

Modeling the effect of electronic banking expansion on profitability using neural networks and system dynamics approach

The effect of
electronic
banking

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Abstract

Purpose – The purpose of this study is to investigate the effects of electronic banking (e-banking) on the profitability of banks is an important subject. Although there are many studies in this area, the effect of using different e-banking instruments, such as internet banking, telephone banking, ATM and POS, was not investigated comprehensively, using a system dynamics approach. To fill this gap, the present study tried to develop an analytical model with a systematic approach through identifying the effects of different areas of e-banking services in a financial institution.

Design/methodology/approach – The income and cost of each transaction via different e-banking services were identified and the incomes and costs, number of transactions and other model variables were predicted for the next period using a single-layer neural network (perceptron). The proposed model was designed based on the system dynamics approach. Then, rates and auxiliary variables were introduced to the model based on the prediction data. Finally, the model was validated and different scenarios were examined.

Findings – Results showed that increased investment on e-banking can increase online customers, thereby boosting the bank's incomes through raising transaction fees and acquiring additional resources. On the other hand, the need for physical branches and associated costs reduces with increasing the tendency of traditional customers toward using e-banking services. Simulation results showed that although the expansion of e-banking carries a huge financial burden on the bank, the costs reduce and profitability significantly increases with time.

Originality/value – This study can be used by senior managers of the bank throughout e-banking planning. This is because it systematically addressed the effects of e-banking expansion on different (banking) areas. The present study may also encourage researchers to conduct more extensive studies.

Keywords Profitability, Neural network, Banking transactions, Electronic banking, System dynamics modelling approach

Paper type Research paper

Introduction

Technological advances have significantly contributed to the growth of the business environment, improved banking capabilities, and provided more services at higher quality through introducing new mechanisms (Boteng, 2016). The internet banking, as a part of e-banking refers to the accessibility of banking services through the internet (Goospodarus, 2005). A more extensive use of e-banking services has a good effect on economy because the provision of products at low prices and atomization of processes have improved not only transaction speed and security but also the overall economy (Polasik, 2013). Electronic banking (e-banking) accelerates money flow, which is essential for a digital economy (Unai and Ozoz, 2012).



The banking industry is turning into a global ecosystem in a highly competitive environment. Banks have to make a balance between the development of their objectives and stability. As a result, e-banking may face with initial barriers to the development of a potential solution for survival in the future (Lot *et al.*, 2011). According to studies, e-banking services will deliver enormous profit in the future through providing the customer with high-quality services in terms of transaction simplicity and fee (Marku, 2012).

Although e-banking results in an increase in banking profitability, the lack of appropriate hardware, software and communicational infrastructures are among the barriers to the expansion of virtual banking, imposing a great financial burden in the short run. There is no doubt that many developing countries are behind the advanced countries with respect to communication facilities. Although the implementation of e-banking may initially have negative impacts on the profitability of the bank, it will start to deliver profit approximately after two years. However, the risk of e-banking will be high for low-income banks (Arnold and van Ewijk, 2011).

Al-Samadi and Al-Wabal (2011), Khrawish and Al-Sa'di (2011), Sumra *et al.* (2011), Hosein (2013), Malhotra and Singh (2006, 2007, 2009) and Gutu (2014) concluded that the applied e-banking programs in developing countries, such as India, Pakistan, Jordan and Romania, reduced operational costs and increased profitability of the banks. However, the implementation costs of e-banking systems and associated measures should be managed by the banks (Sumra *et al.*, 2011). On the other hand, Kharashi and Al-Sa'di (2011) and Al-Samadi and Al-Wabal's (2011) studies on Jordanian banks, Hosein's (2013) study on Asian banks and Gutu's (2014) study on Romanian banks showed negative effects of using e-banking services on the profitability of some banks. This was because their customers were used to traditional banking systems (Al-Samadi and Al-Wabal, 2011).

According to some studies, due to insufficient e-banking users, its high infrastructural costs may cause negative profitability (Ekiser, 2015). However, an increase in online customers does not merely depend on the services provided by the bank, rather national culture has a vital role in the promotion of the e-banking and access to the internet in different countries (Takeddine and Sun, 2015). Regarding cultural diversities, customers are faced with different e-banking models worldwide (Yuen *et al.*, 2015).

