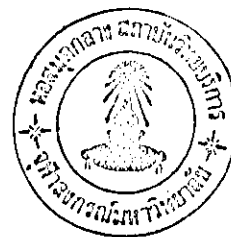


CHAPTER I

INTRODUCTION



1.1 Background

Money is a medium of exchange for goods and service. The most important form of money is banknote. In Thailand, the Bank of Thailand (BOT) is the institution which is responsible for administrating banknote circulation. Some banknotes can be recirculated. Others, which are too old, soiled or damaged, may have to be replaced with new prints. Note printing is done by the Note Printing Works of the BOT. The value of new banknotes required to be issued is an important information for planning of printing new notes. Therefore, proper value forecasts of requirements of new banknotes are essential. The objective of this research is to present a methodology to forecast value of issued banknotes.

1.2 Current Situation

There are three parties involved in banknotes production, i.e., the Economic Research Department, the Issue Department and the Note Printing Works. Figure 1.1 shows how they work.

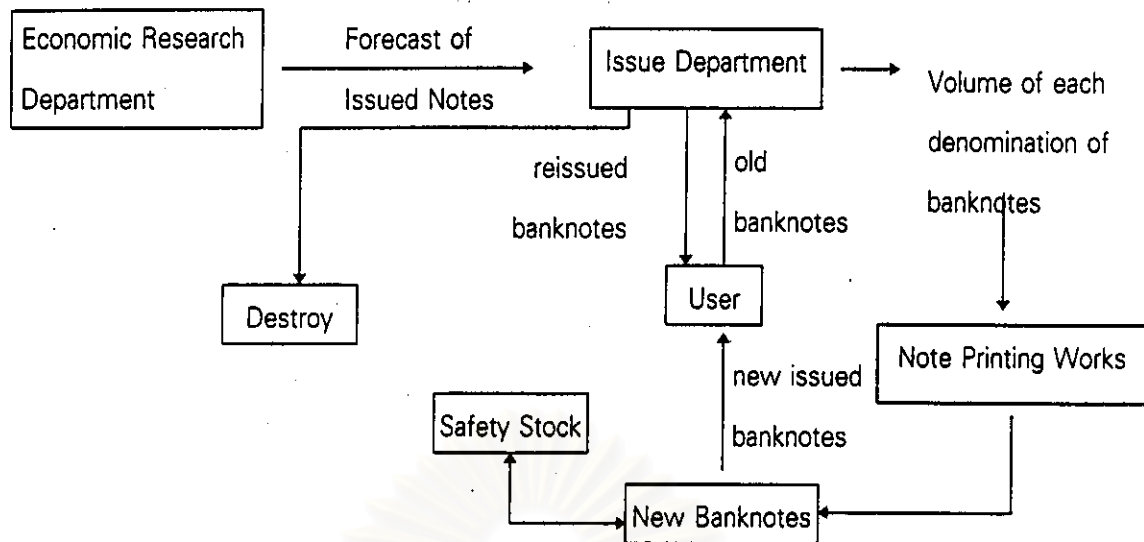


Figure 1.1 - Banknotes Production Process

Firstly the Economic Research Department forecasts all denominations of banknotes in circulation in overall value which is approximately equal to value of issued banknotes. The forecasts are based on GDP and the saving deposit rate. The figures are brought to the Issue Department to divide overall amount into each denomination of banknotes. The division is done manually with past experiences. Finally, the Issue Department gives the requirements of banknotes to the Note Printing Works to print.

After banknotes are issued to the system. They will circulate back to the BOT. Then their conditions will be determined whether they are still fit to use. If they are not, they will be destroyed. Those that are still usable will be reissued into the system.

The Economic Research Department involves with managing all economic information including forecasts of banknotes in circulation. It uses the Regression Analysis technique to forecast banknotes in circulation for Issue Department. The forecasting model is as follows:

$$\ln VN = -2.33 + 0.99 \ln GDP - 0.02 RS - 0.05 D8586 \quad (1.1)$$

$$\ln M1 = 0.03 + 0.52 \ln GDP - 0.02 RS - 0.08 D8586 \quad (1.2)$$

where VN = value of notes in circulation,

GDP = gross domestic product at the current price (million baht),

RS = saving deposit rate and

D8586 = dummy variable involving the existence of ATM during 1985-1986

M1 = the narrow definition of money which consists of banknotes, coins and demand deposit excluding money in the Central Bank and the Ministry of Finance.

The Issue Department is responsible for managing and supervising the currency operations. Its major operations consist of procurement, issuance, inward and outward exchange, storage, cancellation, destruction and verification of banknotes. Those operations must comply with the relevant laws, regulations, rules, orders and procedures. In addition, the Issue Department is also managing the Currency Reserves, the yield of the Currency Reserves, and the Special Reserves Account.

The involvement of the Issue Department in banknotes printing is to classify each denomination of banknotes and order the Note Printing Works to print. The annual orders are usually given six months before the actual printing starts.

The major responsibilities of the Note Printing Works are the printing of all denominations of Thai banknotes and other valued documents as specially requested by governmental agencies.

