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## Screen the Influence Factors of Electronic Banking of City Commercial Banks in Western China Based on GMDH Algorithm

<sup>1</sup>Li Cheng-Gang and <sup>2</sup>Li Xiao-lin

<sup>1</sup>Faculty of Finance, Guizhou University of Finance and Economics, Guiyang, Guizhou, 550025, China

<sup>2</sup>Business School, Sichuan Agriculture University, Chengdu, 600007, Sichuan, China

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**Abstract:** Studying the influence factors of electronic banking has important practical significance for the development of city commercial banks. Taking electronic banking of city commercial banks in western China as the research object, this study uses Group Method of Data Handling (GMDH) to objectively and automatically screen the main influence factors of the commercial bank electronic banking development and to seek the non-linear relationship between the influence factors and the development of electronic banking. The results show that electronic banking transaction volume growth, product planning, internet marketing and e-commerce development are the main factors of the electronic banking development. The impact of electronic bank transaction volume growth and product planning on the development of electronic banking is very large. The impact duration of network marketing on electronic banking is very long and the impact of its interaction with product planning is big. E-commerce impacts the development of electronic banking by its interaction with the pre-electronic banking growth. The conclusions and suggestions of this study are conducive to city commercial banks in western China better develop their electronic banking.

**Key words:** GMDH algorithm, city commercial banks, electronic banking, influence factor

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### INTRODUCTION

With the economic and financial development in western China, city commercial banks develop rapidly. Their electronic banking business is known by people gradually. More and more people use e-banking. Electronic banking has become an important profit point for city commercial banks and also changed the competitive pattern of the banking system. At the same time, the market competition of banking system is also growing fierce. It is an urgent that banks vigorously accelerate the development of electronic banking to hold their ground in the competitive market. It is particularly important for city commercial banks to promote the rapid development of electronic banking and dig out the main factors affecting the development of electronic banking. Therefore, the study on influence factors of city commercial banks' e-banking can provide an important reference for city commercial banks to make e-banking development strategies and help them to develop their electronic banking better.

### LITERATE REVIEWS

Because of the importance of electronic banking for commercial banks, a large number of scholars deeply

study the factors influencing the development of electronic banking and the related issues. Based on the theory of planned behavior (Ajzen, 1991) and the diffusion of innovations theory (Maddux and Rogers, 1983) and Tan and Teo (2000) identify the attitudinal, social and perceived behavioral control factors that would influence the adoption of Internet banking. Their results show that attitudinal and perceived behavioral control factors, rather than social influence, play a significant role in influencing the intention to adopt Internet banking. Using the Theory of Planned Behavior (TPB) and the Theory of Reasoned Action (TRA), Shih and Fang (2004) study how an individual belief, embracing attitude, subjective norm and perceived behavioral control influence the intention of internet banking. The results support TRA and TPB. Wang (2006) analyzes the constraints of commercial banks in the development of electronic banking. He thinks that the main factors restricting the development of electronic banking are market segmentation, the marketing mechanism, system performance, product features and market cultivate.

In the latest recent years, electronic banking developed rapidly and the literatures studying the influence factors of electronic banking are very rich. Li (2008) studies the factors restricting the development

of the electronic bank in China. The results show that the main constraints the development of the e-banking including security factors, credit factors, legal factors, network environment and bank marketing factors, talents and the concept of factors and so on. Based on Critical Success Factors Model of E-commerce System (ECCSF), Huang and Li (2008) revise the model and use it in the study of the critical success factors of online commercial banking. The research results show that the management, technology and customer factors are critical success factors for online banking. Taking the Technology Acceptance Model as the main theoretical basis, Shao and Yang (2008) utilize structural equation model to do a comparative study on the intention of factors affecting the use of online banking of different groups. The results show that the main factor affecting the intention of using online banking is trust in electronic channels. Al-Somali *et al.* (2009) surveys the online banking in Saudi Arabia and does an empirical analysis. The results find that the quality of Internet access, the benefits of online banking, social impact and computer performance significantly affect the use of online banking. Hernandez-Murillo *et al.* (2010) study the influencing factors of using online banking with 2003-2006 panel data of U.S. commercial banks. The empirical results show that despite the bank features is the most important factor, but the competition also significantly impact online banking use. Maiyaki and Mokhtar (2010) study the impact of the electronic banking facilities, customer occupations and customers age on their choosing bank. The results show that there is no significant relationship between the electronic banking facilities and customers choosing bank. But the customer' occupation and customer' age have a significant impact on the choice of bank. Salehi and Alipour (2010) find the development of e-banking in Iran has a role in promoting the development of the banking industry, but people have little knowledge of the electronic banking. The electronic banking knowledge restricted the development of the banking industry. Using the questionnaires, Joshua and Koshy (2011) analyze educated people's e-banking services model in Indian. The results show that ATM machines are widely used in India. Other electronic banking, such as online banking, phone banking and mobile bank are also widely used. With different statistical tools such as weighted average method and ranking, Uppal (2012) empirically analyzes the quality of e-banking services of India banks. They find that most of the customers of e-banks are satisfied with the different e-channels and their services, but the lack of awareness is a major obstacle in the spread of e-banking services. Kong (2012) uses panel data model to

