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A Survey on Cash Demand Forecasting for ATM's Using Different Financial Modelling Techniques

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***Abstract*:**
Optimization of cash management techniques for automated teller machines pose an arduous task due its unpredictable nature of cash withdrawal pattern throughout the year. This uncertainty is caused by several factors such as weekends, salary days, holidays etc. resulting in non-stationary behavior of the users.
Banks usually maintain 40% excess of cash to evade cash out situations, but stocking of cash leads to high operational costs and interest rates. Artificial neural networks and support vector regression techniques were used to analyze the cash flow in atms and to reduce the amount of stocked cash to a minimal safe value.
The survey encompasses analysis and comparison of these two financial modelling techniques and recommends an effectual approach to optimize cash management in atms.

Keywords: *Cash demand forecasting, Automated Teller Machine (ATM), Optimization, Artificial Neural networks (ANN), Support vector regression (SVR)*

1. Introduction

Automated teller machine (atm) is a cash dispensing machine that provides the customers of a bank. The comfort of withdrawing cash without going to the banks. It is a computerized telecommunication device that allows the customers of a financial organization to accomplish basic transactions such as cash withdrawal, checking account balance account management without the aid of a branch representative. Most of the atm's are connected via international banking networks facilitating the opportunity of withdrawing money from any bank in any country. ATM is one of the most decisive aspect which influences the people to open an account in a bank and the banks having a massive network of atm's always tend to boast a higher rate of customers on board. Proper cash management becomes a top priority for such banks so as to ensure no excess cash is sitting idle in atms. Financial, transportation, handling, insurance, interest rates are the main factors contributing to high operational costs incurred by the banks. Most of the banks tend to maintain 40% excess of cash to avoid cash out situations, although many experts consider 15-20% of excess cash to be sufficient. This constitutes 35-60% of the total operational cost incurred by the banks. This survey explores different types of cash demand forecasting models operating on advanced algorithms to optimize cash management in atms by providing automated solutions. A model developed to determine the optimum amount of cash to be uploaded in an atm to comply with the future cash demand is called as cash demand forecasting. Cash demand forecasting for atms is not a simple task as the cash withdrawal pattern follows no definite cyclic order. These models are constructed using the following techniques namely Artificial Neural Networks (ANN), Support vector regression (SVR).

1.1. Artificial Neural Network

Artificial neural network is a computational model tool used to solve non-linear statistical complex problems. It is based on the structure and functions of biological neural systems and is called as the sixth generation of computing. The advantage of neural networks is that it actually learns from constantly varying non-linear datasets and approximates a function efficiently just like a human brain. Neural networks are a tool that can program itself and can learn on its own. Neural network seeks pattern from the input data by learning on its own and further solves complex problems without the need of programming and benefits of an expert. It is primarily used in financial markets for pattern recognition, classification and time series forecasting. However, it requires certain conditions to be effected in order to yield accurate results. The conditions are:

- The dataset must contain all the information necessary to characterize a problem
- The dataset should contain adequate dataset for training and testing.

- Understanding of basic nature of the problem
- Understanding of development tools
- High hardware requirements for achieving necessary processing speed.

1.2. Support Vector Regression (SVR)

Support vector regression is a super intended learning model with suitable advanced algorithms to analyse and forecast data. The principal objective of svr is to classify the hyperplane in order to maximize the margin between two classes. It has the ability to estimate the relationship among different variables with a specific focus on finding relationship between dependent and independent variables. Another crucial factor which gives the svr an edge over other methods is that the data can be separated linearly with a unique global value. A fitting svr model has the capability of producing a hyperplane by completely separating the vectors into two non-overlapping cases. SVR can handle chaotic datasets by finding a hyperplane by maximizing the margin and by minimizing the classifications with ease.

