A system dynamics approach to the diffusion of Intranet banking: A case study from Thailand

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ABSTRACT

This paper proposes a model of Intranet banking using a system dynamics approach. Banks employ Intranet banking, one type of popular banking technology, to furnish their customers with remote banking transaction capacity via a web technology. Thailand has introduced Internet banking in the form of Intranet or Extranet banking, which requires customers to subscribe for usage. Once a bank adopts this technology, effective diffusion to customers is necessary in order to absorb a potential market and obtain returns on investment. This study used one of the largest banks in Thailand as a case study. The diffusion model of Intranet banking was developed, and strategic policies were tested to detect the leveraged ones that may enhance effectiveness in technology diffusion.

1. INTRODUCTION

This paper presents a model development of diffusion of Intranet banking using the Siam Commercial Bank of Thailand as a case study. The model was developed based on system dynamics methodology in order to increase the rate of technology diffusion. It depicted variables, their relationships and feedback loops under three sub-system boundaries of the bank (i.e. the technology group), staff and customers. Then, it was simulated using an incremental technique to verify consistency between the data. The simulation results indicated patterns of diffused Intranet banking which follow an S curve, with differing slopes. The policy analyses also revealed the dominant policies that enhance the rate of technology diffusion.

1.1. Internet/Intranet Banking

Home banking service is an electronic home-banking system using web technology. With this service, bank customers are able to conduct their business transactions with the bank through personal computers in order to reduce costs and time for transportation (Kivel & Rubin, 1996b). The basic computer-based communications systems through this service can be divided into three types: Internet, Intranet and Extranet (Marin, 1998).

- An Internet is the publicly accessible electronic communications system allowing any people or corporations to access banks' web pages on the Internet's World Wide Web.

- An Intranet is a private network designed to limit access within given organisations that require web browser technology. Banks use Intranets for sharing internal information, work-group collaboration, and communication between a bank and particular clients.

- An Extranet is a system by which banks can provide Internet/Intranet access to customers and suppliers. The Extranet is considered as a safer way of conducting online banking services than the Internet system.

There are three main categories of Internet usage: informational, intermediate and full service. Informational usage highlights information content without interactive service or financial transactions. Intermediate usage provides some customer service transaction capabilities but financial transactions are limited to inquiry. Full Service provides a set of banking functions, including account opening and transferring of funds (Kivel & Rubin, 1996b).

Investment and integrated technological infrastructure has become essential in the banking industry to assist their customers in terms of convenience, security improvements, better access to information and an alternative to cash, all of which may ultimately return advantages to the industry. In intensive competition, each bank needs to constantly maintain and improve its image, with relatively little product differentiation to attract its customers. Therefore, Internet banking has become a popular technology because it allows bank customers to conduct real-time, remote banking at any location and time where convenient and without needing to physically transport themselves to a bank, eliminating dealing with tellers, unpleasant weather or traffic. This is especially advantageous for Bangkok where may easily take up to 2 hours to travel to a bank due to traffic congestion. In addition, customers are able to access more updated information online and make their selection for the best financial incentives (Hogan, 1999; WebAustralia, 1996).

On the other hand, the banks themselves may gain fundamental benefits from Internet banking in terms of saving costs for branch establishment and operational costs (e.g. tellers and equipment). The cost of setting up full-service Internet banking is quite similar to opening a single new branch but Internet banking reaches more customers. Furthermore, customers from Internet banking are inclined to be younger, more affluent and better educated than traditional customers. That may lead to a higher demand for financial products and services and more opportunities for cross selling (Phillips, 1998; Tapscott, 1998). The low costs also enable banks to offer more reasonable interest rates, lower fees and more competent services (Anonymous, 1999; Woolley, 1998; Yakal, 1999)

Benefits from Internet banking are contingent upon the completion of the infrastructure in telecommunication, confidence in the security of the system, and acceptance by customers. Therefore, banks wishing to implement this technology need to extend infrastructure, improve skills of their personnel and intensify their security systems (Kivel & Rubin, 1996b; Monroe, 1996; Smith, 1997).

