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Prediction of ATM Device's Income in Acquire Mode Using Data Mining Techniques based on Artificial Neural Networks

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Abstract:

One of the main indicators for making decision in banking area is the income of ATMs. Banks are tended to increase their acquirer incomes against the costs of an ATM which include installation, setting up and maintenance. Due to dependence of cash income on various factors such as geography and physical, ATM's income function is complex which having recognition of its behavior could leads to discovering the mathematical relation between features of an ATM device and the weights of them versus ATM's income. In this study based on artificial neural networks (ANNs) prediction model and the real data of some ATMs, a comprehensive income model presented which can approximate the income of assumptive ATM. In order to have accurate analysis and better training for ANNs, artificial methods are used to find out the correlation between ATM features and its income and also eliminate uncorrelated features. Applying these analyses will help banking organizations and institutions with making future decisions and also finding locations, situations and opportunities for presentation of ATM services to customers.

Keywords:

ATM Income, Statistical Methods, Data Mining, Artificial Neural networks, Location, Correlation

1. Introduction

Following the banking industry changes in the 2020's and the introduction of new electronic channels for delivering financial services in Iran, private banks began to establish and in a competitive market, the major banking institutions have been engaged in a process to expand electronic banking services. The most visible manifestation of this has been the ongoing and widespread installing of ATMs. The research presented in this paper is concerned with the ATM profitability. The empirical problem addressed is how sample bank in Iran can make its ATMs profitable. To do this research we select 374 ATMs as sample, the selected ATMs are installed in the Tehran metropolitan region and other cities in Tehran province. Profitability of ATMs is calculated on the basis of performance indicators that are essentially financial as well as there are some other geographical and demographical variables.

The identification of branches and other locations for installing the ATMs to earn maximum profitability is characterized by a significant spatial dimension. Decisions are based on a consideration of a number of financial and demographical information, geographical criteria and various forms of spatial analysis may be involved. A set of 21 financial, geographical, demographical and spatial variables was used to produce the research model.

The steps in the preparation of the data and the iterative procedure for implementing the research model are explained and illustrated. This involves building the initial evaluation matrix, normalizing the raw criteria scores, assigning weights to the criteria, and calculating priorities. Based on these, the ANN (Artificial Neural Network) were used to design the research model and it can show non-profitable ATMs and can help managers to relocate them to be profitable by predicting the profitability of ATMs in the new places.

Different approaches have been used to validate the initial variables, and analyze their correlation with ATMs profitability. These help identify critical variables among the 21 initial variables selected, and suggest that some of them could be deleted from the list used to generate the model.

The study successfully presents one of the ways of improvement the functionality of financial and geographical information in a model to develop a Decision Support System to aid solving decision-making problems in the banking field.

1.1. Background to the Research

The organizational structure and geography of retail banking in Iran has experience an important change during last 15 years following the introduction of new technologies in the banking sector in the 2000's. Since then, the competition between the major banks and financial institutions was increased substantially. They began to adopt with innovations in information technology that cause to introduction of a range of new and more economical channels for the delivery of retail banking services to customers.

These new services were attractive for customers in comparison with traditional services which were delivered in the bank branches. There was a lot of convenience for consumers such as time saving, no need to going to branches no waiting in bank queues and so on which made the retail banking services attractive for customers. Installing ATMs by banks and financial institutions was one of the changes in retail banking which occurred in Iran. In last 25 years and by introduction of electronic banking services there was an emphasis to reduce the banking costs to maximize the bank profitability. Electronic banking services in comparison with traditional banking services were so cheap. So the banking industry decides to change the retail banking structure and shift the services to new channels. This change in banking structure was argued in [1, 2]. They indicate that banks will shift many of banking services to new channels like ATMs and in the future there will be less need for traditional bank branches. They argue that many full- service ATMs will be installed in order to meet the customers' service needs, and other new channels will be able to deliver most of branch services. All of the major banking institutions in Iran have for some years been actively involved in implementing policies to increase the number of ATMs as well as services which are possible to deliver on them. They tried to find the market segment which will bring them more profit in this business.

According to this, banks should have greater attention on geographical (spatial) considerations in the branch opening or ATM installation decision-making process, as well as the adoption of better procedures and techniques for addressing the multi-dimensional, multi-criteria nature of the branch opening or ATM installation decision-making process. As pointed out in [3] indicates that the adoption of a more formal approach to identifying appropriate places for branch installation could enhance bank profits.

