

INTERNAL CONTROL COMBINATION  
A SIMULATION STUDY

Miklos A. Vasarhelyi

January 1982

COLUMBIA UNIVERSITY  
GRADUATE SCHOOL OF BUSINESS ADMINISTRATION

This project was funded by a grant from the Peat, Marwick, Mitchell Foundation through its Research Opportunities in Auditing program. The author wishes to thank the Foundation for its administrative assistance in carrying out the project. The views expressed herein are those of the author and do not necessarily reflect the views of the Peat, Marwick, Mitchell Foundation.

The assistance of Messrs. Evelyn Faillace and David Wright in the preparation of this paper is gratefully acknowledged. The suggestions of Prof. D.H.Bao of Columbia University were appreciated.

## INTERNAL CONTROL AGGREGATION: A SIMULATION STUDY

## INTRODUCTION

This paper specifies and relates the results of a simulation study aimed at establishing the effect of combination of internal control procedures within a series of assumptions. The question of combination of internal controls is fundamental to any attempt at modeling and measuring the potential reliability of a corporate accounting control system. Cushing [1974] introduced the concept of reliability from engineering to model internal controls. Bodnar [1975] extended Cushing's formulation modeling serial and parallel controls.

Stratton [1981] examined accounting controls, both serial and parallel, through the use of simulation. His approach entailed the modeling of an accounting system (material purchases) and performing sensitivity analysis to determine internal control weaknesses. The approach involved the comparison of simulation results to the reliability model.

This study also relates to a computer simulation. Its purpose, however, is to compare computer simulation studies with a behavioral study in order to establish the combination rules that control the aggregation of internal controls.

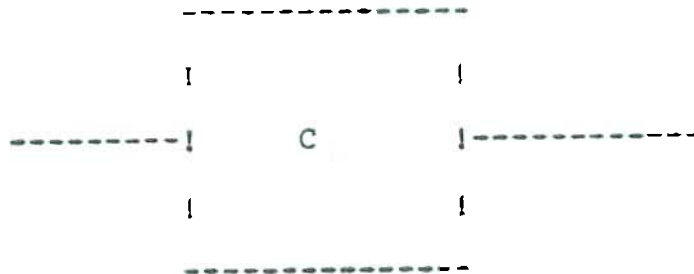
The first section of the paper specifies the problem being considered and the previous related studies. It also proposes the theoretical foundations of the study. The following section describes the methodology being adopted, the particular operationalization decisions and the case framework. The ensuing section describes the simulation scenarios and results. The conclusions explain the assumptions used and the terms that allow the comparison of its results with a behavioral simulation study.

#### THEORY

Most former studies that dealt with the quantitative assessment of the quality of internal controls employed reliability theory. (e.g. Cushing, 1974; Bodnar, 1975) This seems as a natural choice as the auditor's problem is ascertain the potential level of error that an internal control may allow. Cushing (1975) described analytically a Multiple Control-Multiple Error Case of controls. This case was based on a simpler version of the same formulation of Single Control-Single Error graphically described in Figure 1 and which reliability can be expressed as follows:

$$R = p.P(s) + p.(1-P(s)).P(d) + (1-p).P(e).P(c)$$

Figure 1  
Single Control-Single Error Case



Cushing argues that "Once the process and the error or errors are properly identified, even the most unusual type of control procedure is amenable to representation by the model." (p.35)

In addition Cushing concluded that the next step would be the performance of a field study and that it was possible to perform pragmatic applications of behavioral research methodologies. Bodnar extended Cushing's model including the concepts of redundancy and operationalizing some of its concepts. He has used the concepts of parallel and series control systems.



Bao questioned the validity of purely extending the reliability model from engineering and the assumptions of independence between controls and between error probabilities. He differentiated between three systems: (1) the accounting recording system, (2) the accounting internal control system and the correction system.

In addition he differentiated between four reliabilities: (1) the reliability of an accounting internal control system, (2) the reliability of an accounting recording system prior to control and correction, (3) the reliability of an accounting recording system posterior to control and correction and (4) the reliability of a correction system.

