The Banking System: a System Dynamic Profile

By Douglas Franco
UCLA, Apartado 400
Barquisimeto,Venezuela

ABSTRACT

This is a report of several applications of System Dynamic Methodology to banks, with particular emphasis given to their structure and their Decision Making in terms of System Dynamic concepts. Aplications range from policy design and long term planning to the design of Decision Support Systems. The first part presents relationships between money flows and accounting information. Next, some policy design results are presented. Later on, the estimation of the parameters of the SD model is transformed into the heart of a Decision Support System.

INTRODUCTION

The first part presents the Relationships between the money flows and the accounting information. Next, some policy design results are presented. At the beginning, it was desired to build a SD model to be used as tool for designing consistent policies to respond to balance sheets and external pressures. After this experience the Bank officials were interested in using the model for short and medium term planning. Therefore, using the advice of James Lyneis (1981,p.204-213) more details were added, and the model was able to represent the bank in a wide range of scenarios. The model parameters were fine-tuned to fit historical data . The model proved to be more effective than the several statistical models that were in use, at the time, by the bank mainly because the SD model was able to filter out some of the noise present in the data. Besides, its structure resists abrupt changes in the interest rates, money devaluation, and government monetary regulations. Therefore, the model has shown robustness. But, in order to use the model in planning, an online updating of parameters was necessary. An information system was build which working with the accounting system, was able to update the parameters. Typical parameters are: cost of money, average maturity of loans, deposits, smooth average of inputs and outputs to assets and liabilities. This system required a lot of time and effort to develop, and it was thought to be one of the major drawbacks of using SD as a planning tool. Six months later, the model was used only a few times because its usefulness decreased once the main policies were designed. But the decision makers were still using the parameters of the model to feed their own mental models. Therefore, the routines to estimate the parameters of the SD model were the heart of a Decision Support System. A summary of such a system is provided. The dynamic diagrams were converted into tools for integrating and improving the data processing services, because, the MIS are built to fit a specific way of management, to give the information required by their policies for the firm. If you change the policies and the management structure, a typical result of an SD experience, then the MIS should be adapted to the new management style. The information required to feed the new policies should be available at the points where it is needed.

DYNAMIC STRUCTURE OF A FINANCIAL INSTITUTION

This section describes a typical financial institution. In those institutions the customers deposit their money which is accumulated into different levels called liabilities. That money is then invested in different sectors, called assets. The money allocation among those sectors is a typical portfolio kind of investment where the risk and profitability of the different alternatives is considered.

The names of the assets and liabilities vary from one financial institution to another, but they are essentially the same as has been shown by Low (1977, p.27-125).

The numerical values of the leves of accumulated deposits and the levels of accumulated investments are recorded in the Accounting Balance Sheets as shown in Figure 1.

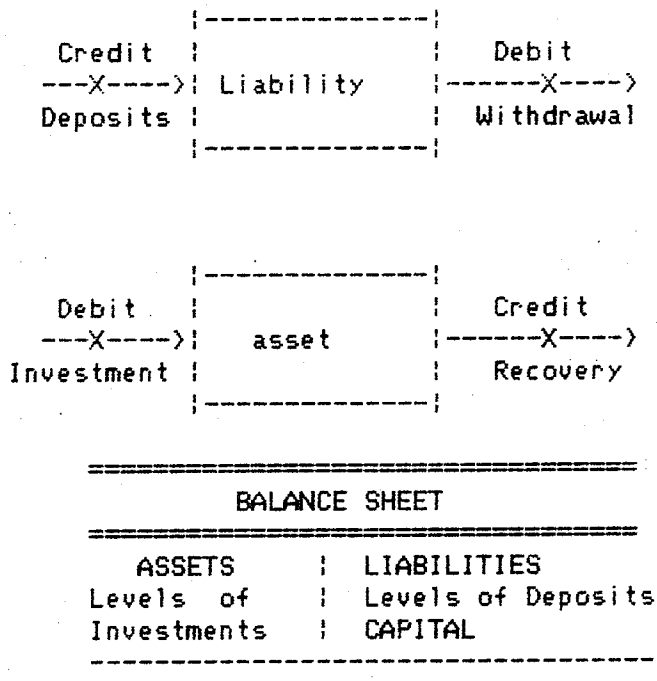

Figure 1. System Dynamic of Accounting.

The assets produce, through interest rates, the financial income which is an input to Superavit. Figure 2 illustrates the structure of this interaction.

