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ECONOMIC CONSIDERATIONS IN ESTIMATING THE UTILITY OF HUMAN RESOURCE PRODUCTIVITY IMPROVEMENT PROGRAMS

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Three economic concepts (variable costs, taxes, and discounting) are applied and incorporated into the previous utility formulas proposed by Brogden (1946, 1949), Cronbach and Gleser (1965), and Schmidt, et al. (1979, 1982). The resulting utility model indicates that the previous formulas are deficient and can produce upwardly biased utility estimates. Empirical examples based on published research (e.g., Schmidt, et al., 1982) are presented indicating the substantial magnitude of the bias given realistic levels of variable costs, taxes, and discount rates. The present utility model is used to adjust for such bias and is shown to provide a more complete and precise utility definition. Implications for future research are discussed.

THE utility or payoff derived from using improved selection procedures has received a great deal of recent attention (e.g., Bobko and Karren, 1982; Cascio, 1980, 1982; Cascio and Silbey, 1979; Landy, Farr and Jacobs, 1982; Schmidt, Hunter and Pearlman, 1982; Schmidt, Hunter, McKenzie and Muldrow, 1979). The basic utility equation was developed through Brogden's (1949) study of testing costs, Brogden's (1946) observations on validity, and Cronbach and Gleser's (1965) discussion of decision theory applied to employee selection. Cascio (1980), Schmidt, et al. (1979) and Hunter and Schmidt (1982b) reviewed this theoretical development.

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The resulting utility formula is:

$$\Delta U = (N)(T)(r_{x,y})(SD_y)(\bar{Z}_x) - C \tag{1}$$

Where:

ΔU = the increase in average dollar-value payoff that results from selecting N employees using a test or procedure (x) instead of selecting randomly,
N = the number of employees selected,
T = the expected tenure of the selected group,
$r_{x,y}$ = the correlation coefficient (among prescreened applicants) between predictor score (x) and dollar-value payoff (y).
SD_y = the standard deviation of dollar-value payoff in the group of prescreened applicants,
$\bar{Z}_x$ = the average standard predictor score of the selected group, and
C = the total selection cost for all applicants.

In a recent *Personnel Psychology* article, Schmidt, et al. (1982) extended the utility model of Equation 1 (for selection utility) to apply to any personnel program designed to increase the job performance of those treated by the program. They showed that the product of $r_{x,y}$ and $\bar{Z}_x$ in Equation 1 may be replaced by the "true difference in job performance" between the treated and untreated group in standard deviation units. The resulting utility formula may be written

$$\Delta U = (N)(T)(d_t)(SD_y) - C \tag{2}$$

Where:

ΔU = is the increase in utility resulting from the program,
N = the number treated,
T = the expected duration of benefits in the treated group,
d_t = the true difference in job performance between the treated and untreated groups in standard deviation units,
SD_y = the standard deviation of dollar-valued job performance among the incumbent employees, and
C = is the cost of treating N employees.

The Schmidt, et al. (1982) extensions of the selection utility model (and their demonstration applying utility analysis to a training intervention) provided an important contribution, paving the way for utility analyses of other personnel programs. Landy, et al. (1982), for example, used the Schmidt, et al. (1982) formula to analyze the utility of a performance feedback program. It appears likely that utility analysis and estimation will play an increasingly greater role in industrial-organizational psychology research and, perhaps, in practice. Indeed, Landy et al. (1982, p. 38) suggest that utility analysis may be capable of "providing the science of personnel research with a more traditional 'bottom line' interpretation."

Such an interpretation requires a utility model which incorporates the same economic considerations applied to traditional management decisions. Investments in personnel programs must be evaluated similarly to other investment options so that their bottom line implications can be readily compared. Previous conceptual contributions (e.g., Brogden, 1946, 1949; Cronbach and Gleser, 1965), most recently exemplified by the Schmidt, et al. (1982) extensions, have integrated decision theory and industrial psychology concepts, but have devoted far less attention to economic theory and its implications. This can be seen most clearly in the definition of the payoff function (y). Schmidt, et al. (1982) estimated SD_y based on an earlier study defining payoff as the "value of products and services" (Schmidt, et al., 1979). This payoff function has been interpreted as the value of "output as sold," what the employer "charges the customer" (Hunter and Schmidt, 1982b, pp. 268–269), or as a function having an average level of twice the salary of the "typical worker" (Schmidt, et al., 1982, p. 339). Cascio and Silbey (1979) and Bobko and Karren (1982) defined their payoff functions simply as the "value of sales." In this article, the value of output "as sold" will be called the "sales value" of productivity.

For several reasons, this payoff definition is a deficient expression of the "institutional" benefit (Cronbach and Gleser, 1965, p. 8) of treating a group of applicants or employees. The definition fails to reflect certain economic concepts which are basic to organizational investment decisions. Utility estimates using this deficient payoff definition may produce large (possibly upward) biases compared to payoff estimates for other investments.

The utility model extensions presented here suggest corrections for three of these deficiencies. The present utility model will incorporate three economic concepts into existing decision-theoretic utility models and demonstrate the effect of these concepts on previous utility estimates. The three economic concepts (in the order of their presentation) are variable costs, taxes, and discounting.

The effects of each concept will be illustrated in three ways. First, by incorporating each concept into the algebraic utility formula (Equation 1).[1] Second, by presenting research propositions indicat-

[1] Though Equation 1 is expressed in terms of validity ($r_{x,y}$) and the average standard predictor score of selectees ($\bar{Z}_x$), the algebraic derivations developed here generalizes to Equation 2 if d_t is substituted for the product of $r_{x,y}$ and $\bar{Z}_x$. For brevity, the derivations are shown only for Equation 1.

ing each concept's implications for utility estimation. Third, by empirically illustrating the effects of each concept using data from previously-published utility research. Data from the recently published utility study by Schmidt, et al. (1982) will provide the primary example, but other published data will be used where they illustrate a specific effect. It will be shown that these three economic considerations (both alone and in combination) identify deficiencies in the existing utility definition which can upwardly bias existing utility estimates. The more complete utility model proposed here provides a framework for identifying and correcting such biases in future research, and suggests new research directions.

