

GMDH Model For Bank Efficiency And Payment Systems In Iran

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Abstract

In this paper we aim to evaluate the relationship between bank efficiency and electronic payment systems in Iran. In this study we used the GMDH-neural network method as an instrument for complicated non-linear trends especially with the limited observations. We employed the model in a bid to delineate relationship between bank efficiency which was proxied by output of banks (net profit-average of inter-banks transactions ratio) and electronic payment system including Automated Teller Machines (ATM) - POS Terminals - Branch PIN Pads and we present two models for each type of banks ownership and a model for all banks in Iran and compare them. The results show that despite the fact that the payment systems are an easy access for everybody, they don't have the same effects and some of them have double effects on bank efficiency in different situations.

Keywords: Payment system - bank efficiency - GMDH-neural network.

JEL Classifications: C13- C45-G21

1. Introduction

The payment mechanism that consumers use to purchase goods and services has changed dramatically over the last 100 years. At the time, almost all consumer transactions were in cash while business payments were in cash or checks. Proprietary charge cards appeared in the early 1900s, followed by "travel and entertainment" cards in 1950. It wasn't until 1966, however, that the first general purpose credit card was introduced. Regarding the definition of Payment System as the mechanism to transfer fund from an account in bank A to another account in bank B, it can be illustrated as the money vessels whose function is to conduct the smooth financial transactions among businesses. In such position, Payment

Systems have gained a considerable Central Banking attention around the globe to ensure safe and sound monetary transactions.

In Iran, the introduction of modern payment instruments can be traced back to early 1990s where commercial bank of Sepah launched its Aber Bank Debit Card and ATM services. Since then almost all Iranian banks have provided their customers with the card payment services focusing on cards with debit function and ATM services to tackle the problem of heavy branch traffics. The interbank card switch (SHETAB) was introduced in 2002 and now all card issuing banks in Iran are connected to the center; building up a uniform card payment network where all issued cards are accepted in all acquiring terminals. It is expected that a unified clearance system, such as Shetab, will provide significantly greater efficiency, reduce crime and money printing costs as well as improve tax collection amongst other benefits. It is also expected to improve the quality of life of citizens who, once the system is fully operational, would no longer be required to spend considerable time organizing things in person and would consequently be able to conduct activities immediately over the phone or over the internet. The impact of the system is already being felt as corporations establish e-commerce, supply chains, online banking and retailing systems. The empirical results strongly suggest the existence of a relation between bank efficiency and payment systems. Our study consists of both type of banks ownership, governmental and private. We use net profit of banks to estimate efficiency at the bank level. The main objective of this study is to empirically explore the relationship between bank efficiency and payment systems by applying a (nonlinear) GMDH model with data available on banks of Iran. These relations are statistically significant at the conventional level of significance.

The remainder of this paper is organized as follows: Section 2 discusses the methodology and data used to obtain the empirical findings reported in this paper. Section 3 provides model specification, empirical results and discussions. Finally, section 4 presents a summary of the main conclusions.

2. METHODOLOGY AND DATA

2-1) MODELING USING GMDH NEURAL NETWORKS

By means of GMDH algorithm a model can be represented as set of neurons in which different pairs of them in each layer are connected through a quadratic polynomial and thus produce new neurons in the next layer. Such representation can be used in modeling to map inputs to outputs. The formal definition of the identification problem is to find a function \hat{f} so that can be approximately used instead of actual one, f in order to predict output \hat{y} for a given input vector $X = (x_1, x_2, x_3, \dots, x_n)$ as close as possible to its actual output y . Therefore, given M observation of multi-input-single-output data pairs so that

$$y_i = f(x_{i1}, x_{i2}, x_{i3}, \dots, x_{in}) \quad (i=1, 2, \dots, M)$$

It is now possible to train a GMDH-type neural network to predict the output values \hat{y}_i for any given input vector $X = (x_{i1}, x_{i2}, x_{i3}, \dots, x_{in})$, that is

$$\hat{y}_i = \hat{f}(x_{i1}, x_{i2}, x_{i3}, \dots, x_{in}) \quad (i=1, 2, \dots, M).$$