It is clear that by increasing in the competition between banks, we can expect that the banking market moves to be more customer driven. Banks focus on the customer needs, and try to response their demands in the banking services field. Obviously in the customer-oriented retail banking market, finding appropriate locations to install ATMs is one of the important challenges for the decision makers. They faced with a complex problem: how best to identify which particular locations are appropriate to install ATMs and in the ATM network which ATM should remain and which should be moved?

However electronic channels are as alternative for branches in new situation, but branches remain as one of the most important points to deliver services to customers. Bank branches are the only places in the banks that a face to face interaction between bankers and customers happens. It means that if banks decide to install ATMs near bank branches then they can earn more profit in this business. This has strengthened the importance of ATM location in banks decision-making. Against this background to the changes taking place in the retail banking services, this research focuses on investigating the way in which the integration of geographical and demographical information with financial information, to recognize were an ATM should be located to be more profitable.

It has been documented in the literature on retail banking that there are three significant aspects to the ATM location problem. The first is that it is inextricably related to the geographically and temporally dynamic nature of the demand for, and supply of, banking products and services that makes it is necessary to constantly revise competitive strategies to service customers through alternative distribution channels.

To the branch or ATM location problem there are three important aspects which has mentioned in the literature review. The first one indicates that because of a competitive nature of retail banking and fast changing in customer demands and needs for banking products and services, it is necessary to continuously revise strategies to deliver services through alternative channels. In this regard it needs to find new locations for ATMs and branches.

We will discuss the related factors to ATM installing in the next section. Obviously these variables have a strong relation with customers' spatial demands to get banking services and products. Retail banking decision makers believes that geographical parameters are very important in their business. Birkin in [4-6] argues that pioneer banks and financial institutions are seeking the ability of GIS technology as an instrument to help them in monitoring the market situations, analyze data, and produce a model to predict how they can change their business strategies to get more positive impact in their business.

Tomlin in [7] argues that by combining geographical and financial information and by integrating them in a model, a complicated tool will be produced that helps managers in storing, retrieving, analyzing, and presenting large amount of location data. The second view is decision about the locations which non-profitable ATMs should be relocated there to earn more profit. This could be another typical problem. It can be discussed that to solve this kind of problems which are related with ATM installation, banks should have a management decision instrument to integrates and analysis various financial, geographical and demographical information. This analysis leads to significant effects in operational cost reduction as well as profit maximization.

Thirdly, the branch opening and ATM installation problem are also a semi-structured one. Malczewski and Ogryczak in [8] have discussed that most of location based problems are semi-structured problems in which managerial judgments and substantive models of the decision making situation are integral elements of the location decision making process.

[9] indicates that all problems are in a range from structured through semi-structured to unstructured one. He explains that in structured problems there is a clear objective and procedures for accessing the best solution. In an unstructured problem there is no standard way to solve it, these kinds of problems are fuzzy and complicated one. A semi-structured problem is between these two extremes. Thus for solving semi-structured problems a combination of standard mathematical procedures with human judgment is needed.

Turban and Aronson in [10] discuss that for solving semi-structured problems Decision Support Systems by providing alternative solutions can enhance the quality of information which are basic for decisions. They result that it is necessary to allow decision-makers to better understand the nature of problem to make better decision.

1.2. Research Aims and Objectives

The main aim of this research is to design a model to predict any ATM profitability based on the geographical, demographical, spatial and financial specifications. In addressing this aim, the focus of the research effort is on accomplishing the following key objectives:

1. The identification of ATM location specifications including all the geographical, demographical and spatial.
2. The identification of ATM operational information including number of

transactions, operational costs and incomes in the research duration to evaluate ATMs profitability.

3. The identification of critical variables which have the most impact on ATM profitability.
4. The development of a comprehensive model to predict ATM profitability using artificial neural network.

The reminder of this paper organized as follows. In section 1 background of the research and the nature of the decision-making process relating to ATM installing is articulated, as well as developing a solution. The issues related to identifying the research aims and objectives, and clarifying the research problems based on the proposed approach to generating solutions, are presented. Section 2 is dedicated to Research Methodology and Data Analysis, the process of data gathering, data processing, finding impact variables and designing the research model using ANN. Section 3 focuses on the research results and finally in section 4 the findings of the research are summarized. The ATM profit prediction model, its capabilities and potential of the methodology developed for ATMs network management are discussed, and comments are made to help the bank managers to make bank ATMs profitable.

2. Data Analysis and Artificial Neural Network Model

This chapter presents the major aspects of the research methodology utilized in this study. In the first section the research design and survey instrument will be described. Specifically, the research population, sampling and data collection method will be defined. There is a discussion of how the constructs and variables of each construct were selected and operationalized in this study. The next section explains how the scale and the survey instrument were defined through the pretest procedures, which include a discussion of data collection and the results. Finally the issues of the designing the research model and its reliability and validity will be addressed. Figure 1 shows the steps of research methodology.