However, providing Internet banking may increase overall costs unless a bank reduces expenditures by closing branches, downsizing staff, and re-engineering operational systems. Internet banking alone may not reduce branch staffing costs or the number of transactions handled at branches because typical transactions (e.g. deposits, cheques, and withdrawals) are currently not well undertaken via Internet. Additionally, while banks may save costs for customer support due to self-servicing systems in the long run, in the short run, they have to meet additional costs for technical and new products/services to support the technology usage. Apart from bill payment fees, potential fees from Internet banking services are as yet unproved. For example, convenience-based services such as statement and cheque viewing are unlikely to provide any fees. Finally, some problems such as the millennium bug may require banks to spend money to resolve the problem and build up the confidence of their customers (Anonymous, 1999; Kivel & Rubin, 1996b).

Since 1995 when Security First Network Bank (SFNB), one of the world' s first Internet banks, was opened (Kivel & Rubin, 1996a; Mahan, 1997), many banks have shown willingness to provide Internet banking; nevertheless, the benefits from it are as yet unclear. According to Meridien Research, (i.e. a consulting firm) by the year 2000, 90 per cent of North America's biggest financial institutions will be offering transactions over the Internet (Orr, 1998). Early bank adoptions of the technology suggests that Internet banking is used not necessarily for making money but at the least for retaining banks' images as innovative organisations, defending their market position from their competitors, and building customer relationships (Orenstein, 1998).

Banks are sometimes placed in a dilemma. If they do not provide Internet banking they may lose the market to their rival banks or even non financial businesses such as post offices or wholesales and retail shops (Phillips, 1998). However, their provision of Internet banking does not assure complete success. The failures of Internet banking are commonly ensure. For example, despite being known as the first Internet banking service, Security First Network Bank (SFNB) sold its banking operations to Royal Bank of Canada in March 1998 (Orr, 1998). Another example, the NatWest, a British bank, which rejected Internet banking after a trial of two and a half years (Anonymous, 1999).

Therefore, in order to maximise utility of invested technologies, once Internet/Intranet banking is adopted by a bank, it is vital for the organisation to quickly diffuse the service to customers before the technology is obsolete, or act faster than its competitors to absorb a limited market.

1.2 Technology Adoption and Diffusion

Adoption is a decision to make full use of an innovation as the best course of action. Diffusion is the process during which an innovation is communicated among members of a social system via certain channels over time. A diffusion process consists of four main elements: an innovation, communication channels, time and a social system (Rogers, 1983).

Technology diffusion process follows the five steps of awareness, interest, evaluation, trial, and adoption (Bee, 1988), and is based on a logistic curve (a s-shape) (Rogers,

1983). Initially, it takes some time for people to adopt technology. Then, a diffused technology curve takes off when people accept it. Eventually, the curve levels off because of the arrival of new technology, market saturation, or dissatisfaction due to obsolescence.

Increasing returns due to technology adoption may be a primary factor that drives technology diffusion. First, in employing new technologies, users may promote development of a learning process that leads to improving technology use and product improvement. Second, economies of scale deriving from technology diffusion may result in higher margins leading to further adoption by both users and producers. Third, widespread use of a main technology always brings about other "infrastructure technologies". Fourth, as a technology becomes more widespread, users may gain advantages from "network externalities" (i.e. a positive relationship between the value of a product and the number of consumers using the same product) (Caskey & Sellon, 1996; Fichman & Kemerer, 1994).

In conclusion, the factors that enhance the rate of adoption and diffusion are relative advantages, technical features, organisational environments, customer behaviours, and economic environments.

First, generally, organisations are inclined to adopt and diffuse technology in which they clearly perceive benefits. These such relative advantages refer to benefits including sales, market shares, competitive advantages, efficiency improvement, accurate and timely information, better image, cost reduction, and effective decision-making (Gagnon & Toulouse, 1996; Herbig & Day, 1992; Manross & Rice, 1986; Preece, 1989; Rogers, 1983; Thompson, 1987; Waema & Walsham, 1990; Wynekoop et al., 1992). Second, technological features, including costs, complexity, reliability, risk, compatibility with existing systems, trialability, observability, and standardisation are the main factors that organisations are considered whenever they adopt or diffuse new technology (Barras, 1994; Kwon & Zmud, 1987; Sharif, 1994). Third, contributing to the success of technology diffusion are positive organisational factors including available facilities, executive support, staff acceptance, communication extent, economic externalities, and experience in technology (Bowonder et al., 1994; Kwon & Zmud, 1987; Manross & Rice, 1986; Sharif, 1994). Fourth, although technologies seem promising, sometimes an organisation hesitates to implement them because of concern about customer acceptance (Herbig & Day, 1992; Jenkins & McKenzie, 1997; Jirapinyo, 1996). Fifth, economic environment is one of most important criteria for technology adoption by the case study bank (Jirapinyo, 1996). In general, diffusion of technology occurs easily when the economic situation of the nation is promising.