The problem is now to determine a GMDH-type neural network so that the square of difference between the actual output and the predicted one is minimised, that is

$$\sum_{i=1}^M [\hat{f}(x_{i1}, x_{i2}, x_{i3}, \dots, x_{in}) - y_i]^2 \rightarrow \min .$$

General connection between inputs and output variables can be expressed by a complicated discrete form of the Volterra functional series in the form of

$$y = a_0 + \sum_{i=1}^n a_i x_i + \sum_{i=1}^n \sum_{j=1}^n a_{ij} x_i x_j + \sum_{i=1}^n \sum_{j=1}^n \sum_{k=1}^n a_{ijk} x_i x_j x_k + \dots \quad (1)$$

Which is known as the Kolmogorov-Gabor polynomial (Sanchez et al. 1997; Iba et al. 1996; Ivakhnenko 1971; Farlow 1984; Nariman-zadeh et al. 2003)? This full form of mathematical description can be represented by a system of partial quadratic polynomials consisting of only two variables (neurons) in the form of

$$\hat{y} = G(x_i, x_j) = a_0 + a_1 x_i + a_2 x_j + a_3 x_i x_j + a_4 x_i^2 + a_5 x_j^2 \quad (2)$$

In this way, such partial quadratic description is recursively used in a network of connected neurons to build the general mathematical relation of inputs and output variables given in equation (1). The coefficient a_i in equation (2) are calculated using regression techniques (Farlow 1984; Nariman-zadeh et al. 2003) so that the difference between actual output, y , and the calculated one, \hat{y} for each pair of x_i, x_j as input variables is minimized. Indeed, it can be seen that a tree of polynomials is constructed using the quadratic form given in equation (2) whose coefficients are obtained in a least-squares sense. In this way, the coefficients of each quadratic function G_i are obtained to optimally fit the output in the whole set of input-output data pair, that is

$$E = \frac{\sum_{i=1}^M (y_i - G_i())^2}{M} \rightarrow \min \quad (3)$$

In the basic form of the GMDH algorithm, all the possibilities of two independent variables out of total n input variables are taken in order to construct the regression polynomial in the form of equation (2) that best fits the dependent observations ($y_i, i=1, 2, \dots, M$) in a least-squares sense. Consequently, $\binom{n}{2} = \frac{n(n-1)}{2}$ neurons will be built up in the first hidden layer of the feed forward network from the observations $\{(y_i, x_{ip}, x_{iq}); (i=1, 2, \dots, M)\}$ for different $p, q \in \{1, 2, \dots, n\}$. In other words, it is now possible to construct M data triples $\{(y_i, x_{ip}, x_{iq}); (i=1, 2, \dots, M)\}$ from observation using such $p, q \in \{1, 2, \dots, n\}$ in the form

$$\begin{bmatrix} x_{1p} & x_{1q} & y_1 \\ x_{2p} & x_{2q} & y_2 \\ \dots & \dots & \dots \\ x_{Mp} & x_{Mq} & y_M \end{bmatrix} \cdot$$

Using the quadratic sub-expression in the form of equation (2) for each row of M data triples, the following matrix equation can be readily obtained as

$$A \mathbf{a} = Y$$

where \mathbf{a} is the vector of unknown coefficients of the quadratic polynomial in equation (2)

$$\mathbf{a} = \{a_0, a_1, a_2, a_3, a_4, a_5\} \quad (4)$$

And

$$Y = \{y_1, y_2, y_3, \dots, y_M\}^T$$

is the vector of output's value from observation. It can be readily seen that

$$A = \begin{bmatrix} 1 & x_{1p} & x_{1q} & x_{1p}x_{1q} & x_{1p}^2 & x_{1q}^2 \\ 1 & x_{2p} & x_{2q} & x_{2p}x_{2q} & x_{2p}^2 & x_{2q}^2 \\ \dots & \dots & \dots & \dots & \dots & \dots \\ 1 & x_{Mp} & x_{Mq} & x_{Mp}x_{Mq} & x_{Mp}^2 & x_{Mq}^2 \end{bmatrix}$$

The least-squares technique from multiple-regression analysis leads to the solution of the normal equations in the form of

$$\mathbf{a} = (A^T A)^{-1} A^T Y \quad (5)$$

Which determines the vector of the best coefficients of the quadratic equation (2) for the whole set of M data triples. It should be noted that this procedure is repeated for each neuron of the next hidden layer according to the connectivity topology of the network. However, such a solution directly from normal equations is rather susceptible to round off errors and, more importantly, to the singularity of these equations.