2.1. Data analysis

For the present research and in order to design a model for profitability of ATMs, all data regarding the transactions of 341 ATM units installed in province of Tehran, in a time duration of 494 days, from 21-2-2013 till 28-6-2014 was collected and analyzed.
The main characteristics of these ATMs are as follows:

- All the said ATMs have been active and working from the beginning of the duration of the research dated (21-2-2013) till the end (28-6-2014).
- All the ATMs have been installed in Tehran and the surrounding cities in the province of Tehran.

There are 5 types of transactions in Shetab network (Iran National Switch), including Cash withdrawal, balance inquiry, money transfer, bill payment and purchasing cell phone credit. Although there have been some more (to very little extent) ATM transactions, just feasible to acquirer bank cards, but as in the present research, the focus has been on the income, and as the income is not supplemented by this type of internal transactions, these few types of transactions have been omitted. For instance, transactions for account statement or changing pins (passwords), which consist less that 0.1 percent of all the ATM transactions, have not been considered in the research. Based on each of the 5 types of feasible transactions, information files of daily transactions of each ATM were collected and organized. A total of approximately 65,000,000 ATM transactions have been collected as initial data, and processed during the present research. The table 1 illustrates the quantity and percentage of each of the 5 types of transactions in the duration of this research. As it is shows, cash withdrawal has the largest share with 43.18%, and bill payment with 2.38% has the minimum share of the total transactions.

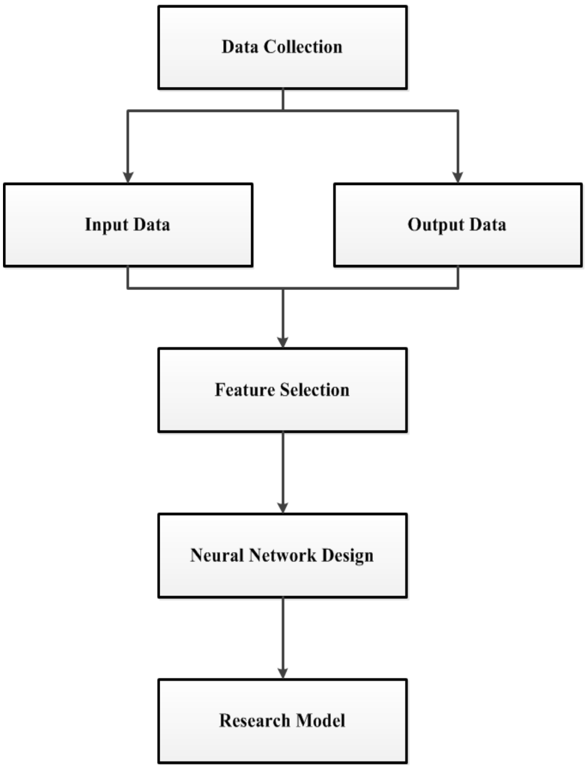

Figure1. The research methodology steps

Income of ATMs: The income of ATMs under study consists entirely of the fees received from the types of transactions (aforementioned) and based on the approved fees by Shetab Network. Considering the number of each of transactions in ATMs and the fees by Shetab Network, the income of these ATMs has been calculated. The share of each type of transactions in the total income of under study ATMs is displayed in the table 2. As it is indicated, however the number of transactions regarding checking balances has been more than transactions regarding money transfer, but the income of the latter has been four times more than the income received from balance inquiry transactions.

Table 1: Processed transaction volume

Transaction Type	Number of Transactions	Percentage

Withdrawing cash	28,038,373	43.18
Balance Inquiry	17,403,309	26.80
Money Transferring	13,471,830	20.74
Purchasing cell phone credit	4,484,650	6.90
Paying bills	1,542,507	2.38
Total	**64,940,669**	**100**

Cost of ATMs: To install each ATM, variety of expenses are paid by the bank. The costs can be varied for the two types of ATM; owned (**purchased**) or non-owned (**leased**). The factors involved in costs for each type of purchased and rented ATM are: the investment costs for ATM, cost of consumable items, service and repair expenses, depreciation expenses, expenses for telecommunication lines, the expenses for installation and setup, personnel costs and The costs for cash in ATMs. Table 3 indicates the expense-related factors, being separated regarding the two types of purchased and leased ATMs in fixed and variable categories (All the amounts are in Rials).

