A STATISTICAL APPROACH TO SOME INTERNATIONAL ACCOUNTING PROBLEMS

Yong Hee Chee

<CONTENTS>

I. Introduction

There are many accounting problems peculiar to multinational businesses. These problems arise in the areas of communications, different legal and tax systems, translation of different currencies, different rates of inflation across countries and other economic and environmental differences.

These accounting problems offer many challenging and rewarding research opportunities for accountants as Professor Mueller pointed out:

> International corporations are in a unique position to innovate accounting and financial reporting practices that transcend national limitations. Free of nearly all precedents and shackles of long traditions, these corporations are in an ideal position to devise sets of accounting, auditing, and reporting standards and practices that are particularly suited to their own special circumstances and are not bound by the social, political, legal, or economic influences of any one country. International corporations should be able to lift their accounting problems above national ramifications and

Author: Assistant of College of Commerce, Seoul National University.

bring all underlying considerations into harmony with the real international character of their business operations. This is a challenge of immence proportions.[1]

In the accounting literature, there have been some attempts to solve these problems and to derive some partial solutions for them. These attempts appear inadequate to satisfy substantial managerial needs for information. For example, financial statements prepared in accordance with generally accepted accounting principles of one country do not convey sufficient information for realistic evaluation of operations of foreign subsidiaries because of distortions caused by inflationary conditions, inappropriate procedures involving price level adjustment in correcting such distortions and other conventional translation procedures of financial statements.

For example, Professors Zenoff and Zwick argued the following:

> In the absence of a clear lead from the accounting profession, management has been left with a choice between retaining the historical cost principle or adopting some method that is not generally accepted for tax or reporting purposes. Concerned with the deficiencies of conventional accounting procedures in periods of inflation, several companies have adopted alternative methods in order to obtain more accurate data for internal decision making...[2]

In focusing on managerial accounting issues, I would not deal with various important issues in international financial reporting for outside users such as consolidation problem of parent and affiliate financial statements, uniformity issue, and other arguments due to international differences in accounting conventions and practices. Rather, my concern in this paper is to study some managerial accounting questions, especially related to estimation and control of cost for headquarters management. Specifically, I will propose some econometric tools and other statistical approaches to such

(1) Mueller, Gerhard G. *International Accounting*, The Macmillan Company, 1967, p. 222
(2) Zenoff, David B., and Zwick, Jack, *International Financial* Management, Prentice-Hall, Inc., 1969, p. 492

complicated problems under a certain set of assumptions.

There have been several applications of econometric tools to accounting problems, especially to cost behavior.(3) In this paper, it is my intention to pursue the analysis of these problems further so that hopefully, I can extend these various studies especially to a multinational firm whose operations are conducted among various foreign divisions. It is also my hope to propose some performance evaluation and cost control scheme based on the cost estimation equation suggested by a regression analysis.

In discussing multiple correlation approach to the problem of multiple product costing, Professors Chiu and De Coster pointed out the utility of this approach for managerial decision making purposes as the following:

> There is tacit recognition that the proper way to develop cost-oriented decisions for products is to utilize the marginal cost of production. Yet, at the same time the traditional accounting methods of allocating costs do not yield marginal information. The use of multiple correlation analysis for product cost allocations generates an approximation of the marginal costs of the products. This knowledge can open the door to many valuable decision tools not otherwise available.(4)

Therefore, I think the multiple regression or correlation model may provide valuable information which conventional accounting information system fails to pinpoint regarding cost behavior in foreign operations as well as

(3) The following articles repesent such studies: Benston, George, "Multiple Regression Analysis of Cost Behavior", *Accounting Rev.*, vol. XLI, no. 4, October 1966, pp. 657-672

Chiu, John S.Y. and De Coster, Don T.,"Multiple Product Costing by Multiple Correlation Analysis", *Accounting Rev.*, vol. XLI, no. 4, October 1966, pp. 673-681

Dopuch, Nicholas and Birnberg, Jacob, *Cost Accounting.*, Harcourt, Brace & World, Inc., 1969, pp. 53-70.