The Effects of Variable Costs

When a decision which increases productivity (e.g., adopting a selection device) also increases/decreases variable costs associated with productivity, then the change in variable costs should be subtracted from/added to the increased value generated by the increased productivity. For example, better-selected sales people may perform better by selling more units. Undoubtedly, the sales revenue would be higher, but not all of this increased revenue accrues to the firm. Higher-producing salespeople often receive higher pay in the form of a bonus or commission. Similarly, higher sales levels often require larger inventories, increased material costs, and production costs. In these cases, the benefits of the increased productivity are less than the increase in sales revenue. Conversely, in some jobs employees who produce at higher levels may also incur less costs than their lower-producing counterparts. For example, drill press operators who produce more units may also produce less scrap than those producing fewer units. Thus, variable costs which vary positively with productivity offset the sales value of the increased productivity while variable costs which vary inversely with productivity augment the sales value of the increased productivity.

Algebraic Derivation: Variable Costs

Analytically, distinguishing the sales value and cost of productivity gains due to treatments requires redefining y, the payoff function in Equation 1. Boudreau and Berger (in press) develop a model of the utility of employee movements through organizations (selection is one type of movement) which supplies useful concepts for developing this point. The model proposes that each movement produces (among other effects) changes in both *sales value* [sv_j, the stream of present and future benefits (e.g., sales revenue) provided by the mover$_j$ (selectee in this case) during his/her tenure in the job or organization] and *service costs* [sc_j, the stream of present and future sacrifices (e.g., wages, benefits, materials) incurred to maintain, support, and induce those services]. The difference between sv_j and sc_j will be termed the *net benefits* of the movement (i.e., $nb_j = sv_j - sc_j$).

Thus, *sv*, *sc* and *nb* are random variables over the population of prescreened applicants (or incumbents in the case of programs for existing employees). Net benefits (*nb*) is proposed here as a more logically correct definition of payoff (*y* in Equation 1) than *sv* alone, *sc* alone, or any other combination of them. Algebraically, Equation 1 becomes

$$\Delta U = (N)(T)(r_{x,nb})(\bar{Z}_x)(SD_{nb}) - C \tag{3}$$

Moreover, it can be shown that Equation 3 is equivalent to

$$\Delta U = (N)(T)[(r_{x,sv})(\bar{Z}_x)(SD_{sv}) - (r_{x,sc})(\bar{Z}_x)(SD_{sc})] - C \tag{4}$$

Equation 4 recognizes that a selection device (x), in addition to correlating with sales value, may also correlate with service costs. These correlations need not be equal. For example, *sv* may reflect the value of increased production speed of selectees. Some service costs may vary positively with production speed (e.g., materials, piece-rate wages) while others may vary inversely (e.g., supervision required). Equation 4 is general enough to include situations where data on both types of variable costs exist. It can also include situations where cost reduction (in addition to or instead of revenue enhancement) is the major payoff associated with a selection device.

In many situations, it may be simpler to treat service costs as perfectly correlated with sales value. In this case $r_{x,sv}$ is equal to the absolute value of $r_{x,sc}$. If *sc* is further treated as a *proportion* of *sv* (e.g., where commissions equal a percent of sales revenue or variable materials costs comprise a percent of selling price) then Equation 4 becomes

$$\Delta U = (N)(T)(r_{x,sv})(\bar{Z}_x)(SD_{sv})(1+V) - C \tag{5}$$

Where V equals the proportion of *sv* represented by *sc* (i.e., $sc/sv = V$). This parameter (V) will be negative when a higher proportion of costs varies positively with sales value, and positive when a higher proportion of costs varies negatively with sales value. For simplicity, and because operational data on variable costs may often be expressed as a proportion of revenue, Equation 5 will serve as the basis for further discussion.

Research Propositions: Variable Costs

Existing literature inconsistently (and often incorrectly) addresses the role of costs in selection utility. The present discussion will focus first on fixed costs (those not varying with changes in productivity) then on wages, and finally on other variable costs.

Fixed costs.

P_1: Utility estimates based on profit including allocated fixed costs will underestimate variability in net benefits.

Fixed costs are irrelevant to utility. From an economic and decision theoretic standpoint, the utility of any decision or action (e.g., use of a selection device) reflects the *changes* that action brings to various outcomes. In the classic utility framework (Cronbach and Gleser, 1965) the phenomenon of interest is the change in payoff (ΔU) resulting from selecting using a particular device instead of selecting randomly. Costs or benefits which do not change as a result of a program have no role in defining the utility of that program.

The pioneering work by Brogden (1949), Brogden and Taylor (1950, p. 143), and Tiffin and McCormick (1958, p. 25) does not reflect this fact. All three studies propose that less overhead "*per unit produced*" should be "prorated" to efficient workers (those producing more output per time unit). This proposition implies that accounting allocations of fixed costs reflect actual cost differences, an implication clearly at odds with economic and financial decision theory (see Brealey and Myers, 1981, p. 86). An organization will incur fixed utility costs, overhead costs, etc., just to continue in operation. Personnel programs generally will not change this. While fixed costs lower the *average* profit obtained from all workers, fixed cost *variability* is zero, and SD_{nb} is the same whether *nb* reflects fixed costs or not. This observation implies that Roche (1961) probably underestimated selection utility by allocating *profit* (revenue minus *both* fixed and variable costs) to workers according to production speed.

Just as fixed costs are irrelevant to decisions, variable cost *relationships* which are not reflected in decisions are also irrelevant. For example, suppose compensation is based not on productivity but on seniority. Further, suppose seniority (tenure) is negatively related to productivity. [This assumption provides an extreme example. In fact, Gordon and Johnson (1982) conclude that little evidence exists to estimate the actual performance-tenure relationship.] Under these assumptions, data from the *incumbent* employee population would indicate a negative correlation between compensation and productivity. One might be tempted to reflect this in utility estimates by increasing V to reflect the proportion of sales value represented by seniority-related variable compensation costs. This would be incorrect, however. Productivity improvement programs (e.g., training, selection) affect the *productivity* not the seniority of treated employees. Higher-performing trainees, for example, would not suffer decreased seniority, so there would be no reason to expect a compensation cost saving to accrue as a result of training even though such a relationship exists in the incumbent population.