1.3 Statement of the Problems

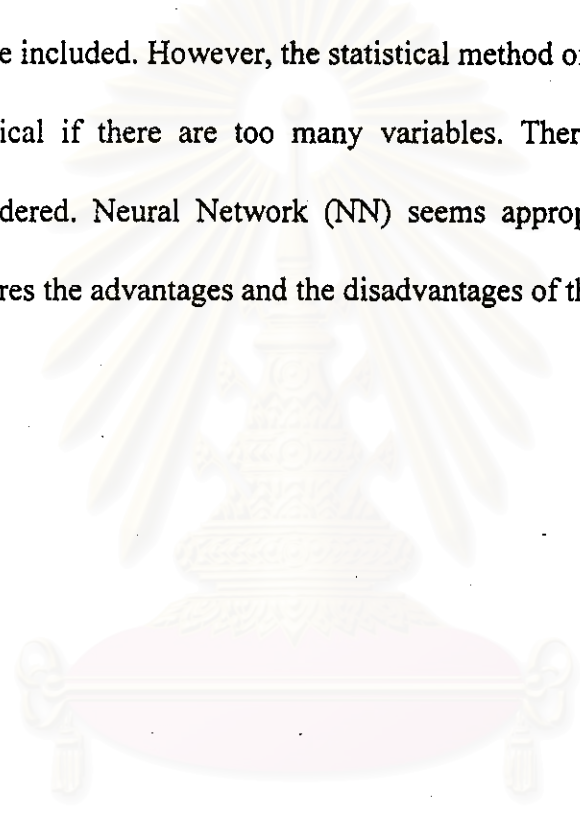
From interviews with officers at BOT, it is found that forecasts of new banknotes requirements should be improved. The forecasts at the beginning of the year resulting from the model described in equation (1.1) and (1.2) and the actual notes in circulation in the year between 1993 and 1996 are compared in Table 1.1. The errors range from -2.45 % to 4.72 %. Even the percentages of error are quite small, the error in terms of value are tremendous.

**Table 1.1 - Comparison of Actual New Issued Banknotes
with Forecasts by the BOT**

Year	Forecast (Millions of Baht)	Actual (Millions of Baht)	Error (Percentage)
1993	240,990.35	235,221	-2.45
1994	275,134.97	279,240	1.47
1995	317,050.22	323,148	1.89
1996	354,069.77	371,620	4.72

The model described above has some flaws. It does not take into consideration the consequences of banknotes already in the system. In addition, if new prints are not sufficient to supply the system, BOT will recirculate more of the old notes. Hence the recirculation should be included in forecasting the new issued banknotes.

For the forecast of the new issued banknotes to be more accurate, several more factors have to be included. However, the statistical method of regression analysis will become impractical if there are too many variables. Therefore, other approaches should be considered. Neural Network (NN) seems appropriate for this situation. Table 1.2 compares the advantages and the disadvantages of the two methods [9].



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Table 1.2 - Comparison of Regression Analysis and Neural Network

Advantages	Disadvantages
<p><u>Regression Analysis</u></p> <ul style="list-style-type: none"> ✓ Easy to use ✓ Easier to interpret the result 	<ul style="list-style-type: none"> ✗ Limited number of variables ✗ Not proper for high non-linear data ✗ Only numerical data can be represented
<p><u>Neural Network</u></p> <ul style="list-style-type: none"> ✓ Ability to handle more variables ✓ Unlimited number of variables and more dimensions of data ✓ Behaviour of data can be detected without identifying as inputs. ✓ There is a trend that output will be more accurate. ✓ Adaptability when parameters or data are changed. 	<ul style="list-style-type: none"> ✗ Appropriate training period is unpredictable. ✗ Different NN methodologies give different output which lead to uncertainty of the best solution. ✗ It may lead to unstable condition. ✗ More difficult and complicate to apply ✗ It is difficult to get the reason why/how the network solves the problem.

In addition, using NN for training data will help to detect the behaviours of banknotes which can not be done in regression analysis. Neural network can automatically transform and represent complex and highly non-linear relationships and automatically detect different states of phenomena through independently variable data patterns and switch on/off model components as appropriate [10].

1.4 Objective of the Study

The objective of this research is to present a forecasting technique of the new issued banknotes for the purpose of planning for new prints.

1.5 Scopes of the Study

The study will be based on the following assumptions:

1. This study focuses on overall new issued banknotes. All other monetary media, such as coins, are excluded.
2. All banknotes are in circulation until destroyed by BOT. Disappearing from circulation due to reasons such as loss and collection is negligible.
3. Forecasted economic factors are based on the information from the Economic Research Department.
4. The data to be used in this study cover the period between 1989-1995.

1.6 Study Methodology

1. Study the relevant literature: forecasting, production planning, neural network and demand for money.
2. Develop a functional model of banknote circulation.
3. Design forecasting models for new issued banknote using Neural Network.

The design involves selecting proper inputs, outputs and paradigm for data training. In this study, a number of different inputs and outputs are involved. Most of them are based on backpropagation approach.

4. Write a computer program for the model developed in 3.
5. Test various parameters, such as learning rates and number of neurons, using for each model in order to obtain results with minimum errors.
6. Investigate the difference of results between the proposed approach and the regression approach.
7. Write final report.

1.7 Expected Benefits of the Study

This study can be used as an alternative methodology for forecasting the new issued banknotes where accuracy improvement is found. It also leads to further studies such as forecasting each denomination of new issued banknotes, and amount of new issued banknotes.

1.8 Organization of the Report

The first three chapters are focused on the background of the thesis while other chapters report results from applying multiple forecasting methodologies of the new issued banknotes.

Chapter I covers general information of the thesis, i.e. statement of the problems, objective of the study, scopes of the study, and so on.

Chapter II introduces the theories of neural networks, i.e. definitions, characterization of neural networks, network structure, perceptron, Widrow-Hoff algorithm, backpropagation, and so forth.

Chapter III analyzes the involvements of each organization unit responsible for banknotes issuance.

Chapter IV, V, VI, and VII reports the applications of various neural network methods to forecast the new issued banknotes. The methods are perceptron (chapter IV), Widrow-Hoff algorithm (chapter V), backpropagation (chapter VI and VII). The results obtained from these methods are concluded so that recommendations regarding the selection of appropriate models and their proper applications may be made as reported in chapter VIII.

Chapter VIII provides the conclusion and recommendations.



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