Jensen, Robert, "Multiple Regression Models for Cost Control: Assumptions and Limitations", *Accounting Rev.*, vol. XLII, no. 2, April 1967, pp. 265-272

McClenon, Paul R., "Cost Finding Through Multiple Correlation Analysis", *Accountig Rev.*, vol. XXXVIII, no. 3, July 1963, pp. 540-547

(4) Chiu, John S.Y., and De Coster, Don T., "Multiple product Costing by Multiple Correlation Analysis", *Accounting Rev.*, vol. XLI, no. 4, October 1966, p. 677

domestic operations. I do not imply that the multiple regression model is the substitute of conventional accounting method on cost estimation, etc. Appropriately used, it may be a valuable information source to management, in addition to conventional accounting management information system. In this sense, they are complementary each other,

In section II, I will study the way of utilizing the regression technique for estimation of cost of a given subsidiary. In section III, statistical cost control framework will be studied by discussing limitations of traditional variance analysis of accountants. In section IV, various limitations and possible extensions of the statistical approach studied will be presented as a conclusion of my study.

II. A Suggested Scheme for Estimation of Subsidiary's Cost

The methods of cost estimation can be divided into two broad categories; engineering estimates and estimates based on an analysis of past cost data. The engineering method is usually limited to estimates of the direct materials and direct labor used in the physical output of a firm. Furthermore, it is a more expensive method of cost estimation than is the analysis of past data.[5]

The second approach to cost estimation tries to derive the relationship between costs and outputs from past data. This approach includes such techniques as visual curve fitting, account classification, the high-low approach and statistical curve fitting. The use of statistical regression analysis to measure cost relationship affords the most rigorous framework within which cost functions can be estimated. More variables can be analyzed, and nonlinear cost functions can be developed. Finally, it answers many of the criticisms raised against the other methodologies.[6]

---

(5) Dopuch, Nicholas and Birnberg, Jacob G.,Cost Accounting, Harcourt, Brace & World, Inc., 1969, pp. 42-43
(6) ibid, p. 53

By using this technique, we can also set up some probabilistic control limit to each parameter as we shall see in section III. Furthermore, we can fully utilize various statistical concepts and techniques involved in this approach.

We can expreess total cost for any particular subsidiary by some implicit functional form of various explanatory variables. That is,

$$C=f(X_2, X_3, \cdots\cdots, X_k, \cdots\cdots X_p).$$

Let ψ: the error due to the linear approximation of some unknown implicit functional form

η: pure noise

Z: the combined influence of all the nonmeasurable variables(i.e. the combined influence of all the left-out variables)

If we assume that we can measure K-1 variables among p variables and that we can express the causal relationship between the dependent variable and explanatory variables by the linear function, the implicit functional form can be explicitly stated as

$$C_i=\beta_2X_{2j}+\beta_3X_{3i}+\cdots\cdots+\beta_kX_{ki}+Z_i+\psi_i+\eta_i$$

for $i=1, 2, \cdots\cdots, n$

In order to give some meaningful interpretation of the constant term and sensible specification of the error term, we may express Z and ψ as deviations from respective means as the following;

$$C=\beta_2X_2+\beta_3X_3+\cdots\cdots+\beta_kX_k+(\bar{Z}+z_{-ii})+(\bar{\psi}+\psi_i)+\eta_i$$

where $Z=\bar{Z}+z_i$ and $\psi=\psi+\psi_i$ (z_i and ψ_i are deviations from their respective means.

By rearrangement of terms, we may rewrite the equation as

$$C_i=\beta_1+\beta_2X_2+\beta_3X_3+\cdots\cdots+\beta_kX_k+ui$$

where $\beta_1=\bar{Z}+\bar{\psi}$ and $u_i=z_i+\psi_i+\eta_i$

Hence, according to Professor Rao, we can interprete the constant term as the mean effect on C of all the nonmeasurable variables for the relevant subpopulation and the mean effect of the error due to the linear approximation of some unknown implicit functional form. If $\bar{\psi}=0$, then the constant will only show the mean effect on C of all the left-out variables. The accounting interpretation of the constant term will essentially depend on what variables are included as explantory variables. In most actual cases, however, such interpretation is going to be complex and difficult.

However, in some cases, the meaningful interpretation of the constant term is possible. If some phisical measure of volume of output is included as a single independent variable in the total cost function, the constant term can be interpreted as fixed costs that remain unchanged regardless of the level of output.[7]

According to Professors Chiu and De Coster, it can also be interpreted as the "standby cost" when we include quantities of various products as independent variables in the linear total cost function.