2. Applications Based on Artificial Neural Networks

[1] PremChand Kumar et.al proposed a cash demand forecasting model for atms using artificial neural network. Cash withdrawal data for three months were acquired from a Chandigarh based Bank. The dataset was segregated into two clusters for training and validating the network. The data were tested by developing two models called as daily model and weekly model. The model was constructed as a three-layer feed forward neural network and trained using a fast back propagation algorithm. Factors affecting cash withdrawal such as working day, week day, holiday, salary day were assigned to each neuron defining the individual values at a specific period of time forming the input layer with size four. Forecasted cash constituted the output layer. Forward selection was applied to determine the hidden layer size to reduce the error to a minimal value and tansig-logsig optimal transfer function was being used. The neural network was tested and forecasted multiple number of times and the average forecasting accuracy per week was found to be 95-96% in weekly model and more than 96% for daily model. This method was implemented using MATLAB, on a Pentium IV machine under Windows XP Professional platform.

[2] Venkatesh Kamini et.al presented a cash demand forecasting model for a group of atm's by clustering and using neural network. Initially all the atm centres with similar day of the week withdrawal pattern were sorted out and clustered into atm clusters using the Taylor-Butina's clustering algorithm. Time series model for each atm was built to determine the various seasonality factors affecting cash withdrawal pattern. Sequence alignment method was used to calculate the similarity of each pair of atm centres based on the seasonality parameters obtained from time series. Four neural networks namely general regression neural network (GRNN), multi-layer feed forward neural network (MLFF), group method of data handling (GMDH) and wavelet neural network (WNN) were built cluster wise to predict cash demand for the respective cluster. It was observed that GRNN yielded the best result of 18.44% symmetric mean absolute percentage error (SMAPE). Cluster level replenishment plans resulted in saving huge operational costs for atm's operating in the same geographical location.

[3] Renu Bhandari et.al employed hybrid neural networks approach to predict the cash demand for atm's by using back propagation and genetic algorithms. Cash withdrawal data sets were collected and normalized by converting it into 0's and 1's to avoid convergence problems and to allow the squashed activity function to work at the beginning of the phase at least. The normalized data was then processed manually to extract features such as day number, week day, weekend, salary day and holiday. With the collected data, network was trained with back propagation and genetic algorithms considering the effects of different parameters. Finally, inputs were fed into the network along with the weights obtained during the training session. The weights were dependent upon the magnitude of the parameters affecting the cash withdrawal. The data was finally tested and outputs were obtained. It was observed that the hybrid network with BP/GA techniques offered benefits from both the algorithms and provided a solution for the need of real time accuracy demanding cash forecasting model.

[4] Darius Silijonas et.at analyzed the electronic service optimization of atm cash management with 13 scenarios in hand. Research found that factors like optimization services, and different owners of the atm network influenced the atm cash optimization dynamically. A tabular column consisting the object for optimization against system service was drawn to release different types of services for different customers. This tabular column incorporated different objects for services provided like quantity of cash, replacement of atm machine, change in terminals, functionality. Various available atm management systems like COBRA, J2EE, The Microsoft
.NET Solutions were compared and the advantages and disadvantages of each software was discussed. An optimized architecture is proposed containing multi tiers (client - server architecture) is drawn. First tier is a GUI made of XML with an application server made of JAVA, RMI, and JDBC.

[5] Mojitaba Zandevakili et al. studied the atm cash demand using fuzzy logic and artificial neural networks by considering days, week, month as factors causing fluctuation in withdrawal pattern. The proposed work is based on time series method that has fewer calculation, greater speed, but with less accuracy. It is combined along with type II fuzzy inference system to deal with uncertain data. This research fuzzifies the input using IF- THEN rules to predict the cash demand. A generic structure of the network is drawn with four layers namely factors affecting cash flow, fuzzification layer, rule base, and defuzzification layer. Average accuracy of 72/92% and minimum accuracy of 15/94% was predicted for the proposed structure.

