THE UTILIZATION OF PREVAILING EVALUATION POLICY IN THE SELECTION OF PERFORMANCE MEASURES

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ABSTRACT

This study considers the problem of inferring a functional evaluation criteria from existing performance measure policies. The objective is to develop a rational basis by which consistent augmentation of an existing set of performance measures can proceed when new measure options become available. The analysis is based on a matrix approach for relating system characteristics to performance measures across a set of activities. A procedure for ranking measure combinations which are candidate implementation alternatives is devised using the characteristic by measure matrix and cost information. An example illustrating the procedure is presented.

KEY WORDS

Performance Measurement
Ranking of Sets
Measure Selection
Activity, Characteristic (operator, operand, process)
Policy Augmentation
Matrix, Per Activity Cost
Measure Combination
Implementation Cost, Characteristic Cost
Feasible Measure Set

1. INTRODUCTION

The general area of performance measurement has been the subject of a number of recent studies [2, 9, 10, 12]. The emphasis of these studies has been on both qualitative [12] and analytical levels [10]. Many quantitative approaches which have emerged [5, 6] have been normative models seeking to optimize a well defined criterion function. An important aspect of performance measurement (within the quantitative paradigm), which has not received extensive study is the analysis of performance measure problems when no obvious objective criteria can be cited.

Part of the problem pertaining to situations where the notion of optimality cannot be explicitly defined relates to the idiosyncracies of any specific application. Since the context of individual analyses of performance measurement problems is so variable, it is difficult to develop normative performance measurement policies for ill structured problems that are valid in any general sense.

The matrix-oriented model of Deutsch and Malmborg [5] provides a means by which the general area of performance measurement can be approached. This arises from the fact that the matrix analysis allows a compact summary of relationships between activities, characteristics and measures within a system. As such, it provides at least some objective basis upon which the comparison of performance measures is possible. Although it is not possible to identify a preferred measure policy in general, using the matrix model does allow a quantification of the differences between policies. As a result, we can use the model to identify similar policies even though specification of an "optimal" policy may not be possible. The purpose of this study then, is to develop a methodology for determining a performance measure policy which is at least consistent with a given or prevailing performance measurement policy.

In the next section, an overview of the matrix-oriented activity model for performance measurement is presented. The third sections discusses the problem of describing a performance measurement policy in compact form. Within the context of this discussion, an objective criteria for selecting among alternative performance measure combinations to achieve consistency with a prevailing policy is developed. The final two sections present an example from the field of automobile insurance illustrating a detailed application of the methodology and conclusions are offered.

2. THE ACTIVITY MODEL

This section provides a review of the model defining the relationship between characteristics and activities used in the analysis. The model exploits the activity-specific nature of performance measures in developing a matrix form which provides a structural basis by which the coverage of system characteristics by measures can be studied.

2.1 A Simple Activity

Figure 1 depicts a simple model of an activity. Activities are viewed as the mechanism or process relating an operator and operand. The operator and operand may both take the forms of information, machines or people. The model depicted in Figure 1 characterizes activities by three general kinds of information; operator, operand and process. The operator is the machine or organization etc. charged with executing a particular task, function or service. The operand

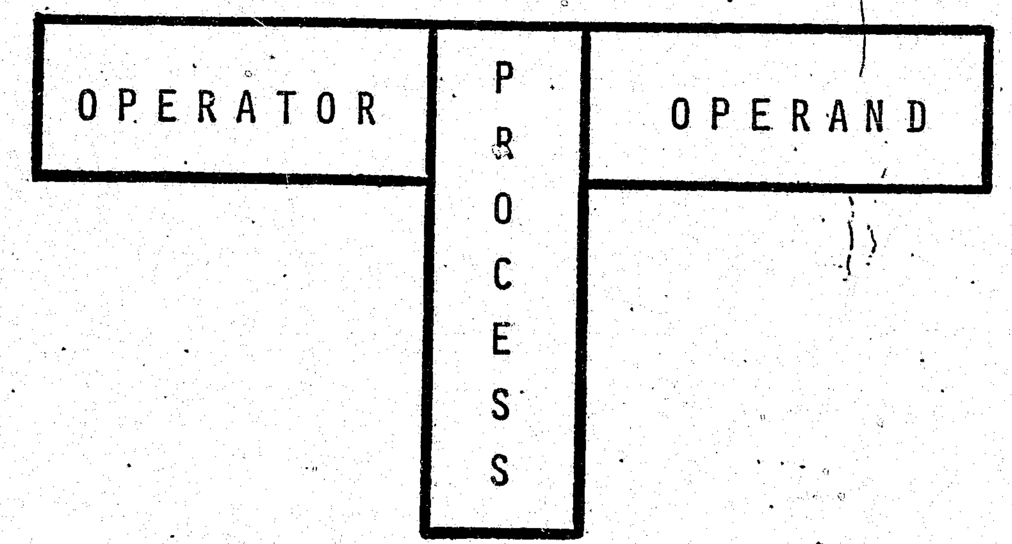

FIGURE 1. Simple Model of an Activity.

