Principle of Accounting System Dynamics
– Modeling Corporate Financial Statements –

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Abstract

Understanding financial statements is imperative for better management of corporations, while system dynamics (SD) offers dynamic modeling and simulation skills for better strategies of management. This paper tries to present a consolidated principle of accounting system dynamics on the basis of simple principles from SD and accounting system. It is, then, specifically applied to model corporate financial statements (income statement, balance sheet and cash flow statement) described in the book [3]. It is shown that cash flow statement is indispensable for modeling financial statements. At the same time, a limitation of the current accounting system as a dynamic guidance for management strategies is pointed out. This demonstrates the importance of SD modeling in the field of accounting system.

1 Introduction

Business accounting system consists of three financial statements such as income statement, balance sheet and cash flow statement. Success or failure of corporations has been measured by these financial statements. In this sense, accounting system has been and will be a foundation for our business activities.

Accounting system is recently undergoing radical reforms in Japan in order to catch up with its global defacto standard of the American accounting system. The so-called Japanese version of financial Big Bang began to be implemented in March 2000. One of its major reforms is a legal requirement of cash flow statement which had been neglected in the Japanese accounting system until recently. Since then many introductory accounting books focusing on cash flows have been lined up in many bookstores, attracting attention to many business people in Japan.

Under such circumstances, recent financial scandals such as Enron and World-Com were a surprise to most Japanese who have been trying to introduce the

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American accounting system as the most trustworthy system. What went wrong with them? One of the reflecting arguments was that the practice of the current accounting system is heavily dependent on professional accountants and specialized accounting software. If current accounting system were more friendly to managers and employees, then abnormal behaviors of financial practices such as mentioned above would have been avoided at its earlier stage, I thought.

It occurred to me then that SD approach to the accounting system could make it more friendly. Furthermore, it would be more practical, I thought, if corporate SD models could incorporate financial statements directly or indirectly, since model performances are better evaluated in terms of financial statements as done in the real world of business.

With these beliefs in mind, I began to search for references on a system dynamics method of modeling corporate financial statements. My search has been unsuccessful except the book [5] which was by chance suggested in the discussions among SD mailing community. It took more than a year to obtain the book through the Amazon on-line search for used books. It turned out, however, that the book was written with DYNAMO, and accordingly has been left unnoticed in my bookshelf.

Failure of the search gave me an incentive to develop a SD method of modeling financial statements from a scratch. I started working in the summer of 2001 when I was spending relatively a quiet time on a daily rehabilitation exercise in order to recover from the physical operation on my shoulder in June of the same year. This environment gave me a good chance for reading books on accounting. My readings mainly consisted of the introductory books such as [2], [3], [4], [7], [8], since I have never taken accounting courses[1]. Through such readings, I have been convinced that system dynamics approach is very effective for understanding the accounting system.

The purpose of this paper is, therefore, to understand the accounting system in terms of system dynamics. A consolidated principle of accounting system dynamics will be constructed for this purpose. It is then applied to model corporate financial statements exemplified in [3]. In the due course, it will be shown how cash flow statement plays an indispensable role in modeling corporate financial systems, contrary to the practice that it has not been required in the Japanese financial statements. I wondered why such an essential cash flow statement has been neglected until recently in Japan. System dynamics approach indeed sheds light on the wholeness of the current accounting system.

On the other hand, SD business models seem to have also neglected the importance of incorporating financial statements for better evaluation of model performances. Business models without such financial statements, whether they are explicitly or implicit built in them, would be indeed incomplete, because they fail to reflect the wholeness of dynamic business activities. In this sense, a corporate financial model that will be suggested at the end of this paper would provide a kind of pecuniary archetype for corporate financial modeling.

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[1]In addition to these books, a paper dealing with corporate financial statements [1] is recently published. However, current research for modeling financial statements is independently carried out here with a heuristic objective in mind.

2 Principles of System Dynamics

System is a self-functioning whole consisting of interdependent parts that are interacting with one another with some influence from its outside world. Examples of systems are abundant such as our bodies, communities, corporations, and public organizations as well as subsystems within these systems. System dynamics is a discipline that tries to describe dynamic movements of these systems. For the understanding of financial accounting system, which is a main purpose of this paper, it would be enough to consider the following three principles of system dynamics.

Principle 1 (System as a collection of stocks) System can be described by a collection of state variables, called *stocks* in system dynamics, whose levels or volumes are measured at a *moment in time*.

In other words, state variables (stocks) of the system are the entity that can be pictured or recorded for its description.

Principle 2 (Stock-flow relation) Levels of a stock can only be changed by the amount of *flows* measured for a *period of time*. The amount of flow that increases the stock is called inflow, while the one that decreases it is called outflow.

In this way, stock and flow constitute an inseparable relational unit in system dynamics [9]. Stock-flow relation is illustrated in Figure 1.

Figure 1: Stock-Flow Relation

Principle 3 (Information feedback) The amount of inflows and outflows is directly or indirectly determined either by the information obtained from the stocks through their feedback loops, or parameters obtained outside the system.

As will be clarified below, modeling dynamic accounting system mostly depends on the parameters of transaction data obtained outside the system.

3 Principles of Accounting System

Accounting system of modern corporations consists of three financial statements such as balance sheet, income statement and cash flow statement. Examples of these statements used in this paper are replicated from the book [3].

Balance Sheet

	A	Cash
	B	Accounts Receivable
	C	Inventories
	D	Prepaid Expenses
A + B + C + D =	E	Current Assets
	F	Other Assets
	G	Fixed Assets @ Cost
	H	Accumulated Depreciation
G - H =	I	Net Fixed Assets
E + F + I =	J	Total Assets
	K	Accounts Payable
	L	Accrued Expenses
	M	Current Portion of Debt
	N	Income Taxes Payable
K + L + M + N =	O	Current Liabilities
	P	Long-Term Debt
	Q	Capital Stock
	R	Retained Earnings
Q + R =	S	Shareholders' Equity
O + P + S =	T	Total Liabilities & Equity

Table 1: Balance Sheet in [3]

How are these three statements related one another, then? Their relationships are best described as follows:

> The balance sheet reports the aggregate effect of transactions at a **point in time**, whereas the income statement, statement of retained earnings, and statement of cash flows report the effect of transactions over a **period of time**. [6, page 35].

The relationship of three financial statements can be thus best understood in terms of the above stock-flow relation of system dynamics as follows:

Principle 4 (Stock-flow relation of financial statements) Balance sheet is a collection of stocks only, while income statement and cash flow statement consist of inflows and outflows of the stocks in balance sheet.

