ACCOUNTING DYNAMICS
--- Its Concepts and Model ---

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ABSTRACT

Accounting Dynamics (AD) is a methodology for the modelling and simulation of accounting using System Dynamics. Accounting identifies and measures economic transactions of an entity, and communicates these data to both internal and external decision makers. Thus it may be said that accounting controls resource allocations in social systems. In this context a simulation model described in terms of accounting will be very effective in order to analyze and project the behavior of social systems. In our model we emphasize the structure-dependent nature of System Dynamics. The AD model depicts the structure of accounts in an economic entity. The structure of accounts reflects charge-and-discharge relationships of accountabilities. Therefore the AD model seems to have a close relationship to the real world. The definition of accounting by R. Mattesich, i.e., the method of quantitative description and projection of income circulation and of wealth aggregates in macro and micro economy (Mattessich 1964), will be best met by AD. And accounting principles will be tested for their validation by the AD model simulation. The AD model will be able to be built at various levels, e.g., industrial, urban, national, in social systems. In our first approach, we have focused on the industrial level, and we have made a prototype of AD corporate model in *a business entity. We will suggest critical issues in the application of the AD model for higher levels of social systems.

CONCEPTUAL FRAMEWORK

Accounting is a most primitive quantification of social process which are composed of interactions of people. Here, most primitive means that accounting is a basic way of symbolizing measurements of relationships among people, especially those important ones related to day-to-day transactions. One could say that there is no other system that measures each and every routine transactions as much as accounting.

With society becoming more and more complex, many social institutions have been formed in order to regulate economic relationships. Accounting also has moved from a primitive level to a level of gigantic social institutions which regulate resource allocations in our society. However, this does not mean that accounting is no more the best way to quantify our everyday life. All economic bodies, whether they be individuals, corporations, municipals, or governments, still process their transaction data through generally accepted accounting procedures. And through this institutionally accepted

accounting information, social relationships relating to resource allocations among people are decided.

Looking from a different point of view, accounting is a vivid control system of resource allocations in our society. As such, it can have a large influence on the dynamic behavior of social systems. However, it can be said that until now, accounting has not had an effective method which analyzes the resource allocation process and interprets the dynamic behavior of social systems macroscopically. But it will be necessary to bring the accounting method of quantifying everyday transactions to a method of operational modelling and simulation of social systems.

Accounting Dynamics (AD) is a new methodology of accounting as social science in this context, that is, AD is a method of analyzing the dynamic behavior of social systems through accounting model simulation.

In order to simulate the real state of the resource allocation in the social system, it is necessary to convert the quantification process of accounting into an operational model. In other word, the accounting mechanism of processing transaction data must be built into the structure of the model. The model also has to be able to withstand simulation tests operationally. Only through this type of model simulation can we expect to accomplish our primary research objectives.

In this context, we use the SD method for our model operations. The reason for using SD is mainly the analogy of two basic variables (level and rate) in SD to the balance sheet accounts and transaction concepts in AD.