represents the form of input and final result stemming from an activity. Finally in Figure 1, the process nature describes the objective served through an activity, the manner in which resource inputs are applied by a process, and the information flow within the process.

2.2 The Characteristic by Activity Matrix

The characteristic by activity matrix, as shown in Figure 2, is used to describe the relationship between characteristics and activities. A zero in the matrix indicates that no association between an activity and the corresponding operator, operand or process characteristic exists; a one would indicate that there is an association between an activity and characteristic. For example, the characteristic by activity matrix element relating maintenance (activity) and a janitor (operator) is likely to be a one. Elements of the matrix are specified by the constituency for which performance measurement is being conducted. Column and row sums of the matrix in Figure 2 which represent the number of associates specific to individual activities and characteristics respectively, can be cited as example of the usefulness of the matrix form.

2.3 The Activity by Measure Matrix

A second matrix representation depicting the relationship between activities and performance measures is shown in Figure 3. Similarly to the characteristic by activity matrix, ones (and zeros) indicate associations (or no associations) between corresponding activities and performance measures. For example, the activity by measure matrix element relating the activity of inspection and a measure such as percentage defective in a manufacturing situation is likely to be a one. Again we can cite column and row sums within the activity by

		1	2	3	4	5	6	7	···	a
Operator Characteristics	1	1	0	1	1	0	0	0	···	1
	2	0	0	1	0	1	0	1	···	1
	3	1	1	1	0	0	1	1	···	0
	4	1	0	1	0	0	1	0	···	1
	5									
Process Characteristics	1	0	1	0	1	0	0	0	···	1
	2	0	1	0	1	1	0	1	···	0
	3	1	1	1	1	0	0	0	···	1
	4	0	0	0	0	1	1	1	···	1
	5	0	0	0	0	1	1	1	···	0
	6	1	1	1	1	0	0	0	···	0
	7	0	0	0	0	1	1	1	···	0
	8	0	0	0	0	0	1	0	···	1
	9	0	0	0	0	1	1	1	···	1
	10	1	1	1	1	0	0	0	···	0
Operand Characteristics	1	1	1	1	1	1	1	1	···	1
	2	1	1	1	1	0	0	0	···	1
	3	0	0	0	0	0	0	0	···	1
	4	1	1	1	1	1	1	1	···	0
	5	0	0	0	0	0	0	0	···	0
	6	1	1	1	0	1	0	1	···	1
	7	0	1	0	1	0	0	0	···	0
	8	0	1	0	1	1	1	1	···	1

ACTIVITY

FIGURE 2. A Hypothetical Characteristic by Activity Matrix.