We can interprete other coefficients, $(\beta_2, \ldots\ldots, \beta_k)$ as marginal effect of each independent variable on the total cost since

$$\beta_2 = \left.\frac{\partial C}{\partial X_2}\right| \text{ given all other variables fixed}$$

$$\beta_3 = \left.\frac{\partial C}{\partial X_3}\right| \text{ given all other variables fixed}$$

$$\vdots$$

When independent variables are various products and the dependent variable is total cost, specifically, the following interpretation can be made:

> With due regard to its limitations, the main advantage in applying multiple regression to estimate the marginal costs of multiple products is its recognition of the *cost structure* of multiple products and hence its *simultaneous estimation* of *all* of the marginal costs. This statistical method corresponds to the *ceteris paribus* or "marginal" concept in economic, i.e., the estimated marginal cost is equal to the change in total cost, per unit change in the output level of any one of the multiple products, other things held constant. This method also corresponds to a very important

(7) Klein, Lawrence R., *An Introduction to Econometrics*, Prentice-Hall, Inc., 1962, p. 116

concept in differential calculus, partial derivatives.[8]

The choice of an appropriate estimation procedure depends on the prospective use of an estimate of the coefficient. According to Gauss-Markov theorem, the ordinary least-squares (OLS) estimation yields the best linear unbiased estimates (BLUE) of coefficients when the cost equation is the truth.(9) However, for decision making purpose, BLUE is not necessarily the best criterion. There is alway a trade-off between bias and precision of the estimates (standard deviations of the estimates) whenever we have left-out variable from the true equation.(10) In this case, separate consideration of either one only may not be desirable.

In order to find the optimum trade-off between bias and precision, we have to define the loss structure of the decision maker involved. One rule that weighs both these aspects equally is the mean square error criterion since

Mean Square Error or MSE of $\hat{\beta}_i$

$$=\text{Limit}_{n\to\infty}\frac{\Sigma(\hat{\beta}_i-\beta_i)^2}{n}=\Sigma P(\hat{\beta}_i)(\hat{\beta}-\beta_i)^2$$

$$=E(\hat{\beta}_i-\beta_i)^2$$

$$=E[\hat{\beta}_i-E(\hat{\beta}_i)+E(\hat{\beta}_i)-\beta_i]^2$$

$$=E[\hat{\beta}_i-E\hat{\beta}_i]^2+[E(\hat{\beta}_i)-\beta_i]^2$$

$$=\text{Variance }(\hat{\beta}_i)+[\text{Bias}(\hat{\beta}_i)^2$$

According to Professor Wallace, we can obtain a smaller MSE for the estimate of β_i by leaving out the variable whose ratio of $\frac{\beta_i}{\sqrt{V(\beta_i)}}$ is less than unity.(11) In this case, we get a smaller MSE by misspecifying the cost equation rather than estimating the true cost equation.

Since the true values of the parameter β_i and of the variance of β_i are

(8) Chiu, John S.Y., and De Coster, Don T., "Multiple Product Costing by Multiple Correlation Analysis", *Accounting Review*, vol. XLI, no. 4, October 1966, p. 677

(9) David, F.N. and Neyman, J., "Extension of the Markoff Theorem on Least Squares," *Statist Research Mems*, vol. 2, pp. 105–116, 1938

(10) Proof of this can be found at *Applied Econometrics* by Potluri Rao and Roger Miller, Unpublished Final Draft, pp. 97–100

(11) Wallace, T.D., "Efficiencies for Stepwise Regressions," *Journal of the American Statistical Association*, vol. 59, 1964, pp. 1179–82

generally unknown, this can only be used when β_i is known less than unity a priori. (If $\beta_i<1$, $\beta_i/\sqrt{V(\beta_i)}<1$ since always $\sqrt{V(\beta_i)}\geq 0$). A uniformly most powerful testing procedure for the MSE criterion for rejecting or adopting restrictions on the parameter space in a regression model along with appropriate tables were developed.[12]