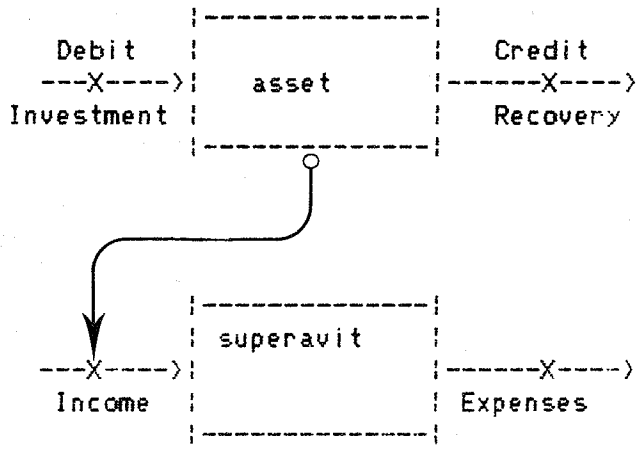

Figure 2. The assets produce financial income.

. The Liabilities produce the main output from Superavit, which are the financial expenses. In other words, the interest paid to depositors.

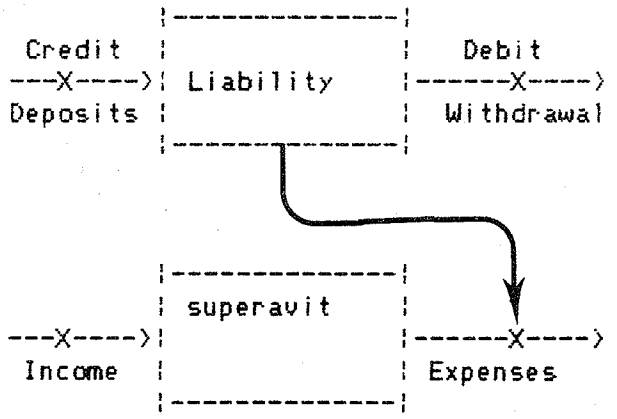

Figure 3. The Liabilities Produce Financial expenses or the cost of money.

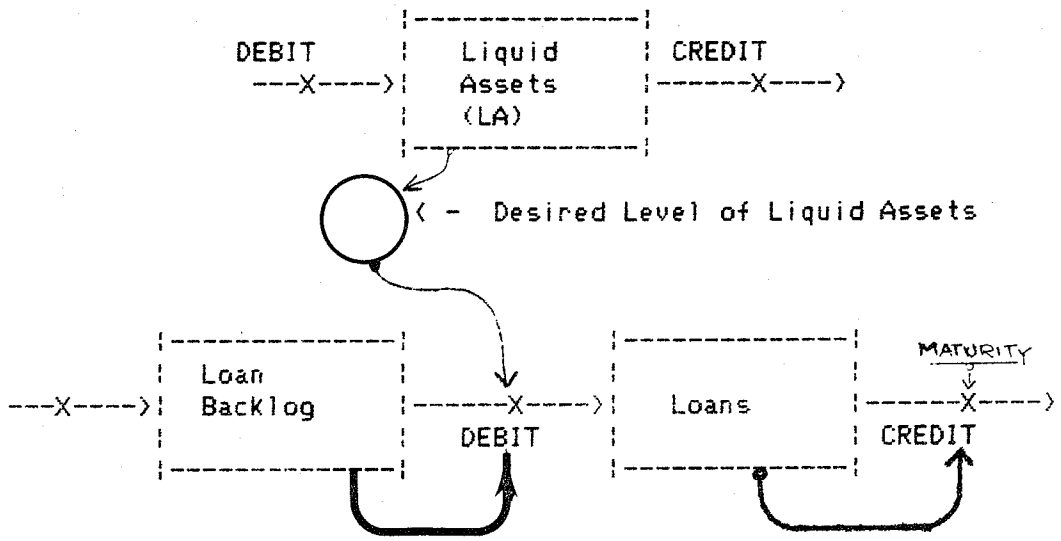

Figure 4. The Loan Extension

Some of the assets are called liquid assets, basically cash and other assets easily convertible to cash; such as government securities and other financial papers from other banks. The loans are granted responding to the loan backlog and to the level of liquid assets.