The case of Intranet banking is similar to other technologies in that once it is adopted, organisations have to put in great effort to diffuse it quickly, enterprise-wide or throughout customers, to avoid prohibitive costs due to the high obsolescence rate of evolving technology. However, as a matter of fact, success in its diffusion relies on various factors, not only technical but also organisational, and often requires a lengthy time period (e.g. training, perceived satisfaction) before it is widely diffused. Therefore, the system dynamics methodology is considered a suitable decision-making tool to develop the diffusion model of Intranet banking because of its ability to capture

inter-relationships between variables and reflect dynamic effects (Coyle, 1996; Wolstenholme, 1994).

1.3 System Dynamics

Jay Forrester first developed system dynamics in 1956 as 'industrial dynamics' at the Massachusetts Institute of Technology (MIT). System dynamics is perceived as a practical profession arising from the solution of distinctive problems. Decision analysts aim to understand structures that produce undesirable symptoms in order to find desirable changes in system structure and policies that will improve a system behaviour (Forrester, 1992).

SD methodology puts emphasis on conceptualisation, formulation and simulation (Richardson, 1996). It is divided into two stages, qualitative and quantitative analysis. Initially, modellers identify system descriptions for problem development and formulate a qualitative analysis. Subsequently, the relationships formulated in the conceptual model are developed for quantified analysis using simulation techniques (Wolstenholme & Coyle, 1983).

System dynamics is used to elicit the targeted people's knowledge and to get them to articulate their perceptions. Feedback structures of a problem are created from those perceptions, and then simulated through them. This helps people to learn about complex dynamic systems and test new policies to improve the system behaviour or resolve the problem (Sterman, 1994). It is also employed to understand long-term implications of decision alternatives in situations where change occurs over time and the complexity of change is compounded by inter-related effects. This leads to decreased uncertainty, gaining more confidence before implementation, speeding up, and strengthening the learning feedback (Reagan-Cirincione et al., 1994; Wolstenholme, 1994).

2. RESEARCH METHOD

2.1 Research Objectives

The objective of this research was to develop a requisite model of diffusion of Intranet banking technology for one of the largest banks in Thailand. The model was then employed to test for strategic policies that may help the bank to diffuse the technology more effectively.

2.2. Research Methodology

This study was developed using two research methodologies: system development research and case study. System development or engineering research is the combination of an artistry of design and the spirit of "making something work" by transforming conceptual ideas in people's minds to actual practical outcomes. (Nunamaker et al., 1991).

A case study is used to investigate organisational and managerial processes of an organisation to gain more holistic and meaningful characteristics of real world events (Galliers, 1990). It is helpful in describing what actually happens, and generating

relevant and useful hypotheses which can be tested in a more rigorous fashion (Andersen et al., 1997).

The Siam Commercial Bank, Pcl. in Thailand was employed as the case study in order to get the general feeling for what is involved in a research domain, tailor the generic variables to a specific case, and to provide sufficient contextual and environmental conditions to improve validity.

2.3. Research Design

The research design consists of five stages: problem definition; constructing a conceptual framework; developing system architecture; testing and validation; and policy experiments (Nunamaker et al., 1991; Vennix et al., 1992).

Initially, information with respect to the topic and its problems was collected from literature reviews, documents and discussion with the bank staff in order to understand its existing systems and future requirements. The obtained information was used to create a preliminary conceptual model. A final conceptual model was developed, revised from the preliminary conceptual model based on the information of people in the bank using interviews and questionnaires. The refined model was formalised using SD methodology, and then simulated with the ITHINK software. The model was presented to the bank for evaluation of its validity and reliability, using tests to build confidence in system dynamics models (Barlas, 1996; Forrester & Senge, 1980). Finally, officials in the bank were further questioned using interview or questionnaire techniques to detect policy parameters for policy analyses that may help the bank to diffuse Intranet banking more productively.