The present study was conducted to investigate the effect of using e-banking on profitability, costs and incomes of the bank at the same time, considering the actual use of it by customers. As each e-banking service, such as the internet banking, telephone banking, ATM and POS, is associated with different costs and incomes, this study predicted the cost and income of each transaction for the following period using neural networks. It also investigated how the expansion of e-banking affects the profitability of the bank through system dynamics modeling.

System dynamics modeling approach

System dynamics is an approach for the analysis, simulation, investigation and improvement of dynamic social, economic and management systems, using a feedback perspective (Barlas and Yasarcan, 2006). The system dynamics is a simulation approach to help management frame required policies for change (Ghoucri and Goldsmith, 2007). The dynamics system is a powerful modeling method because of its capability in prediction, sensitivity analysis, scenario-development and policy formulation (Shayn *et al.*, 2008). During the modeling process, the designer and the employer team are involved in a process that aims at continuous improvement of a model inspired by reality. System simulation often results in a new understanding of system behavior and structure that allows for the development of more complete models in the next period (Caulfield and Maj, 2002).

Theories supporting model's cause-and-effect loops

Previous studies and theories supporting the model's cause-and-effect loops are presented in Table I.

Methodology

System dynamics includes dynamic simulation models that explicitly consider information feedback governing a system's interactions (Liao, 2003). In system dynamics modeling, the model's design and implementation mechanisms and behavior are compared to previous behavior. After validation and ensuring the model's capability in simulating the real behavior of the investigated system, changes were applied to the model based on different policies and results were presented. To develop the cause and effect model, dynamic hypotheses that describe the system structure are constructed. Then, the general system image was illustrated and the cause and effect model was designed. Finally, in addition to the simulation of the dynamic model through different scenarios, some constructive recommendations were provided. The current study aimed to identify the effects and effective relationships with respect to the expansion of e-banking services and profitability of a financial institution. To this end, the effective variables and indices of e-banking expansion concerning the bank's profitability were first identified. Then, a dynamic

Studies/Year	Variable	Results	
Onay and Ozsoz (2013)	Profitability	The acceptance of e-banking has a positive effect on profitability, deposit level and loan level in each branch. However, it can negatively affect profitability if it fosters competition	
Sumra <i>et al.</i> (2011)		On the other hand, e-banking increases profitability of the banks. In addition, as the main reason for accepting e-banking is to increase and maintain customers, profitability of the banks increases the dependence on e-banking and transition to it	
Dietrich and Wanzenried (2011)		With the development of e-banking, the ratio of the bank's incomes to costs increases and subsequently its profitability significantly improves	
Holden and Karsh (2009)		The number of installed ATMs by the banks has a positive effect on their profitability through reducing workforce and transaction costs	
Siam (2006)		E-banking services may have negative impact on the banks' profitability in the short run, which can be due to their investment on infrastructures and training; however, these services will positively affect profitability in the long run	
Kozak (2005)		There is a positive relationship between the level of information technology used by the bank and its profitability	
Park <i>et al.</i> (2009)		Perceived ease of use	There is a direct positive relationship between the easiness of use, cognitive utility and increased use of e-banking
Totolo (2007)			
McKechnie <i>et al.</i> (2006)			
Gu <i>et al.</i> (2009)			The ease of use, along with trust has a significant role in cognitive utility and finally acceptance and application of the technology
Polančič <i>et al.</i> (2010)	Trust and user satisfaction	System support after technology acceptance has a significant role in continuous use of that technology, which largely depends on the tendency toward cognitive use and utility	
Elbanna (2010)		There is a linear direct relationship between the tendency and actual use of technology	
Hernandez <i>et al.</i> (2008)			
Yiu <i>et al.</i> (2007)			

Table I.
Literature on
relationships
between cause-and-
effect loops of
analytical model

analytical model was developed to acquire a better understanding using a systematic perspective. Vensim was used to illustrate the model and (its) cause-and-effect loops. In addition, the historical data of the bank was predicted for the next period and the model's rates and formulas were correspondingly developed.

Problem statement

The development and expansion of e-banking, as an application of information and communication technology in money and banking markets of advanced countries, have stimulated Iran's banking industry in recent years to use this innovation.