Balance sheet in Table 1 is now best illustrated as a collection of stocks as in Figure 2. One remark may be needed on Net Fixed Assets. It is defined in
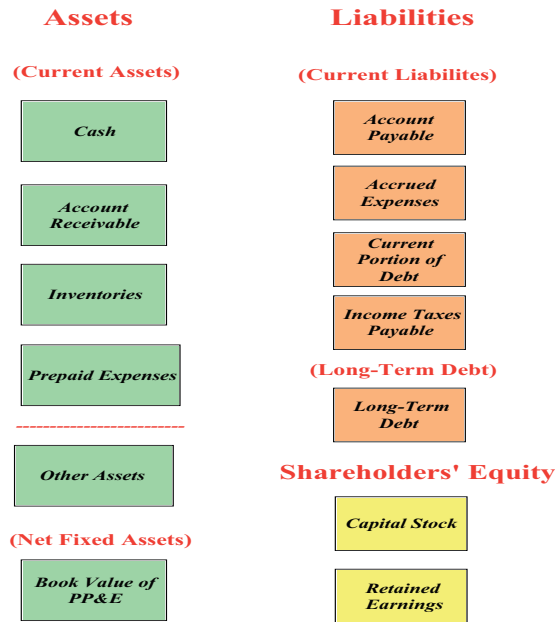
Figure 2: Balance Sheet in [3] as a Collection of Stocks

Table 1 as Fixed Assets @ Cost less Accumulated Depreciation. In Figure 2, it is renamed as Book Value of PP&E (Property, Plant and Equipment) and illustrated as the only stock for the net fixed assets. This is because, with the introduction of stock-flow relation, net fixed assets can be better represented as a book value relation as illustrated in Figure 3 below.

There are 13 stocks in the balance sheet of Figure 2. From the Principle 2, they all need to be illustrated together with inflows and outflows. However, from the Principle 4, only inflows and outflows of Retained Earnings and Cash can be illustrated from the figures in Income and Cash Flow Statements. Specifically, inflows and outflows of Retained Earnings are obtained from the Income Statement in Table 2. That is, its inflow is revenues or net sales, while its outflows consist of costs of goods sold, operating expenses, net interest income, and income taxes. These stock-flow relations are illustrated in Figure 4 below.

On the other hand, inflows and outflows of Cash could also be illustrated from Cash Flow Statement in Table 3. Its inflow is basically cash receipts and its outflow is cash disbursements. Cash flows, however, are better classified in detail into three activities; that is, operating activities, investing activities and financing activities, and accordingly stock-flow relations of Cash are usually described with additional inflows and outflows. They will be thus illustrated in Figure 8 after cash-related transactions are examined in Section 4.

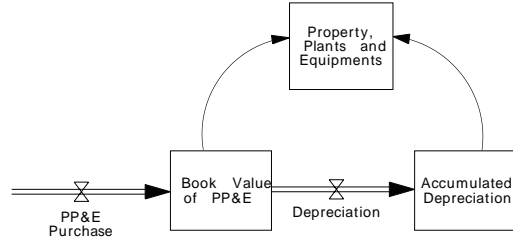To illustrate stock-flow relations of the remaining 11 stocks, we need to add

Figure 3: Net Fixed Assets (Book Value) Relation

Income Statement

1	Net Sales
2	Cost of Goods Sold
1 -2 = 3	Gross Margin
4	Sales & Marketing
5	Research & Development
6	General & Administrative
4+5+6=7	Operating Expenses
3-7=8	Income From Operations
9	Net Interest Income
10	Income Taxes
8+9-10=11	Net Income

Table 2: Income Statement in [3]

inflows and outflows to them by newly defining their names. A generic naming rule is employed here to define them as long as no other appropriate names are found in the existing accounting system. For instance, inflow and outflow of Accounts Payable are named *Accounts Payable Incurred* and *Accounts Payable Paid*. In this way, stock-flow relations of all stocks in the balance sheet are constructed.

How can the levels of these 13 stocks in the balance sheet be changed, then, by the changes in inflows and outflows? In the accounting system, they are changed by a so-called bookkeeping rule of *double entry*. Accounting system has a long history of more than several hundred years, and become a well-established and complete system. Its success has been attained by the introduction of this *double entry* principle. The double entry rule, however, has also been a major source of confusions for the students of accounting.

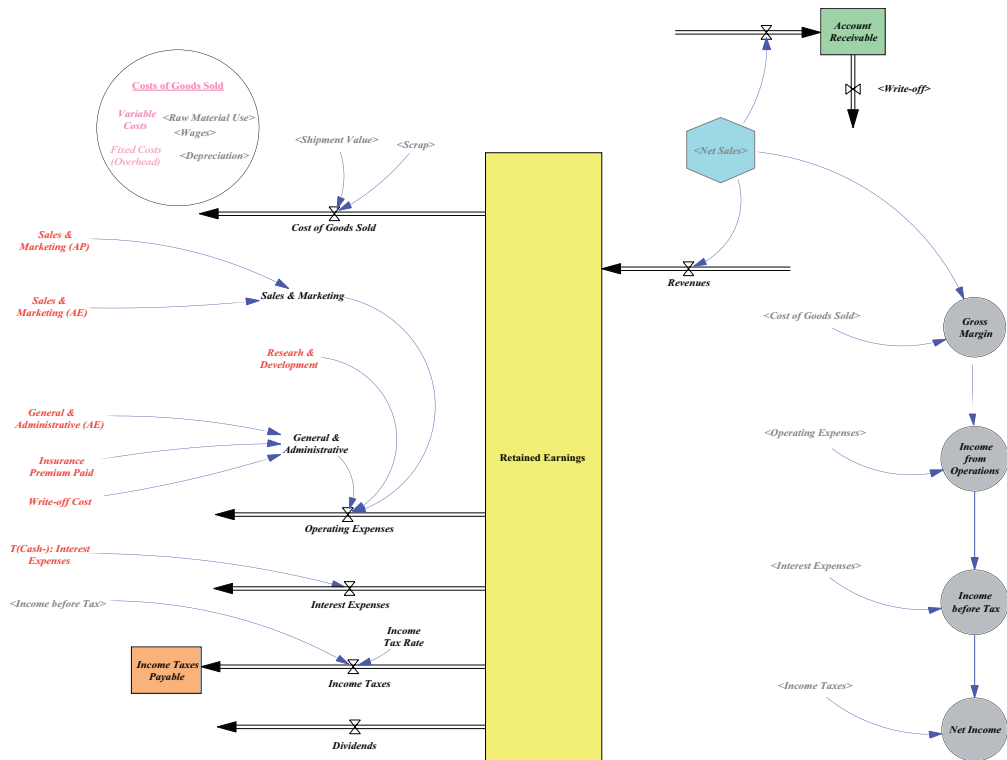With the introduction of stock-flow relation, the double entry principle is

Figure 4: Income Statement as Stock-Flow Relation

now very intuitively illustrated as in Figure 5, in which all stocks in the Balance Sheet are collectively described as Assets and Liabilities, while Shareholders' Equity is described with its original stock names of Capital Stock and Retained Earnings. All inflows to Assets and all outflows from Liabilities and Equity are booked on the left side of debit, while all outflows from Assets and all inflows to Liabilities and Equity are booked on the right side of credit. That is to say, each transaction has to be booked simultaneously on both sides of debit and credit to keep the balance sheet in balance – a very simple rule!. It is formally summarized as follows:

Principle 5 (Double entry rule of bookkeeping) All transactions in the accounting system are recorded as inflows and/or outflows of stocks in the balance sheet so that each transaction causes two corresponding stocks to change simultaneously in balance. For this purpose, each transaction is booked twice on both debit and credit sides. Inflows of assets and outflows of liabilities and shareholders' equity are booked on the debit side, while outflows of assets and inflows of liabilities and shareholders' equity are booked on the credit side.

