direct and indirect) costs of the number of people in question, the decision to not do so entails an opportunity cost of equal amount. In other words, the answer to the (slightly frivolous) question, "What is the true cost of a sailor?" is, "The money that would be saved by removing the sailor—and his or her requisite support—from the force structure." To further explain and illustrate the concept of variable indirect personnel costs, we turn now to the methodology used to develop the indirect cost factors, both in 'Cost of a Sailor' and in this update/improvement.

Methodology

Consider the conceptual sketch shown below:



We have posited, for a generic support activity, the existence of a linear relationship between the total cost of support (*TC*) and the number of personnel requiring support (*X*). The intercept of that linear relationship, F, represents fixed costs, while its slope, c, measures the increase in the cost of support—the variable cost—associated with an increase of one person requiring this type

of support.[3] Thus, it is the slope parameter (c) that represents the variable indirect cost factor of interest.

In principle, there are three ways of obtaining values (estimates) of the conceptual indirect cost factor depicted here. The first would be to obtain a single year's data, make a judgment as to what portion (if any) of the activity's costs are fixed, and then allocate the remainder uniformly to the number of persons requiring support. Some cost models adopt this approach, but we consider it too restrictive and too judgmental. Second, assuming that a sufficiently large number of separate organizations provided support to a corresponding number of separate groups of people, and assuming further that the organizations and groups exhibited sufficient variability in size, a *cross-sectional* database could be assembled and analyzed by statistical regression methods. (The depiction of an *observable range* in the sketch presupposes the use of regression methods.) Unfortunately, that approach is simply inconsistent with the realities of the Navy's way of doing business.

The third approach—and the one that has been adopted here is to assemble and analyze by regression methods a *time-series* database. Each fiscal year in the series provides an observation on the number of persons requiring support and the associated cost of that support. The slope of the regression line fitted to those observations constitutes an empirical estimate of the indirect cost factor depicted above.[4] The scatter diagram and associated regression statistics shown at the top of the next page provide a transition from the conceptual to the empirical.

The dependent variable in this example is the total number of enlisted personnel in the transients account at the end of each fiscal year in the period 1989-2000.[5] The X variable—interchangeably known as the independent, explanatory, or predictor variable—is the total enlisted end-strength, less the number in the transients account. This is the number of people "requiring support" from the enlisted transients account. The regression estimate of the slope parameter indicates that an increase (decrease) of 1000 enlisted personnel supported by the transients account would lead to an increase (decrease) of 34 transients.

By way of a quick review, the R^2 statistic indicates that 76 percent of the variation in the dependent variable (transients) is explained by the independent variable (total end strength minus transients.) That is an acceptable but not especially high value, revealing a fair amount of *noise* in the data. The t statistic, which is the ratio of the slope parameter estimate to its standard error, measures statistical significance. A widely used rule of thumb—arguably conservative in this context—is that $t \geq 2.0$ indicates significance. The value of 5.35 here easily passes that test, and suggests that the observed relationship is almost certainly not due to chance. The standard error of estimate (S.E.E.) is a representative measure of the difference, for any year, between the actual and calculated values of the dependent variable. It is more easily interpreted when expressed as a fraction of the mean of the dependent variable—that fraction being known as the coefficient of variation (C.V.). The value here of 0.09, or 9 percent, is acceptable but not overly impressive. Like the R^2 statistic, it is indicative of noisy data.

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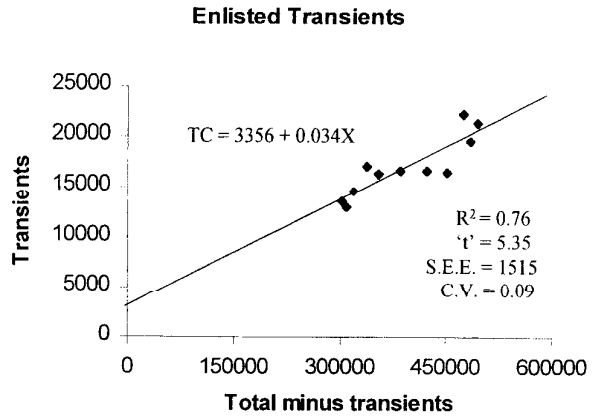
[3] In the case of a reduction in the size of the force, the term *increase* would be replaced by *decrease*.

[4] The intercept in the regression line may or may not constitute a reliable estimate of fixed costs. Fortunately, as noted earlier, fixed costs are of no interest in this analysis.