The use of e-banking in the banking industry of the country is beneficial only when the bank costs significantly reduce and investments on e-banking increase its profitability. It was tried in this study to investigate the incomes and costs of e-banking adoption in a financial institution at the same time by considering different effects of e-banking using the system dynamics approach.

Research dynamic hypotheses

According to theories obtained from the literature, dynamic hypotheses of the study can be expressed as follows:

- H1. The development of e-banking encourages more customers to start using internet banking.
- H2. The development of e-banking encourages a greater number of traditional customers to start using internet banking.
- H3. The development of e-banking reduces the need for physical branches.
- H4. The development of e-banking reduces the bank's costs.
- H5. The development of e-banking increases the bank's profitability.

Status of e-banking in a financial institution

Table II shows an increase in the number of traditional and online banking customers in 2016.

Table III shows an increase in e-banking users in 2016.

Table IV shows an increase in e-banking users in 2016.

Table II.

Increase in number of traditional and online banking customers in 2016

		Increase in number of customers	
		Online customers	Traditional customers
		61,290	19,880

Table III.

An increase in e-banking users

		Increase in e-banking users in 2016		
		Increase in telephone bank users	Increase in internet bank users	Increase in mobile bank users
		3,034	31,145	27,111

Prediction of indices

The investigated indices for the next period were predicted using the neural network in Clementine (Figure 1 and Table V).

Modeling e-banking expansion effect on bank's profitability using system dynamics approach

To model the effect of e-banking expansion on the bank's profitability, this study used the system dynamics modeling approach because of its provision of a more accurate and comprehensive image of the reality. As this study investigated e-banking expansion as a process that takes place with time and considered the effects of model's constructs on the cost reduction, the use of system dynamics modeling approach can be justified better. In investigating the problems through system dynamics modeling approach, the cause-and-effect loops determine dynamic relationships in these problems.

Figure 2 shows the model representing the effect of e-banking expansion on the bank's profitability, using the system dynamics modeling approach. All model variables and dynamisms, along with the relationship between them and theories are presented in Table I.

Dynamic modeling of effect of e-banking application on bank's profitability

Cause-and-effect model

In this study, the system dynamics modeling approach was used to provide a more accurate and comprehensive image of the reality and existing relationships. The current model is the analysis of the e-banking expansion effect on the bank's profitability (Figure 2).

According to Loop 1 (Figure 2), e-banking development, including increased investment on advertisement and different e-banking instruments, increases the actual use of e-banking by customers. As a result, the number of online customers increases and that of traditional customers reduces. With an increase in online customers, the number and fees of online

Total internet bank fees (%)	Fees of different e-banking services Total mobile bank fees (%)	Total telephone bank fees (%)
43	55	2

Table IV.
Fees of different e-banking services

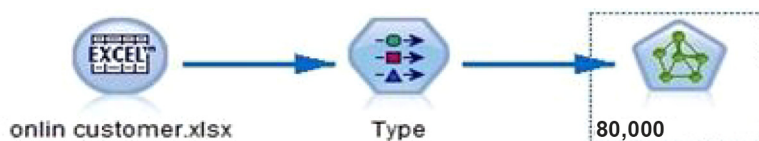


Figure 1.
Fees of different e-banking services

Row	Variables	Forecast for the next period
1	Online customer number	80,000
2	Traditional customer number	20,000
3	Ratio of resources to expenses	0.65
4	Number of internet bank transaction	1,70,000
5	Number of ATM transactions	2,80,000
6	Number of POS transactions	1,88,000

Table V.
Prediction of indices for the next period (next month)