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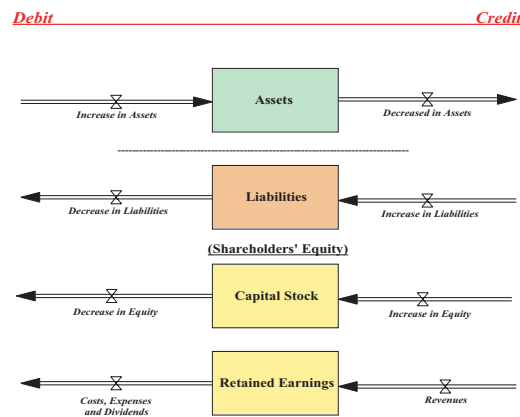| | Cash Flow Statement | |
|---:|:---|
| a | Beginning Cash Balance |
| b | Cash Receipts |
| c | Cash Disbursements |
| b-c=d | Cash Flow From Operations |
| e | PP&E Purchase |
| f | Net Borrowings |
| g | Income Taxes Paid |
| h | Sale of Capital Stock |
| a+d-e+f-g+h=i | Ending Cash Balance |

Table 3: Cash Flow Statement in [3]

Figure 5: Double Entry Rule of Bookkeeping as Debit and Credit

We have now obtained five principles from system dynamics and accounting system. Let us call them collectively Principle of Accounting System Dynamics (PASD).

Principle of Accounting System Dynamics Principles 1 through 5 obtained from system dynamics and accounting system constitutes the Principle of Accounting System Dynamics.

From the principle, four major categories of bookkeeping practices are easily classified as follows.

Debit:inflow ↔ Credit:outflow Transactions within assets are classified in this category. For example, an increase in Fixed Assets by the purchase of PP&E is balanced by the decrease in Cash by its payment.

Debit:outflow ↔ Credit:inflow Transactions within liabilities and equity are classified here. For example, a decrease in Retained Earnings caused by an increase in operating expenses such as sales & marketing expenses is balanced by the increase in Accrued Expenses.

Debit:inflow ↔ Credit:inflow Transactions in this category cause both Assets and Liabilities/Equity to increase. For instance, an increase in net sales causes both Accounts Receivable and Retained Earnings to increase.

Debit:outflow ↔ Credit:outflow Transactions here cause both Assets and Liabilities/Equity to decrease. For instance, payment of Accounts Payable causes both Cash and Accounts Payable to decrease.

4   Examples of Transactions

On the basis of the PASD, we are now in a position to model corporate financial statements by identifying all corresponding flows and stocks that are affected by transactions. Examples of transactions in the book [3] are used for this purpose. That is, all transactions below are quoted from the book, so this section can be better followed with the book at hand.

According to PASD, all transactions have to be booked on both debit and credit sides simultaneously. This bookkeeping rule is formally described here as follows:

⇒ Transaction (Stock1±): Inflow/Outflow ↔ (Stock2±)

Stock1 is a primary stock that is changed by the inflow or outflow of a transaction, and Stock2 is its corresponding stock to be changed to keep the balance sheet in balance. For example, if an item in the accrued expenses is paid in cash, this transaction decreases both Cash and Accrued Expenses, and it is described as follows:

⇒ T(Cash-): Accrued Expenses Paid ↔ (Accrued Expenses -)

This formula implies that payment of accrued expenses lowers both the levels of cash and accrued expenses. Such an identifications of a primary stock affected by the transaction and its corresponding stock is essential for modeling financial statements. In this way, all 31 transactions below are identified one by one with the above formula.

Transaction 1 A group of investors is willing to exchange their $1.5 million in cash for stock certificates representing 150,000 common shares of AppleSeed Enterprises, Inc.
Note: When you formed the company you bought 50,000 shares of "founder's stock" at $1 per share for a total investment of $50,000 in cash. Thus after this sale to the investor group there will be 200,000 shares outstanding.

They will own 75% of AppleSeed and you will own the rest.
⇒ T:New Issue of Shares (= 150,000 common shares) ⇒ (Cash +) ↔ (Capital Stock +)

Transaction 2 Book all payroll-associated company expenses totaling $6,230 including salary, employer's contribution to FICA (Social Security) and various insurance expenses. Issue yourself a payroll check for $3,370 (your $5,000 monthly salary minus $1,250 in federal and state withholding tax and $380 for your own contribution to FICA).
⇒ T(Accrued Expenses+): General and Administrative (= $6,230) ↔ (Retained Earnings -): Operating Expenses
⇒ T(Cash-): Accrued Expenses Paid (= $3,370) ↔ (Accrued Expenses -)

Transaction 3 Borrow $1 million to purchase an all-purpose building. This term note will run for 10 years, calling for yearly principal payments of $100,000 plus interest at a rate of 10% per annum.
⇒ T(Cash+): Long-Term Borrowing (= $1 million) ↔ (Long-Term Debt +)
⇒ T: Principal Payment (= $100,000) ⇒ (Long-Term Debt -) ↔ (Current Portion of Debt +)

Transaction 4 Purchase 100,000 square foot building and land for $1.5 million in cash. This facility will serve as AppleSeed Enterprises' headquarters, manufacturing facility and warehouse.
⇒ T(Cash-): Property, Plant & Equipment Purchase (= $ 1.5 million) ↔ (Book Value of PP & E +)

Transaction 5 Book this month's payroll-associated expenses of $14,790, (that is, $7,680 for Sales & Marketing and $7,110 for G & A). These expenses include salaries, wages, insurance and other fringe benefits. Issue payroll checks totaling $7,960 to SG & A employees.
⇒ T(Accrued Expenses+): Sales and Marketing (= $ 7,680), T(Accrued Expenses+): General and Administrative (= $ 7,110), ↔ (Retained Earnings -): Operating Expenses
⇒ T(Cash-): Accrued Expenses Paid ((= $7,960) ↔ (Accrued Expenses -)

Transaction 6 Pay all the payroll-associated expenses that were accrued in Transaction 2 and Transaction 5, including FICA, withholding tax and unemployment insurance due the government. Also pay to private insurance companies the workmen's compensation and health and life insurance premiums.
⇒ T(Cash-): Accrued Expenses Paid (= $9,690) ↔ (Accrued Expenses -)

Transaction 7 Place an order for $250,000 worth of applesauce-making machinery. Make a prepayment of $125,000 with the balance due upon successful installation.
⇒ T(Cash-): Other Assets Purchase (= $125,000) ↔ (Other Assets +)

Transaction 8 Make final payment of $125,000, the balance due on the applesauce-making machinery.
⇒ T(Cash-): Other Assets Purchase (= $125,000) ↔ (Other Assets +)
After the completion of payment and the delivery of machinery, it is now recorded as PP&E. It may be written in our transaction format as follows.
⇒ T(Other Assets -): Installation (= $250,000) ↔ (Book Value of PP&E +).