In general, it is important to include in the variable cost term (V) *only* those costs which will vary with the increases in sales value *produced by the program options under consideration*. In view of this principle, it seems unlikely that compensation costs would vary negatively with productivity improvements induced by personnel programs. Therefore, subsequent sections will address only the effects of positive or zero covariation between compensation and productivity (sales value).

Salary and benefits.

P_2: When salaries and benefits vary positively with sales value (sv) then the standard deviation of sales value (SD_{sv}) will overestimate the standard deviation of net benefits (SD_{nb}).

Salary and benefit payments to individuals may relate to sv through many mechanisms. Clearly, when individuals are paid on commission or piece rate, or when bonuses are linked to output, the increased productivity achieved (e.g., through better selection) is partly offset by higher direct compensation. Where better performers progress upward through a pay range faster than poorer performers a similar effect would occur. In addition to direct compensation, benefits may also be associated with performance. For example, higher direct pay often means higher employer pension contributions, social security payments, or insurance levels (and premiums).

The more salary and benefit costs which are positively related to sales value, the lower is V in Equation 5, the lower SD_{nb}, and the lower is ΔU. Belcher (1974, p. 511) suggests that incentives may comprise 10% to 35% of total compensation of salespeople. If average sales value is twice average wage (as Hunter and Schmidt, 1982a, p. 305; 1982b, p. 208 suggest) then incentive costs may comprise 5% to 17% of sv. As shown by Equation 5, if V equals $-.17$, then the actual SD_{nb} is 83% of SD_{sv}.

Existing research often ignores potential variable compensation effects. Cascio and Silbey (1979), Landy, et al. (1982), Lee and Booth (1974), Roche (1961), Schmidt, et al. (1979, 1982), Schmidt and Hoffman (1973), and Van Naersson (1963) presented utility analyses with no discussion of the possibility that variable compensation costs may offset increased sales value. While such treatment may have been appropriate in some studies due to the likelihood that all job holders were paid similarly, the analytical issue was not explored and no data were presented to justify such an approach. One study (Cascio and Silbey, 1979) defined the payoff function (y) for sales managers in terms of sales revenue. It seems likely that, for this job, some portion of compensation took the form of incentive pay.

Another misconception regarding the role of wages in selection utility is that wages equal sales value. This position was taken by Brogden and Taylor (1950, p. 144). More recently, Cascio (1982, p. 163–173) described the Cascio-Ramos estimate of performance in dollars (CREPID) which is based on the assumption that "the economic value of each employee's labor is best reflected in his or her annual wage or salary" (Cascio, 1982, p. 164). For analyzing utility to the organization, however, the appropriate "economic value" is not the wage (defined by the labor market), but the value of what is produced (determined by the product/service market) adjusted for variable costs (and other factors discussed subsequently). As Hunter and Schmidt (1982b, p. 268) pointed out, "any accountant would assure you that a business in which dollar value of output is equal to wages would be unable to pay costs and overhead, [much] less profit." Hunter and Schmidt (1982b) were distinguishing wages from *sales value*, while the present utility model distinguishes wages from *net benefits*. In either case, wages are a cost. When they vary positively with sales value they are a cost which reduces the value of SD_{nb}.

Variable costs other than compensation. The general proposition regarding other variable costs is similar to proposition P_2.

P_3: When non-compensation costs vary positively with sales value (sv) then the standard deviation of sales value (SD_{sv}) will overestimate the standard deviation of net benefits (SD_{nb}), and vice versa.

The major non-compensation cost which varies with the sales value of productivity (sv) will probably be raw material costs. For example, production workers producing higher volume may require more raw materials to work with. Similarly, sales people producing higher sales volume require that more units be available for sale. Hunter and Schmidt (1982a, p. 304) note that "increased production by the worker might result in increased [overhead] costs of production; especially if the product has a high raw material cost." They do not, however, include such costs explicitly in the utility model as is done here.

Interpreting proposition P_3 in terms of Equation 5: When the amount of non-compensation costs varying positively is larger, V is smaller (or more negative), the value of SD_{nb} is smaller, and ΔU is less. As noted above, variable compensation costs might make V as low as $-.17$. Non-compensation costs which vary positively with sv would further reduce V. The exact amount of the reduction would vary (across jobs and industries for example). Assuming (for illustration) a range of non-compensation variable costs from 0% to 33% of sales value, and adding this effect to the variable compensation cost range of 0% to 17% implies that when both compensation and non-compensation costs vary positively with increases in sales value, V could range from 0 to $-.50$.

As noted earlier, some non-compensation costs (e.g., scrap, damage, losses) may vary inversely rather than positively with increases in sales value produced by personnel programs. When all variable non-compensation costs behave in this way, V could reach an upper value of $+.33$. (Recall the earlier argument that compensation costs are unlikely to vary negatively with productivity increases).

Total variable cost effects. Combining all the arguments in this section implies a range of V (including variable compensation costs, and positively-related as well as negatively-related non-compensation costs) from $-.50$ to $+.33$. This range implies an adjustment ($1+V$ in Equation 5) ranging from .50 to 1.33. The actual value of V in any application would be the difference between the proportion of sales value represented by costs varying negatively with sales value increases and the proportion of sales value represented by costs varying positively with sales value increases.

Empirical Illustrations: Variable Costs

The empirical effects of variable costs will be illustrated using data reported by Schmidt, et al. (1982) and data reported by Cascio and Silbey (1979). The Schmidt, et al. (1982) utility analysis for training computer programmers (using Equation 2 with N = 100, T = 2 years, d_t = .65, SD_y = \$10,413, and C = \$500 per trainee) produced an estimate of the training program's utility equal to \$1,303,690 (p. 339). Their example ignores variable costs, however. For computer programmers, variable costs may be low because productivity increases may not require increased raw materials or overhead and programmers may not be rewarded differently. Assuming the net effect of positively and negatively correlated variable costs produce V equal to $-.05$, the after-cost utility estimate based on SD_y of \$9,892 [i.e., (\$10,413)(1−.05)] would be \$1,235,960, or 94.8% of the reported utility estimate.