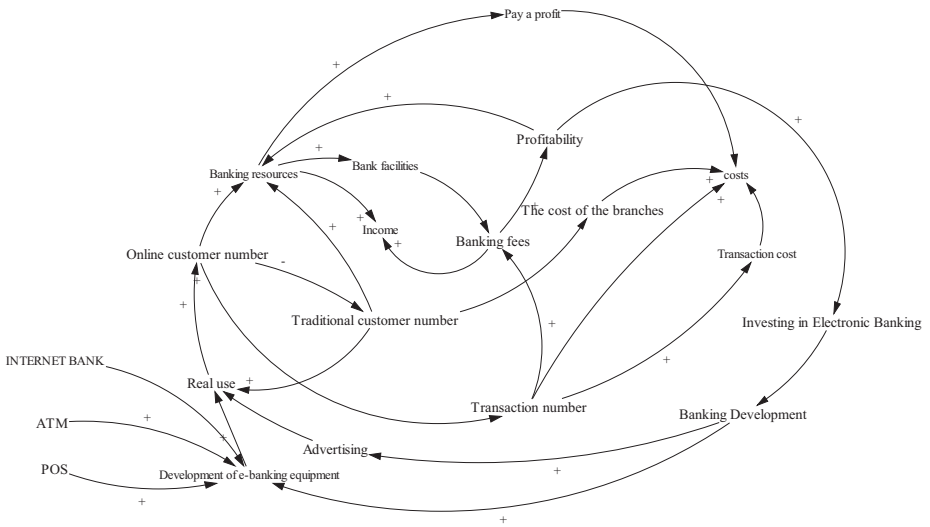


Figure 2. Model presenting effect of using e-banking on bank's profitability

transaction increase, which eventually result in higher income and profitability of the bank. On the other hand, with increasing profitability, the bank can invest more on e-banking, thereby strengthening this loop. According to Loop 2 (Figure 2), with the expansion of e-banking, traditional customers show a greater tendency toward using e-banking services. As a result, the need for physical branches reduces with reducing the number of traditional customers.

With reducing the costs pertaining to physical branches, including human resource costs, purchases, rental costs and current costs of the branches, the overall cost of the bank will reduce, bringing about positive effects on profitability. According to Loop 3 (Figure 2), the implementation of e-banking, along with internet transaction is associated with certain costs. In other words, the bank's costs increase with the increased use of e-banking services, bringing about negative impacts on its profitability. In fact, this loop has a balancing role in the model. According to Loop 4 (Figure 2), the bank can attract more resources with increasing the use of e-banking services. As a result, the bank can increase the rate of term deposits. As the interest rate for term deposit in this bank is low, the coefficient of interest rate was considered to be almost zero in the model. On the other hand, with increasing the resources, the bank's ability to lend will increase, thereby increasing the loan interest rate.

Due to the low loan interest rate of the bank, the applied coefficient was considered to be 2 per cent in this part of the model. According to the proposed model, the need for a physical branch reduces with the increased use of e-banking, thereby significantly reducing the costs of human resources and depreciation of assets. In addition, greater customer satisfaction is achieved, which results in an increase in number of customers, the amount of incomes and cost reduction. It is worth noting that the use of e-banking is an effective factor in increasing the costs. This is because, the costs of e-banking implementation, including infrastructural costs, as well as current costs of e-banking instruments can be considerably high. The bank's profitability, as the most important subject in this study, is affected by incomes and costs from e-banking application.

State and flow model

To simulate, after drawing the state and flow diagrams for the cause-and-effect loops, the state-and-flow and auxiliary variables were designed using a computer (Figure 3).

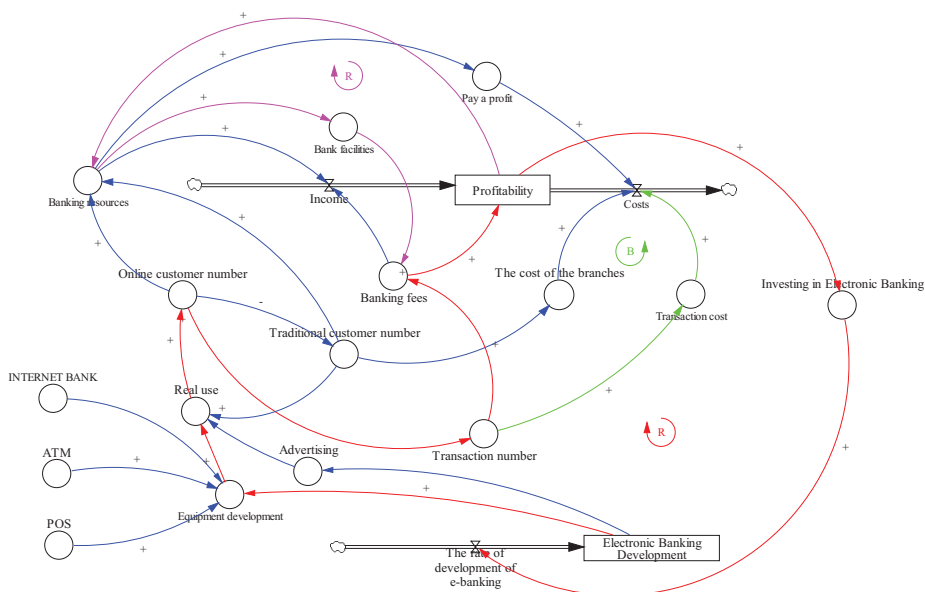


Figure 3. Computerized model representing the effect of e-banking application on profitability of the bank using system dynamics approach