2-2) VARIABLES IN THE MODEL

In this paper we used the net profit-average of interbank card transaction ratio as an index for bank efficiency .we used the card-based payment instrument (card-ATM ratio, card-POS ratio, card- Branch PIN Pads ratio)as inputs for GMDH.

The study utilized monthly data during the years (2004-2007) for model estimation extracted from central bank of Iran and descriptive financial statements of Iranian banks.

3) MODEL SPECIFICATION, RESULTS AND DISCUSSIONS

Bank cards network came into the Islamic Republic of Iran in 2002, and by starting the operation of the in-banking data exchange network (Shetab) as the national switch and a link placed among 17 banks card switches all over the country, has caused usability of all the cards issued by the banks at all the ATMs and sales terminals (shop-based card readers) and the increasing statistics of its transactions indicates a general welcome to such services. It should be mentioned that since 2004, the number of transactions of Shetab center shows an annual growth exceeding 80 percent. Therefore the augmentation or reduction of these rates indicates augmentation or reduction in utilization rate of these systems.

Figure1 shows augmentation in these rates that is the consequence of increasing in availability in payment systems during these three years.

Figure1

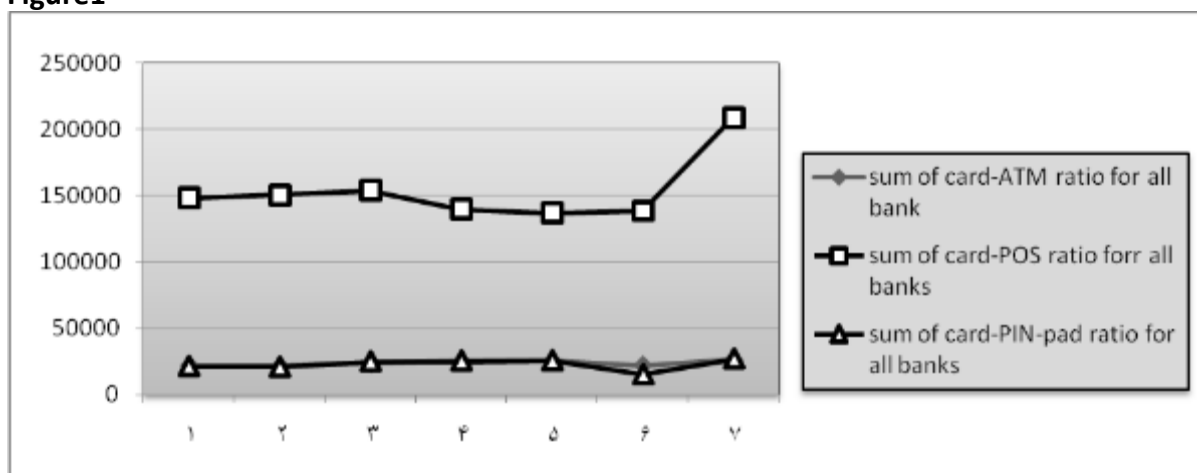
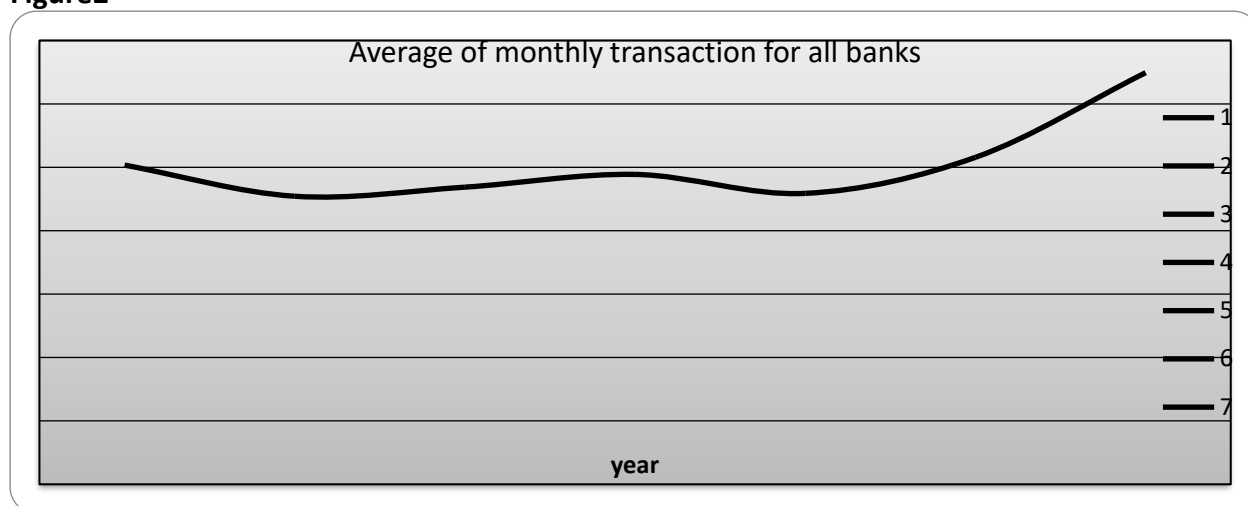