Unlike the Schmidt, et al. (1982) study in which the bias due to omitting variable costs was probably small, the study by Cascio and Silbey (1979) focused on sales managers, a job in which variable costs are likely to have been more substantial. Cascio and Silbey (1979, p. 111) estimated the utility of improved internal selection (i.e., replacing an interview with an assessment center) to be \$153,855 [assuming N equal to 50, T equal to 5, SD_y equal to \$9,500, $\bar{Z}_x$ equal to .80 (i.e., a selection ratio of .50), assessment center validity of .35, interview validity of .25, and a cost difference of \$11,328 in favor of the interview]. In this case, SD_y (estimated using the "dollar value of sales to the company") was for the job of sales manager. Such sales positions would probably be paid (at least in part) on commission or incentive. In addition, it seems likely that raw materials costs for this "food and beverage firm" would also increase with increased sales. Cascio and Silbey report no data on this point, but, for illustration, let us assume that V equals $-.40$ in this situation. The SD_{nb} value would be \$5,700 [i.e., (\$9,500)(.60)] as opposed to \$9,500 estimated by Cascio and Silbey. Thus, the adjusted utility estimate would be \$87,782, or 57% of the reported value.

The Effects of Taxes

Just as variable costs are an economic fact of life for many organizations, so taxes are also an often unavoidable obligation (except for the government and other exceptions discussed later). Yet, the effect of taxes has never been addressed in previous utility research. Taxes are assessed on an organization's reported profits. Thus, unlike variable costs which offset changes in *revenue*, taxes produce a proportional reduction in *both* revenue and costs.

Accounting for taxes in personnel program utility estimates is necessary for two reasons. First, as noted earlier, one purpose of utility analysis is to provide a "bottom line interpretation" for investments in personnel programs so that they can be compared to other investment options. Because taxes affect the flow of costs and benefits from investments, a basic principle in capital budgeting analysis is that after-tax costs and benefits are the appropriate basis for decisions (see Horngren, 1981, p. 321; Weston and Brigham, 1978, pp. 304–305; Bierman and Smidt, 1971, p. 123). Second, because organizations vary in their tax liability, inter-organizational utility comparisons require adjusting utility values to account for different tax consequences. The marginal tax rate (the tax rate applicable to changes in reported profits generated by a decision) is the appropriate adjustment because existing utility definitions express the effects of personnel programs on productivity "as sold" and on costs, both of which usually directly affect reported profits.

Algebraic Derivation: Taxes

Recall that net benefits (*nb*) is defined as the random variable representing sales value minus service costs. If we denote the marginal tax rate as TAX, then after-tax net benefits may be denoted $(1-TAX)(nb)$. Noting that *nb* was earlier defined as $(1+V)(sv)$, we can rewrite Equation 5 as

$$\Delta U = (N)(T)(r_{x,sv})(\bar{Z}_x)(SD_{sv})(1+V)(1-TAX) - (C)(1-TAX) \quad (6)$$

Taxes produce a proportional decrease in SD_{nb} and in C. Because SD_{nb} is usually greater than C, this will usually reduce ΔU.

Research Proposition: Taxes

P_4: The higher an organization's marginal tax rate, the lower utility will be (all else equal).

In order to examine actual tax effects, researchers must obtain estimates of the marginal tax rate. This requires the input of an organization's accountants or financial experts. Although the federal corporate income tax rate ranges from 0% to 46% (U.S. Master Tax Guide, 1981), this range omits the effects of additional State tax liabilities. Copeland and Dasher (1974, p. 226) assume a 55% combined tax rate for their illustrations. Therefore, a range of marginal tax rates (*TAX*) from 0% to 55% will be assumed here. This implies an adjustment ($1-TAX$, in Equation 6) ranging from 1.0 to .45.

Empirical Illustrations: Combined Effects of Variable Costs and Taxes

The combined effects of variable costs and taxes on utility can be seen in Table 1. This table shows the adjustment [i.e., $(1+V)(1-TAX)$ in Equation 6] necessary to account for various combinations of variable cost (V) and tax (TAX) levels.

The implications of Table 1 can be illustrated by returning to the

TABLE 1
Illustrative Adjustments to Correct Utility Estimates for the Combined Effects of Variable Costs (V) and Taxes (TAX)

	TAX					
V	0	.05	.10	.30	.45	.55
.33	1.33	1.26	1.20	.93	.73	.60
.10	1.10	1.04	.99	.77	.60	.50
.05	1.05	1.00	.94	.74	.58	.47
.00	1.00	.95	.90	.70	.55	.45
−.05	.95	.90	.86	.68	.52	.43
−.10	.90	.86	.81	.63	.50	.40
−.20	.80	.76	.72	.56	.44	.36
−.30	.70	.67	.63	.49	.39	.32
−.40	.60	.57	.54	.42	.33	.27
−.50	.50	.48	.45	.35	.28	.22

Note.—Table values equal $(1 + V)(1 - TAX)$. These values would be multiplied by the sales value of increased productivity to adjust for variable costs and taxes.

earlier examples. Assuming variable costs of 5%, it was noted that the Schmidt, et al. (1982) SD_y estimate of $10,413 would be reduced to an SD_{nb} of $9,892. Though the Schmidt, et al. estimate of SD_y was originally derived for the federal government (which is not taxed), generalizing the results to private-sector taxable organizations requires recognizing the tax rate. Assuming a marginal tax rate of 45%, their SD_y estimate would be further reduced to $5,415 [i.e., (.52)($10,413) using Table 1]. In addition, their estimated treatment cost of $500 per person corresponds to an after-tax cost of $275 per person [i.e., (.55)($500)]. Substituting these values into equation 6 along with the other parameters noted by Schmidt, et al. (1982) produces a total utility estimate of $676,450 for one application of the training program. This value equals 52% of the $1,303,690 reported by Schmidt, et al. (1982), though it is still a substantial payoff.

