CONSISTENCY AND OPTIMALITY IN MANAGERIAL DECISION MAKING*[1,2]

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This paper reports some research, ideas, and theory about managerial decision making. The first research projects dealt with are aggregate production and employment scheduling. From this is developed the idea that management's own (past) decisions can be incorporated into a system of improving their present decisions. Decision rules are developed, with the coefficients in the rules derived from management's past decisions (rather than from a cost or value model). Half a dozen test cases are used to illustrate and test these ideas (theory). Some rationale about decision making in organizations and criteria surfaces is supplied to help interpret the major ideas presented.

This paper reports some research in managerial decision making, as well as the ideas and a theory stemming from this research. Presented here is a combination of description and prescription. It combines the talents of the manager with those of the analyst in a method and in a theory. The method is pragmatic rather than utopian in that it offers one way of starting with the managers' actual decisions and building on them to reach a better system.

A referee has summarized this paper as follows: "that managerial decisions might be improved more by making them more consistent from one time to another than by approaches purporting to give 'optimal solutions' to explicit cost models . . . especially for problems where intangibles (run-out costs, delay penalties) must otherwise be estimated or assumed." Though this is a normative statement, it is derived from a number of descriptive concepts (about the world in which we live) which may be of equal interest.

The paper is organized essentially in the sequence in which the research was performed and the ideas generated. The problems, research, and decision rules of production scheduling are set forth first. They introduce the cause of this paper. Next, the approach of using management's own past decisions in order to improve present decisions is described. The theory is then set forth in a more general form, after which several additional empirical tests of the theory are described. Finally, the ideas are summarized. Further questions of validity, generality, and operationality must be answered by future research.

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[1] Draft of a paper given at the Conference on Factory Scheduling at Carnegie Institute's Graduate School of Industrial Administration, May 12, 1961.

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Production Scheduling Decision Rules

The research which led up to the more basic ideas presented here dealt with the general problem of production and employment scheduling. This work is set forth in some detail in order to convey the spirit of the research.

A very simple decision rule for production scheduling might be:

$$P_t = S_t$$

where P_t represents production scheduled in time period t, and S_t represents sales expected in time period t. In this case production would match all fluctuations up and down in sales, and the rule might not be considered a very good one. An extension might be:

$$P_t = S_t + x(P_{t-1} - S_t)$$

where x is a decision rule coefficient to be specified between zero and one, and P_{t-1} represents production in the previous time period. If $x = 1$, then the sales terms cancel out, and production in this period equals production in the previous time period (i.e., with no fluctuation). A value for x between zero and one will supply a damping mechanism in this case, where production does change but not as quickly as sales.[2]

However, using this rule (where production does not necessarily match sales each period) would cause inventories to fluctuate. In order to offer some control of these inventory levels the rule may be further extended:

$$P_t = S_t + x(P_{t-1} - S_t) + y(I_N - I_{t-1})$$

where y is also a decision rule coefficient to be specified between zero and one, I_N represents a concept of "Normal" inventory (possibly an easier label than optimum inventory), and I_{t-1} represents the amount of inventory at the end of the previous period.

Because it is desirable to take into account the anticipated future sales (in the near term), the rule should be extended further:

$$P_t = \sum_{i=t}^{i=t+n} a_i\hat{S}_i + x(P_{t-1} - S_t) + y(I_N - I_{t-1})$$

$$(a_t > a_{t+1} > a_{t+2} > \cdots a_{t+n})$$

with the a_i's representing weighting coefficients of the sales forecasts, $\hat{S}_i$, for future periods.

While such a decision rule could be further extended and elaborated, this will suffice for our introduction. The production scheduling behavior of a firm following such a rule would be critically influenced by the numbers supplied for the coefficients, $a_t \cdots a_n$, x, y, and I_N (which may be conceived of as a number for the moment). Different sets of numbers in the coefficients would result in different behavior patterns through time. Some patterns would undoubtedly be preferable to others. The challenge, of course, is to determine the

[2] This rule may be converted into the more standard feed-back form:

$$P_t = P_{t-1} + (1 - x)(S_t - P_{t-1}).$$

preferred set of coefficients. Three methods for making this determination are listed below:

1) Simulation (experimentation)
2) Analysis
3) Management Decisions

Simulation seems to require no justification at present. Many uses are being made today of this activity in universities and in industry,[4] particularly where the mathematics of a more deductive solution scheme break down. Mathematical analysis may be possible even in problems as complex as this.[5] For industrial problems which are framed in less complex form mathematical analysis is not uncommon. A different source (management decisions) for these decision rule coefficients is developed later in this paper.