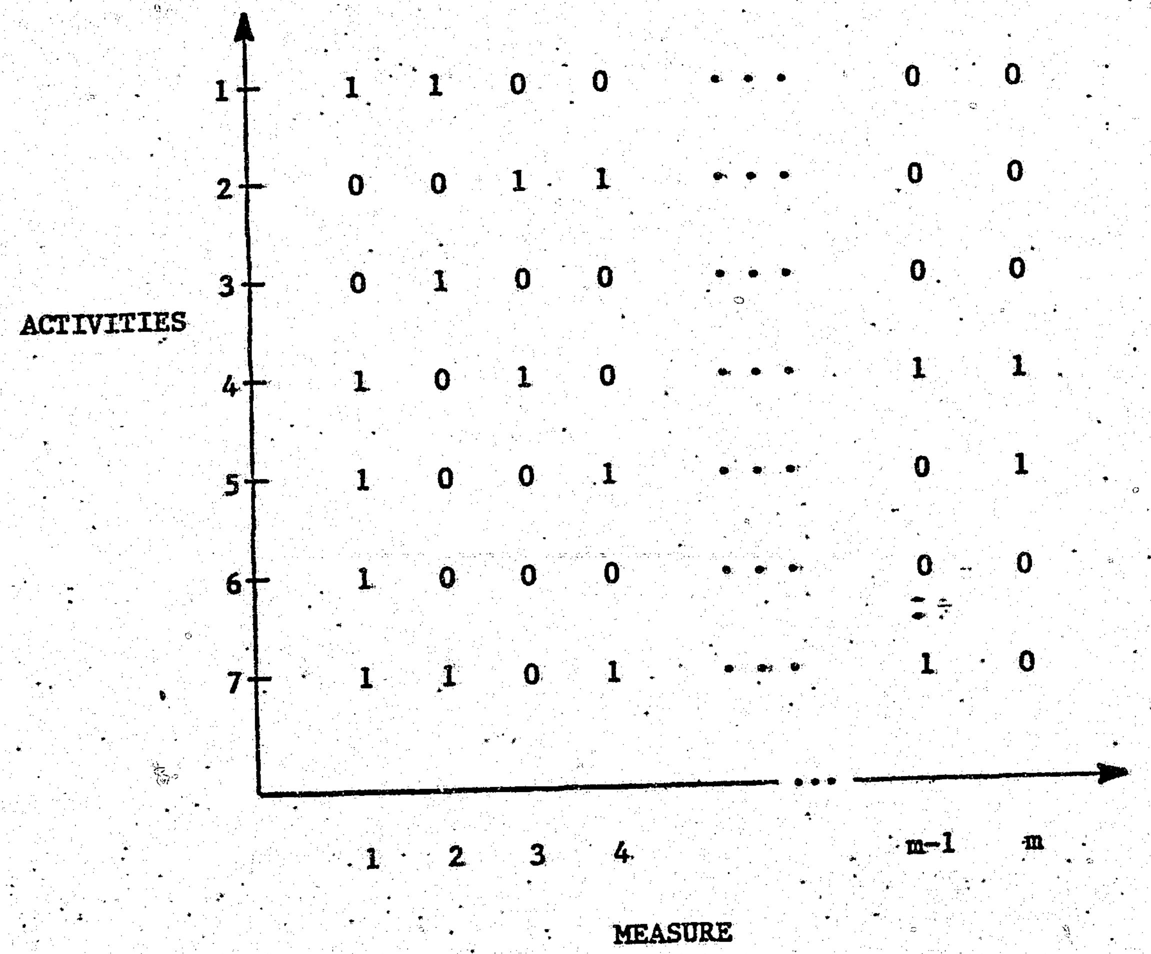

FIGURE 3. A Hypothetical Activity by Measure Matrix.

measure matrix as representing the number of associations characterizing an individual measure or activity respectively.

2.4 The Characteristic by Measure Matrix

Figure 4 shows the results from premultiplication of the matrices in Figures 2 and 3. The result is referred to as the characteristic by measure matrix whose elements indicate the number of activities over which a given characteristic and measure are associated. It provides a basis upon which measures can be compared. In the following sections, the potential for utilizing the matrix-oriented model in the analysis of performance measure policy is explored.

3. UTILITY INFERENCE IN MEASURE SELECTION

In this section we provide a description of the problem context when the evaluator is faced with selecting which of several alternative performance measures should be implemented. We will assume that the individual is making such a selection under conditions of limited resources and is concerned with making a selection which is both economical and consistent with the preferences of the organization. We further assume that the problem can be defined within the activity model structure since the characteristic by measure matrix provides the basis of the analysis.

3.1 Problem Discussion

In the selection of performance measures, the evaluator in business and public organizations is often faced with a situation where a single performance measure is to be selected from a larger set of available performance measure options. Pertinent objectives in making such a decision are to select an alternative which is both consistent with the prevailing policy of the organization and an economical option in terms

Characteristics	1	2	3	4	...	m-1	m
Operator Characteristics							
1	2	1	2	1		1	1
2	2	1	1	3		1	1
3	3	3	1	2		1	0
4	2	1	1	1		0	0
⋮	⋮	⋮	⋮	⋮	...	⋮	⋮
Process Characteristics							
1	1	1	1	0		1	1
2	3	2	1	2		2	2
3	2	2	2	1		1	1
4	3	1	0	2		1	1
5	3	1	0	2		1	1
6	2	2	2	1		1	1
7	3	1	0	2		1	1
8	2	2	2	1		1	1
⋮	⋮	⋮	⋮	⋮	...	⋮	⋮
Operand Characteristics							
1	5	3	2	3		2	2
2	2	2	2	1		1	1
3	0	0	0	0		0	0
4	5	3	2	3		2	2
5	0	0	0	0		0	0
6	3	3	1	3		1	1

Measures

FIGURE 4. A Hypothetical Characteristic by Measure Matrix.

of implementation costs. One approach to dealing with this problem is to analyze the available options relative to the performance measure alternatives which have been previously selected by the organization. In this sense, the prevailing or "inherited" measure set is seen as optimal or at least as accurately reflecting the utility of the organization. It should be stressed that our analysis will define optimality as both consistent with the utility of the organization (as reflected in prevailing policy) and in terms of cost effectiveness. Since it is likely that these objectives will at least be in competition for resources (if not in direct conflict), some means for weighting the two objectives must be devised.