Table 2: Share of each transaction type in total transactions

Transaction Type	**Percentage Share in income**
Withdrawing cash	78.1
Balance Inquiry	3.9
Money Transferring	16.1
Purchasing cell phone credit	1.1
Paying bills	0.8
Total	100

As it was mentioned, the costs of the ATMs are divided into **fixed** and **variable** costs. Considering the expense variables mentioned before, the share of each variable in the costs of purchased and leased ATMs are in the table 4.

Profit of ATMs: After collecting transactions data for each ATM and applying the considered fees for them, the monthly income of each ATM is calculated. The income includes the fees earned from other banks and the fees which were saved (and didn't pay to other banks or to the Shetab) for sample bank cards transactions which were done in this bank ATMs. The amount of fixed and varied monthly costs for each ATM based on the purchased or leased type is also calculated. The profit of each ATM machine equals to (1).

$$\text{Monthly profit} = \text{monthly costs} - \text{monthly income} \qquad (1)$$

Based on the present research, 18 of ATMs were unprofitable. Meaning, their income is less than their costs.

Table 3: Cost factors

Cost type	Cost Description	Purchased ATMs	Leased ATMs
Fixed cost	Investment	1,260,417	0
	Leased	0	7,040,000
	Service & Support	4,000,000	0
	Depreciation	1,250,000	0
	Telecommunication Lines	600,000	600,000
	Installation	83,333	0
	Personnel	4,000,000	4,000,000
Variable Cost	Consumable Items	297 per Transaction	297 per Transaction
	Cash	(0.0822 * Transaction Amount)	(0.0822 * Transaction Amount)

Table 4: Share of cost factors in total cost

Cost type	Cost Description	Purchased ATMs	Leased ATMs
Fixed cost	Investment	7.0 %	0.0%
	Leased	0.0 %	42.9 %
	Service & Support	22.2 %	0.0 %
	Depreciation	6.9 %	0.0 %
	Telecommunication Lines	3.4 %	3.7 %
	Installation	0.5 %	0.0 %
	Personnel	22.2 %	24.4 %
Variable Cost	Consumable Items	18.8 %	14.5 %
	Cash	19.0 %	14.5 %
Total Cost		**100.0 %**	**100.0 %**

In order to categorize ATMs regarding profitability, and introduce a model for the research output, using k-means tools for clustering, all 374 ATMs have been categorized in 9 levels. The quantity of ATMs in each of the 9 levels is displayed in the table 5.

Table 5: ATMs profitability levels

Level of Profitability	Profit Range (max = maximum profit)	Number of ATMs
Level 1	Profit < 5% of max	47
Level 2	5% of max < = profit < 17% of max	59
Level 3	17% of max < = profit < 28% of max	71
Level 4	28% of max < = profit < 41% of max	73
Level 5	41% of max < = profit < 52% of max	57

Level 6	52% of max < = profit < 64% of max	33
Level 7	64% of max < = profit < 76% of max	20
Level 8	76% of max < = profit < 88% of max	7
Level 9	88% of max < profit < = max	7
Total		**374**

In this paper, we want to present the income forecasting problem of Tehran ATMs as a forecasting problem. The income information of 374 ATMs is used for this end, and 21 features are provided as integers for each of them. The Gaussian fuzzification method is used for input data normalization; such that we map each feature values with a Gaussian function on numbers between 0 and 1. This is done in order to increase network flexibility and at each stage of the algorithm implementation, new random numbers are generated based upon Gaussian distribution in order to make the neural network independent of the allocated values. Target values quantization (each ATM profit) is done through a non-uniform quantization approach and quantized them in to 9 levels and at the end of the algorithm; we convert the neural network outputs, which is a number between 0 and 1, to the numbers in the target values scale.

2.2. Artificial Neural Network Model

Artificial Intelligence is branches of computer science, which will make the computers behave like humans (Rajasekaran & Vijaylakshmipai, 2004). For this to happen we first need to know how human thinks and how their brain possibly works. Computers take some inputs, process those inputs and at last produce outputs. The brain consists of neurons which communicate with each other using impulses called synapses. This makes the biological neuron system (Aleksander & Morton, 1995). Inspired by this, artificial neural networks is a massively parallel distributed processing systems made up of highly interconnected neural computing elements that have the ability to learn and thereby acquire knowledge and make it available for use.
An Artificial Neural Network (ANN) is an information processing paradigm, whose key element is the novel structure of the information processing system. It is composed of a large number of highly interconnected processing elements (neurons) working united to solve specific problems (Aleksander & Morton, 1995). Neuron is a data processing unit and in fact, it is the smallest unit composing the neural networks (Rajasekaran & Vijaylakshmipai, 2004). The diagram block illustrates the model of a widely used neuron. The basic elements of a neuron include:

I. A set of synapses or connecting links, to each of which is assigned a weight. The input signal is transferred via the weight to the central core. Unlike the human brain synapses, the synaptic weight in artificial neurons can take both positive and negative values;
II. A collector for collecting the weighted signals;

III. An activation function for limiting the output domain of the neuron. The normalized output domain of a neuron is usually considered between [0, 1] or [-1, 1].
Figure 2 shows the model of linear and nonlinear neurons.