Vasarhelyi (1980) examined the process of internal control and classified it along five dimensions: (1) cycle, (2) objective, (3) department or function, (4) internal control procedures (ICP) and (5) types of errors or irregularities. He also suggested classifications of types of controls and errors as a first necessary step in the formulation of a measurement model.

These considerations in aggregate lead to a series of questions and problems in the representation and modeling of internal control systems.

The basic question is oriented towards the numeric assignment of values to the quality (reliability) of internal control systems. In order to deal with this basic question it is essential to backtrack and state some definitions.

Within the context of this paper we shall define:

An accounting system is a set of rules and procedures to record economic events. An accounting system is basically a measurement tool to provide the history of a system and data for decision making. This decision making may be forward looking (for planning) or backward looking for monitoring and analysis.

The monitoring functions relate to the supervision of activities of the organization both for analytical and policy enforcement purposes as well as outside monitoring by interested parties.

Control activities relate to the comparison of a model to an actual value. This model may be symbolic, iconic, theoretic, numeric or even abstract. In accounting, internal control systems deal with a variety of types of models from theoretic (such as GAAP) to numeric (such as range controls). Vasarhelyi and Ginzberg (1978) defined internal control systems (ICS) as a composite of internal control procedures (ICP). Each ICP has a profile of characteristics which relate to the model against which data

is being compared and the method of comparison.

Each ICS uses a series of ICPs to perform a control function with a certain degree of reliability. The rules of combination of ICPs into ICSSs are the main objective of these studies. At present the characteristics of an ICS are descriptively defined as we don't know how to derive them from component ICPs.

The structure of an organizational internal control system relates to the flow of documents, flow of information and the actual organizational chart. Organizations earn their living through transactions that involve also cash and material flows.

Therefore, key to any simulation is three elements: Structure, transactions and controls. It must also be remembered that accounting transactions are surrogates for actual economic activities while controls compare the measurement of these activities to the actual economic transactions.

#### THE SIMULATOR

The Internal Control Simulator is a general purpose accounting transaction simulator oriented towards the evaluation of internal control systems. Its main elements are:

a) the MP (master program) that controls time flow and the performance of such basic tasks as transaction generation and control monitoring.

This program specifies the parameters relating to time of start, time of termination, error monitoring, error disposition and system module utilization.

b) the SM (structure matrix) that defines the document flow as well as the loci of control.

Figure 2

## Structure Matrix

	loc.	loc.	loc.	.....	loc.
	1	2	3		n
Proc. 1	1	1	1		1
Proc. 2	1	1	1		1
Proc. 3	1	1	1		1
...					
Proc. n	1	1	1		1



The structure matrix represents processes in the rows and locations in the columns. Processes may be similar (multiple processor stations) or different but performed at similar locations. The structure matrix  $S$  is composed of elements  $S_{ik}$  where  $i$  is the row (process) and  $k$  the location. The elements may be 1 or zero and the matrix will be sparsely populated. Values may be added to the structure matrix for cost assessment and audit planning purposes.

c) the CM (control matrix) This defines a particular control in the organization and may be relative to one or more  $S_{ik}$ . Therefore the dimensions of the control matrix will be substantially smaller and different from the SM. The organization and its internal controls system can be symbolically represented by its SM and overlapping control matrices.

Each control matrix has a symbolic value at the particular loci of control that correspond to  $S_{ik}$  being controlled and these symbolic values are correspondent to particular control characteristics.

d) the CE (control x error) matrix

Figure 3 represents the control error matrix that represents the particular effect of a control over a particular type of error.

Figure 3

	Control Error Matrix		
	Error	Error	Error
	Type	Type	Type
	1	2	n
Control Type 1	P	p	n.e.
Control Type 2	n.e.	n.e.	c
.....			
Control Type n	.	.	.

legend:

p probability change

c coverage effect

n.e. no effect

#### e) The Transaction Vectors

Each transaction is specified by different parameters  $T_i$  ( $i=1,2, \dots,10$ ) where the first four are generated by the MP, while the last three are related to the status of the transaction during the simulation.

t(type, amount Reference, time of origin, ---definition  
 book, time , location ---status  
 ....., ....., .....)) ---assignable

The general parameters of the simulation are defined in each MP interactive run and traced to particular configurations. The ICS is a queue oriented transaction management system designed to experiment with alternate control structures.