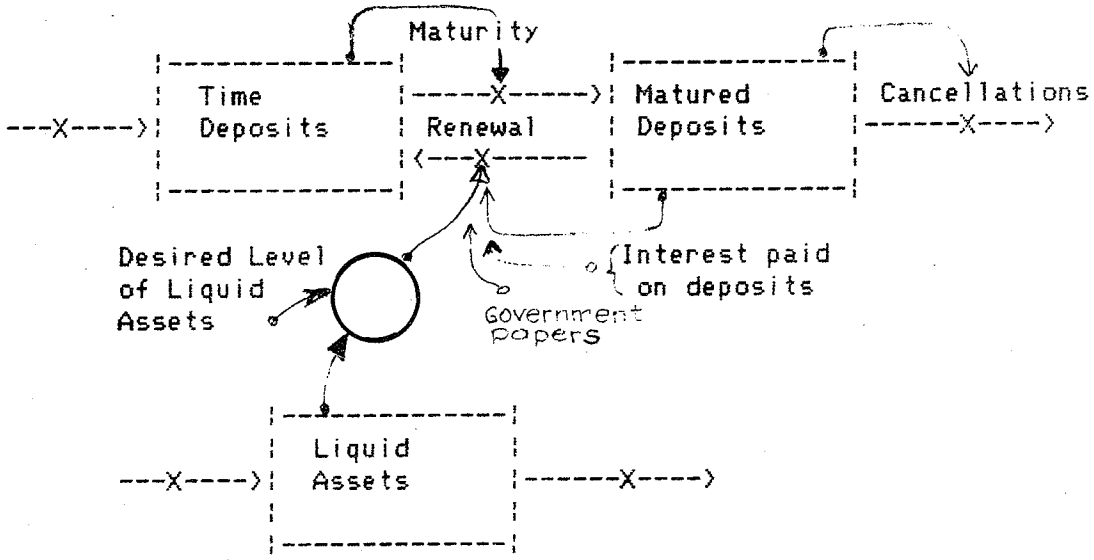

Figure 5. The deposits renewal structure.

On the Liability side, the time deposits are matured after a certain delay, usually 90, 180, 360 and 720 days. Now some of the matured deposits are cancelled and some are renewed. The rate of renewal depends upon the interest rate related to the market interest rate, the level of matured deposits, the availability of liquid assets and the ratio between the loan backlog and the desired loan backlog. The attraction of new deposits is also catalyzed by the same factors. The level of loans may also influence the rate the deposits are made because some Banks give credits mainly to their depositors. Government securities compete with the bank's own papers, therefore they tend to decrease the deposits input rate.

Besides, the rate the deposits are made depends also upon the bank prestige . The bank prestige is a function of previous performance. This make a positive feedback loop between actual and future performance. (Good performance increases prestige, prestige increases deposits, deposits increase posibilities for investment, investment increases profits, profits increase performance). Most of the loans are solicited by depositors of the bank. Therefore the rate the loans are solicited depend upon the level of time deposits.

There are other interactions which represent the conservation of flows in the system.

Next, some policy design examples are presented. Counterintuitive behavior of the system has been encountered. The System Dynamic Model of the Bank provides a tool for the counterintuitive behavior of the decision makers.
One of the policies that was in force at the time the model was built, was to substitute less expensive saving deposits for more expensive time deposits, in order to decrease the cost of money. This was achieved by decreasing the interest rate paid to depositors. The model shows that this policy leads to an increase in the cost of money because the cheaper deposits were less stable than the more expensive time deposits (had a higher variance in their withdrawals). Therefore the bank has to get loans from other banks, in order to manage cash.

Later on, the federal reserve fixed a maximun top rate for the interest to be paid to depositors, because they wanted to keep the cost of money low.
The model has shown that the cost of money is increased in the short term as a result of such a measure. The reason was that the cheaper short term time deposits were renewed at this new higher, minimun rate. Besides, the more expensive time deposits remain at their actual rate until maturity.
This was a highly counterintuitive result for the bank managers. In this case the model, was used to evaluate the real impact of a Federal Reserve decision upon the bank operations.

As is usual, a LTG (Limits to Growtn) kind of shape was also encountered. It was shown that given a fixed capital, the return on equity reaches a peek, and then goes down toward an equilibriun with its environment.

This LTG was associated with the growth of the earned interest pending for collection. Such interest is an unproductive asset and it grows, under the actual collecting policies, until it equals or surpasses the capital of the bank. Once this level has been reached the initial capital stock has been transformed essentially into an account to be collected. Initially you have the yield of your equity plus the yield of your deposits. Later on, only your deposits are producing returns.

It will be beyond the scope of this paper to enumerate all the posible counterintuitive results drawn from the model, even if such a task were not intrinsically impossible. In contrast a different set of applications is presented.