The Cascio and Silbey (1979) study of selection utility not only involved a job (sales manager) probably subject to high variable costs, but involved a private-sector organization probably subject to taxes. Assuming a 45% tax rate in addition to the 40% variable cost level assumed earlier, the yearly SD_y estimate after variable costs and taxes would have been $3,135 [i.e., (.33)($9,500) using Table 1]. The difference in cost between the assessment center and the interview would also be reduced from $11,328 to $6,230 after taxes. Holding the other parameters at the levels noted earlier, the resulting payoff from the assessment center would be $48,280. Still substantial, but only 31% of the $153,855 reported by Cascio and Silbey (1979).

The Effects of Discounting

The third economic consideration is that monetary values received in different time periods are subject to different opportunity costs. Specifically, future monetary values cannot be directly equated with present monetary values because benefits received in the present or costs delayed into the future would be invested to earn returns. Thus, a dollar received today at a 6% annual return would be worth $1.12 in two years. A future benefit worth $1.12 received in two years, then, has a "present value" of $1.00 [i.e., ($1.12)/$(1.06)^2$]. Similarly, a future cost of $1.12 in two years could be paid by investing $1.00 at 6% interest today. In general, the formula for the present value (PV) of an amount (a) received or paid out (t) periods in the future, at a rate of return (i) may be written:

$$PV(a) = [1/(1+i)^t(a)] \tag{7}$$

The principle of discounting becomes relevant because personnel program utility involves benefits and costs which accrue over time. Many previously published studies ignore this fact. For example, Roche (1961) computed utility *per hour* for radial drill operators, Brogden (1949) used cost data from Tiffin (1942) based on *one year's* salary for hosiery loopers, Van Naersson (1963) used the cost of *one year's* accidents and driver training, and Schmidt and Hoffman (1973) computed replacement cost savings for *one year's separations*. As Hunter and Schmidt (1982b, p. 252) noted, such measures are deficient because they fail to reflect that "productivity gains due to increased job performance continue to accumulate for as long as the employee remains on the job."

Some studies have explicitly dealt with the accrual of utility over time. Cascio and Silbey (1979) acknowledged this effect by expressing SD_y (accruing over five years, with a correlation of .70 between any two years) as the one-year SD_y times 4.36 (i.e., $\sqrt{19}$). Schmidt, et al. (1979) simply multiplied the one-year payoff $[(r_{x,y})(\bar{Z}_x)(SD_y)]$ by the average tenure of computer programmers (9.69 years). Both Schmidt, et al. (1982) and Landy, et al. (1982) also simply multiplied by the number of periods over which benefits occur. None of these studies incorporated the effects of discounting.

Algebraic Derivation: Discounting

Including the accrual of benefits and costs over time and the effects of discounting requires altering the formula for net benefits. Total net benefits for individual$_j$ ($nb(sum)_j$) may be written as the sum of a stream of net benefits occurring over T future periods,

$$nb(sum)_j = \sum_{t=1}^{T} nb_{jt} \tag{8}$$

where t signifies the time period in which the net benefits occur. Thus, $nb(sum)$ is actually a random variable over individuals defined by the *sum* of period-to-period net benefits for each individual. To account for a discount rate (i), we may write

$$PV[nb(sum)] = \sum_{t=1}^{T} (nb_t)[1/(1 + i)^t] \tag{9}$$

Which is the correct expression for the pre-tax payoff function in light of the economic concept of discounted present value.

Defining net benefits in this way, Equation 6 now becomes

$$\Delta U = (N) \times \left\{ \sum_{t=1}^{T} [1/(1 + i)^t](SD_{nb_t})(1 - TAX_t)(r_{x,nb_t})(\bar{Z}_x) \right\} - (C)(1 - TAX) \tag{10}$$

Finally, if we note the effects of variable costs by expressing SD_{nb} as the product of SD_{sv} and $1+V$, we may write

$$\Delta U = (N) \times \left\{ \sum_{t=1}^{T} [1/(1 + i)^t](SD_{sv_t})(1 + V_t)(1 - TAX_t)(r_{x,sv_t})(\bar{Z}_x) \right\} - (C)(1 - TAX_t) \tag{11}$$

Equation 11 indicates that the analytically correct expression for the utility accruing from applying a personnel program to a group of employees involves not one constant payoff level [i.e., $(r_{x,y})(\bar{Z}_x)(SD_y)$ in Equation 1], but a *series* of discounted yearly payoffs which may vary over time.

To isolate the effects of the discount rate, let us ignore variability in r_{x,sv_t} and SD_{sv_t} over time, treating them as constants ($r_{x,sv}$ and SD_{sv} respectively). This same assumption is implied by Schmidt, et al. (1979, 1982) and Cascio and Silbey (1979). For purposes of analytical development, let us also assume the variable cost level (V_t) and tax rate (TAX_t) are constant over time. Thus, we may rewrite Equation 11 as

$$\Delta U = (N) \times \left\{ \sum_{t=1}^{T} [1/(1+i)^t](SD_{sv})(1+V)(1-TAX)(r_{x,sv})(\bar{Z}_x) \right\} - (C)(1-TAX) \quad (12)$$

Note that Equation 12 assumes that the costs of a program (C) occur only at the beginning of the program (t=0) and thus are not subject to discounting (when t=0, $PV(a) = a$). This is usually true for selection programs where all testing occurs prior to hiring. Schmidt, et al. (1982, p. 341) noted, however, that some personnel programs (e.g. sensitivity training) may require a continuing intervention in every period. They proposed multiplying the cost term (C) by T. In light of the present discussion of discounting, a more correct approach would be to multiply the cost term by the discount factor

$$\sum_{t=1}^{T} [1/(1+i)^t]$$

to note that program costs as well as payoffs are subject to opportunity costs of time. Costs which occur later affect the present value of utility less strongly than more immediate costs.

Research Proposition: Discounting

P_5: The larger the discount rate (i), the lower the utility of a personnel program (all else equal).