Financial Position | Rate | Integration of Transaction Flow | Financial Position

B/S | Transaction | P/L | B/S

t_0 | | $t_0 - t_1$ | t_1

$$B/S \ (x_1, \ x_2, \ x_3)t_1 = B/S \ (x_1, \ x_2, \ x_3)t_0 + \int_{t_0}^{t_1} T \ (x_1, \ x_2, \ x_3)$$
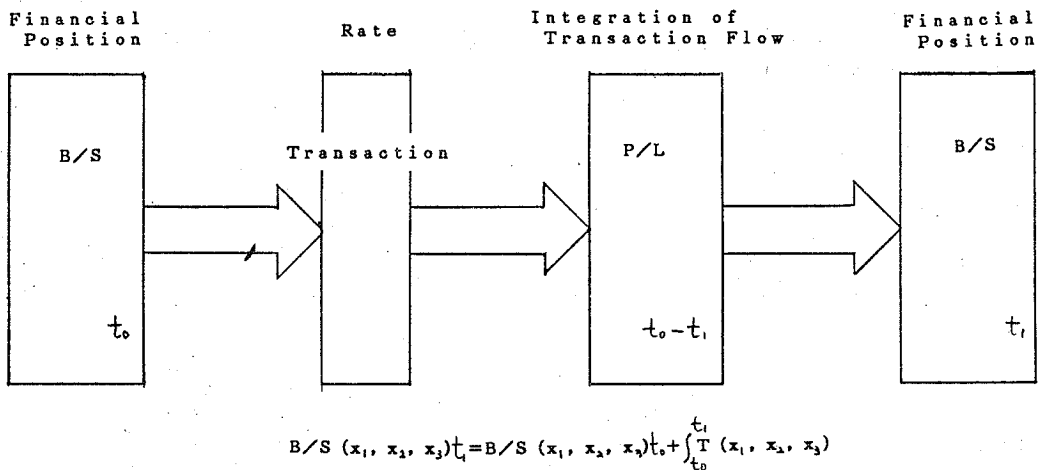
Figure 1   Basic Concept of AD Corporate Model

Furthermore, due to the structure-dependent nature of the SD model, an AD model based on the SD method can include the structure of account and institutional constraints which accounting data processing is subject to. A basic notion of AD is as the following. Corporate financial behavior can be represented as in figure 1. The income statement (P/L) is the integration of the transaction flow in a given period of time. By adding this to the first balance sheet the present balance sheet is obtained. The equation below figure 1 describes this relationship. The AD model formulates this relationship using the simulation language "DYNAMO".

The structure-dependent nature of AD model can be represented as in figure 2. Both the formal postulates of bookkeeping and the institutional postulates of accounting can be included in the model. The structure of balance sheet accounts of double entry bookkeeping forms level variables in causal loop diagram. Transaction flow which connects balance sheet accounts makes rate variables. Institutional constraints are formulated as constants and parameters which are the subconcepts of rate variables. Here it is noticeable that the structure of accounts reflects charge-and-discharge relationships of accountabilities. Therefore AD model is expected to have a close relationship to the real economic world.
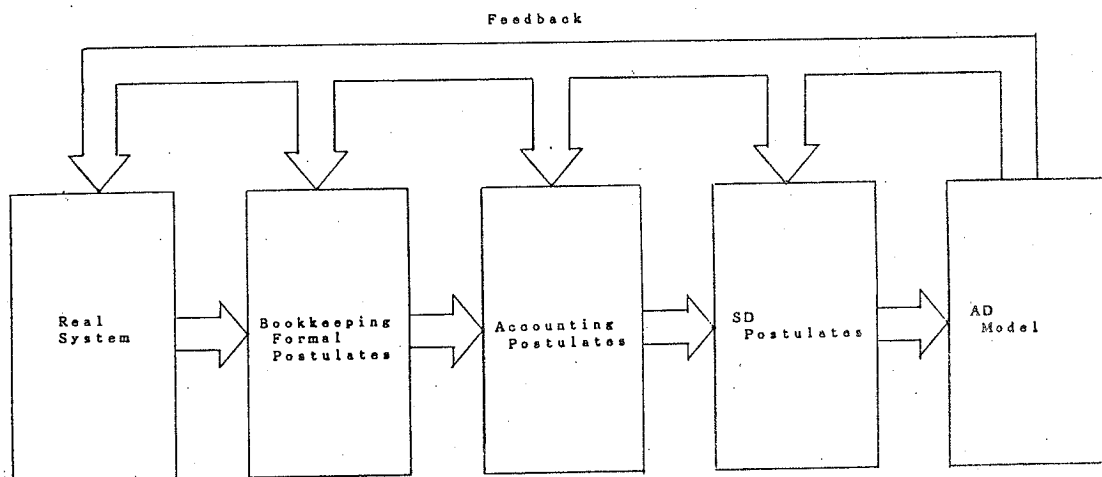
Feedback

Figure 2   Postulates of AD Model

The initial conditions of the AD model are decided by the opening balance sheet. Through the simulation, we can calculate the B/S at any point of time and the P/L for any period in the future.

