

ACCOUNTING MEASUREMENT AND  
METHODOLOGICAL CHARACTERISTICS OF ACCOUNTING DYNAMICS

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ABSTRACT

Accounting Dynamics is a methodology for modeling and simulation of accounting using System Dynamics. Our reasons for presenting Accounting Dynamics are as follows.

- a) Accounting is a primitive quantification of social processes composed of everyday transactions between economic entities.
- b) Therefore, accounting models, which consist of such transaction data, have their actual counterparts in the real economic world.
- c) On the other hand, accounting measurement (including double entry bookkeeping) is very adaptable to the System Dynamics observations.
- d) So that, Accounting Dynamics modeling and simulation seem to be very effective tools for depicting, analyzing, predicting and improving the actual state of resource allocation in social systems.

We believe there is no other system that measures each and every routine transaction as completely as business accounting. Furthermore, in most System Dynamics research on social systems, e.g., the System Dynamics National Model, it is emphasized that there is no macrostructure, other than the aggregation of many microstructures. If the national economy's behavior results from its microstructure, a realistic and reliable model of that microstructure will be an indispensable premise for building a National Model. The accounting Dynamics model will provide such a macrostructural building block at the business level or at the upper social level.

In our presentation, we analyze accounting measurement and identify the methodological characteristics of Accounting Dynamics. Accounting measurement has axiomatic rules (primarily represented by double entry) and institutional constraints. Traditionally, accounting measurement is periodic (discrete) and lacks the feedback concept. We introduce the feedback concept into the accounting model and present generic Accounting Dynamics models in some detail.

THE IMPLICATIONS OF ACCOUNTING MEASUREMENT

Accounting is the most primitive quantification of social process. Accounting measurement has special implications derived from the quantification of the very nature of social process which is distinct from the physical or natural process. There are at least three fundamental requirements for accounting measurement.

The first is a monetary unit as a measurement scale. Monetary scale is a common denominator used to evaluate all human activities. By using the monetary scale, accounting makes it possible to quantify all human interactions. But the value of a monetary unit itself is the

product of many interacting social forces and varies in its substantial purchasing power depending upon the historical date of transaction. However, it may be said that accounting measurement has a dimensional consistency at all times.

The second requirement is the unique measurement form of double entry bookkeeping. The quantity of every transaction is measured by applying a monetary unit and then recording the same amount in the debtor and creditor columns of the corresponding accounts. This procedure is generally called journalizing. The sum of all debtor accounts and of all creditor accounts belonging to an entity are always equal. Here two classes of accounts are identified. One is the balance sheet account and the other is the income statement account. Balance sheet accounts represent assets on the debtor side and equities on the creditor side. Equities mean the legal ownership right for assets. Income statement accounts represent expenses on the debtor side and revenues on the creditor side. Expenses and revenues mean subtraction from and addition to assets and have respectively corresponding influences to equities. Balance sheet accounts are very much like level variables and income statement accounts are rate variables in System Dynamics.

The third requirement refers to accountability. In our society, decisions about resource use and disposition are largely made by a steward or agent represented by a manager personally separated from the legal owner of that resource. Accountability means the social obligation of such a steward reporting his economic performance or how he used his resources to the equity owner. Eventually the object of accounting measurement is accountability in this context. Thus it can be said that accounting measurement is not a mere valuation of goods or services isolated from social context but confirms a human relationship involving the charge and discharge of accountability through performance evaluation of measurement. At the beginning of every accounting period, accountability is charged on the debtor side of the balance sheet account as the sum of various assets, and at the end of the period, accountability is discharged on the creditor side, emphasizing especially the profit figure earned during the period. Income statement accounts, the total of asset inflow and outflow resulting from the profit seeking activities of management, present a causal explanation of net asset increase (profit) or decrease (loss).

The data passing the above three requirements qualify as accounting information. The network of accounting information, as a whole, virtually controls the resource allocation in social systems. In the network, accounting information communicates accountability, that is, the economic performance of management, and influences the decisions of investors (institutional or public). As a result, in the hands of a competent management, more economic resources are accumulated, in other words, more accountabilities are charged. For the total optimization of resource allocation processes through the accounting network, there are many working rules for accounting measurement which are called generally accepted accounting principles or simply accounting rules.