For prediction of the total cost of a subsidiary to a certain future period, the appropriate criterion would be $\bar{R}^2$ which is defined as

$$\bar{R}^2=1-(1-R^2)\left(\frac{N-1}{N-K}\right)$$
$$=1-\left(1-\frac{\Sigma(C-\bar{C})^2-\Sigma e^2}{\Sigma(C-\bar{C})^2}\right)\left(\frac{N-1}{N-K}\right)$$

where $\Sigma(C-\bar{C})^2$: variations of the total cost

Σe^2: variations of the residual

N: total observations

K: total number of parameters, including the constant term

$\bar{R}^2$, adjusted R^2 by its appropriate degrees of freedom can also be denoted as $[1-V(e)/V(C)]$, i.e. one minus the ratio of two variances of residuals and of the total cost. The predicted total cost and the total cost to be actually observed will not be the same, in general, because of the error term. Hence, in order to obtain the predicted total cost with least variance, we should utilize the least residual variance regression. In this case, therefore, maximum $\bar{R}^2$ may be an appropriate criterion in selecting the total cost equation. When a variable with t-ratio smaller than unity is discarded from a regression equation, it can be shown that the $\bar{R}^2$ always increases[13] $[t(\hat{\beta}_i)=\hat{\beta}_i/\text{standard error of }\hat{\beta}_i]$

In selecting an appropriate set of independent variables, we should not

(12) Toro-Vizcarrondo C. and Wallace T.D., "A Test of the Mean Square Error Criterion for Restrictions in Linear Regression," ***American Statistical Association***, vol. 63, June 1968, pp. 558-572 ***and*** Wallace, T.D., Toro-Vizcarrondo, C.E., "Tables for the Mean Square Error Test for Exact Linear Restrictions in Regression," ***American Statistical Association***, December 1969, vol. 64, pp. 1649-63

(13) Haitovsky, Y., "A Note on the Maximization of $\bar{R}^2$, ***American Statistician***, vol. 23, (no. 1) February, 1969, pp. 20-21

solely rely on such mechanical rules. Rather, sound judgment should always be exercised as Professor Friedman pointed out:

> The capacity to judge that these are or are not to be disregarded, that they should or should not affect what observable phenomena are to be identified with what entities in the model, is something that cannot be taught; it can be learned but only by experience and exposure in the "right" scientific atmosphere, not by rote. It is at this point......that the thin line is drawn which distinguishes the "crackpot" from the "scientist."(14)

In estimating the cost function of a subsidiary, we may have to use a simultaneous equation model rather than a single equation model in some cases. The appropriate choice should be based on the degree of control on operations of the subsidiary by the parent company. However, generalization on the degree of control by the parent company is difficult as the following excerpt indicates:

> Controls, as applied to international operations, vary widely from company to company. They can be applied to capital spending, working capital, borrowing, costs, and nearly every other type of operational or financial activity. Every company interviewed for this study said that it applies controls over international operations. But the *scope* of activities subject to controls and the extensiveness of the system of controls vary greatly from company to company, depending mainly on how important top management feels these controls are to the success of operations.(15)

If all operations are directly under control by the parent company, practically all independent variables may be regarded as predetermined from the local management point of view. In this case, we can use the single equation model since there is no problem of simultaneity bias.(Simultaneity

(14) Friedman, Milton, ***Essays in Positive Economics***, University of Chicago Press, Chicago, 1953, p. 24

(15) National Industrial Conference Board, ***Managing the International Financial Function***, Studies in Business Policy, no. 133, p. 106

bias is defined as the bias resulting from presence of other equations in the model, rather than from left-out variables or misspecification of the functional form.)

However, if a given subsidiary determines the amount of output and necessary factor inputs simultaneously, the single cost equation estimation will have a simultaneity bias. In order to see this, let us make the following assumptions:

(1) Profit maximization represents decision process of each subsidiary.

(2) Each subsidiary is confronted with a given form of competition during the time period chosen. Hence, demand and supply relationships facing each subsidiary can be expressed simply as constant prices of output and of each input at the time period. This does not rule out the possibility of inflation in the whole period of time series observed in the sample. It simply means that any given subsidiary is not large enough to change market prices of input and output in a given country at a specified time period of observation.

(3) The production function of each subsidiary is reasonably well represented by the Cobb-Douglas form. It has many interesting properties that make it a very convenient choice. Furthermore, it can be transformed easily into a linear function by converting all variables into logarithms although it is nonlinear. Newly developed CES (Constant Elasticity of Substitution) production function generally does not give reliable estimates of parameters. Many times, there are difficulties in interpreting estimates of parameters of CES production function.