Of course the building of the AD model does not confine to the corporate level. The AD model can be considered in urban, national economics and all

other higher levels in social systems. But, as can be seen in figure 3, it is important to notice that the AD model is built on the second order information space. The space, in which mutual economic transactions by economic bodies such as individuals and corporations are carrying out, can be called the real space. It is clear that an accounting system exists due to the necessity of a total optimization in this real space. Therefore, the accounting system is formed at the first order information space. AD tries to simulate the real condition of the control of the economic activities, which performed by the accounting system. Due to this, AD must be a concept in which both the real space and the first order information space are its objects. Also it can be said that all accounting theory which focuses on accounting in practice is based on the second order information space just as AD. Furthermore, a meta theory, whose object is an accounting theory including AD based on the second order space, can be well conceived.

Feedback

Real
Space

First Order
Information Space

Second Order
Information Space

Economic
Activity

Accounting
System

AD
Concept

Business
Enterprise

Business
Accounting

AD
Corporate
Model

Environment

Social
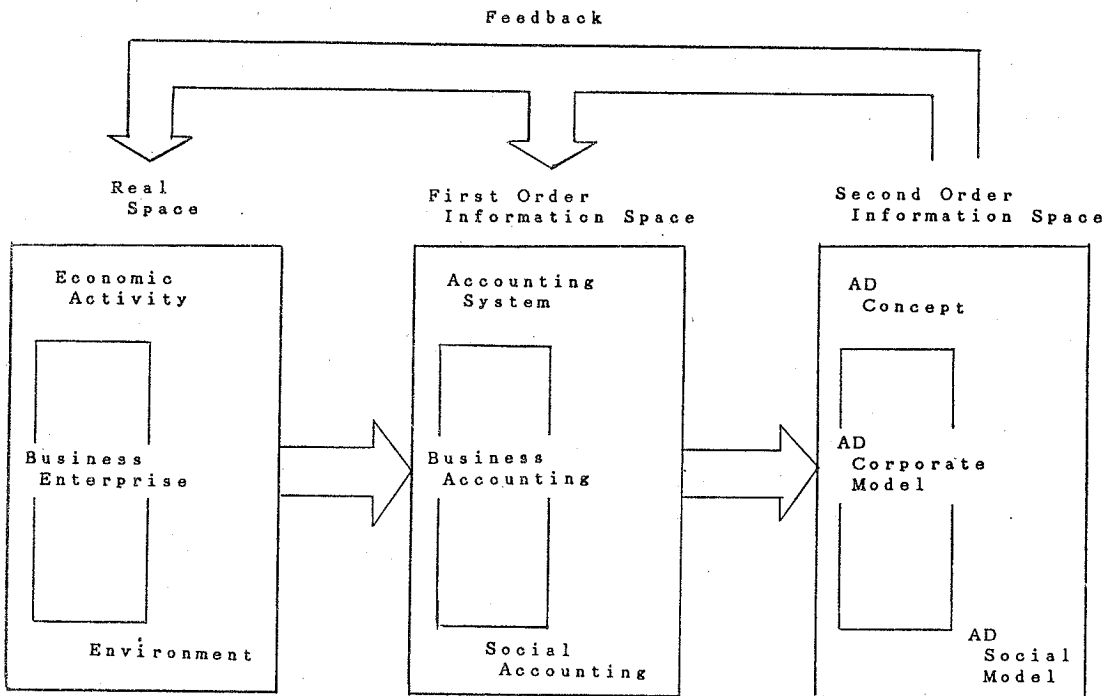Accounting

AD
Social
Model

Figure 3   Relationship of Economic Activity,
Accounting System and AD Model

We think, through the accounting modelling and simulation based on the second order information space, as explained above, accounting has, for the first time, a positive accounting methodology such as said by Friedman (Friedman 1953). As Friedman says, normative research is not possible without positive research. However, the most accounting theories are

normative oriented without positive research. Positive research is also indispensable for the formation of mutual agreements of the related parties in our society. At the beginning of the corporate accounting principles, there is the principle of truth. However, until now, has there really been an effective method to test the truthfulness? In the light of this, we expect AD to be a breakthrough that allows accounting to become a true social science.