2.4 Methods of Data Collection

This study employed four methods of data collection: observations, interviews, questionnaires, and documents. Information obtained from a variety of sources is important in conducting system development research because it provides comprehensive perspectives on the study, contributes to validation and cross-checking findings, and compensates for the limitations of one method of data collection with the strengths of the others (Patter, 1990).

The data of Intranet banking came from three sources, people in charge of the technology, prospective customers and executives. The details of data collection are presented in Table 1.

Table 1. Data Collection

Topic	No. of respondents	Method of data collection	Name of questionnaire/ interview	Purposes
1. Intranet banking (SCB Cash Management)	5 (people in charge)	Questionnaire & interviews & document	*"Intranet Banking"*	Variables regarding Intranet banking
2. Prospective customers of Intranet banking	119 out of 140	Questionnaire & interview	*"Prospective Customers of Internet/ Intranet Banking"*	Information regarding perspective customers (potential market)
3. Policy analyses	16 (executives)	Questionnaire & Interview	*"Policy Analysis"*	Variables for policy analyses

1. **Intranet banking (SCB Cash Management).** People in charge of Intranet banking were interviewed and completed the *"Intranet Banking"* questionnaires. The data was used for identifying variables and developing the diffusion model of Intranet banking based on system dynamics analyses.

2. **Prospective customers of Intranet banking.** The short questionnaires of *"Prospective Customers of Internet/ Intranet banking"* aimed at finding the potential usage of the Internet/Intranet banking in Thailand. At first, telephone interviewing was employed to gather opinions and perceptions from educated people who have a computer background and are in high positions in companies and the public sector in Thailand, because these people have the potential to be novices of Intranet banking. However, since it was a time consuming process and lacked standardisation, the short questionnaires were used instead.

3. **Policy analyses.** The questionnaires and interviews on *"Policy Analysis"* were used to acquire opinions from executives in the bank with regard to solving the problems relating to technological issues and proposing ways to enhance the diffusion rate.

2.5 Data Analyses

The data were interpreted using content analysis (i.e. a research technique for making replicable and valid inferences from data to their context) (Krippendorff, 1980, p.21) in order to identify variables for model development. All the variables were analysed using system dynamics (SD).

3. MODELLING THE DIFFUSING PROCESS USING QUALITATIVE SYSTEM DYNAMICS

3.1 General Background: The SCB Intranet banking

The model of the diffusion of Intranet banking was undertaken because the results from technology evaluation using a multiple criteria decision-making (MCDM) analysis identified that Intranet banking was the most preferred technology that may help the bank achieve the mission of being "*the best managed bank [in Thailand] with sustainable excellent performance"* (Intrapairot & Quaddus, 1998).

Implementation of Intranet banking technology by the Siam Commercial Bank, Pcl. was completed in August 1996. With this service, customers are able access the bank databases to carry out their banking transactions for up to 24 hours a day. The concept of this service is similar to Internet banking or Intranet banking but the bank calls this technology Extranet banking and its service is known as *SCB Cash Management*. At the beginning of 1998, there were approximately 2,000 subscribers paying subscription fees based on service options, with a maximum rate of baht 1,800 per year. Two main services are provided: financial administration data (e.g. balance checking, account transferring, transferring to a third party, bank statement viewing, bill payment and stopping payment) and business data (e.g. currency exchange rates, stock exchange, interest rates, financial information and economic information).

In this study, the main issues of Intranet banking were identified from two sources of information: bank staff who are in charge of this technology, and prospective customers.

Initially, the bank staff was interviewed in order to detect the issues or problems that the bank has confronted so far with regard to this technology. Subsequently, additional questionnaires aimed at verifying the perceptions of bank staff towards Intranet banking were distributed to 119 respondents who were potential customers of this technology (e.g. those with high educational backgrounds and substantial positions in private and public organisations). The issues examined were as follows.

1. ***Potential market.*** The bank staff felt confident that Intranet banking could be diffused to absorb a potential market without difficulty. At present, direct sales focusing only on customers from corporate business enterprises is a marketing strategy to gain 10,000 customers within 5 years. The bank has not expanded this technology to retail customers due to three main reasons. Firstly, this technology would compete with other bank services (i.e. *TELE-BANKING*) which aim mainly to serve retail bank customers. Secondly, if the bank provides this service to retail customers, the hardware and the security systems have to be upgraded or expanded. Third, the subscription fee is considered too expensive for retail customers to afford.