Transaction 9 Book supervisor's salary and associated payroll expenses as a General & Administrative expense since we have not yet started production. Issue first month's salary check. Make no entries for hourly workers since they have not yet reported for work.
⇒ T(Accrued Expenses+): General and Administrative (= $4,880) ↔ (Retained Earnings -): Operating Expenses
⇒ T(Cash-): Accrued Expenses Paid (= $2,720) ↔ (Accrued Expenses -)

Transaction 10 Order and receive 1 million applesauce jar labels at a cost of $0.02 each for a total of $20,000 to be paid 30 days after delivery.
⇒ T(Accounts Payable+): Raw Material Purchase (= $20,000) ↔ (Inventories +)

Transaction 11 Receive a two months' supply of all raw materials (apples, sugar, cinnamon, jars, caps, boxes) worth $332,400 in total. (That is, $8.55 total materials per case less $0.24 for the already received labels times 40,000 cases.)
⇒ T(Accounts Payable+): Raw Material Purchase (= $332,400) ↔ (Inventories +)

Transaction 12 Pay production workers' wages and supervisor's salary for the month. Book associated fringe benefits and payroll taxes. (Now that we are manufacturing product, these salary and wages are costs that increase the value of our product, and are shown as an increase in inventory.)
⇒ T(Cash-): Wages (= $9,020) ↔ (Inventories +)
⇒ T(Accrued Expenses+): Payroll-associated Fringes and Taxes (= $8,160) ↔ (Inventories +)

As production starts, raw material use may be written as follows.
⇒ T: Raw Material Use (= $171,000) ⇒T(Inventories -) ↔ (Inventories +)

Transaction 13 Book this month's manufacturing depreciation of $7,143 and $8,677 covering "all other" overhead costs. Note that depreciation is not a cash expense and will not lower our cash balance. But, the "all other" overhead we will eventually have to pay with cash.
⇒ T(Accounts Payable+): All Other Overhead (= $8,677) ↔ (Inventories +)
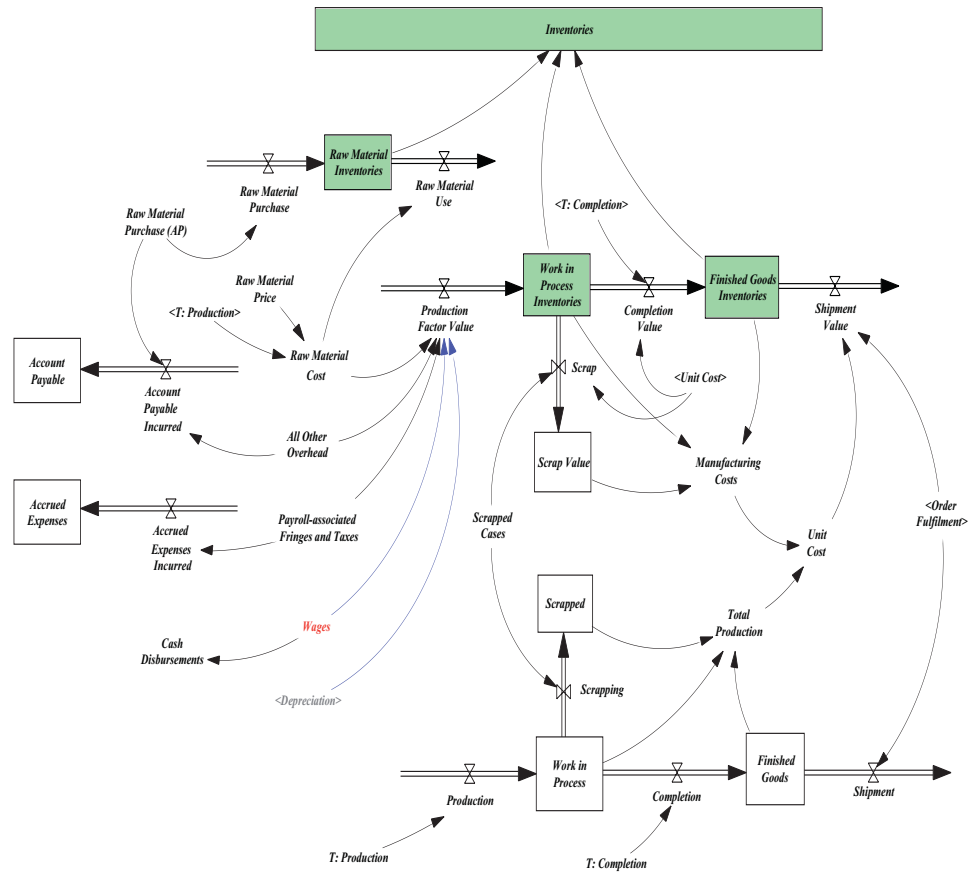⇒ T(Book Value of PP&E -): Depreciation (= $7,143) ↔ (Inventories +)

Figure 6: Inventories with Production

Transaction 14 Pay for 1 million labels received in Transaction 10. Issue a check to our vendor for $20,000 as payment in full.
⇒ T(Cash-): Accounts Payable Paid (= $20,000) ↔ (Accounts Payable -)

Transaction 15 Finish production of 19,500 cases of our applesauce. Move product from work-in-process ("WIP") Inventory into Finished Goods. This movement of inventory into a different class is really just an internal management control transaction as far as the financial statements are concerned. There is no effect on the three major financial statements of AppleSeed. INVENTORIES on the *Balance Sheet* remains the same. Our Inventory Valuation Worksheet, as shown below, reflects the change in inventory status.

K. Receive a month's raw material supply less labels. (see T10)	$166,200
L. Move a month's supply of raw materials into WIP. (see T12).	$171,000
M. Pay hourly workers/supervisor for another month. (see T12)	$17,180
N. Book manufacturing depreciation for the month. (see T13)	$7,143
O. Book "all other" mfg. overhead for another month. (see T13)	$8,677
P. Move 19,000 cases to finished goods standard cost.	$193,800
Q. Scrap 150 cases from WIP. (see T16)	$1,530

Table 4: Inventory Valuation Worksheet for Transaction 18

This may be written as follows.
⇒ T: Completion (= $198,900) ⇒T(Inventories -) ↔ (Inventories +)

Transaction 16 Scrap the value of 500 cases of applesauce from the work-in-process inventory. Take a loss on the *Income Statement* for this amount.
⇒ T(Inventories-): Scrapped Cases (= 500 cases) ↔ (Retained Earnings -): Cost of Goods Sold

Transaction 17 Pay a major supplier a portion of what is due for apples and jars. Cut a check for $150,000 in partial payment.
⇒ T(Cash-): Accounts Payable Paid (= $150,000) ↔ (Accounts Payable -)