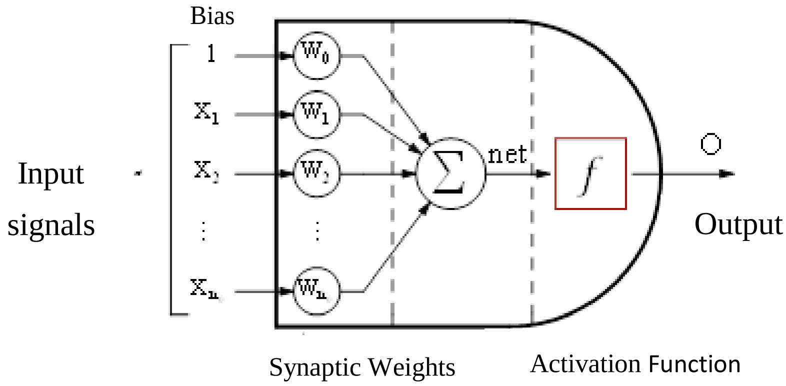

Figure 2: The model of linear and nonlinear neurons

In addition, neural model has an external bias which is shown by a constant number, *e. g.* w_0. Accordingly, the mathematical form of a neuron can be defined as (2) and (3).

$$net = \sum_{i=1}^{n_0} w_i x_i + w_0 \quad \textbf{(2)}$$

$$O = F(net) \quad \textbf{(3)}$$

Where $\{x_1, \dots, x_{n_0}\}$ indicate the input signals and $\{w_1, \dots, w_{n_0}\}$ denote the synaptic weights; output *net* is the linear combiner of the input signals and the bias or in other words, it is the sum of neuron weighted inputs. The F function is the activation function of *O*, the neuron's output signal [3].

The prediction model used in this study is a model based on artificial neural networks. These networks are able to extrapolate complex nonlinear functions. In this study, we are faced with a function that maps the features of an ATM on its profit amount and in fact, it can also estimate the values outside the sample by having some sample of the function. ATMs data are the neural network input which are normalized between [0, 1]. The typology of neural network that used in this study is a multi-layer perceptron (MLP) with a hidden layer. The number of hidden layer neurons is equal to the number of inputs (n), which is adjustable. Number of neurons in the final layer is equal to one. Functions used in the hidden neurons, which are the same activation functions, are the *tangent hyperbolic* functions and the function used in the final layer is the linear function of *f(x) = x*. Thus, we set the *n* network inputs to the *n* features of an ATM and try to bring the output near to it. In this research we use two kinds of Neural Network: Feed-forward Neural Network and Elman Neural Network.

Feed-forward Neural Network: A feed-forward neural network is a type of neural network where the unit connections do not travel in a loop, but rather in a single directed path. This differs from a recurrent neural network, where information can move both forwards and backward throughout the system. Figure 3 shows the feed-forward neural network architecture.

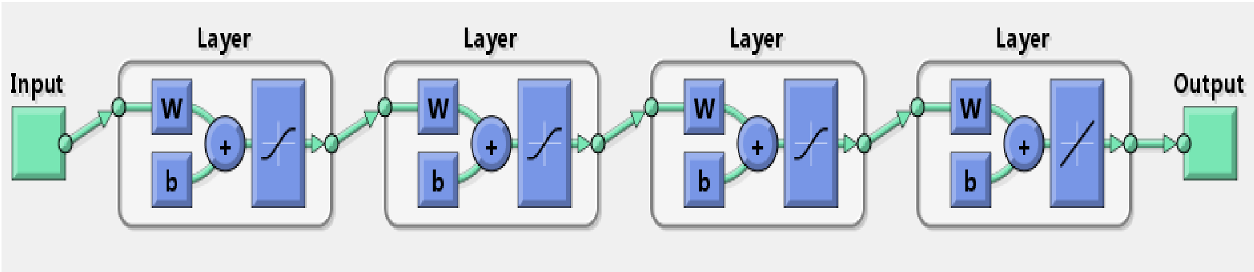

Figure 3: Feedforward Neural Network architecture

Elman Neural Network: is one type of the partial recurrent neural network, which consists of two-layer Back Propagation Networks (BPN) with an additional feedback connection from the output of the hidden layer to its input. This feedback path represents a dynamic mapping between its outputs and inputs. Figure 4 shows the Elman neural network architecture.