It goes without saying that the results of simulations of the AD model are fed back to economic activities that occurs in the real space, and to accounting system that controls the real space. This is shown by the arrows in figures 2 and 3. At this point, the nature of the AD model which is structural dependent must be especially emphasized. The reason for this is that, through the simulation of AD model which have institutional rules in their structure, we could have an effective way to feedback simulation results to the improvement of our social institutions. Also, using the AD model, so called "what if" simulations are very effective for "policy" tests, that is, its applications for the DSS (Decision Support Systems) model in the management accounting area are very effective.

CHARACTERISTICS OF THE AD MODEL

Recently, there exist two paradigms in relation to the modelling of social systems (Meadows 1980). One being the structural dependent approach, represented by SD, and the other being the data dependent approach, represented by the econometrics model. As mentioned earlier, one outstanding characteristic of the AD model is that it is structural dependent. For reasons explained later, we consider further that essentially all accounting models must be structurally dependent.

When saying that accounting is a most primitive quantification of social processes, it means that there are at least three essential factors. One being the monetary valuation as a measurement scale, the second being the account mechanism of double entry bookkeeping as a measurement formality, and the third being the communication of accountability as the measurement contents. We think that two points are the essence of accounting. One is to measure economic transactions through the double entry account mechanism in monetary terms, and the other is to communicate social consequences of accountabilities. Therefore, the three essential factors mentioned above, must all be indispensable factors to accounting data.

The concept of quantification in accounting is so different with that of normally understood in general. For example, Professor Takeuchi says that the quantification is an application of mathematical logic to observation of objects. He places more importance on a formal relationship between objects, which represented by a formal relationship between numbers and he calls it as "structure", rather than the object itself. The formal relationship between numbers is a prerequisite as an axiom in these contexts, and it is the end of quantification to investigate all the results deducted logically from that formal relationship (Takeuchi 1971).

In the fields such as natural science and econometrics, it is normal for quantification to be understood as Professor Takeuchi said. Underlying observed data, what actually has observed exists separately to the data, and the structure of the model is in all respects something that emphasizes the formal relationship among observed data. It cannot be guaranteed that corresponding structure exists actually in the real system.

Can this type of relationship be applied, as it is, to accounting data? In this, the unique meaning of quantification of accounting becomes clear. The relationship, where what actually has observed exists separately behind the accounting data, cannot be plainly said at the least. According to accounting data, it is impossible to deny an aspect where the real human relationships in society are restricted to what the accounting data say. Therefore it can be said that at least one aspect of the social system is produced through accounting data processing.

Of course, when looking at accounting models in general, especially the AD model, we are discussing on the second order space, as explained in figure 3. However, there is a need to pay careful attention to the fact that the data used here is the result of the unique quantification of accounting as mentioned above. Only searching for the formal relationship between data and the operational nature of the model is inappropriate. No matter how the data is processed, we think that if it is accounting data, it must possess the three essential factors mentioned above. Behind accounting data there exist, not separately but identically, the human relationships concerned with social resource allocations. So the structure of the accounting model reflects the real social system that controls resource allocations.

By building in this way the real social process into the structure of the model, AD can effectively feedback the results of model simulation into real world. We think that at this point, in a sense, the AD model strengthens the SD method. A normal modelling approach in SD first pays attention to the time pattern of the behavior shown by real systems (this is called the reference mode). Then, the basic mechanism of the system from which the mode comes is made clear, and the cause and effect loop is formulated into the model (Randers 1980). However, up to now, there was criticism that the process was often subjective. In contrast to this, the AD modelling takes, as its reference mode, financial indexes such as gross sales and profit which disclosed in financial statements. By putting the structure of accounts and institutional regulations that produce these indexes into the structure of the models feedback loop, a model with extremely high reliability can be available.