[5] Data for FY 1999 have been excluded because, for some inexplicable reason, the transients entry for that year was zero in the database supporting this work.



Four additional points need to be made to complete this discussion of methodology. First, the conceptual sketch shows total cost on the vertical axis, and here that variable is the enlisted transients account. The explanation is that multiplication of the estimated slope parameter by a suitable measure of enlisted annual cost—a weighted-average Navy Composite Standard Rate, for instance—produces an estimate of the variable indirect (dollar) cost of transient support. For some types of support, there are three separate dependent variables: officers, enlisted, and Operation and Maintenance, Navy (O&MN) funding. We have estimated a separate relationship for officer transients, but there are no O&MN funds associated with this activity.

Second, what these relationships reflect is *not* how the various personnel support activities *should* respond to change, but in fact how they *have* responded. These are strictly empirical relationships, and they carry with them the implicit assumption that past behavior can be used to predict future behavior.

Third, and closely related to the second point, is the fact that the form and magnitude of response to change has not, at least for a number of support activities, been consistent over the full range of years in the database. That is usually revealed in the scatter diagrams and regression results. In such cases, we have made a judgment to use only a subset of the available data. The transients relationship shown above is a typical case in point. We eliminated the years prior to fiscal 1989 on the belief that, for various policy reasons, data for those years were not consistent with the more recent data. (It turns out that the estimated indirect cost factor was virtually the same for the full set of years as for the abbreviated set.)

Finally, as underscored by the reference to noise in the enlisted transients data, these indirect cost relationships are statistical, not deterministic. What this means is that the emergent parameter values are *estimates*, subject to some degree of error. No one is especially pleased with that situation, but the alternative is to ignore the indirect costs, implicitly assigning a value of zero to each parameter of interest. We know both logically and empirically that, in almost all cases, zero is a poor estimate and one that can be improved upon. Thus we regard the full body of this work as a move in the direction of better cost-estimates, and hence better-informed decisions, while recognizing that absolute accuracy may always be an elusive goal.

Sources of Data

The 'Cost of a Sailor' study used the *Historical FYDP* (Future Years Defense Program) as its primary data source. That source was supplemented by data drawn from the Navy's classified programming database, known as WINPAT. Although it contains considerably more detail than the FYDP, WINPAT can be formatted to match the FYDP, i.e., organized around program elements (PEs) as basic building blocks.[6] It turns out that PEs represent convenient aggregations within which to analyze indirect support costs. There is a PE for the transients account, one for the personnel holding account, one for personnel administration, and two or more for the remaining support activities.

The current analysis is drawing from the unclassified programming database that the Navy has recently made available. That database is known as WEBPAT. It spans the years FY 1989-2001, although we have eliminated FY 2001. The reason is that, at the time of this analysis, data for that year do not yet represent "actuals." We have carried over data for FY 1980-1988 from the earlier study, but for several reasons, we do not feel compelled to use those data in every case. First, the assembly of that information some five years ago may have differed in small ways from how the current data were assembled. Second, we have recently found a way to enrich the WEBPAT data for analytical purposes that is not possible with the Historical FYDP. That will be further discussed below. Finally, the period FY 1980-1988 was one of rapid expansion of U.S. Navy personnel strength. The relevance of that experience for estimating future personnel costs is subject to question. However, in cases where there are no clear indications of inconsistency between the earlier and more recent data sets, we have integrated the two.

Variable Indirect Training Costs

Because estimation of training costs poses the greatest challenge, both conceptually and empirically, and because those costs are the most important in terms of size, we decided that a separate discussion of training costs is in order. We deal first with the general subject of variable indirect training costs, and then discuss officer and enlisted costs separately.

The concept of *variable indirect training costs* is not an easy one to embrace. The principal reason is that in thinking about training costs, we are conditioned to think in terms of *costs to train*. We have all heard statements such as, "It costs a million dollars to train a pilot." Just as 'Cost of a Sailor' did not attempt to estimate *costs to train*, neither does this update. Our interest is in how annual training costs—of any type—*change* in response to a change in the requirement for that type of training. Expressed in more mathematical terms, our interest is in total training costs as a function of the number of people requiring training support, whereas the traditional interest is in total training costs as a function of the number of trainees. In the case of, for example, nuclear submarine training for officers, the number of people requiring this type of training support is determined by the number of nuclear submarines in the fleet—and hence the number of nuclear submarine officers.. As that latter number increases and decreases over time,

[6] Program elements were introduced as part of the Planning, Programming, and Budgeting System that arose in the Pentagon during the early 1960s. Their purpose is to display collections of resources—people, funding, and, in some cases, weapons and support systems—having a common output orientation.

so will the number of people in training—and hence the costs of training. Those are the variable indirect costs that we seek to estimate.