empirically study the factors affecting the development of electronic banking in China. The results show that the size of the board and the proportion of independent directors could not play a role in promoting the development of e-banking. Asset size strongly supports the development of electronic banking business.

From the above research results, it can be seen that, the existing researchers have broadly and deeply studied the influence factors affecting the development of electronic banking of commercial banking. However, some researchers only qualitatively analyze the influence factors. In the empirical analysis, because some researchers subjectively chose the influence factors and chose different methods, they get different influence factors. On the establishment of research model, the majority of scholars have only established a linear model and this can only analyze factors influencing the linear relationship between influence factors and the development of electronic banking. This can not reflect the nonlinear relationship between them. Therefore, this study introduces a new research method, which is Group Method of Data Handling, to objectively screen the influence factors of electronic banking of commercial banking. This method can automatically and objectively screen the influence factors electronic banking of commercial bank. It can analyze the non-linear effects of these factors on the development of electronic banking and avoid the artificial subjective interference of selection influence factors. We take the electronic banking of city commercial banks in western region of China as an example and empirically study the influence factors affecting the development of electronic banking of city commercial banks in western China.

## MATERIALS AND METHODS

**Brief introduction of GMDH algorithm:** This study uses GMDH algorithm to empirically analyze the factors affecting the development of electronic banking of city commercial banks in western China. GMDH algorithm was first proposed by A.G. Ivakhnenko academician of National Academy of Science of Ukraine in 1967. A.G. Ivakhnenko proposed GMDH algorithm using multi-layer neural network theory and the self-organizing principle of biological cybernetics theory. GMDH algorithm strongly reflects the evolution process from simplicity to complexity, the biological evolution process of competition and survival of the fittest and the self-organization process of the ongoing restructuring of the intermediate models. It can objectively and automatically filter out the factors that have important impacts on the research object.

**Steps of GMDH algorithm:**

- Divide sample data set (including N data samples) into Training Set A and Test Set B. If we construct prediction model, sample data needs further to be divided into Prediction Set C
- Construct the general relationship between dependent variables (output) and independent variables (input). Select K-G multinomial as reference function. Taking the system with three inputs but only one output for example, we can adopt the following quadratic K-G polynomial as reference function:

$$f(x_1, x_2, x_3) = a_0 + a_1x_1 + a_2x_2 + a_3x_3 + a_4x_1^2 + a_5x_2^2 + a_6x_3^2 + a_7x_1x_2 + a_8x_1x_3 + a_9x_2x_3 \quad (1)$$

And we take its sub-items as m initial models of modeling network structure:

$$v_1 = a_0, v_2 = a_1x_1, v_3 = a_2x_2, \dots, v_{10} = a_9x_2x_3 \quad (2)$$

where, m = 10

- Select one or several selection criteria from selection criteria with external complementary nature as objective functions (or systems), namely external standards (or systems). External standards mainly include accuracy standard, compatibility criteria, correlativity criteria, portfolio guideline, cross-validation criteria, variable balance criteria and so on. As the criteria and rule of model selection, external standards directly affect the selection and quality of the optimal model. Modelers select external standards according to concrete conditions
- Obtain the first layer intermediate models. The transfer functions  $y_k = f_k(v_i, v_j)$ , ( $v = 1, 2, 3, \dots, 10$ ) are the first layer of intermediate models. They are generated adaptively by the self-organization process and the number of their variables and function structure are different from each other. At the same time, estimating the parameters of  $y_k$  is in the Training Set A
- Filter the first layer of intermediate models. Filter them according to external standards in the Test Set B and obtain intermediate models  $w_k$ . Take  $w_k$  as the input variables of the second layer of the network
- Form the optimal complexity network structure. Repeating Step (3) and (4) can successively generate the second layer of intermediate models, the third layer of intermediate models, ..... Ultimately we gain the optimal model that we use it to analyze our problem