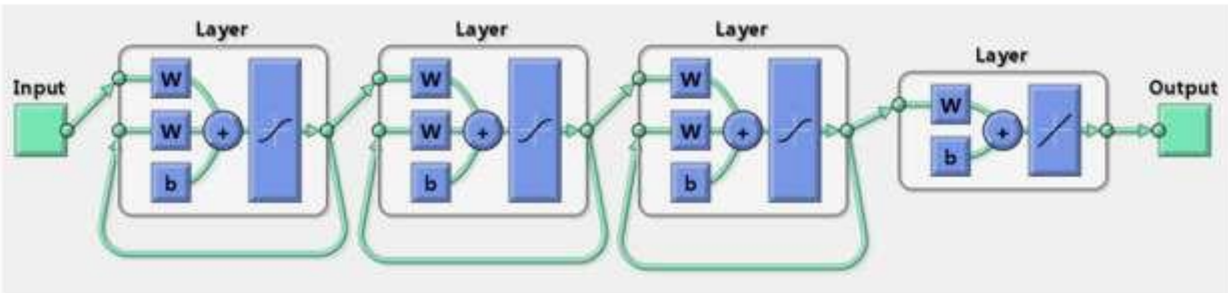

Figure 4: Elman Neural Network architecture

3. Simulation Results

In this research we had 374 sample ATMs totally. We used 341 ATMs data as training data in the network and 33 ATMs were remained as the test data. Figure 5 shows the predicted profit in comparison with actual profit. In the section 2 we explained that the profitability is categorized to 9 levels. The result of feed-forward method shows that in the 66.67% of ATMs the predicted profit level is same as actual profit level and in 21.21% of ATMs they have just 1 level difference. In addition there is no ATM with more than 2 levels different in predicted and actual profit. Figure 6 displays the result diagram in Feed-forward method.