Including the effect of discounting on utility estimates requires estimating the appropriate discount rate. Ogan (1976, p. 310) states, "The discount rate may be the average interest rate on U.S. Government securities or any other externally determined, objective factor." This definition is inappropriate for purposes of utility analysis for two reasons. First, Ogan's (1976) model estimates the value of "human assets" on a "nominal" basis (that is, in dollars which may include inflation effects). Previous utility treatments have not adjusted future amounts upward to account for inflation. Instead, current payoffs have been multiplied by T to reflect only accrual of "real" (unadjusted for inflation) amounts. The average interest rate on government securities includes an amount to cover expected inflation, and thus might overestimate i.

Second, the interest rate on government securities reflects a guaranteed (risk-free) return. Because personnel programs will be employed in all types of organizations from very risky endeavors to relatively risk-free endeavors, the discount rate (i) must reflect the fact that risky firms must earn a risk premium and face a higher discount rate than less risky firms.

Operationally, then, the appropriate discount rate for utility analysis should be the rate applied to uninflated benefits and costs given the organization's evaluation of overall risk and return requirements. With this definition in place, we can estimate an illustrative range of discount rates.

The low end of the range would equal the rate of interest on the highest-quality (least risky) investment adjusted for inflation. Ehrenberg and Smith (1982, p. 249) reported that the average real interest rate (actual rate minus inflation) on the safest corporate bonds from 1953 to 1977 was 2.14%. Thus, at a minimum, i would probably equal about .02.

The upper end of the range would equal the rate of return used by risky firms to evaluate capital budgeting decisions. Two surveys of corporate practices provide some guidance. Gittman and Forrestal (1977) found (p. 69) that firms' cost of capital ranged from roughly 5% to "above" 20%. These rates would apply to *nominal* (including inflation) after-tax benefits and costs, so they must be adjusted downward. Using a 1976-77 inflation rate of 6%, the corresponding discount rates for *real* returns would be zero to above 13% (see Bierman, 1981, p. 123 for the formula). A similar survey (Schall, Sundem, and Geijsbeek, 1978) found nominal rates of 7 to "greater than 17" percent. Using an 8% inflation rate for 1977-1978, these correspond to real rates from zero to greater than 8%. The authors note that this sample was "biased toward large, stable firms," (p. 281) which may account for the lower values.

As a rough range, then, values for i (in Equation 12) between 0% and 15% will be used. Table 2 illustrates the effect of various discount rates and tenure levels on the discount factor (DF) defined

TABLE 2
Values of the Discount Factor (DF) Adjustment Computed Using Illustrative Combinations of Values for the Discount Rate (i) and the Duration of the Program's Effects (T)

	T				
i	1	2	5	7	10
.00	1.00	2.00	5.00	7.00	10.00
.05	.95	1.86	4.33	5.79	7.72
.10	.91	1.74	3.79	4.87	6.14
.15	.87	1.62	3.35	4.16	5.02

Note.—Table values are computed using the formula

$$DF = \sum_{t=1}^{T} [1/(1+i)^t].$$

as

$$\sum_{t=1}^{T} [1/(1+i)^t].$$

Table 3 shows the Table 2 values divided by *T*. Because Landy, et al. (1982), Schmidt, et al. (1979, 1982), and Cascio and Silbey (1979) essentially multiplied their one-year values by *T*, Table 3 shows the adjustment needed to discount their values at various levels of *T* and *i*. Tables 2 and 3 illustrate that the longer the duration of a personnel program's effects (*T*) and the higher the discount rate (*i*), the larger the effect of discounting. That is, the larger the reduction in undiscounted utility gains [such as those reported by Landy, et al. (1982), Schmidt, et al. (1979, 1982) and Cascio and Silbey, (1979)], especially in later periods.

TABLE 3
Values of the Discount Factor Adjustment (From Table 2) Divided by the Duration of the Program's Effects (T)

	T				
i	1	2	5	7	10
.00	1.00	1.00	1.00	1.00	1.00
.05	.95	.93	.87	.83	.77
.10	.91	.87	.76	.70	.61
.15	.87	.81	.67	.59	.50

Note.—Table values are computed using the formula

$$DF/T = \sum_{t=1}^{T} [1/(1+i)^t]/T.$$

These adjustments would be applied to utility estimates which multiplied one-year utility values by the duration of the program's effects (*T*).

Empirical Illustrations: Combining the Effects of Variable Costs, Taxes, and Discounting

Earlier, it was shown that the combined effects of variable costs and taxes could reduce the yearly SD_y estimate for computer programmers reported by Schmidt, et al. (1982) from \$10,413 to \$5,415, producing a reduced total utility estimate. The effects of discounting can be illustrated by noting that Schmidt, et al. (1982) multiply their one-year payoff by T (equal to 2), the duration of the training program's effect. Table 2 indicates that the appropriate multiplication factor would be less than 2 if the discount rate is non-zero. For example, at a discount rate of 10% (i.e., i = .10), the appropriate multiplication factor would be 1.74, not 2. Table 3 indicates that this is 87% of the multiplication factor used by Schmidt, et al. (1982). The result is that the yearly payoff from increased performance (after taxes and variable costs) of \$5,415 is multiplied by 1.74 instead of 2. Subtracting after-tax treatment costs (which are not discounted in this case because they occur at time period zero, prior to any payoff) of \$275 per person, the discounted, after-cost, after-tax utility estimate for the training program is \$584,937. This equals 45% of the \$1,303,690 value reported by Schmidt, et al. (1982).

Unlike Schmidt, et al. (1982), the Cascio and Silbey (1979) study of selection utility accounted for instability in expected performance. Assuming a correlation of .70 between performance in any pair of periods had the effect of multiplying the yearly SD_y estimate by 4.36 (i.e., $\sqrt{19}$), rather than the value of T (5 in this case). Though Cascio and Silbey did not discuss discounting, this instability adjustment has the same effect as assuming a discount rate of 4.75%. If the discount rate were higher, the appropriate multiplication factor would be lower and vice versa. Given the earlier assumptions, and using a discount rate of 10%, the resulting discounted after-cost, after-tax utility estimate for replacing an interview with an assessment center would be \$41,154. This value equals 27% of the \$153,855 reported by Cascio and Silbey.