The HMMS Decision Rules

The production and employment scheduling problem faced by most manufacturing firms, where in each scheduling period both a production quantity and an employment level must be chosen, has been analysed in research work by Holt, Modigliani, Muth, and Simon (HMMS) on a paint company. Working with quadratic cost forms, and a long term scheduling horizon the following production and work force rules were derived:

$$\begin{aligned} P_t = &+.463\, O_t \qquad +.993\, W_{t-1} + 153 - .464\, I_{t-1} \\ &+.234\, O_{t+1} \\ &+.111\, O_{t+2} \\ &\quad \vdots\ O_{t+11} \end{aligned}$$

$$\begin{aligned} W_t = &+.0101\, O_t \qquad +.743\, W_{t-1} + 2.09 - .010\, I_{t-1} \\ &+.0088\, O_{t+1} \\ &+.0071\, O_{t+2} \\ &\quad \vdots\ O_{t+11} \end{aligned}$$

where the subscripts are time period notation, P stands for production, W for workers, O for sales orders, and I for inventory. The analyses leading to these decision rules are quite involved and will not be described here, as it is not essential to the major ideas presented in this paper. They may be found in the literature.[6]

[4] See for a large example Jay Forrester, *Industrial Dynamics*, MIT Press and John Wiley, 1961.

[5] See especially Holt, Modigliani, Muth and Simon, *Planning Production, Inventories, and Work Force*, Prentice-Hall, Inc., 1960.

[6] "A Linear Decision Rule for Production and Employment Scheduling", by Holt, Modigliani, and Simon, *Management Science*, October 1955, and "Derivation of a Linear Decision Rule for Production and Employment," by Holt, Modigliani and Muth, *Management Science*, January, 1956. Reprinted in *Analyses of Industrial Operations*, Bowman and Fetter (eds.), Irwin, Inc., 1959; also included in *Planning Production, Inventories, and Work Force*, Holt, Modigliani, Muth and Simon, Prentice-Hall, Inc., 1960.

It is important to explain, however, that the rule *and* the coefficients—the numbers .463, .993, 153, −.464,—were derived by mathematical analysis from the cost structure model of this one paint factory studied. Had the company followed these rules, the physical behavior pattern and, therefore, the costs of the behavior would have been different. The HMMS group present the following normalized summary cost data for three cases:

Paint Company

	1949–53 (Korean War included)	1952–54
Decision Rule (perfect forecast)	100%	
Decision Rule (moving average forecast)	110%	100%
Company Performance	139%	108.5%
(cost base about $3,000,000)		

Since the decision rules require estimates of future sales over the next 12 months, both the actual sales (now known and entitled perfect forecast), and a moving average forecast (entitled naive forecast) were used to reconstruct the behavior of the system over the years listed. The total costs (normalized to 100%) for the company's own behavior, and that from the decision rules, is given. It can be seen that the decision rule consistently used would have shown an appreciable cost saving.

Other Applications

In our research, we applied the HMMS analysis previously cited to the production and employment scheduling problems of an ice cream company,[7] a chocolate company,[8] and a candy company.[9]

The results, in the same form as before, were as follows:

	Ice Cream	Chocolate	Candy
Decision Rule (perfect forecast)	100%	100%	100%
Decision Rule (moving average forecast)	104.9%	102.0%	103.5%
Company Performance	105.4%	105.3%	111.5%
Approximate Cost Base	$500,000	$150,000	$1,500,000

With less margin of improvement, it appeared that the linear decision rules, derived from the quadratic approximations to the costs structures of each firm might have resulted in the cost savings shown.

[7] "An Application of a Linear Decision Rule for Production and Employment Scheduling" by Rien T. van der Velde, an MIT Master's thesis, 1957.

[8] "An Empirical Study of Actual and Optimum Decision Rules for Production and Employment Scheduling," Wallace Crowston, MIT Master's thesis, 1958.

[9] Constructed from "Production and Inventory Control, Analysis of the Decision-Making Process," Clinton M. Jones, MIT Master's thesis, 1958.