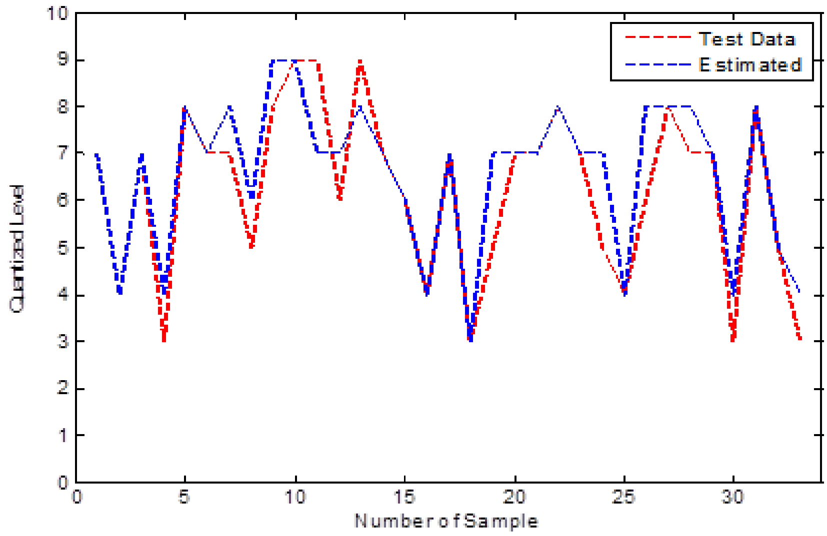

Figure 5: feed-forward predicted and actual profit

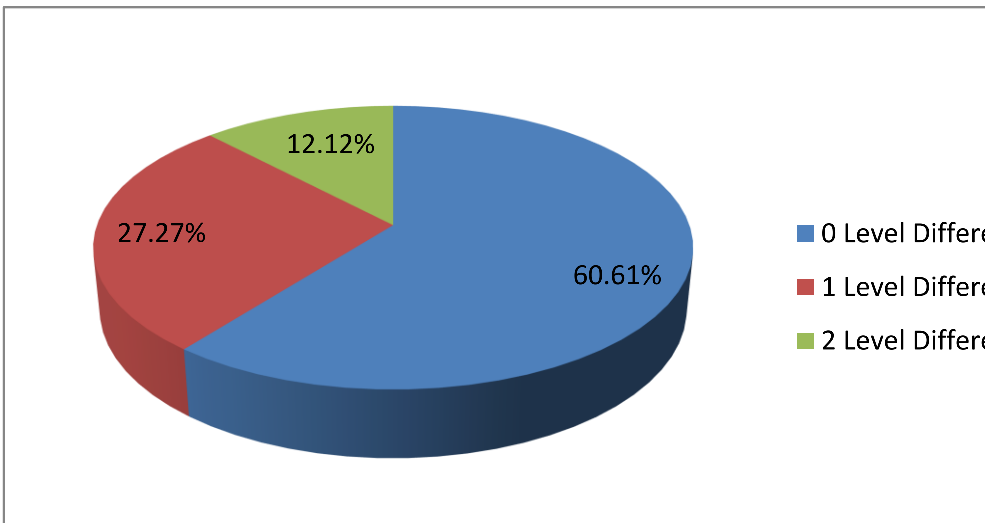

Figure 6: feed-forward predicted and actual profit difference

As we described in section 4, the profitability is non-uniformly quantized to 9 levels. The result of Elman method shows that in the 54.55% of ATMs the predicted profit level is same as actual profit level and in 45.45% of ATMs they have just 1 level difference. In addition there is no ATM with more than 1 level difference in predicted and actual profit. Figure 7 displays the result diagram in Elman method.

Figure 9 shows the comparison between two different types of ANN which are used in this research and indicates that an Elman method significantly outperforms the feed-forward method according to prediction and actual values.