The effects of discounting are even more pronounced than these examples illustrate when the tenure of those selected or the duration of treatment benefits is longer. Schmidt et al. (1979) published an empirical study of a sample with longer tenure. The average tenure of computer programmers was 9.69 years. Schmidt, et al. accounted for benefits accruing over time by multiplying their one-year estimated payoffs by 9.69. For organizations facing a discount rate this is unrealistic and inflates estimated utility. For example, when i

equals .10, the values reported by Schmidt, et al. (1979, Table 1) would be reduced by about 40%. Specifically (using $T=10$), the range of undiscounted utility reported ($9,061 per selectee to $157,282 per selectee) would correspond to a corrected (discounted) utility range of $5,741 per selectee. [i.e., ($9,061)(6.14/9.69)] to $99,587 per selectee. (The latter figure reflects costs of $10 per applicant when only the PAT is used).

This range, however, still reflects the SD_y value of $10,413, which does not account for variable costs or taxes. While this may have been appropriate for the federal government jobs used in Schmidt, et al. (1979), it would not be appropriate for private-sector organizations facing variable costs and/or taxes. As noted earlier, assuming variable costs of 5% and a tax rate of 45%, the after-cost, after-tax, one-year SD_{nb} value would be $5,415 [i.e., (.52)($10,413)]. Using this yearly SD_{nb} value, and adjusting for the effects of discounting at a rate of 10%, the range of utility values reported by Schmidt, et al. (1979, Table 1) would be from $2,985 [i.e., ($9,061)(6.14/9.69)(.52)] to $51,779 per selectee. (The latter figure reflects after-tax costs of $5.50 per applicant). These values are still substantial, but are only 33% of the reported values.

Summary

Individually, and in combination, the economic considerations presented here indicate substantial biases (especially upward biases) in published utility estimates when such estimates do not reflect the effects of variable costs, taxes, and discounting. Table 4 summarizes the magnitude of the adjustments implied by these considerations.

TABLE 4
Illustrative Adjustments to Correct Utility Estimates for the Combined Effects of Selected Levels of Variable Costs (V), Taxes (TAX), and Discount Rates (i)

Type of Adjustment	Utility Model Parameter Level			Combined Adjustment[a]
	V	*TAX*	*i*	
No Change	.00	.00	.00	1.00
Largest Upward	.33	.00	.00	1.33
Moderate Downward	−.15	.20	.05	.59
Largest Downward	−.50	.55	.15	.16

[a] These values are computed using the formula

$$(1 + V)\,(1\text{-}TAX)\,\{\sum_{t=1}^{T} [1/(1 + i)^t]/T\}.$$

The duration of program effects (T) is assumed to be 5 periods.

The last column of Table 4 contains the adjustment which would be multiplied by the estimated sales value of increased job performance [i.e., $(N)(T)(r_{x,y})(\bar{Z}_x)(SD_y)$ in Equation 1, or $(N)(T)(d_t)(SD_y)$ in Equation 2] from existing utility models. The adjustments in the last column correspond to three levels of each variable. Previous utility treatments have implied that V, TAX, and i all equal zero, as shown in the first row of Table 4. The second row of Table 4 indicates the set of assumptions producing the highest upward adjustment. Large cost reductions are associated with sales value increases ($V=+.33$) and the applicable taxes and discount rates are assumed to equal zero. Adjusted utility estimates would equal 133% of previously reported values. The third row of Table 4 depicts the results of assuming a moderate and positively-variable cost proportion ($V=-.15$), a moderate tax rate ($TAX = .20$) and a moderate discount rate ($i=.05$). Under these assumptions, the adjusted utility estimates would equal 59% of reported values. Finally, in the fourth row, all parameters are set at levels which would lead to large downward adjustments in utility values as typically reported. These adjustment levels reduce pre-cost, pre-tax, undiscounted utility estimates to 16% of previously reported levels. If T were greater than five periods [as in Schmidt, et al. (1979)], the reductions would be still greater.

Across various situations, the actual levels of these variables will differ. The values in Table 4 are provided to illustrate the substantial range of the effects variable costs, taxes, and discounting can have on personnel program utility. In view of the variability and magnitude of such effects, Equation 12 provides a more complete utility formula than those previously used, (Equations 1 and 2); a formula likely to produce less biased (though often lower) utility estimates for personnel programs.

Implications for Future Research

The three economic concepts discussed here indicate that existing utility estimates can overstate actual economic utility whenever positively-related variable costs, taxes, and/or discount rates affect an organization's payoff function and decision making. The algebraic formulas incorporating these factors are conceptually straightforward. In view of the magnitude of the possible effects of these factors (especially in combination), the utility formulas presented here provide a more complete definition of utility than previous models. Future research should incorporate these economic concepts into utility analyses to avoid producing deficient and possibly upwardly biased utility estimates.

Estimates of the tax rate and discount rate are already frequently used by organizations in evaluating other financial and economic decisions, so it is likely that an organization's accountants or financial experts can provide reasonably accurate estimates of these parameters. The present utility model contributes to this process by specifying the precise nature of these parameters. For example, because utility analyses usually produce estimates of the real (unadjusted for inflation) sales value of increased productivity over time, utility analysts must adjust the traditional discount rates used in financial analysis (which reflect inflation) downward. As noted earlier, when inflation is high this adjustment substantially reduces the nominal discount rate.

Estimates of variable service costs are probably less readily available. Financial records are often not designed to separate costs which vary with program-induced increases in productivity from fixed costs. The present discussion has identified the service cost concept more precisely than previous treatments, pointing out the pitfalls of mistaking allocated fixed costs for variable costs and of mistaking wages or salaries for sales value. Thus, data on service costs may now be gathered more systematically. Further research is needed which explores ways to estimate service costs within this conceptual definition.

The present utility model provides a more precise definition of economic utility considerations which can facilitate the "closer liason between personnel psychologists and cost accountants" proposed by Cascio and Silbey (1979, p. 116). Landy, et al. (1982) suggest that validity may be indicated by positive correlations between cost accounting procedures and direct utility estimation procedures. Cost accounting utility estimates will (and should) incorporate the economic concepts discussed here. Recognizing these concepts in direct utility estimates provides a much stronger test of the convergence between the two procedures (both in terms of shape, indicated by correlations, and in terms of level). In addition, by making such economic considerations explicit, inconsistencies may be more thoroughly explained and addressed.