Figure 2 indicates the augmentation in average of transactions, hence augmentation in availability of payment systems shows that utilization of these systems increase during 2004-2007.

Figure2



So money turnover increases in inter-bank transactions, in other words by absorbing financial resource and reduction in cash purchases power consortium lending of banks and the amount of net profit increase.

In this paper we have three models estimation. The divisions are in basis of types of banks ownership that consist of: governmental banks, private banks and a model for both of them.

3-1) MODELING THE RELATIONSHIP BETWEEN BANK EFFICIENCY AND PAYMENT SYSTEMS IN GOVERNMENTAL BANKS OF IRAN:

In this section we used the monthly data(2004-2007) of seven governmental banks as input for GMDH. One of the most important features of GMDH algorithm is the ability of omitting the redundant variables and distinguishing the variables with double effect.

The results are shown in table1:

Table1

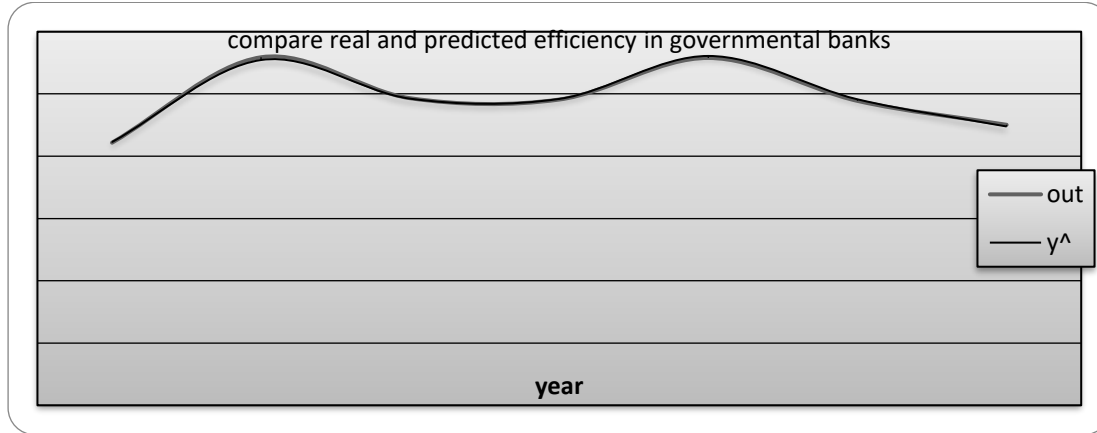
Variables	ATM – POS terminals- PIN-pad branches
Omitted variables	-----
Variables with double effect	POS terminals- branch PIN pads
RMSE ¹	0.004946215