**EMPIRICAL ANALYSIS**

**Variables selection:**

- **Growth rate of electronic banking transaction volume:** With the development of electronic banking of city commercial banks in western China, more and more individuals and corporate customers transact business through electronic channels. Therefore, the electronic banking transaction volume of city commercial banks will increase correspondingly. This study selects the growth rate of electronic banking transaction volume ( $X_1$ ) in western China to measure the development of electronic banking
- **Economic environment:** Good economic environment and rapidly developing economic will bring growth in various industries and business. Meanwhile, the electronic banking transaction volume of city commercial banks will grow. The Change of economic environment will affect the development of electronic banking of city commercial banks, so we select the weighted average growth rate of GDP of Western provinces or municipalities in China ( $X_2$ ) to reflect the change of economic environment
- **Policy factors:** The policies on electronic banking development will affect the development of electronic banking of city commercial banks. Usually, the introduction of the policy will promote the development of electronic banking. In order to reflect the impacts of policy factors on the development of electronic banking of city commercial banks, this study establishes a dummy variable ( $X_3$ ). If the government introduces a policy about electronic banking,  $X_3$  is equal to 1; otherwise,  $X_3$  is equal to 0
- **Product planning:** The product planning of electronic banking of city commercial banks can improve the users' experience, including optimizing the use processes, adding personalized settings, upgrading the quality of service and meeting customer's individual needs and so on. In this study, we select the number of electronic banking products launched by city commercial banks in western China ( $X_4$ ) to reflect their product planning
- **Network marketing:** Network marketing has some advantages, such as wide range spread, strong interaction and strong sensory. For city commercial banks, network marketing has the advantages of lower cost, fewer links and high efficiency. Enhancing electronic banking network marketing, city commercial banks can make more consumers and enterprises know electronic banking at a low cost, improve business and transaction volume of electronic banking. In this study, the number of

online bank ads ( $X_5$ ) is used to measure network marketing efforts of city commercial banks

- Security:** The rise of electronic banking greatly reduces the cost of banks and improves service efficiency and also makes people's financial life more convenient and humane. However, security issue also has been important issue accompany with the development of electronic banking. Jaruwachirathanakul and Fink (2005) as well as Chen (2009) show that, security is an important factor affecting customers to use electronic banking. Xia *et al.* (2007) study the security issue of electronic banking and think that USB-Key digital certificate can effectively protect the security of online transactions. Therefore, this study adopts the number of USB-Key digital certificates opened by city commercial banks ( $X_6$ ) to measure the security of electronic banking
- Development of e-commerce:** With the development of network technology and the convenience of transportation, China's e-commerce has developed rapidly. Most of the e-commerce transactions are completed through the network channels and electronic channels. E-commerce enterprises also prefer electronic bank payment. Obviously, the development of e-commerce has increased the demand for electronic banking. In this study, the growth rate of e-commerce transaction volume in western China ( $X_7$ ) is adopted to measure the development of e-commerce

**Data selection and sources:** According to the selected variables, the data cover 2000-2012. The data are quarterly data, a total of 72 sets of data. The data come from the statistical yearbook of the provinces in western China, China Online Banking Research Report, Forecast and Investment Strategy Analysis Report of China Electronic Banking, China E-banking Survey Report, China E-commerce Market Data Monitoring Report, China electronic banking website (<http://www.cebnet.com.cn/>) and the websites of western city commercial banks.

**Empirical results analysis:** GMDH algorithm can weed out the variables from the model whose correlation is not obvious during the learning process. Before GMDH modeling, we need the data to do dimensionless processing. We make dimensionless process using the following equation:

$$\bar{x}_i = \frac{x_i}{\max(x_i)} \quad (3)$$

We introduce variable data after dimensionless processing into GMDH algorithm and train them. Through training, GMDH algorithm will filter out those variables which have little, even no impact. Then GMDH algorithm outputs a linear or nonlinear model and we gain the input-output model.