There are four main loops in **Figure 3**. The blue loop stands for those variables that increase the profitability of the bank by reducing its costs. The red loop presents an increase in income, thereby improving the profitability of the bank. The green loop represents an increase in costs, thereby reducing profitability. The violet loop includes variables representing an increase in the bank's resources, ability to loan, and interest rates paid to the customers.

To obtain a better understanding, one of the model's cause-and-effect loops was investigated as a sample (the bank's cost reduction loop). The figure below presents the cause-and-effect loops of the bank's cost reduction through continuous use of e-banking.

According to **Figure 4**, the variable state, i.e. profitability, is affected by the variable rate, i.e. the net cost reduction rate. The variable rate in this loop is affected by the reduced number of traditional customers and subsequent reduction in the number of branches. The extent of e-banking application has a direct relationship with an increased number of online customers and the tendency of traditional customers toward using online services, which can reduce the need for physical branches with time. There are some balancing factors, namely, e-banking implementation and current costs, as well as online transaction costs, presented by a rectangular loop in the model.

Model testing

Validation in the system dynamics modeling refers to ensuring the model accuracy in defining the relationships and formulating them. Validation can be used to ensure the model's behavior is a reflection of reality. Among the most difficult problems facing a simulation, an analyst is to determine whether the proposed model is a reflection of reality. With respect to the system dynamics model accuracy, there is almost no model with 100 per cent accuracy, as they all reflect some degrees of reality.

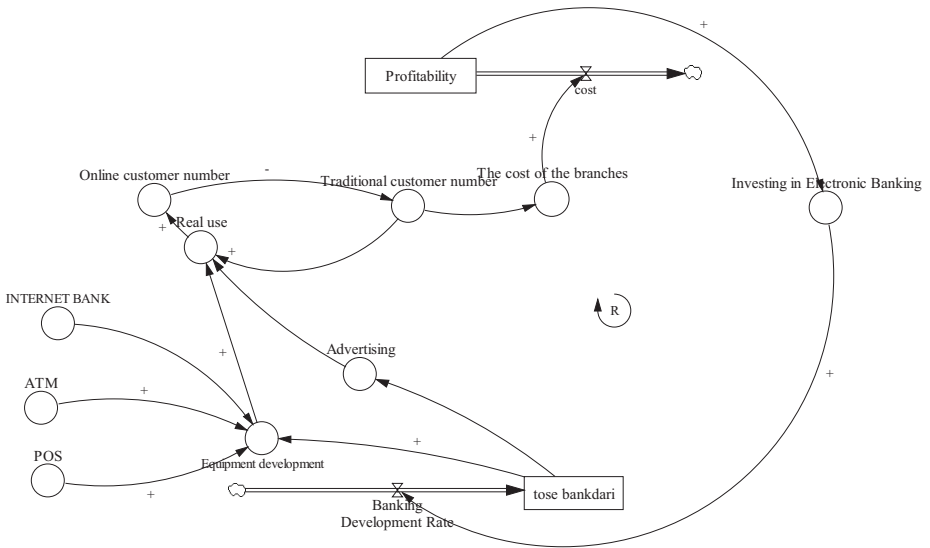


Figure 4.
The cause-and-effect
loop of branch cost
reduction through
continuous use of
e-banking

With respect to the system dynamics validation approach in Literature Review, the model was tested to evaluate its adaptability to the system's structural behavior. Regarding that the model's parameters and equations are approximate, the model was tested as conceptual and computerized models. With respect to the conceptual model, descriptions provided in Table I represent theories supporting the model's equations. In addition, the opinions of professors and experts were used to design the relationships and dynamisms between the model's constructs.