The economic theory of a firm can be couched in terms of a production function, profit function, and conditions of marginal productivity, or, alternatively, in terms of a cost function, profit function, and conditions of marginal cost. The cost function summarizes many of the factors that make up the theory in terms of production function and marginal productivity conditions.[16]

Professor Klein pointed out that the production function enjoys higher degree of autonomy than the cost function and said:

> By the *autonomy of a relation,* we mean the extent to which that relation will remain valid under differing circumstances. Particulary, if we are estimating statistical relations from a sample, we mean by an autonomous relation, one that will be valid in fresh samples that may be collected under environmental conditions different from those at hand in the sample being used for estimation.[17]

Because of the differences in technology, resource endowments, and market potentialities among countries, and the barriers to international mobility of assets and personnel, both the production function and the cost function will be substantially different among various subsidiaries, depending on the country in which a given subsidiary locates. However, the production function may be more stable throughout various subsidiaries because of the high degree of autonomy of the relation. Since the production function is the inverse of the cost function, or, vice versa, I will use the production function to see the possibility of the simultaneity bias.

In order to simplify the discussion further, let us assume that a given subsidiary can decide the amount of labor to be hired but not the amount of capital. This may not be too restricting assumption as we infer from the following finding:

> In most cases, parent company's controls over capital expenditure by the operating international units are quite formalized, and guidelines specifying the procedural steps are carefully spelled out. Almost without exception, specific capital expenditures require corporate authorization even when they have already been approved in principle during the budgetary

(16) Klein, Lawrence R., *An Introduction to Econometrics*, Prentice-Hall, Inc., 1962, p. 111
(17) ibid, p. 84

review. The size of an expenditure often determines who within the parent organization can approve it.[18]

Let Q: Physical Output

L: Labor in Manhours

K: Capital Hired

α: Elasticity of Output with respect to Labor

β: Elasticity of Output with respect to Capital

A: Constant

The Cobb-Douglas production function for a given subsidiary can be expressed as

$$Q=AL^{\alpha}K^{\beta}e^{u}$$

$$\text{or } \log Q=\log A+\alpha\log L+\beta\log K+u$$

Given certain amount of capital, the profit function for the subsidiary can be written as

$$\varphi=Qp\cdot Q-Lp\cdot L=Qp\cdot A\cdot L^{\alpha}\cdot K^{\beta}\cdot e^{u}-Lp\cdot L$$

where Qp: Price of Output

Lp: Factor Price of Labor

From assumption (1), the equibrium quantity of labor required to maximize profits of the subsidiary can be found by

$$\frac{\partial\varphi}{\partial L}=Qp\cdot A\cdot\alpha\cdot L^{\alpha-1}\cdot K^{\beta}\cdot e^{u}-Lp$$

$$=Qp\cdot\alpha\cdot\frac{Q}{L}-Lp=0$$

or, the equibrium quantity of L is

$$L^{*}=Qp\cdot\alpha\cdot\frac{Q}{Lp}$$

$$=\alpha\cdot\left(\frac{Qp}{Lp}\right)\cdot Q$$

In the real world, the subsidiary cannot instantly adjust to changing market conditions. Hence, there may be some discrepancy between desired

(18) National Industrial Conference Board, *Managing the International Financial Function*, Studies in Business Policy, No. 133, pp. 106-107

labor and actual labor hired. Hence, we should include an error term in the equation. That is,

$$L=\alpha\cdot\left(\frac{Qp}{Lp}\right)\cdot Q\cdot e^{v}$$

$$\text{or } \log L=\log\alpha+\log\left(\frac{Qp}{Lp}\right)+\log Q+v$$

Hence, we can see that Q and L are jointly determined by the two sets of equations. The amount of bias of OLS estimates can be found as

$$\text{Bias}(\bar{\alpha})\simeq(1-\alpha)\frac{\sigma_u^2}{\sigma_u^2+\sigma_v^2+\sigma_\tau^2(1-r^2_{k\tau})}$$

$$\text{Bias}(\hat{\beta})\simeq-(\beta-b_{k\tau})\frac{\sigma_u^2}{\sigma_u^2+\sigma_v^2+\sigma_\tau^2(1-r^2_{k\tau})}$$

where $\tau=\log\left(\frac{Qp}{Lp}\right)$

$k=\log K-\text{Mean }(\log K)$

$b_{k\tau}=\frac{\Sigma k\tau}{\Sigma\tau^2}$

A general case of this is shown under somewhat differrent assumtions.[19] This is a bias for a finite sample size, but direct least squares estimates are also inconsistent: that is, a bias persists even for infinitely large samples.[20] In this case, it may be desirable to use other estimation methods such as the indirect least squares method, two-stage least squares method or least variance ratio method, etc.