Transaction 18 Make entries in the *Income Statement, Cash Flow Statement* and *Balance Sheet* as shown in the total column at below right. Note that for each worksheet entry (K through Q below), the change in Assets equals the change in Liabilities.
⇒ T(Accounts Payable+): Raw Material Purchase (= $166,200) ↔ (Inventories +)
⇒ T(Cash-): Wages (= $9,020) ↔ (Inventories +)
⇒ T(Accrued Expenses+): Payroll-associated Fringes and Taxes (= $8,160) ↔ (Inventories +)
⇒ T(Book Value of PP&E -): Depreciation (= $7,143) ↔ (Inventories +)
⇒ T(Accounts Payable+): All Other Overhead (= $8,677) ↔ (Inventories +)
⇒ T(Inventories-): Scrapped Cases (=150 cases) ↔ (Retained Earnings -): Cost of Goods Sold

In addition, raw material use and completion of work in process may be written as follows.
⇒ T: Raw Material Use (= $171,000) ⇒T(Inventories -) ↔ (Inventories +))
(⇒ T: Completion (= $193,800) ⇒T(Inventories -) ↔ (Inventories +)

Transaction 19 Our advertising agency submits a bill for designing, printing and mailing 4,500 very fancy brochures for a $38,250 total cost.The T-shirts cost $6.50 each for a total of $65,000 for 10,000 shirts. Book these

amounts (totaling $103,250) as an AppleSeed Enterprises marketing and selling expense.
⇒ T(Accounts Payable+): Sales & Marketing (= $103,250) ↔ (Retained Earnings -): Operating Expenses

Transaction 20 Receive order for 1,000 cases of applesauce at a selling price of $15.90 per case. Ship product and send a $15,900 invoice to the customer. Book on the *Income Statement* the 2% commission ($318) for our broker as a SALES & MARKETING expense.
⇒ T: Customer Order (= 1,000 cases) ⇒ (Retained Earnings +): Revenues ↔ (Accounts Receivable +): Net Sales
⇒ (Inventories -): Shipment (= $10,200 for 1,000 cases) ↔ (Retained Earnings -): Costs of Goods Sold
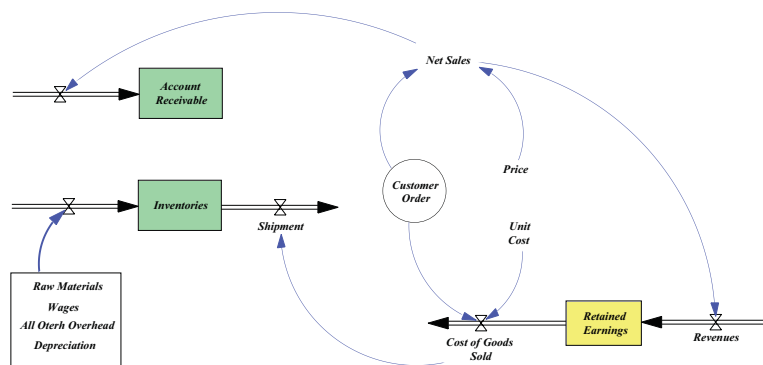⇒ T(Accrued Expenses+): Sales & Marketing (= $318) ↔ (Retained Earnings -): Operating Expenses

Figure 7: Double Transactions caused by Customer Order

Transaction 21 Receive an order for 15,000 cases of applesauce at a selling price of $15.66 per case, $234,900 for the total order.
Note: Receiving an order has no effect on the three major financial statements. Only when the product ordered is shipped to customers do you record a SALE and the associated COST OF GOODS SOLD.
⇒ (Backlog +): Order

Transaction 22 Ship 15,000 cases of applesauce and send a $234,900 invoice to the customer.
⇒ T: Customer Order (= 15,000 cases) ⇒ (Retained Earnings +): Revenues ↔ (Accounts Receivable +): Net Sales
⇒ (Inventories -): Shipment (= $153,000 for 15,000 cases) ↔ (Retained

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Earnings -): Costs of Goods Sold

⇒ T(Accrued Expenses+): Sales & Marketing (= $4,698) ↔ (Retained Earnings -): Operating Expenses

Transaction 23 Receive payment of $234,900 for shipment that was made in Transaction 22. Pay the broker his $4,698 selling commission.

Note: A customer's cash payment for goods in no way changes the *Income Statement*. The *Income Statement* recorded a sale when first, we shipped the goods, and second, the customer incurred the obligation to pay (our accounts receivable).

⇒ T(Cash+): Accounts Receivable Paid (= $234,900) ↔ (Accounts Receivable -)

⇒ T(Cash-): Accrued Expenses Paid (= $4,698) ↔(Accrued Expenses -)

Transaction 24 Write off the $15,900 accounts receivable that was entered when you made the 1,000 case shipment. Also, reduce the amount payable to our broker by what would have been his commission on the sale. If we don't get paid, he doesn't either !

Note: Our out-of-pocket loss is really just the $10,200 inventory value of the goods shipped. Remember that in Transaction 20 we booked a profit from this sale of $5,382 – the $15,900 sale minus the $10,200 cost of goods minus the $318 selling commission. Thus, if you combine the $15,582 drop in RETAINED EARNINGS booked in this transaction plus the $5,382 increase in RETAINED EARNINGS from Transaction 20, you are left with our loss of $10,200 from this bad debt.

⇒ T(Accounts Receivable-): write-off (= $15,900) ↔ (Retained Earnings -): Operating Expenses

⇒ T(Accrued Expenses +): Sales & Marketing (= $-318) ↔ (Retained Earnings -): Operating Expenses

Transaction 25 With this transaction we will pay a full year's insurance premium of $26,000, giving us three months' prior coverage (the amount of time we have been in business) and also coverage for the remaining nine months in our fiscal year.

Note: As time goes by, we will take this remaining $19,500 as an expense through the *Income Statement*. The transaction at that time will be to book the expense in the *Income Statement* and at the same time lower the amount of PREPAID EXPENSE in the *Balance Sheet*.

⇒ T(Cash -): Insurance Premium (= $26,000) ↔ (Prepaid Expenses +)

⇒ T(Prepaid Expenses -): Insurance Premium Paid (= $6,500) ↔ (Retained Earnings -): Operating Expenses

Transaction 26 Make a quarterly payment of $25,000 in principal and also a $25,000 interest payment on the building mortgage.

⇒ T(Cash -): Current Debt Paid (= $25,000) ↔ (Current Portion of Debt -)

$\Rightarrow$ T: Principal Payment (= \$25,000) $\Rightarrow$ (Long-Term Debt -) $\leftrightarrow$ (Current Portion of Debt +)

$\Rightarrow$ T(Cash -): Interest Expenses (= \$25,000) $\leftrightarrow$ (Retained Earnings -)

Transaction 27 Pay payroll taxes, fringe benefits and insurance premiums. Write checks to the government and to insurance companies totaling \$18,480 for payment of withholding and FICA taxes and for payroll associated fringe benefits.

Note: The Income Statement and RETAINED EARNINGS are not affected by this payment transaction. Because AppleSeed runs its books on an accrual basis, we already "expensed" these expenses when they occurred – not when the actual payment is made.
$\Rightarrow$ T(Cash -): Accrued Expenses Paid (= \$18,480) $\leftrightarrow$ (Accrued Expenses -)

Transaction 28 Pay suppliers a portion of what is due for apples and jars. Cut a check for \$150,000 in partial payment.
$\Rightarrow$ T(Cash -): Accounts Payable Paid (= \$150,000) $\leftrightarrow$ (Accounts Payable -)

Transaction 29 Book a series of entries in the Income Statement, Cash Flow Statement and the Balance Sheet summarizing transactions that take place in the remaining nine months of AppleSeed Enterprises' first fiscal year.
($\Rightarrow$ Transaction Items are not specified in the book!)