[6] Achilleas Zapranis et al. analyzed withdrawal from atm neural network association and NN5 competition method to decompose the datasets into eleven differ time series. Data of two years of withdrawal from atm located at different parts of England was collected and data sets were analyzed using wavelet networks to find the cash demand forecast for next 56 days. A table was drawn to

describe the eleven-time series analysing its mean, standard deviation, kurtosis, skewness. It was found that non-stationary behaviour have caused inconvenience in the original time series. A wavelet equation consisting of dilation and translation factors was derived. Approximation without the noise part was fed as input to wavelet network while topology and training timing along with different dynamic periodicity was got as output. The structure of neural networks with its node according to the equation was derived. The output had sample errors due to limited information and design problems.

[7] Rimvyadas Simutis et.al advocated a method using auto associative neural network that finds the unexpected behaviour of the atm. The errors in an atm may be due to environmental factors, illegal activities, disturbances etc. Non- linear correlation techniques were used to describe the input i.e. the cash withdrawal in atm. Historical transactions were clustered and analyzed to find the similar behaviour. Auto associative neural network technique was used to find the square prediction error (SPE) between inputs and outputs. A graph for SPE was drawn against days. An error was detected and reported if the SPE is greater than predefined threshold value which is six times the standard deviation of model error. Due to various combinations of inputs it is also possible to find the occurrence of error. Associative neural network was trained and 86% of disturbance accuracy was detected along with 77% unexpected behaviour accuracy.

[8] Cagatay Catal et al. used NN5 competition datasets obtained from 735 withdrawal amount from 111 atms across UK to find the optimal cash required daily by an atm machine. Nineteen special days were taken into account. The evaluation criteria used was SMAPE (Symmetric Mean Absolute Percentage Error) to detect errors. SAS was used as a tool to compare performance of various methods like MLP, Radial Basis,

Function Networks, and Generalized Linear Model and found that exponential smoothening technique was better than artificial neural network. This work also found that cash demand was also affected based on summer and winter seasons. Quarter factor (1, 2, 3, 4) was used to categorize months of a year. SMAPE was formulated using actual value and forecast value. The value of SMAPE by exponential method was 21.7%.

3. Applications Based on Support Vector Regression

[9] Chihli Hung et.al proposed a hybrid approach for predicting the cash demand in atm's in England by integrating the traditional moving average models with support vector regression. Smoothing and time series prediction were carried out using traditional moving average method. The time series data was obtained from the cash withdrawals of different atm's for the past two years located throughout England. It was observed that the cash withdrawal pattern was influenced by various seasonality factors such as holiday, weekend, salary day, weekday and occasional system failures. Moving average approach on a weekly basis was adopted to reduce the amount of fluctuations in the time series and serve as a smoothing function. Sequential minimal optimization algorithm was adopted in the svr to develop a cash demand forecasting model to predict the difference between the actual withdrawal and its median of various weekly moving averages.

[10] Pushkar V. Dandekar et.al conducted a comparison between artificial neural networks and support vector regression models in predicting the cash demand for atms.

Cash withdrawal data were collected and cash remaining in atm's were analyzed to predict the historic withdrawal pattern of the atm's and the factors influencing it. The atms were grouped into three clusters namely high, medium, and low depending on the withdrawal amount and number of withdrawals. Datasets for year 1 and year 2 were considered for training and year 3 for forecasting purpose. Neural network and regression models were developed to forecast the cash demand for year 3 and then was tested with the actual demand. The main focus was to estimate the relationship among different variables and most importantly between dependent and independent variables.

For missing data's in time series, the average of historic demand was employed to avoid cash out situations.