To evaluate the behavior of the computerized model's structure, the behavioral mode of real use variables was first considered to be the pivotal variables and then the limit and structural state tests were performed.

Limit state test

The development rate of e-banking facilities was considered higher than the reality. The model simulation showed that the actual profitability becomes stable.

Structural state test

The simulation results in the current study were relatively similar to the actual profitability of the bank and report in previous studies, indicating the modeling accuracy.

Simulation

Regarding the system behavior, the bank's profitability was increasing slightly in the beginning, because of increased costs of e-banking implementation. Then, it experienced an exponential growth, which was decelerated with time. (Figure 5) Factors, such as e-banking implementation and current costs, as well as the cost of each online transaction, can reduce the growth rate of this loop. To explain, it can be said that the bank's profitability can be increased by adopting different policies and programs. In other words, a greater shift can be observed in customers from using traditional banking services toward e-banking services. If traditional and e-banking system users are considered to be the Sources 1 and 2, the

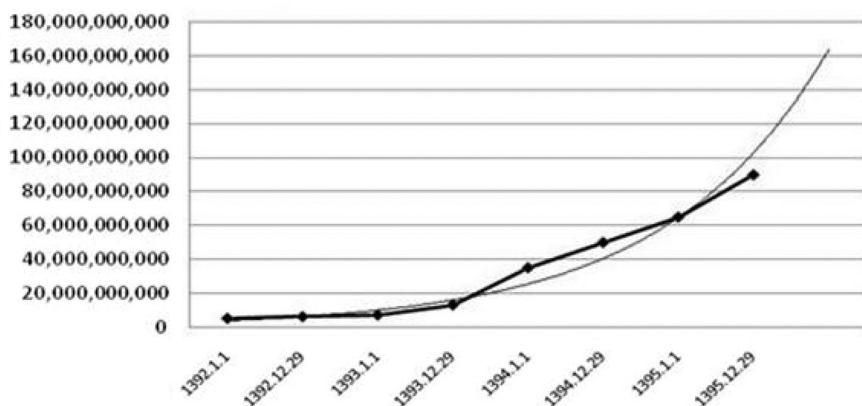


Figure 5.
Actual profitability process of a financial institution

transitional flow from the former toward the latter can be regarded as a shift from traditional to e-banking. It is worth noting that the goal of the current study was to accelerate this process.

Figure 6 presents the real profitability trend and increased number of real online customers.

To compare the system behavior, the profitability growth diagram of a financial institution in the past five years was drawn. It is worth noting that the number of the card to card transfers was regarded as the representative of the extent of e-banking application.

Investigation into different scenarios

In this section, different scenarios, which can be introduced to the model, were presented. After completing the model, results from the introduction of these scenarios can be analyzed.

To design the scenarios, the pivotal points of the problem were first identified. According to the recommendations on e-banking adoption growth policies, as well as variables in the cause-and-effect model, the pivotal points of e-banking adoption growth are:

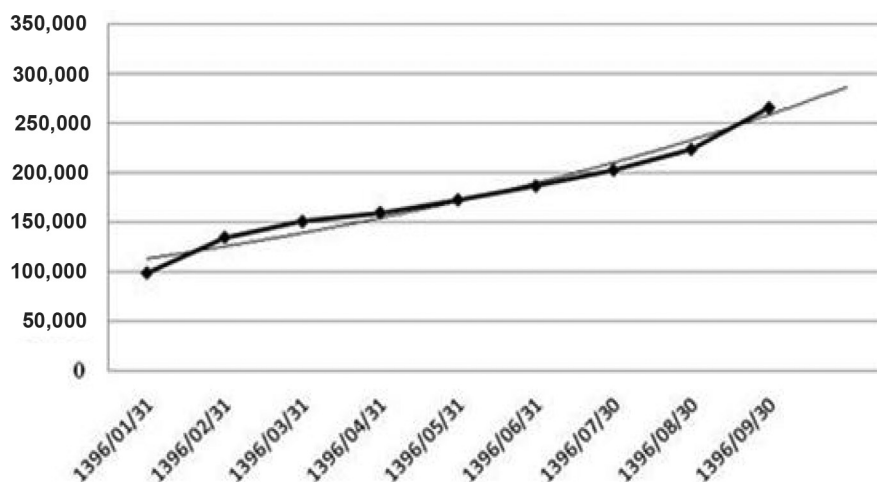


Figure 6.
Growth trend of transactions in a financial institution

- maintaining the status quo; and
- increasing investment on e-banking development and investigating its outcomes.