It should be noted that, in reality, the relationship between total costs of training and the number of people requiring training support is very complex. Not only does it involve time to train, it also involves rotation, progression, and attrition rates. Disentangling those effects would require far more sophisticated modeling than has been undertaken here. The simple linear relationships developed here represent amalgams of the separate effects. To some extent, we return to this issue in the discussion of enlisted training costs.

Officer Training

As something of an addendum to 'Cost of a Sailor,' variable indirect training costs were estimated for a single officer community: aviation. That was the only officer community for which training costs were clearly visible in the PE structure. Interim estimates of comparable costs for the other two large operational communities, submarines and surface warfare, were based on the aviation results. However, it has recently been determined that the number of officer students and trainees in those communities can be identified by matching Resource Sponsor codes in WEBPAT with the entries in the General Skill Training PE (0804731N). The estimates that were generated from those data are decidedly superior to the interim estimates, but the process introduces certain problems not encountered in estimating aviation costs. The full set of officer variable indirect training cost estimates includes some that are not community-specific.

Enlisted Training

In contrast to the relatively small number of community-specific training programs for officers, there are well over 100 different enlisted occupational specialties. Although development of a generic variable indirect training cost factor for enlisted personnel—after recruit training has been separately estimated—is both straightforward and useful, developing factors that are sensitive to differences in the large number of occupational specialties is far more complex. The admittedly imperfect approach taken to the latter process involves the application of weights to the generic factor, with the weights being directly related to *time to train* and *specialty population*, and inversely related to *continuation rates*.

Empirical Estimates

Table 1 summarizes the empirical estimates of variable indirect personnel cost factors. Detailed regression results, together with certain clarifying notes, are shown in the appendix. O&MN factors are expressed in thousands of Budget Year 2001 dollars.

Table 1. Summary of Empirical Estimates

Part A - Officer Community Training

Community	Dependent variable	Explanatory variable	Factor est.
Aviation	Officers in aviation trng	Operational aviators	0.303
Aviation	Enlisted in aviation trng	Officers in aviation training	0.775
Aviation	O&MN in aviation trng	Officers in aviation training	171.4
Submarine	Officers in sub trng	Operational submariners	0.367
Surtace/Exp	Off in surface/exp	Operational surf/exp	0.183

Part B - Other Officer Variable Indirect Factors

Sector	Dependent variable	Explanatory variable	Factor est.
Prof education	Off in prof education	All off less prof ed off	0.035
Transients	Officers in trans acct	All off less trans off	0.021
Holding acct	Off in holding acct	All off less hold acct off	0.006
Pers admin	Off in pers admin	Non-PA off + enl	No statistically significant results
Base ops	Officers in BOS	Non-BOS off + enl	0.008
Base ops	O&MN in BOS	Non-BOS off + enl	2.805

Part C - Enlisted Variable Indirect Factors

Sector	Dependent variable	Explanatory variable	Factor est.
Recruit & exam	Enlisted in R&E	Non-R&E enlisted	0.008
Recruit & exam	Officers in R&E	Non-R&E enlisted	0.001
Recruit & exam	O&MN in R&E	Non-R&E enlisted	No statistically significant results
Recruit training	Enlisted in recruit trng	Non-R/T enlisted	0.056
Recruit training	Officers in recruit trng	Non-R/T enlisted	0.0002
Recruit training	O&MN in recruit trng	Non-R/T enlisted	0.005
Gen skills trng	Enl in general skills trng	Non-trng enlisted	0.090
Gen skills trng	O&MN in gen skills trng	Non-trng enlisted	0.173
Health care trng	Enl in health care trng	Non H/C off + enl	0.005
Transients	Enlisted in trans acct	Non T/A enlisted	0.035
Holding acct	Enl in holding acct	All enl less hold acct enl	0.009
Pers admin	Enl in pers admin	Non-PA off + enl	0.002
Base ops	Enl in BOS	Non-BOS off + enl	0.066
Base ops	O&MN in BOS	Non-BOS off + enl	2.805