Transaction 30 On a pretax income of \$391,687 AppleSeed owes 34% in federal income taxes (\$133,173), and \$6,631 in state income taxes for a total income tax bill of \$139,804. We will not actually pay the tax for several months.
Income tax is calculated as Income before tax times Income tax rate of 34%, and built in the program.
$\Rightarrow$ (Income Tax Payable +) $\leftrightarrow$ (Retained Earnings -)

Transaction 31 Declare and pay a \$0.375 per share dividend to AppleSeed's shareholders. (With 200,000 shares outstanding, this dividend will cost the company \$75,000.)
$\Rightarrow$ T: Par Share Dividend (= \$0.375 per share) $\Rightarrow$ (Cash -): Dividends Paid to Stockholders $\leftrightarrow$ (Retained Earnings -): Dividends

Modeling corporate financial statements are now completed. They consists of Income Statement (Figure 4), Inventories (Figure 6) and Cash Flow Statements (Figures 8 and 9). The reader can connect six arrows in Cash Flow Statements to see how the double entry rule of bookkeeping is modeled.
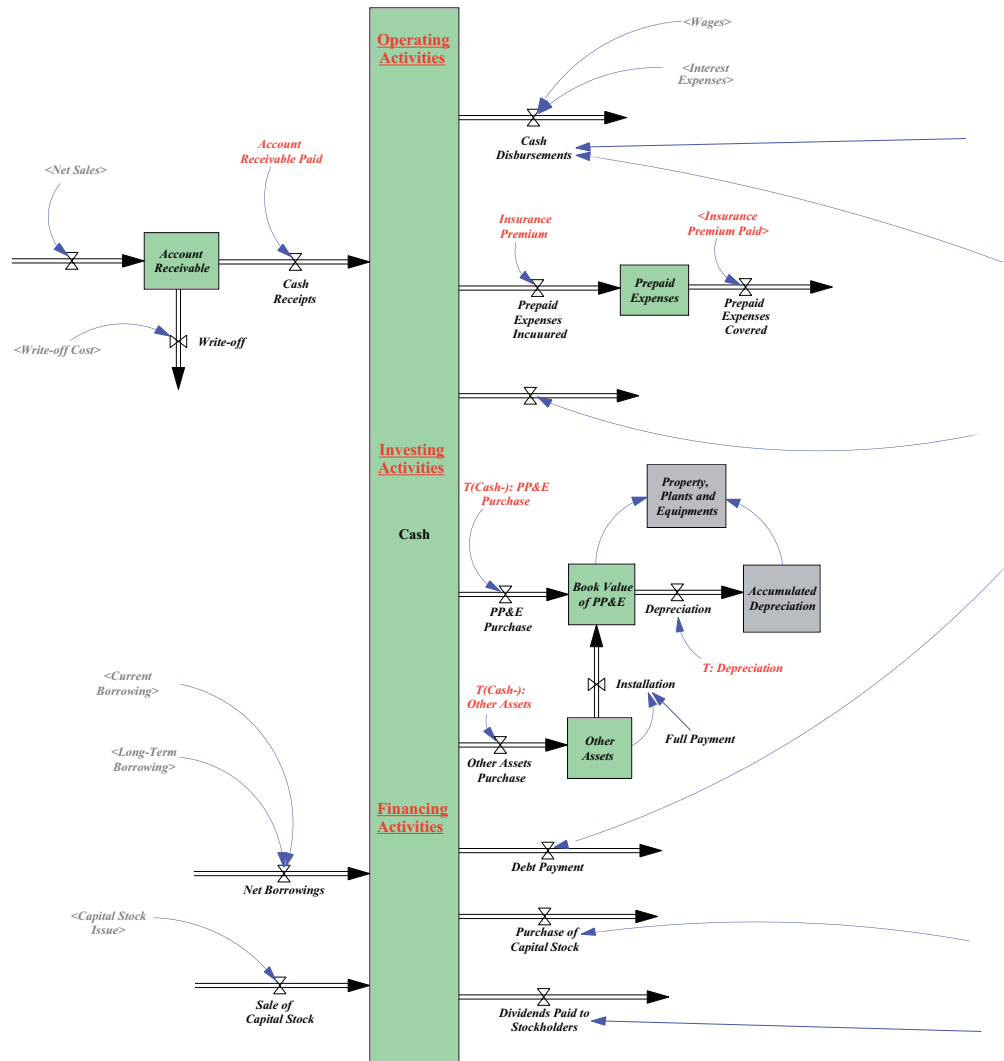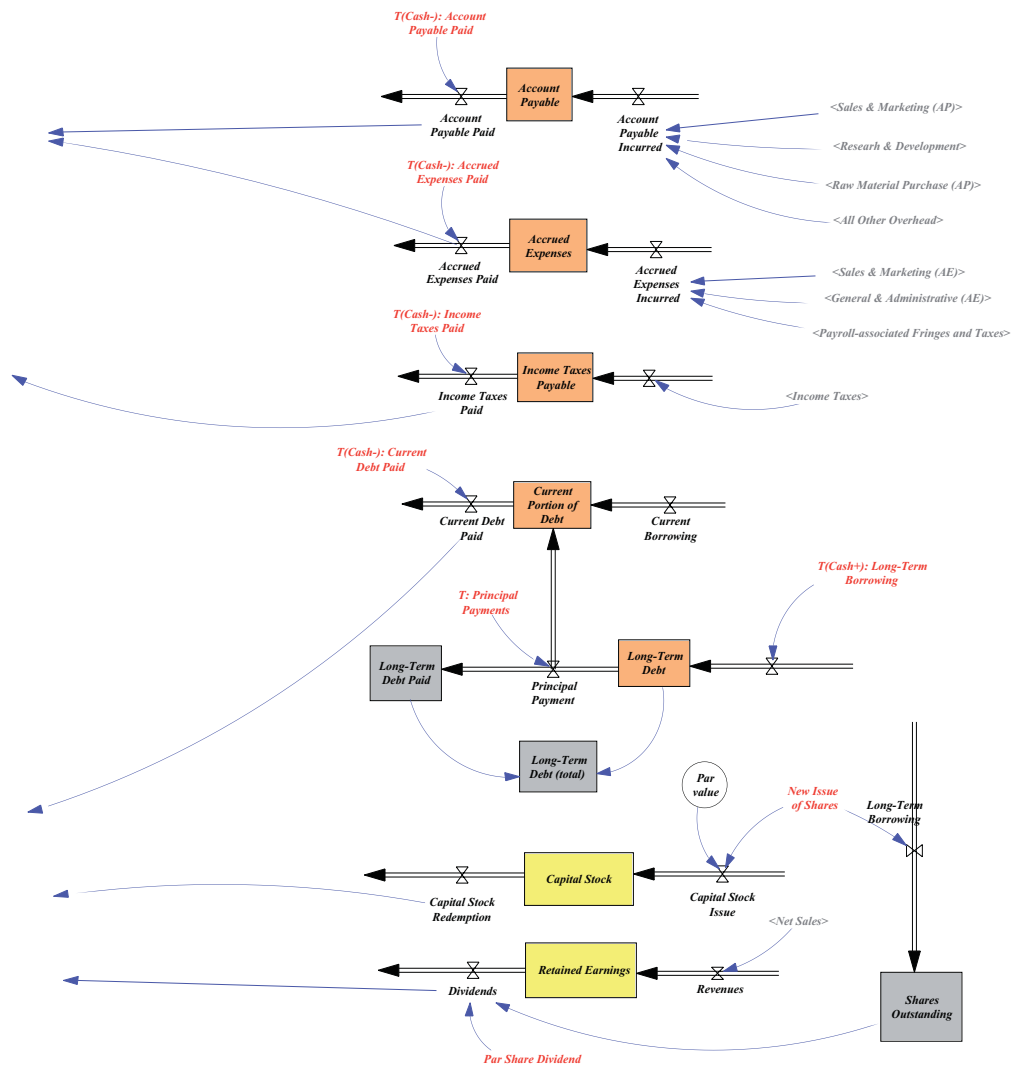
Figure 8: Cash Flow Statement