3.2 Calculating the Per Activity Costs of Covering Characteristics

One way to measure the cost efficiency of a set of performance measures (if cost information is available on measures) is to calculate the price paid for covering each individual characteristic. This figure can then be reviewed against the average price for covering each individual characteristic. In order to calculate the average price for covering a characteristic. In order to calculate the average price for covering a characteristic over an activity, the average cost per activity is calculated for each measure. This figure is then averaged across measures for each characteristic. The result is the average price of covering each characteristic over one activity.

3.2.1 A Hypothetical Illustration

For example, suppose we had the three characteristics (a), (b), and (c) covered by the three measures (1), (2), and (3), and the following characteristic by measure matrix:

	(1)	(2)	(3)
(a)	2	0	1
(b)	1	3	1
(c)	1	0	1

The costs for measures (1), (2), and (3) are 150, 200, and 100 dollars respectively. The average cost per activity of coverage by measure (1) is 37.5, by measure (2) is 66.67, and by measure (3) is 33.33. For characteristic (a), two activities are covered by measure (1) at a cost of 37.5 each, and one activity at 33.33 is covered by measure (3). The average cost per activity of covering characteristics (b) and (c) is \$54.17 and \$35.42 respectively. That is,

Cost of coverage	Number of activities times per cost per/#activities measure(1) measure(2) measure(3)
Characteristic (a) = 36.11 =	{ 2(37.5) + 0(66.67) + 1(33.33) }/4
Characteristic (b) = 54.17 =	{ 1(37.5) + 3(66.67) + 1(33.33) }/5
Characteristic (c) = 35.42 =	{ 1(37.5) + 0(66.67) + 1(33.33) }/2

3.3 Determining the Spending Emphasis of a Policy

One way to describe the policy embodied in a set of performance measures is to determine the emphasis in spending directed toward individual characteristics. If implementation cost information on individual performance measures is available, we can describe a prevailing policy by calculating that proportion of total spending which is used for individual characteristics. Referring to our previous example, if we chose to implement measure (1) alone, (at a cost of \$150), we would be spending 50% of our resources to cover characteristic (a) and 25% for coverage of characteristics (b) and (c). The cost per activity would be \$37.5 for each characteristic. Using this criteria then, we could describe the policy by the equation;

$$.5(a) + .25(b) + .25(c) \quad .$$

3.3.1 The Case of No Cost Information Available

If implementation costs on individual measures are not available, a description of a policy implied by a set of performance measures can be based on the relative number of activities covered for each characteristic. If the measures (1) and (2) from the example were implemented, we would merely calculate the ratio of the number of activities covered for each activity to the total number of activities covered. Using this criteria, we can describe the measure (1) and (2) policy using no cost information by the equation;

$$.2857(a) + .5714(b) + .1429(c) \quad .$$

If we utilize the cost information available for this policy, we can determine that the costs per activity of covering characteristics (a), (b) and (c) are 37.5, 59.38 and 37.5 respectively. Using this information to weight total spending, the equation describing the policy using cost information becomes:

$$\frac{2(37.5)}{(150 + 200)}(a) + \frac{4(59.38)}{(150 + 200)}(b) + \frac{1(37.5)}{(150 + 200)}(c)$$

or

$$.2143(a) + .6786(b) + .1071(c) \quad .$$

That is, about 21.4% of spending is directed toward covering characteristic (a), about 67.9% for (b) and the remainder is allotted for coverage of characteristic (c).

3.3.2 A Simple Measure Selection Model Based on Spending Emphasis

If the sole objective in choosing between alternative performance measure options is to be consistent with previous policy, we can utilize the analysis developed so far in formulating an objective function.

To develop a model for choosing among alternative measure sets, define the notation;

C_i – cost of measure i.

Y_{ij} – the number of activities over which measure i covers characteristic j.

b_j – total number of activities covering characteristic j over all measures in a feasible set.

K_ℓ – the ℓ^{th} member of the set of feasible measure combinations.