Appendix: Detailed Regression Results

O&MN Results in thousands of BY 2001 dollars

Part A - Officer Community Training

Community	Dependent variable	Explanatory variable	Sample yrs	Factor est.	t-ratio	R^2	S.E.E.	Dep mean	Coef of var
Aviation	Officers in avn trng	Operational aviators	1981:2000	0.303	7.93	0.78	234	3281	0.071
Aviation[1]	Enl in avn trng	Officers in avn trng	1989:2000	0.775	3.60	0.57	327	1840	0.178
Aviation[1]	O&MN in avn trng	Officers in avn trng	1983:2000	171.4	9.69	0.85	37,124	438,782	0.085
Submarine[2]	Officers in sub trng	Operational submariners	1989:2000	0.367	5.66	0.91	86	1164	0.074
Surface/Exp[2]	Off in surface/exp	Operational surf/exp	1989:2000	0.183	6.22	0.88	106	1410	0.075

Part B - Other Officer Variable Indirect Factors

Sector	Dependent variable	Explanatory variable	Sample yrs	Factor est.	t-ratio	R^2	S.E.E.	Dep mean	Coef of var
Prof education	Off in prof education	All off less prof ed off	1989:2000	0.035	7.09	0.83	126	1469	0.086
Transients[3]	Officers in trans acct	All off less trans off	1989:2000	0.021	1.91	0.28	256	3280	0.078
Holding acct[4]	Off in holding acct	All off less hold acct off	1991:2000	0.006	4.32	0.73	24	104	0.231
Pers admin	Off in pers admin	Non-PA off + enl	No statistically significant results						
Base ops[5]	Officers in BOS	Non-BOS off + enl	1989:1998	0.008	10.13	0.93	167	3384	0.049
Base ops	O&MN in BOS	Non-BOS off + enl	1989:2000	2.805	6.08	0.89	118,116	1,723,116	0.069

Notes:

1. In applying this factor to operational aviators, it should be multiplied by the primary factor estimate, 0.303.
2. The available data did not permit estimation of enlisted support or O&MN for this community.
3. FY 1999 was eliminated because data for that year were missing from the database.
4. FY 1999 was eliminated because data for that year were implausibly low.
5. FY 1999 and FY2000 were eliminated because data for those years were implausibly low.

Part C - Enlisted Variable Indirect Factors

Sector	Dependent variable	Explanatory variable	Sample yrs	Factor est.	t-ratio	R^2	S.E.E.	Dep mean	Coef of var
Recruit & exam[6]	Enlisted in R&E	Non-R&E enlisted	1989:1998	0.008	5.18	0.77	342	6001	0.057
Recruit & exam	Officers in R&E	Non-R&E enlisted	1980:2000	0.001	16.98	0.94	26	606	0.043
Recruit & exam	O&MN in R&E	Non-R&E enlisted	No statistically significant results						
Recruit training	Enlisted in recruit trng	Non-R/T enlisted	1989:2000	0.056	3.81	0.59	3,579	16,235	0.220
Recruit training	Officers in recruit trng	Non-R/T enlisted	1989:2000	0.0002	5.10	0.72	9	58	0.155
Recruit training	O&MN in recruit trng	Non-R/T enlisted	1989:2000	0.005	2.77	0.71	452	5677	0.080
Gen skills trng	Enl in general skills trng	Non-trng enlisted	1989:2000	0.090	4.21	0.64	4,787	33,853	0.141
Gen skills trng	O&MN in gen skills trng	Non-trng enlisted	1989:2000	0.173	2.89	0.46	13,432	211,043	0.064
Health care trng	Enl in health care trng	Non H/C off + enl	1989:2000	0.005	3.00	0.47	456	3205	0.142
Transients[7]	Enlisted in trans acct	Non T/A enlisted	1989:2000	0.035	5.35	0.76	1,515	17,078	0.089
Holding acct[8]	Enl in holding acct	All enl less hold acct enl	1989:2000	0.009	9.74	0.91	215	2749	0.078
Pers admin	Enl in pers admin	Non-PA off + enl	1987:1997	0.002	10.79	0.93	34	1209	0.028
Base ops[9]	Enl in BOS	Non-BOS off + enl	1989:1998	0.066	6.02	0.85	2,165	32,328	0.067
Base ops	O&MN in BOS	Non-BOS off + enl	1989:2000	2.805	6.08	0.89	118,116	1,723,116	0.069

Notes

6. FY 1999 and FY2000 were eliminated because data for those years were implausibly high
7. FY 1999 was eliminated because data for that year were missing from the database.
8. FY 1999 was eliminated because data for that year were implausibly low.
9. FY 1999 and FY2000 were eliminated because data for those years were implausibly low.