This is only a rough picture of the everyday function of accounting in our society. But there lie numerous problems inside and outside accountancy. The main reason for these problems is that most accounting rules originate in daily practices and are not established scientific tests. Nobody, so far, has been able to see the whole picture of the accounting function. For example, there is an accounting rule concerning the historical cost basis in assets valuation which is one of the most influential rules at present. According to this rule, all assets, in principle, are recorded at acquisition price under the date

of the acquisition. This price is called the historical cost of asset, because its value originates in historical fact of acquisition, and thereafter is kept constant, through the manufacturing stage until the time of product sale (in the case of raw materials). Here, it is obvious that the matching of revenue with expense (a major accounting principle) has very a curious result in an economic sense, because revenue and expense are respectively measured at different nominal monetary values originating from their transaction dates. Furthermore, it is also obvious that the total book value of assets is a mixture of a wide variety of assets measured at different nominal monetary values. It is not a representation of the substantial economic value of a business entity but a mere summation of the historical cost of assets. This gap between the book value and the substantial market value are revealed, for instance, at merger and acquisition. These and other troublesome problems involved in business accounting are rarely taken up for scientific discussion. It is very important to make clear the actual state of resource allocation controlled by an accounting information network.

#### INTRODUCTION OF THE FEEDBACK CONCEPT INTO THE ACCOUNTING MODEL

To understand the real condition of resource allocation, it is desirable to model and simulate the social system in terms of accounting. This is the basic view point of Accounting Dynamics. Accounting Dynamics depends on System Dynamics for modeling and simulation methodology. But Accounting Dynamics also has special methodological issues derived from accounting measurement. In this section, we discuss this problem.

One of the most important problems in developing Accounting Dynamics methodology is the introduction of the feedback concept into the accounting model. The feedback concept naturally premises a continuous time concept. But traditionally, the accounting discipline has no continuous time concept, only a discrete time period concept. The accounting period is one of the basic conventions of modern accounting theory. Periodical income determination of a business entity for performance evaluation is the main objective of accounting measurement and it is attained by the matching of revenues realized during a specific period with expenses accrued during that period. But, as stated above, this periodical matching of revenue with expense has only nominal meaning. All accounting variables, including revenue and expense are, in the real sense of the word, not variables but legally confirmed amounts. They reflect social human relationships, but have no time-varying nature. In this context, accounting measurement is essentially discrete.

Thus, in order to introduce the feedback concept into the accounting model, it is necessary first to describe the accounting variable as a function of continuous time, even though it is a constant. Traditional accounting formulas are as follows.

$$A = L + C \quad \text{or} \quad C = A - L \quad (1)$$

$$E + P = R \quad \text{or} \quad P = R - E \quad (2)$$

A : Asset      L : Liability      C : Equity capital  
E : Expense    R : Revenue      P : Profit

As generally known, formula (1) is called the balance sheet equation and (2) the income statement equation. Each variable is then restated as a time function with the elements of subaccount in parenthesis.

$$\begin{aligned}
 &A(X_{a1}, X_{a2}, \dots, X_{an}; t) \\
 &L(X_{l1}, X_{l2}, \dots, X_{ln}; t) \\
 &R(X_{r1}, X_{r2}, \dots, X_{rn}; t) \\
 &E(X_{e1}, X_{e2}, \dots, X_{en}; t)
 \end{aligned}$$

Totally differentiating (1), we get

$$dC = \sum \frac{\partial A}{\partial X_{ai}} dt - \sum \frac{\partial L}{\partial X_{li}} dt \quad (1')$$

here, dC (increment of Equity Capital) means P, so that

$$dC = P = R - E \quad (2')$$

Equations (1') and (2') respectively are only conversions of equations (1) and (2) in terms of differentiation. But it should be noted that the former equations are of different order from the latter. Especially, it should be emphasized that by their nature, the terms R, E, and P are in a different order than A, L, and C. This is essential to the understanding of the transformation of accounting variables into variables of a time-varying nature. Consequently, if equation (1) represents the opening balance of a specific accounting period, and (2) represents economic performance during that period, then the closing balance are:

$$A = L + C + \int (R - E)dt \quad \text{or} \quad A = L + C + \int \left( \sum \frac{\partial A}{\partial X_{ai}} - \sum \frac{\partial L}{\partial X_{li}} \right) dt \quad (3)$$

This is an exact representation of the relationship between equation (1) and (2).