Result show that branch PIN pads and POS terminals have double effects in bank efficiency. It can be explained by this reason: governmental banks in Iran have more money resources so there is not any limitation for them in spending, and they could switch these payment systems sooner than the other banks and , consequently, branch PIN pads and POS terminals were easy of access for everybody.

1.Root Mean Square Error

Figure3 shows that bank efficiency increase during the time that it corroborates the explanations.

Figure3



3.2) MODELING THE RELATINSHIP BETWEEN BANK EFFICIENCY AND PAYMENT SYSTEMS IN PRIVATE BANKS OF IRAN:

In this section we used the monthly data(2004-2007) of five private banks as input for GMDH. The results are shown in table2.

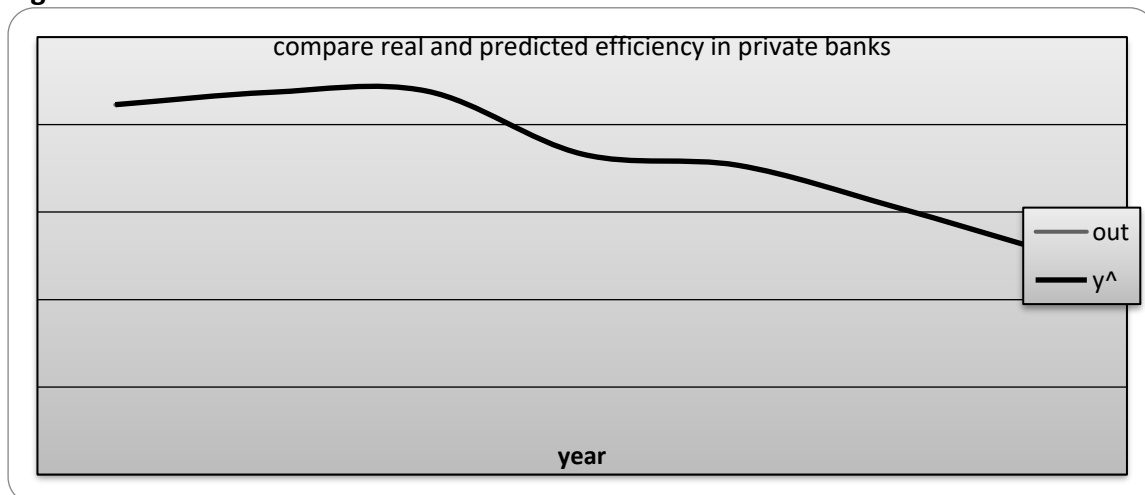
Table2

Variables	ATM – POS terminals - branchPIN pads
Omitted variables	-----
Variables with double effect	ATM
RMSE	0.000113924

Results show that ATM has double effect on private banks efficiency in Iran. It is due to that these banks have more limitations in their money resources so they couldn't switch these payment systems soon and ATM was much more applicable.

Figure4 shows that bank efficiency reduce during these years because of that above-mentioned fact. But it is for a short-term and our prediction is that efficiency in private banks will increase in long-term and they will have the similar results to governmental banks in future.

Figure4



3.3) MODELING THE RELATIONSHIP BETWEEN BANK EFFICIENCY AND PAYMENT SYSTEMS IN BOTH TYPES OF BANKS IN IRAN:

In this section we used the monthly data(2004-2007) of twelve banks as input for GMDH.