#### MODEL

In order to have comparability, a series of simplified basic assumptions will be made in the initial runs. Two basic types of controls exist: blanket controls (that affect more than one locus and ICP) and specific controls located at one locus of control. The first are treated as modifiers of statistical properties of controls while the second deal directly with the particular transactions.

Therefore, once combination rules are specified (e.g. additivity or multiplicativity), they can be implemented using the ICS and then compared with the results out of real life (or as in this case with behavioral simulations).

The simulator itself is being programmed in APL with the general characteristics of a queue simulator (such as GPSS). The simulation is discrete and time increments are variable. The MCP is invoked to run the simulation but a series of parameter definition runs have to be performed prior to the actual simulation. Flowcharting and video representations can be added as future features.

## AN EXAMPLE

A salesman takes an order from a customer, fills up a sales slip, supplies the goods from stock on hand and collects cash in full settlement. The company relies on matches between inventory supplied and amounts declared in the sales reports. Duplicate copies of the sales slips are attached to the sales report. The sales slips are part of a prenumbered book assigned to the salesman.

In this simplified example, considering the salesman as the processor and the locus being considered as the sales point we have an 1 by 1 SM. In addition the organization has three 1 by 1 control matrices acting over S11.

The first is control is salesman training. This is considered a blanket control which affects the probability of error in the process. The second control is an ex post facto control on amounts reordered, inventory levels and sales slips. These are reconciled. The third control is a check on sales slip sequence at sales book reorder point.

Let us then assume running this simulation through the MP. First the general parameters of transaction type 1 (sale from inventory on salesman hand) are setup. This process is described as a Poisson arrival process with mean arrival time of 2 hours over a 40 hour week. Each sale is set up having an average value of \$40.00 with a standard deviation of \$8.00 normally distributed. Transaction type 1



is described as having three potential types of errors.

Error 1 - Incorrectly recorded amount

Error 2 - Inventory not reconciling

Error 3 - Sales slip serial inconsistency

A matrix CE can be set up whereby: Control 1 decreases the probability of errors 1,2 and 3 by, on a blanket basis, decreasing the incidence of the three errors by 10%. Control 2 has a deterrent effect over error 2. Control 3 has only an effect over error 3. The question being asked is the combined effect over the error rates of controls 1, 2 and 3. Are these controls additive, multiplicative or obey some more complex combination rule? The simulation will permit statistical assessment of the effect of these combination rules to be compared with the results of behavioral simulations. This comparison may facilitate conclusions on combination rules to be used in practice.

A second simple example may relate to data preparation (key entry) where checks are prepared for computer processing. There, key operators read the amount on the check and encode it magnetically on the check. This process can be controlled by a preventive control such as key punch operator training or by a second process of key verification this time not based on the numeric amount written on the check but on the amount written in long hand on these checks. Errors are defined by two types, the first, bad encoding of the check and the second, inconsistent checks



(where long hand and numbers do not match). The first error is a process originated error, while the second is a transaction oriented error that has substantially different probabilities of detection (and correction) based on the existence of one or two controls. The same modeling method described in the earlier section may be applied now to a two processing station (or two location) process.

## CONCLUSIONS

This paper is just a preliminary description of the internal control simulation with the purpose of system specification and simulator structure discussion. It serves to expose the key features of the proposed system and attempts to apply this structure to a particular example. It will be completed with the simulation of the two examples described in the previous section. These type of simulation results are the ones to be mapped with the results of behavioral simulations representing the same types of processes. The combination of a series of simple simulations already parameterized may lead to the ability to model more complex and interesting systems. Sensitivity analysis applied to simple models with more than one control will be used to establish control (ICP) combination rules.

## BIBLIOGRAPHY

AICPA, The Auditor's Study and Evaluation of Internal Control Systems, American Institute of Certified Public Accountants, New York, 1977.

\_\_\_\_\_. Codification of Statements on Auditing Standards. New York: AICPA, 1977.

\_\_\_\_\_. Management Control and Audit of Advanced EDP Systems, American Institute of Certified Public Accountants, New York, 1977.