[11] Rimvydas Simutis et.al demonstrated a comparison between flexible artificial neural network and support vector regression techniques to find the most efficient method for cash demand forecasting. Cash withdrawal data from 15 atm's were collected. Artificial neural network and support vector regression models were constructed and were trained using data records of two years. Suitable values for regularization terms D for ann model and C value for svr model were determined using cross validation technique. Cash demand for every atm was processed by these models. Mean average proportional error (MAPE) for daily cash demand estimated for the next fifty days. MAPE was found to be 0.76% for ann and 41% for svr model. Accuracy varied between 15-28% for ann and 17-40% for svr thereby proving ann to be the most efficient method despite some overenthusiastic beliefs about capabilities of svr.

[12] Jieping Ye et.al performed a comparative study between Support Vector Machines (SVM) and Least Squares SVM (LS- SVM) by parting the data set into training and testing. Training pack contained two-thirds whereas the testing pack contained one-third of the data set. Partitioning the data sets was repeated for 30 number of times to improve the estimation of accuracy with the resulting accuracies being averaged. Under certain specific conditions, characteristics of both SVM and LS-SVM were examined and the intrinsic relationship between them was found out. Regularization constants were evaluated through cross-validation technique to establish Soft SVM and LS-SVM. Provided with the accurate regularization terms, this technique can be further implemented in cash demand forecasting models operated by support vector regression algorithms.

[13] Johan A.K. Suykens et.al illustrated a new approach focusing on the advantages of least squares support vector machine formulation (LS-SVM) over support vector machines (SVM) in solving corpulent complicated modelling problems, under capricious circumstances. Standard SVMs were operated on latent problems such as classification and function estimation whereas LS-SVM were utilized on cyclic and optimal control problems. Weighted least squares and pruning techniques were used to make LS-SVMs fit for hefty nonlinear estimation courses and sparse approximation processes. This new approach has been influential in solving convex

optimization problems from which the prototype convolution follows from the solution. Employment of (LS)-SVMs to an extensive variety of simulated and real data stacks indicates the proficiency of these methods to be incorporated in forecasting cash demand in atm's.

[14] Roberto Armenise et.al investigated the efficiency of genetic algorithms in atm cash optimization in order to produce optimal upload strategies to reduce the amount of stocked money, ensuring cash dispensing service without cash out situations. Data was collected from a cluster of 30 Poste Italian ATMs, chosen to provide a protracted coverage. ATMs were located in different cities designated by large scale cash withdrawals. The whole data set of 30 ATMs were divided into two categories containing 20 in one and 10 in the other, with at least one representative from each category. Genetic algorithms were applied on the partitioned dataset and conclusions were drawn. These algorithms can be applied on a svr model to yield ideal strategies to refill atm cash stocks depending on factors influencing cash demand.

[15] G. Žylius et.al demonstrated a comparison between different artificial intelligence techniques such as v-support vector regression(V-SVR), least squares support vector regression(LSSVR), relevance vector regression(RVR), feed- forward neural network (FFNN), Generalized Regression Neural Network (GRNN), Adaptive neuro-fuzzy inference system (ANFIS), to develop a cash flow forecasting model for one day. Time series data containing cash demand from 200 ATM's for a period of 26 months was collected. Input selection and parameter selection with training data was carried out using 10-fold cross validation technique for each and every forecasting model in order to enhance the flexibility of the comparison. The research was conducted by implementing V-SVR code in LIBSVM library, LSSVR code in LS-SVM lab, RVR in Sparse Bayes, FFNN and GRNN in Mat Lab Neural Network Toolbox, ANFIS in Mat Lab Fuzzy Logic Toolbox. V-SVR was found to be the most accurate model with average SMAPE value of 44.30% using adaptive input selection. The results also showed that protracted collection of datasets can yield high accuracy.

[16] Kubra Bilignol et.al proposed a method for site selection of ATM's to cater high cash requirement in certain areas using ordinary least squares regression technique based on population, social media, POI and rival information. Regression analysis with least squares method was initially used to minimize errors caused by multiple factors affecting the site selection. The least squares algorithm was implemented in ArcGIS Spatial Statistics toolbox using the OLS (Ordinary Least Squares)-Least Squares (LS) tool. The results revealed the negative correlation between POI and population and the positive correlation between social media and rival distribution influencing the site selection.