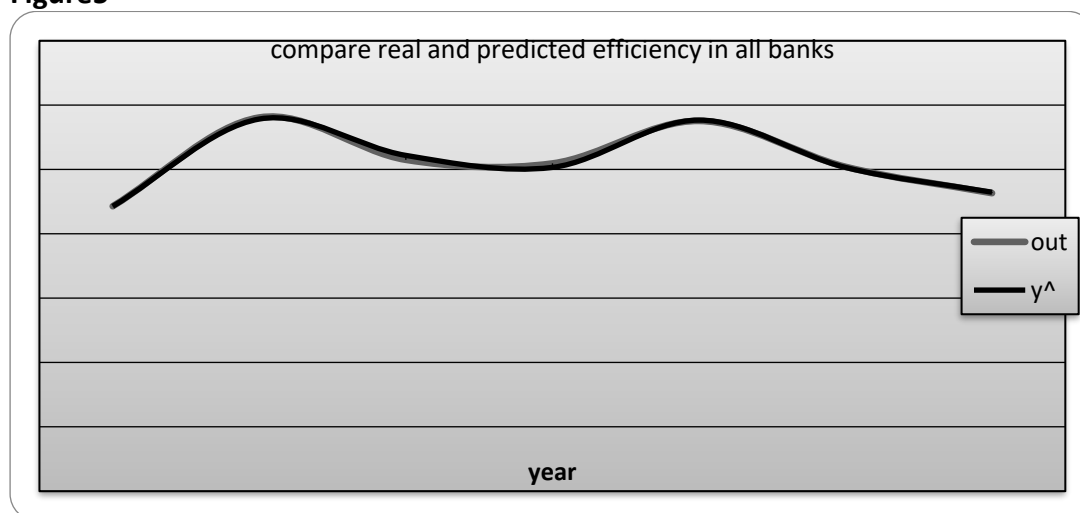
The results are shown at table3:

Table3

Variables	ATM – POS terminals- branch PIN pads
Omitted variables	-----
Variables with double effect	POS terminals- branch PIN pads
RMSE	0.00711039

The results are similar to the results for the governmental banks. The most important reason is that the most government financial accounts are in some governmental banks like: Melli bank or Sepah bank that concludes the most money resource that can deal with the effects of private banks.

Figure5



4. CONCLUSION

Despite the mechanism of electronic payment systems in Iran has not developed like some developed countries, they have significant effect on bank efficiency. One of the most important observations is the various effects of the variables; some of them have double effect in different situations on bank efficiency. Branch PIN pads and POS terminals have double effect on governmental banks efficiency and ATM has double effect on private banks efficiency in Iran. Lifestyles have changed in different societies in these days so payment systems become necessity for each society and the effectiveness of them will increase in future.

REFERENCES

1. Central Bank of Iran Web site, WWW.web.cbi.net/Simplelist/2571.aspx
2. Iranian Banking Institute, (2007), Inter- banking cash transfer, Electronic banking seminar (pp.1-10).

3. Informatics Services Company, (2004), the Modern Payment System in Iran (P.2).
4. Rahimi, masoud, (2007), Summary of Report of Settlement and Payment System Development in Electronic Banking (PP.4-6)
5. SCOTT, D.E., and HUTCHINSON, C.E. (1976).” The GMDH Algorithm- A Technique for Economic Modeling.” Report No.ECE-SY-67-1, University of Massachusetts, Dep. of Computer Science.
6. N Nariman-Zadeh; A Darvizeh; G R Ahmad-Zadeh. (2003)“Hybrid genetic design of GMDH-type neural networks using singular value decomposition for modeling and prediction of the explosive cutting process”, Journal of Engineering manufacture Proceedings of the I MECH E Part B, Volume: 217 Page: 779 -- 790.
7. K. Atashkari, N. Nariman-Zadeh, M. Gölcü, A. Khalkhali and A. Jamali, March (2007) "Modeling and multi-objective optimization of a variable valve-timing spark-ignition engine using polynomial neural networks and evolutionary algorithms", Energy Conversion and Management, Volume 48, Issue 3, , Pages 1029
8. N. Amanifard, N. Nariman-Zadeh, M. Borji, A. Khalkhali and A. Habibdoust, (2007) "Modeling and Pareto optimization of heat transfer and flow coefficients in micro channels using GMDH type neural networks and genetic algorithms", Energy Conversion and Management.