Figure 9: Cash Flow Statement (Continued)

5   Making Financial Statements

Transactions given in the book [3] are not arranged as monthly data. To run the SD model, those data need to be reinterpreted as monthly data. For instance, Transaction 5 has to be regarded as the one in the 5th month. This is what is assumed here for the SD modeling.

There are two methods to import transaction data into the model. They could be put in the table functions, whose names are given in the list of Figure 10. Almost half of the names in the list are related with the stock: Cash. This is

Cash (Receipts)

T(Cash+): Account Receivable Paid

T(Cash+): Long-Term Borrowing

T: Principal Payments

T: New Issue of Shares

T: Par Share Dividend

Cash (Disbursements)

T(Cash-): Wages

T(Cash-): PP&E Purchase

T(Cash-): Other Assets

T(Cash-): Account Payable Paid

T(Cash-): Accrued Expenses Paid

T(Cash-): Current Debt Paid

T(Cash-): Income Taxes Paid

T(Cash-): Insurance Premium

T(Cash-): Interest Expenses

Account Receivable

T: Customer Order

Data: Price Change

T(AR): Write-off Cost

Inventories

T: Production

T: Completion

T: Depreciation

T(Inventories): Scrapped Cases

Prepaid Expenses

T(PE): Insurance Premium Paid

Account Payable

T(AP): Raw Mateial Purchase

T(AP): All Other Overhead

T(AP): Sales and Marketing

T(AP): Research and Development

Accrued Expenses

T(AE): Payroll-associated Fringes and Taxes

T(AE): Sales and Marketing

T(AE): General and Administrative

Figure 10: List of Transaction Data

because all transactions in a market economy need to be eventually paid in cash, and cash-related transactions constitute a large portion of transactions. Hence, Cash becomes the largest group among the primary stocks to be changed. The other major groups are related with the transactions by credits such as Accounts (Receivable or Payable), and (Prepaid or Accrued) Expenses. Transaction data in Figure 10 are arranged to reflect these facts.

Alternatively, transaction data could be prepared outside the model as those of spreadsheet such as Excel, then imported to the model. There are quite a few accounting software on the market that enable to keep recording daily trans-

Time(Month)	1	5	10	15	20
Cash	50,000	1.046M	776,260	747,240	588,220
Accounts Receivable	0	0	0	0	0
Inventories	0	0	0	385,400	577,970
Prepaid Expenses	0	0	0	0	0
Current Assets	50,000	1.046M	776,260	1.132M	1.166M
Other Assets	0	0	0	0	0
Book Value of PP&E	0	1.5M	1.75M	1.742M	1.735M
Assets	50,000	2.546M	2.526M	2.875M	2.901M
Accounts Payable	0	0	0	341,077	469,204
Accrued Expenses	0	2,860	2,160	10,320	18,480
Current Portion of Debt	0	100,000	100,000	100,000	100,000
Income Taxes Payable	0	0	0	0	0
Current Liabilities	0	102,860	102,160	451,397	587,684
Long-Term Debt	0	900,000	900,000	900,000	900,000
Capital Stock	50,000	1.55M	1.55M	1.55M	1.55M
Retained Earnings	0	-6,230	-25,900	-25,900	-135,780
Shareholders' Equity	50,000	1.543M	1.524M	1.524M	1.414M
Liabilities & Equity	50,000	2.546M	2.526M	2.875M	2.901M

Table 5: Balance Sheet Table

actions. These booked data are later classified as ledgers of items to construct balance sheet. Using spreadsheet such as Excel, therefore, it may not be hard to import them to the SD model as the data of inflows and outflows as shown in the list in Figure 10. The SD model could then become an alternative accounting software. Moreover, it could become a better one as a financial analysis tool as shown in the next section.

In fact, balance sheet in Table 5 is constructed by using the data given in Figure 10 (or alternatively by importing them as spreadsheet data). Due to a limitation of space, only figures of five different months among 31 months are shown here. Income statement and cash flow statement can be procured in a similar fashion.

6   Ratio Analysis of Financial Statements

Structure of the corporate financial model developed above is very static in the sense that accounting system is merely to keep records of all transactions of the past business activities. In other words, transaction data are just imported to the inflows and outflows of the model as the outside parameters. In this sense, accounting system is not a SD system. To be a truly dynamic SD system, information for dynamic decision-making needs to be obtained within the system through the information feedback loops as depicted in Principle 3.

In the accounting system, balance sheet could become a main source of in-

formation from which many important feedback loops originate for management strategies and policies. Traditional method of obtaining such feedback information is a so-called financial ratio analysis. In the book [3], eleven such ratios are defined and grouped into four types as follows.

Liquidity Ratios

$$\text{Current Ratio} = \frac{\text{Current Assets}}{\text{Current Liabilities}}$$

$$\text{Quick Ratio} = \frac{\text{Cash} + \text{Accounts Receivable}}{\text{Current Liabilities}}$$

Asset Management Ratios

$$\text{Inventory Turnover} = \frac{\text{Cost of Goods Sold}}{\text{Inventories}}$$

$$\text{Asset Turn Ratio} = \frac{\text{Net Sales}}{\text{Assets}}$$

$$\text{Accounts Receivable Turnover} = \frac{\text{Net Sales}}{\text{Accounts Receivable}}$$

Profitability Ratios

$$\text{Return on Assets (ROA)} = \frac{\text{Net Income}}{\text{Assets}}$$

$$\text{Return on Equity (ROE)} = \frac{\text{Net Income}}{\text{Shareholders' Equity}}$$

$$\text{Return on Sales (Profit Margin)} = \frac{\text{Net Income}}{\text{Net Sales}}$$

$$\text{Gross Margin (Gross Profits)} = \frac{\text{Gross Margin}}{\text{Net Sales}}$$