Ashton, Robert H. "An Experimental Study of Internal Control Judgments", Journal of Accounting Research, Spring 1974.

\_\_\_\_\_. "Cue Utilization and Expert Judgments: A Comparison of Independent Auditors with Other Judges", Journal of Applied Psychology, August 1974.

\_\_\_\_\_. "Judgment Formation in the Evaluation of Internal Control: An Application of Brunswick's Lens Model", University of Minnesota.

Bao, D.H. "Reliability Modeling of Accounting Internal Controls: A Laboratory Testing," Working Paper Graduate School of Business, Columbia University, April 1981.

\_\_\_\_\_. "Reliability Modeling of Accounting Internal Controls: A Framework," Working Paper Graduate School of Business, Columbia University, September 1981.

Barefield, Russell M. "The Impact of Audit Frequency on the Quality of Internal Control", Studies in Accounting Research, AAA, no. 11, 1975.

Bariff, Martin L. "A Study of EDP Auditors' Evaluations of Internal Control Systems", University of Chicago, 1979.

Bartfield, Charles I. "Systems Control in Organizations by Analogous Model", Ph.D. dissertation Columbia University, 1969.

Block, Dennis J. and Ellen J. Odoner. "Enforcing the Accounting Standards of the Foreign Corrupt Practices Act", Financial Executive, July 1979, pp. 19-26.

Bodnar, George. "Reliability Modeling and Internal Control Systems", The Accounting Review, Vol. 50, No. 4, October 1975, pp. 745-757.

Brown, R. Gene. A Scientific Approach to Auditing, Ph.D. Dissertation, Ohio State University, 1961.

\_\_\_\_\_. "Objective Internal Control Evaluation", Journal of Accountancy, November 1962, pp. 50-56.

Brown, N. V. "Auditors & Internal Controls: An Analyst's View", CPA Journal, Vol. 47, Summer 1977, pp. 27-31.

Burns, David C. and James K. Loebbecke. "Internal Control Evaluation: How the Computer Can Help", Journal of Accountancy, Autumn 1977, pp. 60-70.

Carmichael, D. R. "Behavioral Hypotheses of Internal Control", The Accounting Review, Vol 45, No.2, April 1970, pp 235-245.

Erick, Norbert. "Quality Control and Reliability", 6th Edition, Industrial Press, 1972.

Felix, William L. and James L. Goodfellow. "Audit Tests for Internal Control Reliance," Proceedings of the Symposium on Audit Research III, University of Illinois at Urbana-Champaign, 1979.

Fraser, J. D. "Some Aspects of Internal Control", Certified General Accountant, May-June 1965, pp. 8-12.

Hinsey, Joseph. "The Foreign Corrupt Practices Act--The Legislation as Enacted", Financial Executive, July 1979, pp. 13-18.

Ishikawa, Akira. "A Mathematical Approach to the Analysis and Design of Internal Control Systems: A Brief Comment", The Accounting review, Vol. 50, No. 1, January 1975, pp. 148-150.

King, Barry G. "A Statistical Basis for Audit Reliance on Internal Control", Ohio State University, 1964.

Kinney, W. R. Jr. "Decision Theory Aspects of Internal Control System Design Compliance and Substantive Tests", Journal of Accounting Research, Vol. 13, Supplement 1975, pp. 14-29.

Kirchheimer, Harry W. "Flow Charting--The Modern Method of Evaluating Internal Control and Procedures", Internal Auditor, Vol. 24, Fall 1967, pp. 46-50.



Kneer, Dan C. "Auditing Distributed Data Processing Systems: Evaluation of Internal Controls", dissertation proposal University of Missouri at Columbia, 1979.

Lea, Richard B. "Issues Involved in Mandatory Public Reporting by the Auditor on the Quality of Internal Accounting Control Systems," draft, Peat Marwick, Mitchell & Co., New York, March 1977.

Lin, W. Thomas, et al. A Review of Audit Research, Working Paper, Graduate School of Business, University of Southern California March 1978.

Liberman, Arthur Z. "Methodology for the Automation of the Audit Process Involving the Evaluation of the Plan of Internal Control", University of Arizona, December 1977-January 1978.