It was desired to use the model in short and mediun term planning. Naturally, this is not an application considered important by a System Dynamicist in the "purist" sense of Jorge Randers mainly because the selffulfilling nature of the forecasting prophecies. But, this application was oriented toward finding the logical implications of several management decisions rather than "predicting" the future. So the intention was more in line with the scenarios experiments of the Edward Roberts group. Therefore, following Lyneis'advice (1981,p.204-213) more details were added to the model in order to capture the main variables to which middle managers respond. Besides, the model parameters(specially delays, interest rates, desired backlogs, desired level of assets, and desired level of liabilites) have to be calculated online because they vary continuously Moreover, there was a need to forecast some of them. It was found that due to the high noise that characterizes this kind of system, smoothed information of inputs and outputs (credits and debits in the accounting system) has certain constancy through the time. In addition, this financial institution was a matured institution, almost in equilibrium with its environment. In such cases the smoothed averages tend to give excellent forecasting values. The classical forcasting technique introduced by Jay Forrester in Industrial Dynamic was also used to forecast future averages of the Federal Reserve maximum loans rate.

Therefore, in order to use the model in planning an online updating of the parameters was necessary. An information system was built which, working with the accounting system, was able to update the parameters(Mainly the cost of money, average maturity of loans, average maturity of deposits, average withdrawal of deposits, average of payments, average loan extension delay, delays to submit a retarded loan to collection, average of inputs and output to assets and liabilities). This information system has required a lot of time and effort to develop. Therefore, it was thought to be one of the major drawbacks of using System Dynamic as a planning tool. However, the online estimation of the parameters of the model become the heart of a Decision Support System consistent with the SD policies. The main features of this system are described next.

THE BANK DECISION SUPPORT SYSTEM

This section describes the development of a decision support system for the bank based upon System Dynamic concepts.
Management involves observing levels and transforming such information into actions upon certain rates because managers have to create the components and the interactions that make the system stable around its objectives. Sometimes, auxilliary calculations are necessary to convey the information from levels to rates. For instance, it is usual to transform a level and its level of averaged output rate into an observed delay, which affects certain other rates. In this case such management operation is typical, because it represants the calculation of average maturities of assets or liabilities.

The Accounting Information System records the inputs and outputs to every level (account) of assets or liabilities. The levels of accumulated rate of input and output in a month, are recorded in a file called the prebalance. For instance, this file, tipically contains the account number, the previous balance, the debits, credits and actual balance on any month.

ACCOUNT NUMBER	PREVIOUS BALANCE	DEBIT	CREDIT	ACTUAL BALANCE
170601	2,225,000.00	28,000.00	87,000.00	2,166,000.00

Naturaly the maturity of the account (level), will be the previous balance divided by the acumulated rate. This calculation can be made even more precise by using the average of the previous and the actual balance in the month, or by any other more precise calculation.

The interest rate produced or consumed by any account(level) is also recorded as another account level: Expenses and Income accounts respectively.
Therefore you can calculate the actual average rate by the appropiate use of such information.

In synthesis, the Accounting system has a file which is called the prebalance. This file contains the information about the actual values of the levels and the actual values of the accumulated input and output rates in the month(Credits and Debits) . From the information contained in that file the following information can be produced :

1) A list of the levels of the different assets and liabilities, the smoothed averages of input and output rates, the yield and cost of each of them, the nominal and real maturity, the renewal percentage, and almost any function of the previous information.

2) A collection of Performance indices is also produced. This includes the yield and the cost of money, the relation between real maturity of liabilities and real maturity of assets (stability index), the average delay to grant loans, desired levels of liquidity, desired backlog of loans, and many other functions of the values of the rates and levels. Those performance indices where part of the feedback required by the System Dynamic model to manage the system. Those indices are not the ones that tipically come with the Management Information Systems (MIS) used by Banks. The MIS come with their own implicit management policies . This implicit management may create instabilities and other management problems in the firm. John Morecroft(1979a, p.35, 36; 1979b, p.3-25,218-224) has done extensive and illustrative research in thir area, especially for the Material Requirement Planning computer package. The conclusion of Morecroft's studies is that there is a need to adapt the Management Information System in oder to feed the data required by the System Dynamic policies in the points where they are needed . If not, the MIS will impose its own management style. So there is a need to represent System Dynamic models in terms of MIS notation. It has been found that the notation presented by Gane and Sarson(1979,p.25-47) is convenient to achive such a goal. In simplified terms, the levels of material and information flows are transformed into files. The rates are transformed into processes. The auxilliares will be auxililiary processes. Figure 7 shows this transformation in graphical form.