Incorporating these economic variables into utility estimates will require research addressing the nature of the economic variables themselves. Landy, et al. (1982) suggest a need for *descriptive* research elaborating the contextual or boundary conditions affecting utility. This research would examine the behavior of SD_y across job families and job titles. Such research can provide information on inter- and intraorganizational SD_y variation. It is critical that such research recognize and include the economic concepts discussed here. Not only are jobs, job families, companies, and industries likely to differ in SD_y based on *sales value or revenue* (as measured by previous authors), but the proportion of variable costs, effective tax levels, and discount rates are also likely to vary. In fact, it is possible that a great deal of interorganizational variability in utility within job families may be due to such economic variables. Including such variables in future utility analyses is likely to increase the ability to predict, explain, and more precisely generalize the utility implications of personnel programs.

Apart from assessing the behavior of the economic parameters themselves, future research incorporating these concepts may help to *explain* inconsistencies in SD_y estimates produced by existing "rational" estimation methods. Two very different concepts have been used to define the underlying dollar scale in previous SD_y estimates. Schmidt, et al. (1979) asked supervisors to estimate the "value of output" (p. 621) of computer programmers, and instructed them to "consider what the *cost* would be of having an outside firm provide these products and services" (emphasis added). Cascio and Silbey (1979), as noted earlier, asked third-level sales managers to estimate the yearly "dollar value of *sales* to the company" produced by second-level sales managers (p. 110, emphasis added).

One recent study (Bobko and Karren, 1982) compared both approaches by having 13 supervisors estimate the "total yearly dollar sales" produced by insurance counsellors in one year, and then having the supervisors make another estimate considering what it would cost to have an outside firm provide the products and services. Bobko and Karren's results indicate that the average supervisory estimate of the standard deviation of "sales revenue" was not significantly different from the actual standard deviation of sales revenue. The within-sample standard deviations of these *estimates* however, were roughly as large as the averages, indicating inconsistencies in the SD_y estimates. When estimates of the cost of obtaining services from an outside firm were gathered, the averages were much smaller and the within-sample standard deviations of the estimates were *larger* than the averages, again indicating inconsistency within the sample. Bobko and Karren note that the "substantial variation [in SD_y estimates] suggests a need for research to explain differences among supervisors in these cognitive estimates" (p. 275).

The economic considerations presented here provide a framework for systematically conducting such research and for explaining such results more thoroughly. For example, these considerations indicate that the "concrete standard" suggested by Schmidt, et al. (1979) may be inappropriate or confusing in an economic sense. The value of products and services "as sold" is not equal to the cost of obtaining them from outside contractors. A rational economic organization would pay an outside firm a maximum of the *costs* to provide the services in-house, not their sales value. Paying more would not be rational because at higher contractor prices the firm or manager would rather provide the services themselves and save the cost difference.

By using both the "overall value of" and the "costs of obtaining" goods and services as standards in the same measure, the Schmidt, et al. (1979) estimation procedure may introduce confusion and resulting unreliability into SD_y estimates. Moreover, to interpret estimates based on this "standard" as reflecting the value of products and services "as sold" (Hunter and Schmidt, 1982b) may be highly speculative.

This observation is not intended to discount the genuine operational advantages of "rational" SD_y estimates or the contributions of those who have applied them. It does illustrate, however, that the economic concepts embodied in the present utility model provide a framework for investigating how such "rational" estimates are made, what phenomena they reflect, and how to improve future operational SD_y estimation procedures.

An important research direction not addressed previously but implied by the present discussion involves the temporal stability of utility parameters. All previous treatments have assumed $r_{x,y}$ and SD_y are constant over time within the treated (e.g., selected) group. The present utility discussion has also added the assumption that variable costs and taxes remain constant. As shown in Equation 11, however, these assumptions are not necessary to utility analysis. They are made for convenience and may obscure important phenomena. For example, the most recently proposed selection utility estimation procedures (Cascio and Silbey, 1979; Cascio, 1982; Schmidt, et al., 1979; Janz and Dunnette, 1977) estimate SD_{sv} for the existing *incumbent* population and then assume this value applies to the *selected group* throughout its tenure. Schmidt, et al. (1979) and Hunter and Schmidt (1982b) note that such estimates may underestimate SD_{sv} in the applicant population due to range restriction. However, such estimates also fail to recognize that the analytically correct SD_{sv} value comprises a sum of single-period values reflecting the *tenure* of the cohort and might change with increasing tenure (see Equation 11). Thus SD_{sv_1} (in period 1) should reflect variability in service value among applicants who begin with *no work experience*. In period 2, SD_{sv_2} should reflect variability in service value among applicants who begin with *one year's experience*, and so on.

No existing research has addressed this effect, so its magnitude remains an empirical question.

Conclusion

In their recent *Personnel Psychology* article, Schmidt, et al. (1982) suggest that their reported utility estimates may be "greater than has generally been assumed" (p. 345). If so, one explanation may be that such utility estimates overlook economic considerations which affect organizational investment planning and decision making. This is especially true when these considerations indicate substantial reductions in reported utility estimates, as demonstrated here. This discussion has shown that utility estimates recognizing such economic considerations reflect a substantially different, more realistic, and more complete description of the effect of personnel programs. In view of the economic nature of most organizations, utility estimates incorporating these economic concepts are likely to better reflect the "bottom line" (Landy, et al., 1982) contribution of personnel programs.

By incorporating economic adjustments into the Brogden-Cronbach-Gleser selection utility model [as well as the more recent Schmidt, et al. (1982) version of this model extending it to other personnel programs], the present utility model provides a utility definition arguably more consistent with the economic nature of most organizations, and more compatible with typical investment analyses. The dollar-valued effects of personnel programs often remain substantial even after accounting for variable costs, taxes, and discounting. This is apparent in the illustrations presented. Thus, in addition to extending the theoretical definition of utility and suggesting new research directions, the present model may provide a more defensible and realistic utility definition. This utility definition can often lead to lower utility estimates, but when such estimates remain substantial, they provide more compelling evidence for the utility to be derived from personnel programs.

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