Behavior and Statistical Regression

The author of the chocolate company thesis was requested to do a statistical least squares regression of the company's actual scheduling behavior against the linear decision rule. He added another variable, sales contracted for the next 6 months, and used a sales level which was derived from exponentially weighted past sales. For the W_t rule he obtained a multiple correlation coefficient of $r = .971$. For the P_t rule he obtained a multiple correlation coefficient of $r = .87$. In other words, the *form* of these rules gave a pretty fair indication of the chocolate company managers' decisions. That is, the managers were sensitive to these same variables in their decision behavior.

We then did a graphical multiple regression for the candy company using these rules (with a single "sales level" figure). Again we obtained a fair correlation with the addition that more inventory was "tolerated" in the busy half of the year.

Next for all four companies—paint, ice cream, chocolate, and candy—we did a statistical least squares regression for the company management scheduling behavior on the "open form" of the decision rules, e.g.,

$$P_t = a + b_1\hat{S}_1 + b_2\hat{S}_2 + b_3\hat{S}_3 + b_4\hat{S}_4 + b_5\hat{S}_5 + b_6Wt_{-1} + b_7I_{t-1}$$

These regressions gave us rather poor results. The sales estimates, $\hat{S}$, were highly correlated, and the t tests on the coefficients came out poorly.

With advice concerning regression, "Use all the good restrictions you have—you'll get better estimates," we were able to use the feed back form (modified) of the original decision rules.[10]

The versions of the decision rules developed for regression were:

$$\Delta W_t = b_1[\bar{S}_{2\text{-}4} - (\bar{S}/W)W_{t-1}] + b_2[S_t(\bar{I}/\bar{S}) - I_{t-1}] + a_1$$

$$P_t = b_3W_t + b_4[(\bar{W}/\bar{S})\bar{S}_{2\text{-}4} - W_t] + b_5[S_t(\bar{I}/\bar{S}) - I_{t-1}] + a_2$$

where W, P, and I are as given before, S_t represents actual sales in the current period, $\bar{S}_{2\text{-}4}$ represents average actual sales in the next three periods, and $\bar{S}$, $\bar{W}$, and $\bar{I}$ represent averages of these variables over the total period of investigation. These rules are a bit simpler though they follow from the feed back rules which Yance proves equivalent to the Carnegie rules. The exact form of the rules is not important for this paper, though the modification using variables which are the normalized differences between variables, e.g., $[S_t(\bar{I}/\bar{S}) - I_{t-1}]$, permitted a more meaningful regression to be made. Using these rules as the form, regressions were done for the four companies to obtain the (estimates of) decision rule coefficients from management's actual behavior. These gave significant correlations which permitted the development described next.

[10] The HMMS rules had been factored into feedback form by Joseph V. Yance in his unpublished paper, "Marshallian Elements in the Carnegie Tech Rules".

Costing The Regression Rules

With the feed back production and employment scheduling rules, and with the coefficients developed from management's own scheduling behavior, it was possible to reconstruct (simulate) the companies' scheduling behavior following these rules (with moving average forecast) as was done in the original work. The results are as shown in the table.

	Ice Cream	Chocolate	Candy	Paint
Decision Rule (perfect)......	100%	100%	100%	100%
Decision Rule (move.av.)....	104.9%	102.0%	103.3%	110%
Company Performance.......	105.3%	105.3%	111.4%	139.5%
Management Coefficients.....	102.3%	100.0%	124.1%[11]	124.7%[12]
Correlation	W_t, $r = .78$ P_t, $r = .97$	W_t, $r = .57$ P_t, $r = .93$	W_t, $r = .73$ P_t, $r = .86$	W_t, $r = .40$ P_t, $r = .66$

As can be seen from the table, in all cases but the candy company, using the decision rules with the coefficients supplied by regression of management's own behavior, and a rather simple estimating scheme for future sales, the costs would have been less than the company's actual behavior. In the Ice Cream Company and the Chocolate Company, it would have been even cheaper than the decision rule derived from the standard quantitative analysis and the same sales forecasting scheme.

Several points of explanation may help. It is suspected that the somewhat surprising results of better performance with the managers' coefficients than that supplied by the analysis is due to the fact that the *analysis* is optimum only in the sense that the quadratic cost models from which the rules were derived is a perfect fit for these costs. This, of course, is not the case. It is important to keep in mind that *optimization* is always of a (mathematical) model, which hopefully bears some resemblance to important facets of the real world. The graphical multiple regression done earlier on the candy company (the refuting case here) suggests that had the split inventory policy between slack and busy times of the year been permitted in the rule, the then adjusted management coefficients rule would have been better.