Based on the pivotal points, the following scenarios can be recommended for the dynamic technology acceptance model.

Scenario 1: maintaining the status quo

In this condition, no specific policy is introduced to the model and the model works according to its initial presumptions.

Figure 7 shows the real profitability behavior and increased rate of real online customers. According to this model, although the bank's profitability will increase in the next three years with maintaining the status quo, it will afterward start reducing toward zero.

Scenario 2: increasing investment on e-banking development and investigating its outcomes

Regarding the designed system and factor affecting the bank's profitability in the real world, the e-banking development is among the controllable variables in the system, which

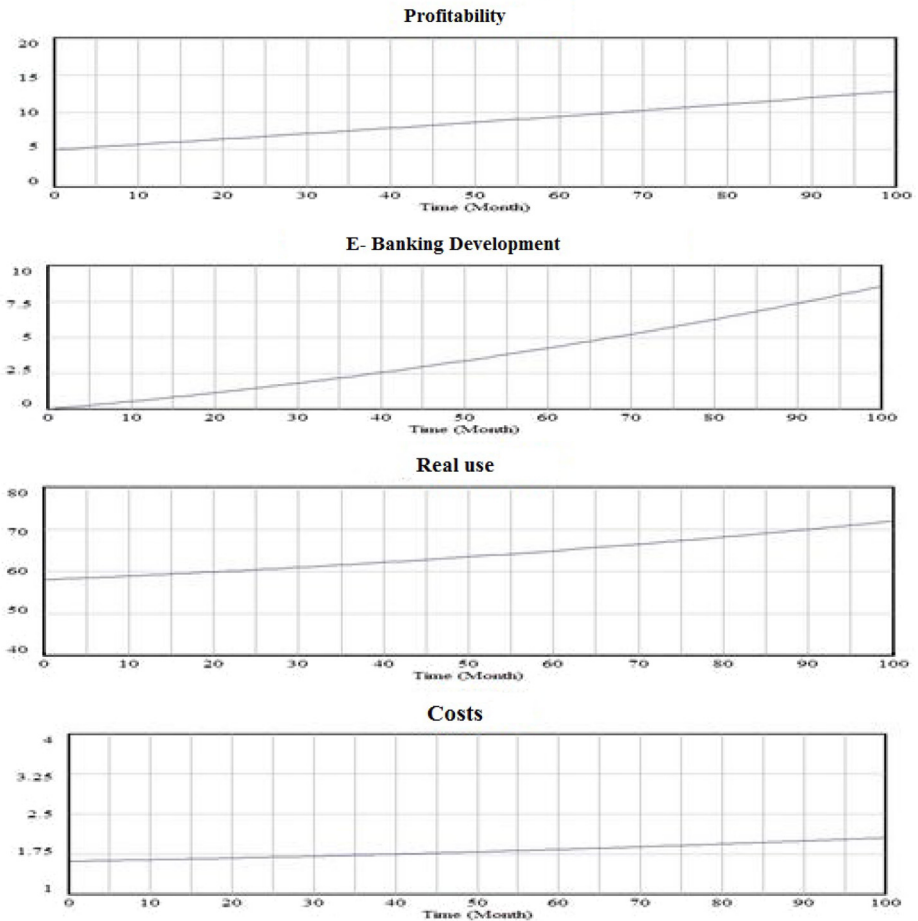


Figure 7.
Maintaining the
status quo

can be introduced through expanding e-banking facilities and advertisements. The e-banking development policy can be investigated in different ways. For example, one way is to increase the advertisement budget to investigate the system behavior. The other way is increasing the number of e-banking instruments to analyze its impact at the national level.

Figure 8 shows the system behavior after introducing the investment promotion policy to e-banking.

According to Figure 8, the number of online customers and e-banking services increased with increasing the investment on e-banking development and a number of e-banking instruments. As a result, the *H1* is confirmed. On the other hand, the introduction of this policy attracts more traditional customers toward using e-banking instruments and becoming online customers. According to the results, traditional customers reduce with time, confirming the *H2*. The need for physical branches reduces with reducing the number of traditional customers. According to Figure 8, the number of physical branches and subsequently the costs reduce with introducing this policy. Therefore, the *H3* and *H4* are confirmed. All of these changes in system behavior will eventually result in increased profitability of the bank and confirmation of the *H5*.