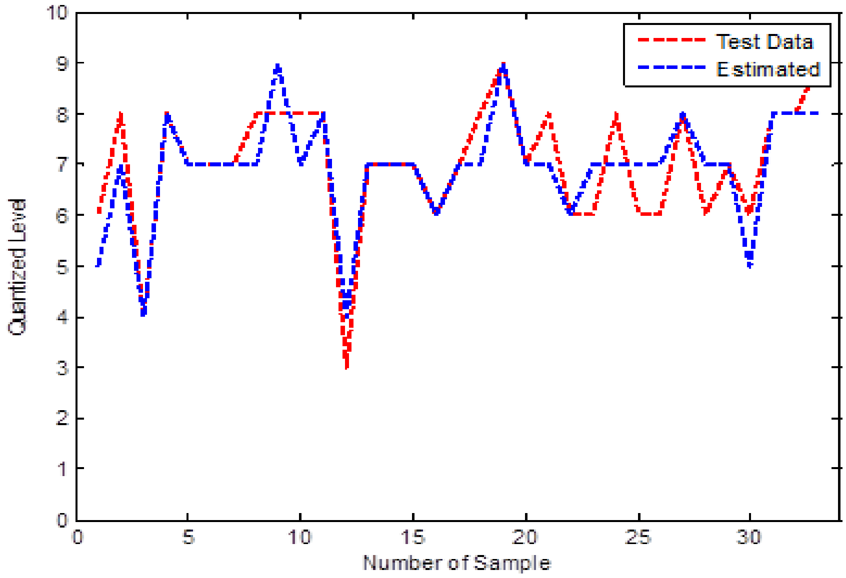

Figure 7: Elman predicted and actual profit

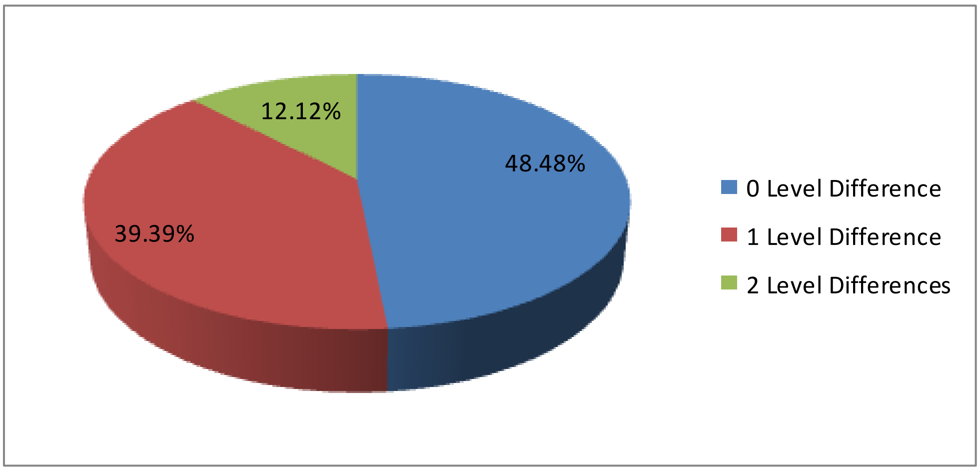

Figure 8: feed-forward predicted and actual profit difference

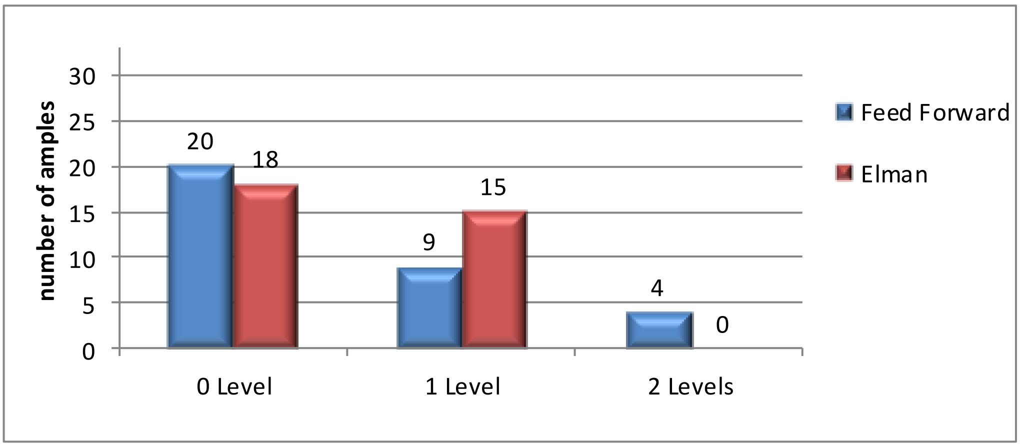

Figure 9: difference level between estimated and real values

4. Conclusion and Recommendation for Future Research

It is believed, based on the research accomplished and documented in this paper, that the five initial objectives that formed the framework for the research have been satisfactorily achieved. By realizing the research aims and objectives and providing a solution to the research problem addressed, it is believed that the research demonstrates that geographical, demographical and spatial variables are an important consideration for ATM profitability, and that the development of a prediction model based on artificial neural networks provides decision makers with a valuable tool for generating feasible solutions based on a different viewpoint to predict ATMs profitability.

There were some limitations to our study which provides opportunities for future research. Some of these limitations are as follows:

- As the ATM installation business in sample bank was started more than 20 years ago, there was no reliable information about each ATM installation date. Despite the importance of this variable, it was ignored in this research.
- Sample bank has installed more than 2500 ATMs all over the country, and as the location information for all of them was not possible, the research focused on the Tehran

province's ATMs which include 15% of ATMs.

- The financial information of other banks' ATMs was not available in this research, so the impact of other banks' ATMs on the profitability of the sample bank ATMs was ignored.

In recognition of the research completed, the following recommendations regarding future research are presented for ways of involving a decision maker or a group of decision makers in real-world decision making processes.

It is acknowledged that the performance of the model would be greatly improved if it had been possible to involve actual decision-makers at critical stage in developing inputs to the system. This was unfortunately not possible. Spatial decision-making problems typically involve several decision-makers and interest groups that, in the end, have to arrive at some consensus in making final recommendations. Their experiences and knowledge of the institutional constrains and requirements for installing ATMs, in the context of re-configuring the ATM network, would have been of considerable assistance in a number of key decision areas. Important among these are the identification of appropriate alternatives (ATMs) to be included in the analysis, the selection of the criteria used, helping determine their relative importance, and in the evaluation of the results.

It has already been stressed that the results of the application would be greatly improved by the inclusion of more demographical, financial and spatial data in the list of criteria used for the demonstration and actual decision-makers would have been able to assist with this. They would also be able to offer valuable insights into the appropriateness of the spatial criteria on which the application is based and might assist in developing a more formal approach for selecting criteria based on the institution's priorities and requirements. Criteria selection could be improved and simplified if users were able to eliminate irrelevant criteria (as well as the alternatives to be considered) prior to engaging in the formal process of evaluation on the basis of a preliminary screening process. With their help it might even be possible to develop a structured model for selecting the most relevant criteria.

Involvement of actual decision-makers also would have made an important contribution to deciding the specific weights assigned to the criteria. In the last resort, the allocation of weights to the criteria is subjective and the weights used in this research reflect this, even though they were thoroughly subjected to an objective sensitivity analysis.

Decision-makers might be able to assist in developing a formal method to reduce the level of subjectivity (as far as this is possible), based perhaps on the notion that any of the criteria for which the weight was below some desired threshold should be eliminated from the analysis and excluded at the outset. They would certainly be able to provide important inputs to the design of the decision value tree and assigning the criteria to the appropriate levels in its hierarchical structure that constitutes a necessary prerequisite in the determination of weights.

It has already been noticed that each type of transactions which are done on the ATMs may have different impact on the ATMs' profitability. In this research we have studied the impact of total transactions on the ATMs' revenue. Future researches could focus on the impact of each type of ATM transactions on the profitability.

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