The Management Coefficients Theory

An attempt at something like an axiomatic treatment of these concepts is presented *in order to stimulate more ideas*:

1) Experienced managers are quite aware of and sensitive to the criteria of a system.

[11] Using a perfect sales forecast would have reduced this to 112.5%.

[12] This figure must be viewed with some reservation as we were working with the publications and working papers from HMMS, not the data as such. We could not reconstruct some of their costs, and the five years are '50–'54 rather than '49–'53, though both cover the extreme years of the Korean War.

2) Experienced managers are aware of the system variables which influence these criteria.

3) Managers, in their present position through a process of natural screening, make decisions, i.e., implicitly operate decision rules, with a sense and intuition which relates the variables to the criteria imperfectly—*but more erratic than biased.*

4) Most cost or criteria surfaces as a function of the decision variables are shallow, dish-shaped at the bottom (top) and even with bias in the manager's behavior, it is the far out (variance) examples of behavior which are really expensive or damaging.

5) If manager's behavior had paralleled the decision rules with their average or mean coefficients, their experience would have been better according to the their) criteria.

It seems useful to attempt an explanation of why decision rules derived from management's own average behavior might yield better results than the aggregate behavior itself. Man seems to respond to selective cues in his environment—particular things seem to catch his attention at times (the last telephone call), while at other times it is a different set of stimuli. Not only is this selective cueing the case, but a threshold concept seems to apply. He may respond not at all up to some point and then overrespond beyond that. It is this type of behavior which helps explain the variance in the organization's (or its management's) behavior.

Departures of the decision making behavior of management from the preferred results, in this sense then can be divided or factored into two components, one which in the manner of a grand average departing from some preferred figure, we call bias (which causes a relatively small criteria loss due to the dish shaped bottom of the criteria surface), and one which representing individual occurrences of experience departing from the grand average, we call variance (which causes larger criteria losses due to the individual occurrences up the sides of the criteria dish-shaped surface). It is the latter and more important component which seems to offer the tempting possibility of elimination through the use of decision rules incorporating coefficients derived from management's own recurrent behavior.

What can be done with this management coefficients theory?

1) It may yield fresh insight into a management problem or a decision process—it may lead to further ideas. (This is operational in an academic world.)[13]

a) Several approaches to the same problem are often of benefit.

b) Patterns of behavior variance against the decision rule may point to missed elements in the analysis.

c) It gives us a chance to see (indirectly) the criteria through the manager's eyes (or action).

[13] Harlow Shapely, the Harvard astronomer, in reviewing *The Universe at Large* by Hermann Bondi, includes "It is not the purpose of any scientific theory," wisely remarks Dr. Bondi, "to be infallible or final or true. Its purpose is to be fertile; to suggest new observations that suggest new ramifications of the subject."

2) Sampling in the current system may be possible—e.g., with 10,000 items in inventory, maybe the managers will look carefully at 100, and make the necessary decisions for these 100; then these 100 items (along with their relevant variables) may be used in estimating the coefficients in the decision rules for the 10,000–100 items (an inventory test case is given later in the paper).

3) Balance the present system structure—e.g., with many branch plants, it may be possible to arrange a better configuration of plant sizes (a plant size test case is given later in the paper).

4) Let the manager look at the decision rule with his regression coefficients and then decide what his decision will be, e.g., run in parallel with joint feed back between manager and rules.[14]

5) Decouple the manager, but record his decisions. (This is not seriously offered as a suggestion but just to stimulate ideas). The manager has continual access to his changing environment—he makes his decisions—these are filed and this operation (e.g., production and employment scheduling) is determined by the decision rule (not his decision). Then periodically the decision rule is updated from the file of recent decisions. The idea here is to eliminate the effects of the variance in decision behavior, while at the same time permitting the decision rule to reflect the current environment.

6) If the theory can be verified where it is felt that the system criteria can be measured (as in the cases presented in this paper), then some assurance might exist for using it where the criteria can't be measured.[15]

7) Automatic decision making (by computer) to save executive time will require decision rules with coefficients—these may be supplied by regression.

8) At the bounds of analysis, the new theory may help structure the system. Where aggregation is used in the analysis and the question is raised as to what happens when the clerk breaks open the aggregate, rules with regression coefficients can be supplied.