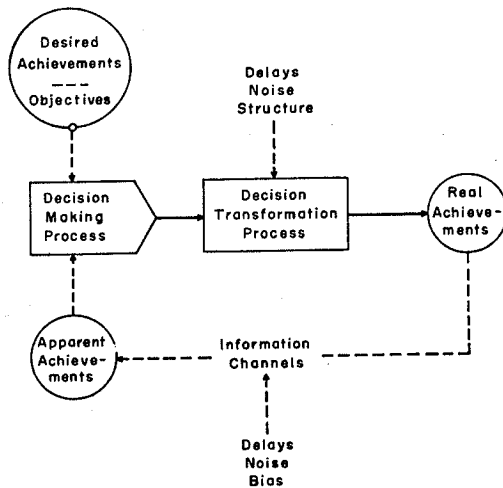


Figure 1. Control System Structure of Organization (Roberts, 1978)

The next step in introducing the feedback concept into the accounting model is depicting the closed network of accounting information that communicates the charge and discharge relationships within accountability. The accounting feedback loop model is not different from that of the control loop of organization in general, except its concepts are represented by accounting terms. Roberts(1987) presented a typical diagram of the control system structure of organizations as shown in figure 1.

Roberts points out four characteristics of the diagram that are noteworthy. We discuss the same points from an accounting perspective. First, Roberts says that the transformation of decision into results takes place through a complex process, which includes a basic structure of organizational, human, and market relationships. He says this structure is sometimes not apparent because of its numerous sources of noise or random behavior and due to its often lengthy time delays between cause and effect. It should be noted first that the feedback loop around the decision transformation process in figure 1 is applicable to various levels of social systems. At the national economy, industrial, corporate, divisional, departmental, and even at individual personnel levels, there will be a feedback loop just as in figure 1. In the Accounting Dynamics approach, the decision transformation process represents the accountability center at each level and legally confirms charge and discharge human relationships. But, as we stated above, there are a lot of problems in the accounting measurement of performance evaluation. However, in the Accounting Dynamics model, it is obvious that the process should not be a black box, because it represents a legal credit and debt human relationship. Further, it is clear that the decision transformation process depicted in the rectangle, namely, as a level variable, fits nicely into the notion of a balance sheet, even though it consists of only one account.

The second aspect to be noted in the diagram, Roberts says, is the distinction between the achievements that are apparent and those that are real. As long as the accounting information channel, then time delay is the only problem in the communication process. If any biases exist, most of them are socially accepted and originate in the accounting measurement process itself. Time delays are derived from the monthly closing of the books in cost accounting and the yearly closing in financial accounting.

The third feature of the diagram is the decision process as a response to the gap between the objectives of the organization and its apparent progress toward those objectives. As Roberts says, such goalseeking behavior is present in all organizations. They are also common observations in the budgetary control process of management accounting.

Finally, Roberts points out that the fourth characteristic of figure 1 is the continuous feedback path of the decision-results-measurement-evaluation-decision, and he emphasizes that it is vital to treat each element of this feedback path properly and to recognize its continuous nature. Roberts's emphasis ought to apply to Accounting Dynamics.

#### BUILDING THE ACCOUNTING DYNAMICS MODEL

In order to simulate the real state of resource allocation in the social system, the quantification process of accounting, that is, the accounting mechanism of processing daily transaction data, must be built into the model. The Accounting Dynamics model can be conceived at the corporate, urban, national, and higher levels in social systems. However, as a first step, we have developed the prototype model

at the corporate level and discussed technical problems actually encountered in building it.

In building the AD corporate model, we have referred to the System Dynamics Corporate Model by Lyneis(1980). Lyneis's model includes a lot of important factors such as the structure of inventory and the production system; forecasting in decision making; interactions with suppliers, labor, customers and competitors; and evaluating and controlling financial performances. Many interesting dynamic behaviors are analyzed in Lyneis's model. For example, capacity expansion, financial constraints and professional resource expansions. We appreciate Lyneis's model, but we take a somewhat different approach to the Accounting model.

We chose a company listed on the first section of the Tokyo Stock Exchange for our study. The main activities of the company are the manufacture of concrete piles and pipes, and steel frames and construction work. It is capitalized at 1,200 million Yen (\$8 million), has gross sales of about 20,000 million Yen (\$133 million), and employs 800 people. The company produces on order, and the production process is relatively simple. The financial performance of the company shows gradual decline as is seen in the trend of gross sales. The problems have been mainly caused by general economic crises, especially the so-called structural crises in process industry, and have resulted in operational losses.