Social systems are, by nature, open, and are said to be the systems essentially lacking in data. It is best to say that there is a limit to analyzing the behavior of complicated social systems and predicting its future only through the logical deduction from observed data. In order to understand the behavior of systems which reflect non-linear, often one time only, sometimes irrational, and extremely complicated human interactions, it is most effective to resort to a simulation of a model in which a institutional mechanism that controls human relationships is built. In this

respect it must be recognized that accounting, the most primitive
quantification of social process, shows a fundamental research area in
building social system models. The method of AD emphasizes this point.

AD CORPORATE MODEL

Now we investigate the technical problems that occur when actually building
the AD model.
A very close analogy can be seen between the method of SD and the basic
accounting concepts. Forrester himself has said concerning accounting, "The
balance-sheet variables are levels, giving the financial condition of the
business system at one point in time. The balance-sheet levels show the
effect of accumulating the rates of flow over all past time. The profit-
and-loss statement, by contrast, gives the rates of flow that have existed
since the previous balance sheet. The profit-and-loss rates cause the
changes from the previous balance sheet to the present." (Forrester 1968)
Figure 1 is a summary of the corresponding relationships of basic concepts
in accounting and SD.
Furthermore, it has already been noted that the institutional constraints,
such as accounting principles and the commercial law, which control
transactions have been included in the AD model as subconcepts of rate
variables.

In order to develop the AD prototype model which occurs at corporate level,
we chose company A which is listed on the first section of the Tokyo Stock
Exchange as an object of our investigation. As in table 1, the main
products of company A are concrete piles and pipes. It has a capital of
1,200 million Yen ($8 million), gross sales are about 20,000 million Yen
($133 million), and the number of employees is 800. Company A produces on
order, and the production process is relatively simple. As can be seen in
table 1, financial performances of company A show gradual decline as in
the trend of gross sales. The problems mainly have been caused by general
economic crises, especially called structural crises in process industries,
and resulted in operational losses.

As prototype of the AD corporate model, we have developed two models (type
1 and type 2) of company A. Type 1 model overviews physical structure and
accounting structure of company A and gives the basic behaviors and
critical issues of company A. The model also shows one possible approach to
cope with actual problems. Type 2 model (Figure 4) covers physical
structure and accounting structure of the company in detail. This model
includes factors occurred in external environments at the same time, and
tries to analyze the correlations of simulation results of the model and
critical problems of company A.