[14] March and Simon, *Organizations*, John Wiley and Sons, 1958, p. 209, state: "... since there is no reason to suppose that *any* technique of decision-making, whether centralized or decentralized, will bring the organization into the neighborhood of a genuine 'optimum', the search for decision mechanisms cannot take criteria of optimization too seriously, but must seek 'workable' techniques for satisficing. The exploration of decision-making techniques along these lines is still in a very undeveloped state... A number of decision rules for production control and scheduling decisions in individual firms have been developed—but again with only small forays beyond the familiar terrain of optimization." The new theory departs a bit from this familiar terrain.

[15] Herbert Simon in *The New Science of Management Decision*, Harper Bros., 1961, makes several statements relevant to this idea. If the new theory offers anything then the first quotation is not necessarily true—p. 17, (talking about operations research) "... The model will call for certain parameters of its structure (the system) to be estimated before it can be applied in a particular situation. Hence, it is necessary that there be ways of making actual numerical estimates of these parameters (he is talking about the system not the decision rules derived therefrom) of sufficient accuracy for the practical task at hand."

The second quotation, however, is cited for reinforcement here—p. 18. "For the operations research approach to work, nothing has to be exact—it just has to be close enough to give better results than could be obtained by common sense without the mathematics."

The management coefficients theory is, of course, not without its problems. It may kill the goose that lays the golden eggs. The manager may follow the rule with his past (average) coefficients, and not adjust to new conditions as they take place. March and Simon[16] make the distinction between a) short run adaptation as problem solving (here, using the decision rule as fulcrum), and b) long run adaptation as learning (here, using the manager to modify decision rules). The problem is how to bypass (a) without inhibiting (b).

Plant Size

As an additional check on the theory presented here an analysis described in the *Operations Research* journal[17] was reexamined. The study concerned the question of the optimum size ice cream plant for a particular company operating ten plants over a seven state area. For purposes here, the analysis need not be repeated, but it led up to a decision rule for the optimum volume plant:

$$V_{opt} = (K)^{1/3}(2b/c)^{2/3}$$

where K was the sales density in thousand gallons per square mile (per year), and b and c were particular cost factors relevant to the ice cream production and distribution system. Had the system been restructured according to the analysis and decision rule, gross cost savings appeared to be available. These along with the results of the new theory are presented in the table.

		Savings
Original	$V_{opt} = (K)^{1/3}(2b/c)^{2/3}$	\$207,000
Regression (first model)	$V = (K)^{1/3} d_1$	\$133,000
Regression (naive model)	$V = a + d_2K$	\$20,000

Using the same decision rule from (with $(K)^{1/3}$ as the independent variable and permitting no intercept, $a = 0$), the company's actual plant volumes were used to estimate d_1, the decision rule coefficient. Had the plant system then been restructured using their own (behavior) coefficient in the decision rule, the projected gross cost savings would be \$133,000.

For test purposes a naive decision rule, $V = a + d_2K$, was used in the same manner—it included the relevant variable, sales density, but not to the "right" power, as well as permitting an intercept a. Here a and d_2 were estimated from the actual plants, and as can be seen the savings are quite small. In other words, *any old decision rule will not do*. It is certain that the most simple, $V = \bar{V}$, i.e., have all plants the average size, would have been more costly for the firm than the present arrangement.

It is interesting to note that the naive rule actually gave a better fit to the data. While it is the cost savings rather than the good fit which is the choice here, if a collaboration were now in existence between the analyst and the

[16] March and Simon, *op. cit.*, p. 170.

[17] E. H. Bowman, "Scale of Operations—An Empirical Study," *Journal of the Operations Research Society of America*, May–June, 1958.

managers, this point would be worthy of discussion and reflection for both parties. That is, the new theory might be a very useful part of a more general analytic procedure, rather than being *directly* prescriptive.

Idlewild Aircraft Spares

A further check was made on the new theory using the basic work of a thesis[18] dealing with a spare parts inventory maintained at Idlewild Airport. Waiting line theory had been used for the inventory analysis with an n channel service facility for n pieces of an item. An idle channel corresponded to an item in stock; a busy channel corresponded to an empty space; no queues were allowed.