Loebbecke, James K. "Impact and Implementation of the Auditing Statement on Internal Control", The Journal of Accountancy, May 1975, pp. 81-83.

\_\_\_\_\_. "Some Developments Regarding Audit Judgment Making", Touche, Ross & Co., 1979.

\_\_\_\_\_. "Use of Decision Theory in Auditing", Auditing Symposium III, Proceedings of the 1976 Touche Ross University of Kansas Symposium on Auditing Problems, pp. 107-123.

Mair, William C., Donald R. Wood and Keagle W. Davis. Computer Control and Audit, The Institute of Internal Auditors, Altamonte Springs, Florida, 1976.

Martin, Albert S. and Kenneth P. Johnson. "Assessing Internal Accountancy Control: A Workable Approach", Coopers & Lybrand, 1978.

Neter, J. and Loebbecke, J.K. Behavior of Major Statistical Estimators in Sampling Accounting Populations: An Empirical Study, AICPA, New York, 1975.

Roberts, N. A. Mathematical Methods in Reliability Engineering (New York: McGraw Hill, 1970).

SEC. "Statement of Management on Internal Accounting Control", Securities & Exchange Commission, Release No. 34-15722, File No. 57-779, U.S. Government, 1979.

See, Malin E. and Tom S. Eason. "Systems Auditability & Control", Executive Report for the Institute of Internal Auditors, Stanford Research Institute, 1977.

Short, Frank G. "Internal Control from the Viewpoint of the Auditor", Journal of Accountancy, September 1940, p. 226.

Smith, Kenneth A. "Measurement of Internal Control in Audit Environments", University of Texas at Austin.

Stratton, William O. "Accounting Internal Control Systems: Their Reliability & Dichotomic Structure Functions" Ph.D. dissertation, Claremont Graduate School, 1977.

\_\_\_\_\_. "Accounting Systems: The Reliability Approach to Internal Control Evaluation," Decision Sciences, Vol 12, 1981, pp. 51-67.

Strong, Earl P. and Robert D. Smith. Management Control Models. New York: Holt, Rinehart, 1968.

Swieringa, Robert Jay. "A Behavioral Approach to Internal Control Evaluation", Journal of Internal Auditors, March-April 1972, pp. 30-45.

\_\_\_\_\_. "A Positional Analysis of Internal Control", The Journal of Accountancy, February 1971, pp. 34-42.

Toba, Yoshihide. "A General Theory of Evidence as the Conceptual Foundation in Auditing Theory." The Accounting Review, Jan. 1975, pp. 7-24.

Turner, Jerry L. and Theodore J. Mock. "Economic Considerations in Designing Audit Programs", University of Southern California, November 1978.

\_\_\_\_\_. "The Economics of Audit Evidence Collection and Evaluation", draft, Peat Marwick, Mitchell and Co., April 1978.

\_\_\_\_\_. Internal Accounting Control Evaluation and Audit Judgment, Auditing Research Monograph, AICPA, 1981.

Vasarhelyi, Miklos Antal and Michael Jay Ginsberg. "Experimental Studies in the Measurement of Internal Controls", Columbia University, November 1978.

Vasarhelyi, M.A. "A Taxonomization of Internal Controls and Errors for Audit Research," Proceedings of the Kansas Audit Conference, Laurence, Kansas, May 1981.

Warren, Carl S. "Discussion of a Statistical Technique for Analytical Review", Journal of Accounting Research, Vol. 13, Supplement 1975, pp. 10-13.



Whittington, Oliver R. "An Examination of the Effects of Analytical Evidence & Time Budgets on Audit Judgments", University of Houston, Ph.D. dissertation, Sep-Oct '78.

Willingham, J. J. and D. R. Carmichael. Auditing Concepts and Methods (New York: McGraw Hill, 1971).

Yu, Seongjae. "A Markovian Model for the Review of the Internal Control Systems", University of Minnesota.

Yu, Seongjae and John Neter. "A Stochastic Model for the Internal Control System", Journal of Accounting Research, Vol. 2, No. 2, Autumn 1973, pp. 273-295.