We apply self-organizing data mining software (Knowledgeminer 5.0) to build model and obtain models as follows:

$$X_1 = 1.3894z_{12} + 2.5163e^{-1}z_{11}^2 + 6.5628e^{-1} \quad (4)$$

$$z_{11} = 6.1293X_4 + 1.8557X_5(t-4) + 2.3788 \quad (5)$$

$$z_{12} = 8.2159X_1(t-1) + 2.1156e^{-1}X_7X_1(t-1) - 1.8452 \quad (6)$$

where,  $X_1$  is Growth rate of electronic banking transaction volume of city commercial banks.  $X_4$  is the number of electronic banking products launched by city commercial banks in China's western region.  $X_5$  is the number of online bank ads.  $X_7$  is the growth rate of western region's e-commerce transaction volume.  $z_{11}$  and  $z_{12}$  are two intermediate variables given by computer autonomously. Introduce equation (5) and (6) into (4) and gain the following results:

$$X_1 = 1.3894(8.2159X_1(t-1) + 2.1156e^{-1}X_7X_1(t-1) - 1.8452) + 2.5163e^{-1}(6.1293X_4 + 1.8557X_5(t-4) + 2.3788)^2 + 6.5628e^{-1} \quad (7)$$

Simplify Eq. 7 and then get the optimal complexity model with influence factors affecting e-banking development as follows:

$$X_1 = 11.4152X_1(t-1) + 1.0814X_7X_1(t-1) + 37.5683X_4^2 + 3.4436X_5(t-4)^2 + 22.7483X_4X_5(t-4) + 29.1608X_4 + 8.8287X_5(t-4) + 3.9048 \quad (8)$$

Seen from Eq. 8, the model is nonlinear. This indicates that there is non-linear relationship between the development of e-banking and its influence factors. As can be seen from the structure of the non-linear model, there are not only linear factors influencing the development of electronic banking, but also there are nonlinear factors.

From the results of the above model, we find that the influence factors of the development of the electronic banking filtered out by GMDH algorithm mainly include the growth rate of electronic banking transaction volume, product planning, network marketing and e-commerce development.

First,  $X_1(t-1)$  has a positive impact on electronic banking and its coefficient is 11.4152, which indicates that the growth rate of electronic banking transaction volume at the time  $t-1$  has a great impact on the one at the time  $t$ . Secondly, in the impact of product planning on the development of electronic banking, the coefficients of  $X_4^2$ ,  $X_4X_5(t-4)$  and  $X_4$  are 37.5684, 22.7483 and 29.1608, respectively. This shows that product planning has important impacts on the development of electronic banking. Again, in model (8), there is the  $X_5(t-4)$  term, suggesting that the development of electronic banking responds to internet marketing at a relatively long lag. Due to the restriction of the selection of the maximum lag, we do not select a larger lag. Therefore, we cannot conclude that the cycle of the impact of network marketing on the development of electronic banking is four. Furthermore,  $X_4X_5(t-4)$  term in Model (8) means that the lagged network marketing and product planning have some interaction to the development of electronic banking. Its coefficient is 22.7483, which indicates its impacts on the development of electronic banking to a larger extent. Finally, the results show that the development of e-commerce affects electronic banking, mainly through its interaction with electronic banking growth at  $t-1$ .

### CONCLUSIONS AND SUGGESTIONS

This study uses the GMDH algorithm to study the influence factors affecting the development of electronic banking of city commercial banks in western China. We found that there are nonlinear relationship between the development of electronic banking and its influencing factors. In western China, the influence factors not only have linear impacts but also non-linear ones on the development of city electronic banking of commercial banks. The main influence factors of the development of electronic banking filtered out by GMDH algorithm automatically and objectively include early period growth rate of electronic banking transaction volume, product planning, network marketing, security and the development of e-commerce. The impacts of product planning and security on the development of electronic banking are greater than other factors. The impact of network marketing on the development of electronic banking lasts long. And the interaction between network marketing and product planning has great effect on the development of electronic banking. E-commerce affects the development of electronic banking through the interaction with the early period growth of electronic banking transaction volume.

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