$P_{j\ell}$ – the per-activity price of covering characteristic j within K_ℓ.

q_j – the proportion of total spending directed toward characteristic j in previous policy.

$\mathcal{C}$ – the number of characteristics to be covered.

The set of feasible measure combinations, K is formed and the selection model is written as;

$$\text{Min:} \sum_{j=1}^{\mathcal{C}} \left| \frac{Y_{ij} P_{j\ell}}{\sum_{i \in K_\ell} C_i} - q_j \right|$$

subject to:

$$\sum_{i \in K_\ell} Y_{ij} = b_j \qquad j=1 \ldots \mathcal{C}$$

and

$$\ell \in K$$

Since the above model form does not take account of the relative implementation costs of measures, (other than to identify them as feasible or infeasible) its practicality is questionable. In addition, the discrete nature of the problem would make solutions for large problems

extremely difficult. In the following section we use the above model form in developing a measure selection model taking explicit account of the relative costs of alternatives as well as prevailing policy parameters.

3.4 The Implied Economy of a Measure Policy

Up to this point, we have not accounted for cost considerations in discussing ways for selecting among performance measure alternatives. One way to do this is to compare the per activity cost of covering each characteristic with per activity costs over all available measures. The ratio of these costs for each characteristic, under each alternative, provides a measure of the relative cost efficiency obtained in implementing a particular measure set. We can again use the earlier example for illustration. For the alternative of implementing measure (1) alone, the per activity costs of covering characteristics (a), (b), and (c) are all 37.5. The per activity costs over all available measures are; 36.11 for characteristic (a), 54.17 for characteristic (b), and 35.42 for characteristic (c). Taking the ratio of overall costs to the costs stemming from implementation of measure (1) alone yields the equation;

$$0.9629(a) + 1.4445(b) + 0.9445(c)$$

In order to make the above form compatible with other equations developed to this point, we can normalize the expression by;

$$\frac{0.9629}{(0.9629 + 1.4445 + 0.9445)}(a) + \frac{1.4445}{(0.9629 + 1.4445 + 0.9445)}(b)$$

$$+ \frac{0.9445}{(0.9629 + 1.4445 + 0.9445)}(c)$$

This simplifies to the following equation whose coefficients sum to one;

$$0.2873(a) + 0.4309(b) + 0.2818(c)$$

Essentially, the above equation implies that characteristic (b) is the most economical characteristic to purchase, if we can assume that coverage of all characteristics are equally valid. However, this is merely a re-statement of the fundamental assumption necessary for using the activity model [5]. It is also important to note that this equation is valid only for the alternative of implementing measure (1) alone.

3.4.1 The Case of No Cost Information Available

It should be noted that this analysis is possible only in cases where cost information is available. Where no cost information is available, and the objective in choosing among alternative performance measure options is to achieve consistency with prevailing policy, an objective function form can be inferred from the relative number of activities covered for each characteristic. That is, we assume that preference among characteristics is proportional to the number of activities over which a characteristic is covered. As an example, if prevailing policy were to implement measures (1) and (3), the number of activities covered is three for characteristic (a), two for characteristic (b), and two for characteristic (c). The normalized objective function for selecting among performance measure alternatives is therefore;

$$0.4286(a) + 0.2857(b) + 0.2857(c)$$

for the policy of implementing measures (1) and (3).

3.4.2 Setting up the Measure Selection Problem

To set up the measure selection problem, the objective function must be augmented by the appropriate constraints defining the context of the problem. These include constraints on the resources available for measure implementation and constraints defining the available measure options. Within the measure selection problem, feasible solutions are ranked according to how the number of activities they cover for each characteristic is evaluated in accordance with the objective criteria. In the section which follows, an example of the complete cycle of setting up and solving a measure selection problem, where the objective is consistency with prevailing policy, is presented.

3.5 Development of a Composite Measure Selection Criteria

If our objective in selecting among alternative measure sets is to achieve consistency with prevailing policy, it is possible to combine the measures of spending emphasis and economy developed so far. Assuming that these objectives are equally weighted, we can merely take their product in order to develop an objective function for the measure selection model. To see this, consider the prevailing policy of implementing measure (1) in our earlier example. By multiplying the vectors of coefficients from the equation describing spending emphasis;

$$.5(a) + .25(b) + .25(c)$$

and policy economy;

$$0.2873(a) + 0.4309(b) + 0.2818(c)$$

we obtain the objective equation;

$$0.1437(a) + 0.1077(b) + 0.0705(c)$$

Normalization yields;

$$0.4464(a) + 0.3346(b) + 0.2190(c)$$

It is important to keep in mind that this procedure is applicable in situations where relative prices are reasonably stable over time.