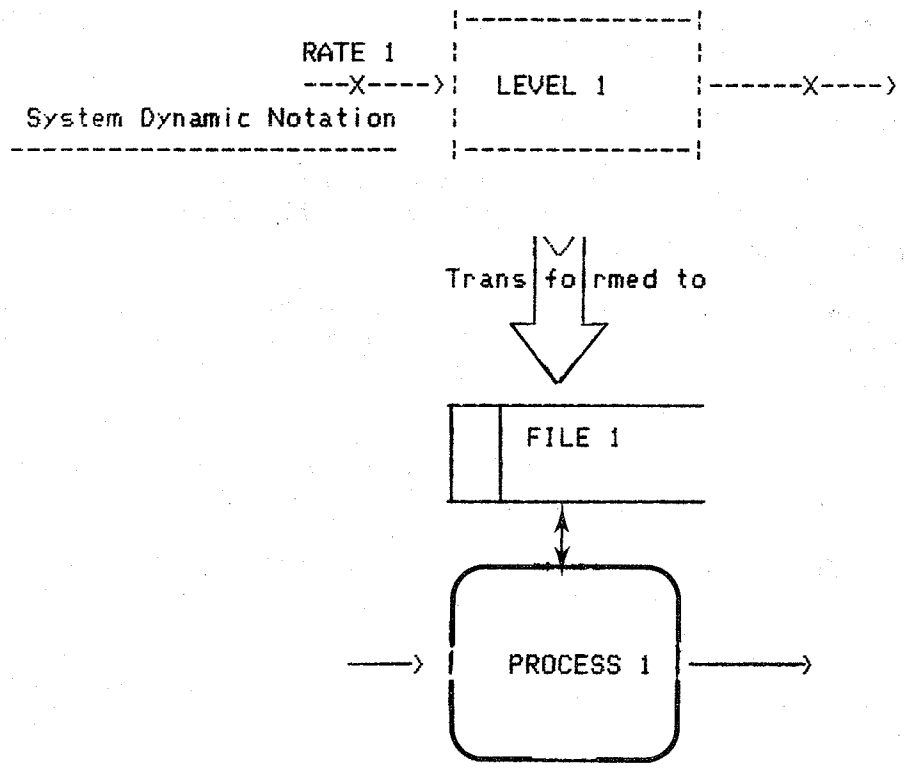

Figure 6 . From System Dynamic to Gane and Sarson Notation

Once the SD model is expressed in terms of MIS notation , then both structures are easily compared and the adaptations can be designed.

CONCLUSION

As a final statement it can be said that System Dynamic can capture the structure of a bank, much better than many other modeling approaches, as it had been shown by Gilbert Low(1977,p. 27-125). This particular application adds a new confirmation to the Low findings. Besides, the SD models can find a more permanent place in the organization if they are expressed in terms that are more understandable by Decision Makers, especially if the policies that are designed in the SD experiments are incorporated in the planning system of the firm. Usually, this requires adding more details to the model in order to represent the structural disagregation required to reach the medium level managers . Besides, it requires the "fitting" or the calculation of the parameters of the model online with the Management Information System. Lyneis and Morecroft have done extensive studies of this transition. Practical hints to implement their findings have been suggested in this paper.

REFERENCES

Gane Ch., Sarson T. " Structured System Analysis. Tools and Techniques ". New York: Prentice Hall, 1977.

Herrick, Tracy " Bank Analyst Handbook ". New York : J. Wiley, 1977

Low, Gilbert " Finantial Market Dynamics : an analysis of credit extension and saving allocation " Unpublished PhD dissertation . Cambridge , Mass: MIT, 1977

Lyneis, James " Increasing the effectiveness of corporate policy models " . Proceedings of the 1981 System Dynamic Conference . Cambridge Massachusets. MIT, 1981

Morecroft, John " Influence From Information Technology on Industry Cycles. Unpublished PhD dissertation . Cambridge: MIT, 1979

Morecroft, John " An Evaluation of Material Requirements Plannig using Industrial Dynamics ". Cambridge, Mass: System Dynamic Group D-Memo 3131. MIT, 1979

Senge, Peter. "The National Model Investment Function ". Unpublished PhD dissertation. Cambridge, Mass: MIT, 1978.