The linear cost function may be too restricting in some cases. The U-shaped marginal and average cost functions imply a nonlinear total cost function. However, the linear approximation may be fairly good when the observed range of operation is relatively small. Professor Dean,s various study on cost functions of firms also shows that the linear cost function fits fair well to actual cost data.

(19) Hoch, Irving, "Simultaneous Equation Bias in the Context of the Cobb-Douglas Production Function," *Econometrica*, October 1958, pp. 566-578

(20) Johnston, J., *Econometric Methods*, McGraw-Hill, Inc., 1960, p. 233

III. A Statistical Cost Control Framework for Multination Firm

The following was extracted from the article, "Statistical Variance Control: Through Performance Reports and On-the-Spot Observation" by R.W. Koehler (Management Accounting, December 1969).

"Soon after the end of his first month Pearson (CPA) presented Benz with the performance report...Benz glanced at the report and uttered a few words of praise, 'Tom, I'm delighted at receiving this summarized information so soon after the end of the month, but I'm a little perplexed about its intent. Is it just information or am I to take some specific action on the basis of these figures?'

'Well sir,' Pearson responded 'Perforformance reports are supposed to help you control costs by pin-pointing out-of-line conditions. You can investigate areas that indicate significant variances in order to find the cause and make corrections before the situation becomes too costly'.

'Good answer' replied Benz. 'But, how do I know when a variance is significant? Does any of the variances on this report signal the need for an investigation?'

Pearson scanned the report quickly and observed that all the variances were less than 10 percent of standard. In fact they were also less than 5 percent. As a result he assured Mr. Benz that things were preceeding nicely.

Benz wondered why 10 percent (or 5 percent for that matter) was selected as a cut-off point. Pearson confessed that there wasn't anything very scientific about it. He reported that it was just a rule of thumb that had gained rather wide acceptance. He even recalled that an NAA research study designated a 10 percent cut-off point.(21)

Mr. Benz was still not convinced that the 10 percent guidelines were particularly useful, but he decided to hold this matter in abeyance because he was curious about a few other points. Happily, all of the costs were within the 10 percent guidelines...."

(21) National Association of Accountants Research Report 22, The Analysis of Manufacturing Cost Variances. NAA, New York, August 1, 1952, p. 12

This quote illustrates fairly well the point that the conventional procedure in evaluating performance heavily depends upon the intuition of management. Using statistics to provide control limits for determining the significance of the observed performances can improve the conventional procedure in evaluation of performance.

In reporting and analyzing the variances of the actual performance, one of the most important problems that arises is to decide when a variance is worthy of investigation as the following excerpt indicate:

> If the variance is small in amount or results from noncontrollable factors, or if future operations would not improve even if the cause of the variance was determined, management would prefer not to waste time and money by investigating such variances, On the other hand, if investigation will result in substantial future savings and more efficient operations, management will probably want the variance investigated. The problem of when to investigate is an important part of the control process. The best conceived budget or control procedures will be ineffective unless the decision of when to investigate a variance is made in a reasonable manner. Yet, this problem have received little attention in the accounting literature.[22]

Therefore, it is very important to know how and when management should assess the significance of variances. Because of costs involved in investigating variances especially for foreign operations, management should also compare these costs with possible future benefits from such investigation. Cost accountants should help management to decide an appropriate action by analyzing data on variances.