To see this, consider a situation when new measures are introduced in a selection problem where covering the previously most expensive characteristics is now the most economical alternative. Although, this is not very realistic in most practical situations, it is easy to see how such a development could completely undermine the analysis. In situations where relative price stability across characteristics (as reflected in the implementation cost of corresponding measures) is not expected to be stable, formation of the objective criteria utilizing spending emphasis information alone would be more appropriate.

It is also worth noting that this procedure implicitly incorporates the previous relative economy across characteristics in selecting among alternative measures. With each application of the measure selection procedure, however, the relative economy across characteristics for the most recent measure options presented is integrated into the selection. This "cascading" effect of the economic criteria provides a means of utilizing both old and new cost information is deriving an expected value of the relative economy embodied in new measures. Furthermore, if relative prices across characteristics are stable, the expected value provides a very satisfactory forecast of these relative prices implied in the implementation costs of new performance measure options.

4. AN EXAMPLE INVOLVING AUTOMOBILE INSURANCE

To illustrate an application of the procedure presented in the preceeding section, we consider the hypothetical case of the automotive division of an insurance agency. In this example, the evaluation utilizes the model presented in [5] to measure how well the auto insurance division serves its constituency of stockholders.

The activities of the agency consist of performing six major functions which include:

1. Making decisions concerning which new policy applicants to accept for automobile insurance.
2. Investigating claims.
3. Updating renewal premiums for new moving violations and statute of limitations on old violations.
4. Processing changes in current customer status such as new automobiles, added coverage, etc.
5. Increasing market share by recruiting new preferred risk policy holders.
6. Processing claims data for preparation of new rate hike request submittals to state government.

Pertinent characteristics include policy holders, stockholders and the three major functions employed by the agency. They are summarized as follows:

1. Policy holders
2. The Sales force
3. Claims Adjusters
4. Actuarial
5. Stockholders

The set of currently available overall performance measures of the auto division include:

1.) An online sales growth report—This measure requires the installation of a relatively unsophisticated inquiry capability providing continuous update and display capability integrating sales figures with the customer information data base. The estimated system cost is $800.

2.) Motor Vehicle Department records inquiry system--This system allows the agency to access up-to-date records of violations maintained by the state office of motor vehicle registration. The system allows for prompt notification of moving violations and renewal premium revisions, its estimated cost is $2,000.

3.) A detailed report breaking down loss experience by customer and vehicle categories--This measure requires the design, preparation and processing of data collection forms to be completed by claims adjusters. The estimated cost is $2,200.

4.) Services of the Local Commercial Credit Rating Agency--This measure provides credit histories of new policy applicants supplied by the Credit Services Bureau. The cost of this service is $2,400.

5.) Implementation of coordinated personal referrals--This measure involves agency personnel investigating personal references offered on new applications. The estimated implementation cost is $1,600.

The characteristic by activity and activity by measure matrices for this example are shown in Tables 1 and 2, respectively. Pre-multiplication results in the following activity by measure matrix:

Measure

		Sales Report	Motor Vehicle Inquiry System	Loss Experience Report	Credit Services Bureau	Personal Referrals
		(1)	(2)	(3)	(4)	(5)
Policy holders	(a)	1	3	2	3	1
Sales force	(b)	1	1	1	2	2
Claims Adjusters	(c)	0	1	2	0	0
Actuarial	(d)	1	2	1	3	1
Stockholders	(e)	1	0	1	1	1

ACTIVITIES

CHARACTERISTICS	Acceptance of New Applicants	Claims Investigation	Update for current violations	Changes in Customer Status	Recruiting new Policy holders	Preparation of Rate hike requests
Policy holders	1	1	1	1	0	0
Sales force	1	0	0	0	1	0
Claims Adjusters	0	1	0	0	0	1
Acturial	1	0	1	1	0	0
Stockholders	0	0	0	0	1	1

Table 1. Characteristic by Activity Matrix

MEASURES

ACTIVITIES	Sales Report	Motor Vehicle Inquiry	Loss Experience Report	Credit Services Bureau	Personal Referrals
Acceptance of New Applicants	0	1	1	1	1
Claims Adjustment	0	1	1	0	0
Update for Current Violations	0	1	0	1	0
Changes in Customer Status	1	0	0	1	0
Recruiting new Policy holders	1	0	0	1	1
Preparation of Rate hike requests	0	0	1	0	0