Of course, we are aiming for positive feedback of simulation results to
real problems through use of the AD model. But the detailed simulation
results of two types of models are left. Here we only emphasize that the
models in these types show to be prototype of AD corporate model and that
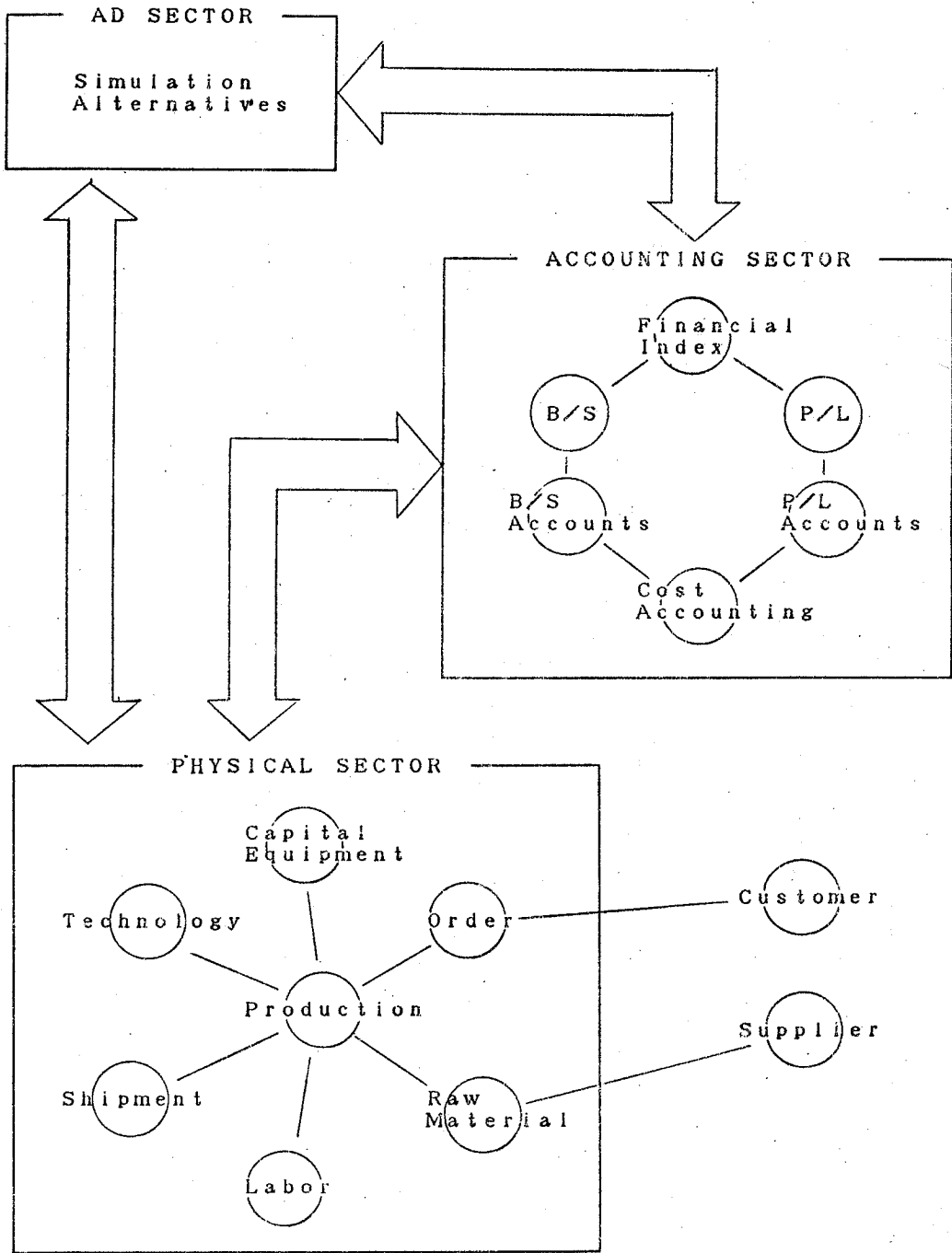they have the potential power for developing a useful tool to cope against

Figure 4   Framework of AD Corporate Model
(Prototype Type 2)

actual problems. Therefore, it should be noticed that the emphasis is not feedback to reality in actual case, but its possiblity and methodological issues.

Table 1 The Company A

(1) Industry : Ceramics
(2) Capital : ¥1,200,000,000
                   ($8,000,000)
(3) Sales   : Operating Profit :

Year	Sales		Operating Profit	
	¥	$	¥	$
1980	23,800	(159)	774	(5.16)
81	23,050	(154)	510	(3.40)
82	27,270	(181)	1,031	(6.87)
83	21,870	(146)	8	(0.05)
84	18,040	(120)	-1,001	(-6.67)

(¥.$.millions)

(4) Products :
      Pile and Pipe
      Construction Work
      Steel Framework
(5) Raw Materials :
      Cement
      Sand,Gravel
      Steel wire
(6) Expenses :
      Depreciation
      Fuel
      Repair

CONCLUSION

We have presented a new method of Accounting Dynamics, a new methodology for the modelling and simulation of accounting using SD. The AD model is effective in analyzing dynamic behavior of social systems and feedback its simulation results to real world, because the model has both charge-and-discharge relationship of accountability and the institutional constraints to accounting data processing in its structure. We think that the AD method is a breakthrough for accounting to become genuine social science. But we have only presented the prototype model of corporate level.

Our next step is to build the AD model of higher level of social systems, for example, AD national model, where we will have to treat the difficult

problem of data aggregation and statistics. Furthermore, it is necessary to maintain the structure-dependent nature of the model. However we expect that the AD model of higher social level will integrate the two paradigms of modelling approach, that is, data-dependent and structure-dependent, as mentioned earlier. This integration is, as it is likely to be, very troublesome but it is our fruitful research target.

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