If we assume a cost equation of the form of $C=X\beta+u$ in matrix notation

(22) Bierman, H. Jr., Fouraker, L.E., and Jaedicke, R.K., "A Use of Probability and Statistics in Performance Evaluation," Accounting Rev., vol. XXXVI, no. 3, July 1961, p. 409

for a given subsidiary and the normality of the error term, we can construct a 100 (1-E) per cent confidence interval for β_i ($i=1,2,\dots,$ k) as

$$\hat{\beta}_i \pm t_{E/2}\ \hat{S}\sqrt{a_{ii}}$$

where $\hat{S}=\sqrt{e'e/n\text{-}k}$ (e: residual vector)

a_{ii}: i th element in principal diagonal of $(X'X)^{-1}$

If the nature of the distribution is not normal or unknown, our confidence in the estimate will be reduced. In this case, professor Z. Zannetos suggested the use of Chebyshev's inequality:

> Chebyshev's inequality gives the lower bound of the probability that an observation will fall within a certain distance from the mean or the upper bound of the probability that it will fall outside, irrespective of the applicable probability law. In mathematical notation if P stands for the probability, X represents the observation, u_x the mean of the universe, σ_x^2 the variance and ε a positive measure of distance:
>
> ⋮
>
> $$P(|x-u_x|>c\sigma_x)\leq\frac{1}{c^2}$$
>
> where $\epsilon=c\sigma_x$[23]

It may also be useful to prepare a control chart for the variability of a process because the mean would remain stable while the variance(or standard deviation) would change. This can occur if there are newly-employed unskilled workers. There is no conceptual difficulty in constructing such confidence interval for such variability. However, we need some estimate of the true standard deviation of the process in order to construct a control chart for the variability component.

Once we determine the tolerable limit for the variability in terms of probability, we can assess the significance of variance in terms of probability

(23) Zannetos, Z., "Standard Costs as a First Step to Probabilistic Control: A Theoretical Justification, and Extension and Implications," *Accounting Review*, vol. XXXIX, no. 2, April 1964, p. 298

chosen (for example, 95%). That is, if the magnitude of the variance is not in the confidence interval, we can say the variance observed is statistically significant. If the magnitude of the variance falls in the confidence interval, we could conclude that the particular variance observed is not statistically significant since the variance observed can be considered to be caused by chance or random factors.

This kind of an assessment of the significance of variances in terms of probability limits is the first step to do. After a variance is considered statistically significant, the next step to do is to determine the costs of investigating the statistically significant variance and then to compare the investigation costs with the opportunity costs of not investigating such significant variance.

Management has a choice at the very start: to investigate or not to investigate. If management refuses to investigate, there is no need to incur the cost of investigating variance. If variance came from nonrandom causes, the costs of not investigating a variance would be in the form of opportunity costs.

If management wants to investigate, there are the cost of investigating variance. However, there will be no opportunity cost if variance came from nonrandom causes.

Let S_1: the true state of nature is such that the variance observed came from random causes

S_2: the true state of nature is such that the variance observed came from nonrandom causes

A_1: investigate a variance

A_2: do not investigate a variance

C_I: the cost of investigating a variance

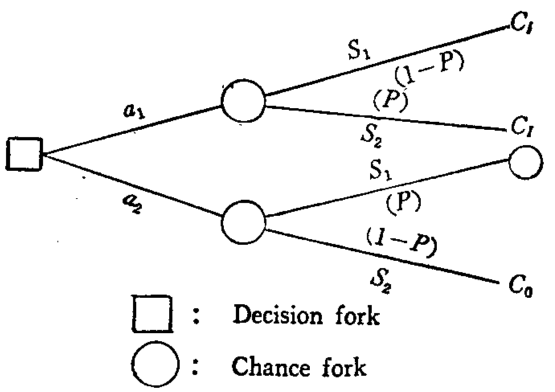
C_0: the opportunity cost of not investigating a variance

P: the probability that variance came from nonrandom causes

I-P: the probability that a variance came from random causes

We can construct the following cost control decision-flow diagram:

Expected Cost



$$C_I\cdot(1-P)+C_I\cdot P=C_I-C_I\cdot P+C_I\cdot P=C_I$$

$$O\cdot P+C_0(1-P)=C_0(1-P)$$

In order to estimate C_0 in the real situation, we can regard C_0 as the cost of repetition of the inefficiency in the future if investigation is not carried out. That is, C_0 is a present value of the estimated future cost inefficiencies which are avoidable by investigating a variance now.

We know that if we investigate, the cost will be C_I no matter which state is the true state of nature. If we do not investigate, the cost is zero if the variance was from random causes while the cost is C_0 if the variance was from factors which management can control.

If $C_I<C_0(1-P)$, i.e., the expected cost of A_1 is less than the expected cost of A_2, then we should investigate the variance. If $C_I>C_0(1-P)$, i.e., the expected cost of A_1 is greater than the expected cost of A_2, then we should not investigate the variance.