4. Comparative Study Between ANN and SVR for Cash Demand Forecasting

Title of the paper	Input	Technique used	Output
A Methodology to Improve Cash Demand Forecasting for ATM Network	Daily, weekly and monthly seasonality along with long-term trends and special events or localized abrupt changes (holiday and festival effects) of 25 atms were given as input	• Interval Type-2 Fuzzy Neural Network (IT2FNN)	The average generalization forecast accuracy per week was found to be 97.72% while the minimum forecast accuracy was 94.15%. Fuzzy neural network when compared with time series had 13% reduction in the mean forecast error making it the effective model that can provide reasonable predictions even with highly non-stationary behaviour
Cash Forecasting: An Application of Artificial Neural Networks in Finance	Real datasets from a Chandigarh based bank was collected for three months. Values of factors such as holidays, weekends, salary days were included and further the whole dataset was parted into training and testing sets.	• Artificial neural network with daily and weekly models, • Time series, • Alyuda forecaster	Minimum forecast accuracy of 88- 92 % and average forecast accuracy of 95-96% was observed for a weekly model and generalization accuracy of 94% was observed for a daily model. ANN proved to be the efficient model with a mean forecast error of 6.566% with the time series and Alyuda forecaster acquiring 19.438% and 10.109% respectively
ATM Cash Flow Management	Historical data from middle eastern bank were used with each transaction entry containing a sequence number for estimating the number of missing values	• Artificial neural network • Support vector regression	Results attained showed that ANN was feasible over SVR with overall saving of 25% of money to be deposited and 3% saving over SVR.10% more cash was added to the proposed replenishment amount in order to accommodate inflation rates causing cash out situations
Optimization of ATMs filling-in with cash	Quantified costs associated with filling in schedules such as Cost of insurance, Cost of cash freezing, Cost of filling in were fed to the optimization algorithm.	• Linear regression models, • Compound Poisson process,	The final results containing the dates of deposits and the amount of money to be deposited were obtained. The algorithm checks every solution and provides a global minimum cost for the schedule optimized for required days. In case of shortage, algorithm was running again.
A Flexible Neural Network for ATM Cash Demand	Historical data for 2-3 years of an atm were fed as input with 70% used for training and	• Artificial neural network using Levenberg-Marquard method	Results obtained from ANN showed that mean average proportional error (MAPE) of daily cash demand prediction for various
Forecasting	remaining testing 30% for		simulation runs varied between 1,5 - 2 %. ANN proved to be significantly better than linear models with 25-30% error for real datasets

Table 1: Comparison between SVR and ANN methodologies

5. Conclusion and Future Work

Overstocking and frequent uploading of cash results in the inability of the banks to generate interest income and inflating transportation costs, uploading costs, insurance costs in addition with risk of robbery. Cash management thereby plays an inevitable role in maintaining the cash flow in atms for a bank in an economical custom. But cash demand forecasting does not seem to be a yielding task due to the unpredictable nature of consumer behavior. This oscillating pattern is caused by various seasonality factors and abrupt changes that happen in day to day life. Different techniques were adopted to incorporate all such factors to determine the optimal amount of money to be deposited in atms avoiding cash out situations, A survey on related papers were conducted on artificial neural networks and support vector regression techniques to optimize cash management in atm's. The objective of this survey is to analyses and propose the most efficacious method for developing a cash demand forecasting model for future work. Though ANN is difficult to understand when compared to SVR in practical financial scenarios, it proves to be the most accurate and competent method in every facet. Accuracy can be further enhanced by providing qualitative input data without any missing values. Fuzzy logic and genetic algorithms can be incorporated in ANN's to make it robust and even more authentic. Thus artificial neural networks being the sought after technique paves way for future work of this paper.

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