Table 2. Activity by Measure Matrix

4.1 Development of the Measure Selection Criteria

Using the cost information on measures and the characteristic by measure matrix, we can determine the overall per activity cost for each measure as:

Per Activity Cost

Measure	(1)	(2)	(3)	(4)	(5)
	800/4	2000/7	2200/7	2400/9	1600/5
	"	"	"	"	"
	200	285.71	314.29	266.67	320

The per activity cost for individual measures can be used to obtain the per activity cost for each characteristic as follows:

Characteristic

(a) = [1(200) + 3(285.71) + 2(314.29) + 3(266.67) + 1(320)]/10 = 280.57

(b) = [1(200) + 1(285.71) + 1(314.29) + 2(266.67) + 2(320)]/7 = 281.91

(c) = [0(200) + 1(285.71) + 2(314.29) + 0(266.67) + 0(320)]/3 = 304.76

(d) = [1(200) + 2(285.71) + 1(314.29) + 3(266.67) + 1(320)]/8 = 275.72

(e) = [1(200) + 0(285.71) + 1(314.29) + 1(266.67) + 1(320)]/4 = 275.24

If the prevailing measure policy is to maintain the motor vehicle inquiry system and to follow up personal referrals, (total policy cost of 3600), we can compute the per activity cost for each characteristic under this policy as follows:

Characteristic

(a) = [3(285.71) + 1(320)]/4 = 294.28

(b) = [1(285.71) + 2(320)]/3 = 308.57

(c) = [1(285.71) + 0(320)]/1 = 285.71

(d) = [2(285.71) + 1(320)]/3 = 297.14

(e) = [0(285.71) + 1(320)]/1 = 320

Taking the ratio of overall costs to the costs stemming from prevailing policy yields the equation:

0.9534(a) + 0.9136(b) + 1.0667(c) + 0.9279(d) + 0.8601(e) .

Normalizing, we obtain the following cost efficiency equation for the prevailing policy:

0.2019(a) + 0.1935(b) + 0.2259(c) + 0.1965(d) + 0.1822(e) .

The next step is to develop the equation describing the spending emphasis for the two-measure policy. This can be done by determining the amount spent on covering each characteristic and taking the ratio of this amount for each characteristic to the total cost of the policy, i.e., 3600. The necessary calculations can be summarized as follows;

Characteristic

(a) → 4(294.28)/3600 = 0.3270

(b) → 3(308.57)/3600 = 0.2571

(c) → 1(285.71)/3600 = 0.0794

(d) → 3(297.14)/3600 = 0.2476

(e) → 1(320)/3600 = 0.0889

The equation describing spending emphasis embodied in the prevailing policy is therefore;

0.3270(a) + 0.2571(b) + 0.0794(c) + 0.2476(d) + 0.0889(e) .

To obtain the objective equation for selecting among new measures, we first take the product of the coefficients from the spending emphasis and cost efficiency equations for each characteristic yielding:

(0.2019)(0.3270)(a) + (0.1935)(0.2571)(b) + (0.2259)(0.0794)(c)
+ (0.1965)(0.2476)(d) + (0.1822)(0.0889)(e) .

This expression simplifies to;

$$0.0660(a) + 0.0497(b) + 0.0179(c) + 0.0487(d) + 0.0162(e)$$

By normalizing we obtain the objective function for selecting among new performance measure alternatives as;

$$0.3325(a) + 0.2504(b) + 0.0902(c) + 0.2453(d) + 0.0816(e)$$

4.1.1 The Case of No Cost Information Available

Before proceeding further, it is worth noting that the objective function which would have been developed had no cost information been available on individual measures. Recall that the objective function for this case is based on the notion that policy preferences are expressed by the relative number of activities covered for each characteristic. If we assume once again that the prevailing policy is to implement measures (2) and (5) which cover a total of 12 activities, the objective function is determined as follows;

$$(4/12)(a) + (3/12)(b) + (1/12)(c) + (3/12)(d) + (1/12)(e)$$

which can be rewritten as;

$$0.3333(a) + 0.2500(b) + 0.0833(c) + 0.2500(d) + 0.0833(e)$$

Interestingly, the objective function determined for the case of no cost information resembles the one determined with cost information quite closely. In fact, the objective which utilizes cost information can often times be thought as amore precise version of the above.

4.2 Application of the Selection Criteria

Once an objective criteria is selected, specification of the measure selection problem is completed by identifying the set of remaining feasible measure combinations, and the appropriate constraints. For our example, we will assume that the following two additional performance measures are made available;

6.) Industry data pool membership--This measure would allow member agencies to access the policy histories of new applicants from records of other insurance companies. The cost of membership is $1,000.