The whole objective of this analysis is to balance the expected costs of both states of nature. We can easily find the indifference point which is $C_I=C_0(1-P)$ or $P=\frac{C_0-C_I}{C_0}$. Professor H. Bierman Jr. called this probability as the critical probability. If the actual probability of the variance is greater than this probability, management should not investigate, since C_I will be greater than $C_0(1-P)$. If the actual probability is less than the critical probability, then management should investigate, since C_I will be less than $C_0(1-P)$.

Generally, it may not be difficult to estimate the cost of investigation. We may expect that this cost is relatively stable over wide range of investigating activities. However, it may be difficult to obtain reliable estimates of the costs of not investigating variances. If the variance observed was from nonrandom causes, in some cases it may represent a deviation in worker performances. In this case the benefits from investigation of the variance may be the elimination of the same kind of variance in the future. If the observed variance represents a permanent change in the production process, the benefits from investigation will be savings resulting from a shift to a new process. In any case, C_0 will be a function of the size of the cost variance. The larger the variance, the more we are inclined to investi gate the variance observed.

Prior knowledge of a given management in the parent company will also influence such decision. For operations of domestic subsidiaries, management may generally have more prior knowledge, compared with foreign operations. Hence, the prior distribution of management on domestic cost occurence may have smaller variance than that of foreign cost distribution. However, the final direction of the influence of such differences in the two prior distributions on the posterior distribution for final decision making will depend on the shapes of sample distribution as well as prior distribution involved. The only thing we can say on this regard may be that sample information may be more decisive in the cases of foreign subsidiaries because of relatively weak prior distribution(larger variance) of a given management on foreign operations.

IV. Limitations and Conclusion of the Study

There are many limitations in this approach. Professors Chiu and De Coster pointed out product, equation, period and causation limitations.(24) Standard statistical problems such as errors of variables, multicollinearity, heteroscedasticity and autocorrelation have been discussed in the accounting literature.(25)

In addition to these, we may also expect the problems of contemporaneous correlation of error terms among subsidiaries as well as noncontemporaneous correlation among them if we combine time-series cost data with crosssection data. Theoretically, we may solve substantial portion of this problem.(26)

Despite of all these limitations, this approach has its own value as Professors Chiu and De Coster concluded in the article previously mentioned:

> In conclusion, multiple correlation analysis frees the accountant from making the assumption that marginal costs per product are always too difficult to unearth. For products that have an output proportion that is variable, multiple correlation allocates costs in a method valuable for decision-making. As with any statistical method, there are factors that lie in wait to trap the unwary. But in a practical setting these limitations will often fall by the wayside.

Especially in multinational business setting, I think accountants should actively investigate new ways to solve their challenging problems. Such

(24) Chiu, John S.Y. and De Coster, Don T., "Multiple Product Costing by Multiple Correlation Analysis," *Accounting Rev.*, vol. XLI, no. 4, October 1966, pp. 678–679

(25) For example, these problem are discussed by Benston, George J., "Multiple Regression Analysis of Cost Behavior," *Accounting Rev.*, vol. XLI, no. 4, October 1966, pp. 664–667 *and* Dopuch, Nicholas and Birnberg, Jacob G., *Cost Accounting*, Harcourt, Brace& World, Inc., 1966, pp. 65–70

(26) For the suggested solution, we can resort to Professor Richard Park's article in *American Statistical Association*, June 1967. His model allows autocorrelation as well as heteroscedasticity of error terms. Hence, this may be regarded as the most general case.

efforts should start from neighboring disciplines such as statistics, behavioral sciences, economics, etc. From such disciplines, we may gain some insights into such complicating problems. This point was brought by Professor Mueller as the following:

> The major reason why accounting has become so fractionated and overspecialized is that most of us working within the discipline have been unwilling or unable to extend our reasoning and our attitudes beyond the pure technology of accounting. This, I reiterate, has not only divided us to the point of near crisis but is undermining our house of learning and potentially could grind to a halt all new growth and development.(27)

In this regard, I think investigations into the field of econometrics which can be roughly defined as statistics of economics will be potentially very fruitful in solving international accounting problems, especially those accounting problems for internal decision making.

---

(27) Mueller, Gerhard G., On the Unity of Accounting, A published pamphlet, p. 112