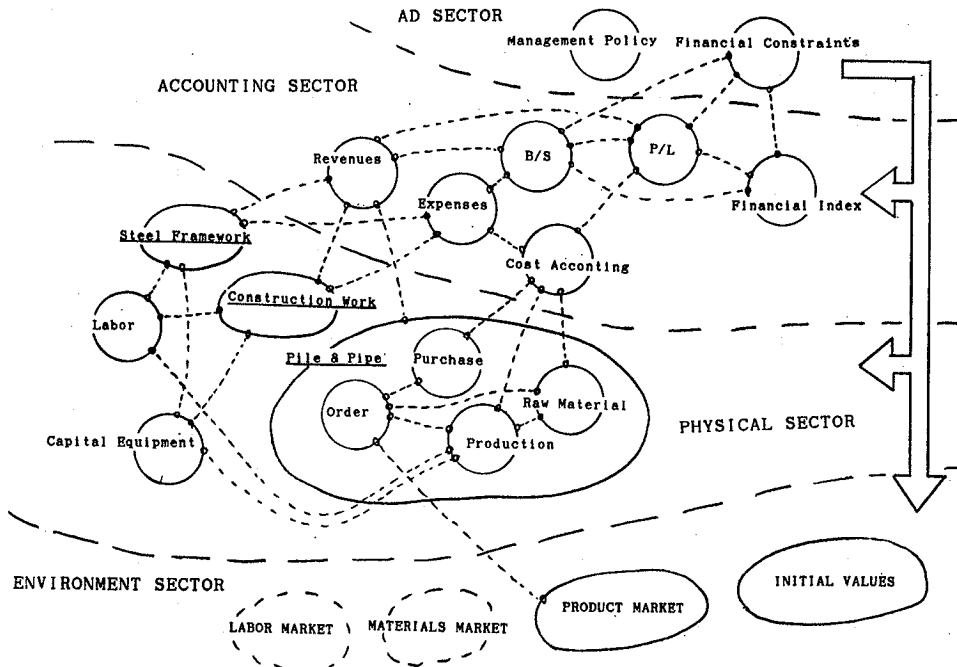


Figure 2. Overview of the Accounting Dynamics Corporate Model, Type II

As a prototype of the AD corporate model, we have developed two models (type 1 and type 2) of the company. Type 1 overviews the physical and accounting structures of the company and portrays its basic behavior and critical issues. The model also shows one possible approach to coping with actual problems. Type 2 covers the physical and accounting structures of the company in more detail.

Figure 2 is an overview of type 2. There are four main sectors. The first one is the AD sector, which is controlled by management policy or feedback from financial constraints. So far the model does not include the management subsector, and management policy performs manually by changing the initial conditions or rebuilding a part of the model. The second sector is accounting sector which includes subsectors of revenues, expenses, cost accounting, B/S, P/L, and financial index. The first three subsectors represent auxiliary variables. B/S and P/L subsectors are made by level variables and rate variables, which are induced from the above two auxiliary variables. The financial index subsector calculates and shows the financial indexes. One purpose of AD modeling and simulation is to test accounting principles. We can choose any accounting rule in the accounting sector. For example, we can change cost accounting rules by restructuring them in the accounting sector. The third sector is the physical sector. There are four product subsectors as well as labor and capital equipment subsectors in the physical sector. But because of the similarity between piles and pipes, we assume them to form one production subsector. The basic structure of a production subsector is similar to Lyneis's model. The fourth sector is called the environment sector because it mainly describes external variables and initial values. It includes the product market and other subsectors. Labor and materials market subsectors do not yet exist.

This model thus includes many factors occurring in the internal and external environments. Using this model, we have tried to analyze the causal relationships between the critical problems of the company.

We have to recognize that there are many problems in order to realize the full implications of the concept of Accounting Dynamics. However, as far as its methodological aspects are concerned, we have made clear considerable Accounting Dynamics issues and have created a prototype of the AD corporate model.

## CONCLUSION

We believe that the Accounting Dynamics model is the most typical System Dynamics application model to social systems for following three reasons. First, the Accounting Dynamics approach is very much like the relativist view of scientific theory (Barlas and Carpenter, 1978). As discussed above, the accounting quantification of the social process is a confirmation of human relationships, which communicates charge and discharge of accountability. That is to say, accounting measurement is, in its very nature, conversational and not confrontational. Accounting data represents not an objective and absolute truth, but a mere trade-off amount of transactions among interested parties. Second, a validation of the Accounting Dynamics model is naturally built on confidence among interested parties. Building confidence is the most important criteria of System Dynamics model validation (Forrester and Senge, 1980). Because of its legal aspect, accounting measurement has various social constraints in the quantification process. These constraints are called generally accounting principles or accounting rules. "Generally accepted" is the only justification for accounting. So far, institutionalism has deep-

ly influenced accounting theory. But, now, accounting principles have to be reformed based on a more appropriate causal explanation of the resource allocation process, the endorsed new methodology of social science. Third, Accounting Dynamics model is a theory of economic resource allocation in social systems. Accounting, as we emphasized, measures every day transactions in our society almost exhaustively. Based on such accounting data, the Accounting Dynamics model has explanatory power about resource allocation process. The simulation model, which captures the resource allocation process operationally will become one of the most powerful theories of social science.

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