For the management coefficients theory test, an extremely simple decision rule was developed:[19]

$$\text{Spares} = a + bx$$

where: $$x = \frac{\text{useage during repair cycle}}{\text{unit price of item}}$$

The thesis studied in some detail ten stock items of widely scattered characteristics. For our purposes, the results are shown below.

	Company Actual	Thesis Analysis	New Theory
Investment	\$17,000	\$16,000	\$16,500
Stock-outs in 6 years	186	69	143

From this small sample, at least, the simple decision rule with the coefficients (a and b) would have saved half as much investment and one third as many run outs as the analysis. No more detailed analysis was made here.

Other Applications

In a very detailed study of equipment replacement policies in the trucking industry,[20] a number of conclusions supporting ideas presented here are found. A well accepted model[21] was used with empirical data from industry studies. The following items were determined:

A. Estimates of obsolescence
   a) carrying capacity of trailer
   b) internal combustion engine technology

[18] Giyora Doeh, "Overhauled Spares Inventory for Aircraft Components," MIT Master's thesis, 1958.

[19] For an incremental approach:
Δ Cost = Δ Gain
Unit Cost = (Δ prob)(run out cost)
Let Δ prob α (1/spares) (useage), with tail of hyperbola a rough approximation to tail of poisson distribution.
Then, Unit Cost α (useage/spares) (run out cost) and Spares α (useage/unit cost) (run out cost)

[20] Vernon Smith, "Economic Equipment Policies: An Evaluation," *Management Science*, October 1957.

[21] $V = \sum_{K=0}^{\infty} e^{-\rho kl}\{\int_0^L Q(KL, t)e^{-\rho t}\, dt - p + S(L)e^{-\rho L}\}$

B. Estimates of operating cost
   a) fuel
   b) maintenance

The study resulted in very flat curves of total yearly average value as a function of equipment life. Replacement anywhere between 2.2 years and 4.4 years will lead to losses of at most $50 short of "exact" optimum. Smith reports:

> "This is a remarkable result especially when one considers that on the average about $\frac{2}{3}$ of the total investment of trucking firms is in the form of trucking equipment (i.e., capital goods of intermediate durability requiring regular maintenance). It would seem that this of all industries would find equipment *replacement* policies of considerable importance, yet precision in such policies turns out to be of minor significance. It is not argued that it makes no difference when equipment is replaced. Rather the point is that profits are not sufficiently sensitive to replacement that the firm is likely to miss the optimum by a costly margin even when using relatively crude methods of analysis."

He also states that an optimum service period of 3 to 4 years is about 1 to 2 years shorter than the actual replacement behavior of the firm in question.

He then goes on to explain that delayed replacement in effect is a relatively cheap source of capital for this firm. This is equivalent to saying that the management senses a somewhat different criteria surface than his analysis explicitly considers. Regression of behavior should permit this sensing to be incorporated in the decision rule.

A good deal of interest today seems to exist in heuristics and management problem solving. While these processes may be largely programmatic and qualitative, some coefficients are embedded therein. The question of how far to go down some path or how many of these parts to combine may still require parameters. Where this is so, observation and regression of experienced problem solvers may be helpful.

For a case in point, a thesis student has been working on heuristics for a dispatching rule to be associated with a key process in an aircraft plant. The question involves the order in which waiting parts should proceed through the equipment. He has identified four characteristics (e.g., cost, due date) of the parts which are relevant for this sequencing (dispatching). He needs coefficients to weight these characteristics. Simulation had already occurred to him. He agreed that analysis, at least conceptually, might be possible. The new theory suggests to him that he might obtain from the shop the actual dispatching decisions by the men directly involved on a long list of parts along with their characteristics in order to do a regression for the weighting coefficients.

The management coefficients theory says something about the behavior of managers and their organizations. There seems to be no apparent reason why these ideas should apply to production only and not marketing, or industrial organizations only and not governmental, or even microeconomic problems only and not macroeconomic as well. But, perhaps this overstates the case.

Summary

The gist of the management coefficients theory is a relatively simple notion:

a) In their decision making behavior, managers and/or their organizations can be *conceived* of as decision rule coefficient estimators, (not that they explicitly *are* coefficient estimators).

b) It is the variance in the decision making rather than the bias that hurts due to dish-shaped criteria surfaces.

c) A decision rule with mean coefficients estimated from management's behavior should be better than actual performance.

d) It may be better than a rule with coefficients supplied by traditional analysis.

e) Systematic and comparative studies using this idea may lead to further ideas.