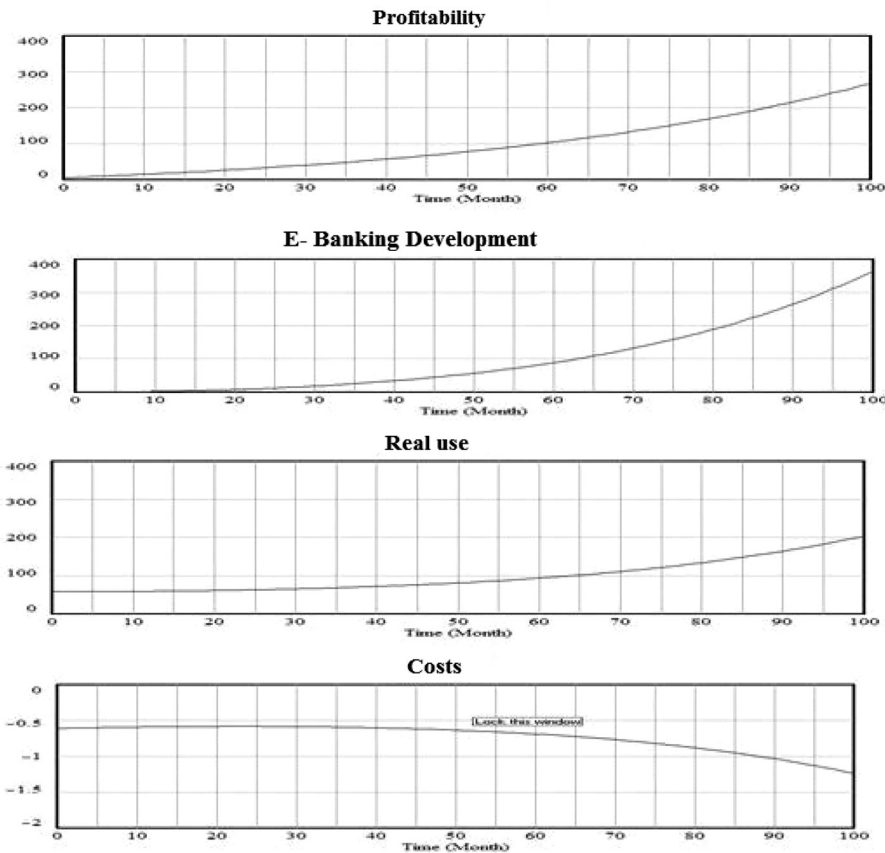


Figure 8. Investment promotion policy on e-banking advertisement and e-banking instrument development

Conclusion and recommendations

Although e-banking development carries a huge cost, such as implementation and transaction costs, to the bank, its cost and profitability diagrams will show respectively a significant decline and growth in the long run. The simulation results showed that the physical branches are associated with a considerable cost to the bank. As all banking services can be delivered through e-banking systems, the banks should change the behavior of their traditional customers through increasing their investment on advertisement and e-banking instruments to reduced visits to physical branches. In this way, traditional customers tend more to use e-banking services and the potential customers turn into an actual customer of the bank.

According to the results and proposed scenarios, the following recommendations are formulated:

- Increasing investment on advertisement and providing more information about the use of new e-banking systems and their advantages.
- Developing a solution to reduce the lack of trust in and fear of new systems.
- Increasing the quality and number of profitable e-banking instruments, which can be achieved through increasing the number and speed of transactions and network connection, reducing e-banking crashes, and increasing the number of e-banking instrument at the national level.
- Encouraging customers to make more use of modern banking systems through motivational and legal techniques.
- Providing customer-centered management and continuous connection with customers.
- Designing a user-friendly and attractive website.

The simulation results showed that the number of online customers increases with increasing the investment on e-banking development. As a result, the bank's income will increase through increasing transaction fee and resource absorption. On the other hand, the number of physical branches and relevant expenses reduce with increasing the tendency of traditional customers toward using e-banking services.

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