Leverage Ratios

$$\text{Debt-to-Equity} = \frac{\text{Current Portion of Debt} + \text{Long-Term Debt}}{\text{Shareholders' Equity}}$$

$$\text{Debt Ratio} = \frac{\text{Current Portion of Debt} + \text{Long-Term Debt}}{\text{Assets}}$$

In SD modeling, these ratios can be easily calculated for financial analysis as illustrated in Figure 11. For instance, Returns on Assets (ROA) and Equity (ROE) are illustrated as in Figures 12.
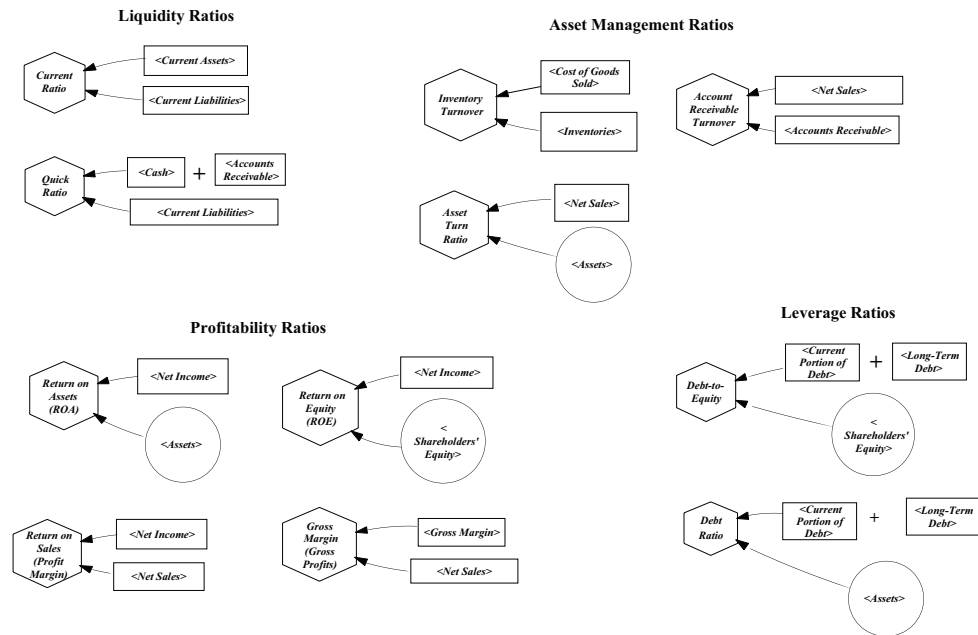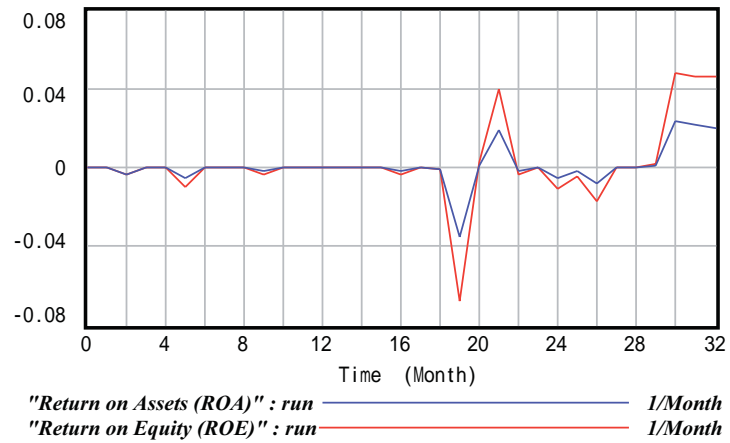
Figure 11: Ratio Analysis Diagram

Figure 12: Returns on Assets and Equity

7 Toward A Corporate Archetype Modeling

Balance sheet represents a whole system of financial activities for corporations, and managers have to rely on the information obtained within the system for their strategies and policies. Liquidity ratios, asset management ratios, profitability ratios and leverage ratios presented in the previous section provides essential indices of management strategies and financial policies. In other words, stocks in the balance sheet provide very important sources of information for corporations. From system dynamics viewpoint, the use of such information is nothing but establishing feedback loops from the sources of information (that is, stocks in the balance sheet) to the inflows and outflows. In this sense, 11 ratios illustrated in Figure 11 could be important parts of system feedback loops. With the introduction of such feedback loops, our corporate financial model could become a relatively closed system and provide a wholistic picture of corporate dynamics.

It could be inferred, however, that such traditional ratio analysis is not the only method for managers to extract managerial information. For instance, a discrepancy between net cash flow and net income, as illustrated in Figure 13, could be another important source of information for better liquidity management. In this way, a lot of essential information could be derived within the SD accounting system, depending on the objectives of management.
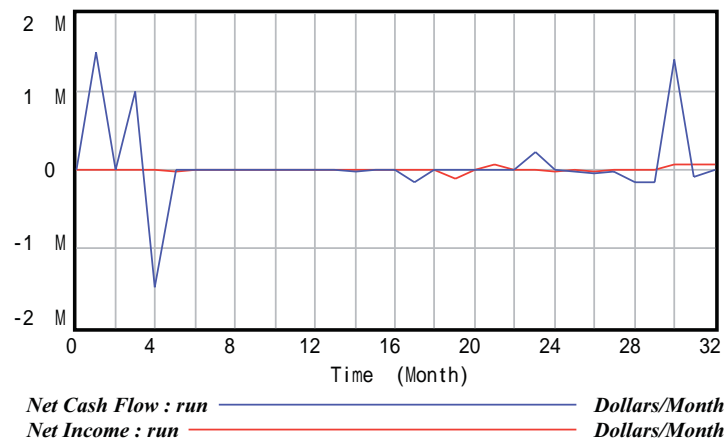

Figure 13: Net Cash Flow and Net Income

What kind of information feedback loops, then, need to be built and how? Learning the current accounting system merely gives us no clue. In order to incorporate information feedback loops, we have to know how decisions on transactions such as the ones considered in section 4 are made. The introduction of appropriate feedback loops, in this sense, depends on the types of business

activities of corporations. Only when such decision-making processes are specifically incorporated into our corporate financial model, it becomes a truly SD accounting model.

Even so, as long as modern corporations are part of the global market economic system, there could be generally accepted rules of drawing financial information feedback loops to make our SD model a truly corporate financial model. Such a model, if constructed, could be a corporate business archetype. In this sense, our research here is nothing but a beginning, though an important start, toward a truly corporate archetype modeling. This will be our task to be challenged in the near future.

Conclusion

We have demonstrated how to construct a SD model of corporate financial statements such as given in the book [3], by establishing the principle of accounting system dynamics (PASD) that consists 5 principles obtained from system dynamics and accounting system. It is shown that cash flow statement is indispensable, contrary to the practice that it has been long neglected in the Japanese financial statements. The model is shown to be static in the sense that all transaction data are given as parameters outside the system and no information obtained from the stocks in the balance sheet is utilized for better management practices - a limitation of the current accounting system. To make it a truly dynamic SD model, information feedback loops have to be incorporated in it.

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