7.) Customer service feedback evaluation poll--This measure would record and process data from a customer survey concerning the service level provided by the agency. The cost of this measure is estimated at $900.

Introduction of the two new measures resulted in the augmentation of the characteristic by measure matrix as follows;

	Measure						
	Sales Report (1)	Motor Vehicle Inquiry System (2)	Loss Experience Report (3)	Credit Bureau (4)	Personal Referrals (5)	Data Pool (6)	Cust. Survey (7)
Policy holders (a)	1	3	2	3	1	1	3
Sales forces (b)	1	1	1	2	2	2	0
Claims Adjusters (c)	0	1	2	0	0	0	1
Actuarial (d)	1	2	1	[illegible]	1	1	2
Stockholders (e)	1	0	1	1	1	1	0

In addition to the prevailing measure policy (implementation of measures (2) and (5)), management has budgeted an additional $2,500 to evaluators. Using this information, it is possible to define the set of feasible combinations of measures from the candidate measures (1), (3), (4), (6) and (7). The feasible set of measures is shown in Table 3 along with the corresponding objective value calculated for each combination.

The Set of Feasible Measure Combinations

(i.e., costing $2,500 or less)

Measure Combination	Cost	Obj. Value
{(1)}	800	0.9098
{(3)}	2,200	1.4227
{(4)}	2,400	2.3158
{(6)}	1,000	1.1602
{(7)}	900	1.5783
{(1),(6)}	1,800	2.0700
{(1),(7)}	1,700	2.4881
{(6),(7)}	1,900	2.7385

Table 3. The Set of Feasible Measure Combinations.

From Table 3, we can see that the measure combination of (6) and (7) maximizes the objective value. That is, implementation of the customer service feedback evaluation, and membership in the industry client data pool is the alternative most consistent with prevailing policy.

4.3 Post-Selection Objective Criteria Revision

At this point, we are also able to revise our objective criteria in accordance with the new prevailing policy for the next time at which measures are to be selected. The revised overall per activity costs for each characteristic are;

(a) - 246.84, (b) - 263.71, (c) - 266.07, (d) - 245.98,

(e) - 260.19 .

The revised policy per activity costs for each characteristic are;

(a) - 228.39, (b) - 265.14, (c) - 217.86, (d) - 231.90,

(e) - 260.00 .

The revised cost efficiency equation is therefore;

$$1.808(a) + 0.9946(b) + 1.2213(c) + 1.0607(d) + 1.0007(e) \quad .$$

Normalizing yields the equation;

$$0.2971(a) + 0.1634(b) + 0.2007(c) + 0.1743(d) + 0.1644(e) \quad .$$

The revised spending emphasis equation becomes;

$$\frac{1827.12}{5500}(a) + \frac{1325.70}{5500}(b) + \frac{435.72}{5500}(c) + \frac{1391.4}{5500}(d) + \frac{520.00}{5500}(e) \quad .$$

Simplifying we obtain;

$$0.3322(a) + .2410(b) + 0.0792(c) + 0.2530(d) + 0.0945(e) \quad .$$

Taking the product of the coefficients from the cost efficiency and spending emphasis equations, we obtain the equation;

$$0.0987(a) + 0.0394(b) + 0.0159(c) + 0.0441(d) + 0.01550(e)$$

which is the revised objective criteria for selecting among new performance measure combinations.

5. CONCLUSION

In this study, we have developed a rational basis by which to select performance measure sets which have comparable properties with a prevailing measure set. The analysis would be particularly applicable in cases where no clear definitions of optimality can be discerned other than consistency with the status quo and extremely basic economic considerations. Although the discrete nature of the problem form makes the solution difficult when the number of possible measure combinations is large, it provides a viable alternative to arbitrary selection procedures. Also, the problem formulation is based upon such straightforward and unsophisticated mathematics, that it should be understandable to individuals with little in the way of quantitative knowledge.

An important issue which remains unaddressed in this study is how to modify the solution procedure to simplify the formation of feasible measure combinations. One promising area for future research then, is the application of the methodology developed in [6] aimed at reducing the effort required in determining the set of feasible measure combinations. In addition, more investigation is needed to investigate the validity of the assumptions upon which application of the model is based, particularly the assumption concerning price stability of measures over time. Also, the convergent properties of the methodology over many policy revisions should be examined. Finally, the case of falliable cost information is worthy of a more detailed future research.

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