   Information from prospective customers revealed that Thai people still prefer to go to their banks physically or to use ATM machines. Preference for an Internet/ Intranet access is low. According to Table 2, approximately 49.68 per

cent of bank transactions have been undertaken via ATM machines and 35.78 per cent via personal visit. The transaction via electronic banking is low, with 11.10 per cent via telephone banking and 3.45 per cent via Intranet banking.

Table 2. Methods of Business Transaction with a Bank

Method of transaction	Number of transaction per month					
	Bangkok		Chiang Mai		Total	
	Number	Per cent	Number	Per cent	Number	Per cent
Bank in person	258	35.93	74	35.24	332	35.78
Using ATM machines	332	46.24	129	61.43	461	49.68
Using telephone banking	96	13.37	7	3.33	103	11.10
Using Internet Banking	32	4.46	0	0.00	32	3.45
Total	718	100.00	210	100.00	928	100.00

Source: Data derived from "Prospective Customers of Internet/ Intranet Banking" questionnaire and interview, 1998

However, while actual use of electronic banking was low, since the respondents came from a leading group in Thai society (e.g. education and career positions), their intention and inclination in using Intranet banking was high. Further data indicated that the respondents were going to use it (38.66 per cent) or may use it in the future (17.65 per cent).

2. ***Insufficient skills***. The bank has insufficient salespersons, who have both information technology (IT) and business knowledge, to demonstrate the Intranet banking service to prospective customers. Concurrently, customers of this technology should also have knowledge of both. Thus, prospective customers were hesitant to use it because they (13.94% of the respondents) felt that they have deficient knowledge of computer technology (See Table 3).

3. ***Costs for usage.*** The bank perception is that customers are hesitant in using this technology because they have to outlay an initial substantial investment themselves (e.g. for personal computers and modems). This perception is consistent with the information from prospective users. According to Table 3, respondents (25 per cent) indicated that they do not have sufficient computer facilities to connect with their banks and are not willing to invest their own money for this. Many respondents also commented that the use of Internet or e-mail from their offices, especially in public sectors, is still restricted. Some executives still perceive that computer facilities are too expensive to allow for common usage, and limit the quantity of usage to save costs, protect security and keep confidentiality of organisations.

4. ***Reliability and security***. The bank has high confidence in the reliability and security of Intranet banking due to the many intensively protective procedures

available to prevent its technology from errors and business frauds. Yet, the security issue is one of the main concerns that still deters potential customers from using this technology. The potential customers (8.65 per cent) revealed that they do not trust Intranet banking. Some added comments that even though ATM has been implemented for a long time, errors still occur. In fact, they are obliged to use a certain technology such as ATM only because their organisations transfer salaries to an ATM system. Voluntary usage of technology, especially a high technology as Intranet banking, is far beyond their perceived interests.

5. ***Infrastructure.*** According to the bank information, diffusion of this technology is also contingent upon infrastructures such as telephone lines and speed of modems. Congestion of telephone lines, low speed of modems, and high costs in using telephones may hinder the rate of technology.

Based on prospective customers' perceptions, the other two reasons for not using Intranet banking were that this was *beyond their needs*, and their *lack of information* (see Table 3). Firstly, 27.40 per cent of respondents felt that Intranet banking was beyond their needs because of their own low levels of business transactions. The usage of Intranet banking in Chiang Mai (i.e. the second largest city in Thailand) is zero. This may be because clients felt that if they used Intranet banking, they would be charged for long distance calls, which would be much more expensive than going to banks or dropping in to ATM machines. Secondly, 25 per cent of respondents revealed that they did not know that Intranet banking was currently available. This is because banks prefer to provide Intranet banking to corporate enterprises rather than to retail customers. Therefore, the banks have not spent much money on advertising such service.

Table 3. Reasons for Not Using Intranet Banking by Prospective Customers

Reasons	Bangkok		Chiang Mai		Total	
	Number	Per cent	Number	Per cent	Number	Per cent
Not necessary	24	25.53	33	28.95	57	27.40
Lack of equipment (e.g. computer, modem)	26	27.66	26	22.81	52	25.00
Unaware that the bank provides this service	26	27.66	26	22.81	52	25.00
Insufficient computer knowledge	9	9.57	20	17.54	29	13.94
Uncertain about security systems	9	9.57	9	7.89	18	8.65
Total	94	100.00	114	100.00	208	100.00

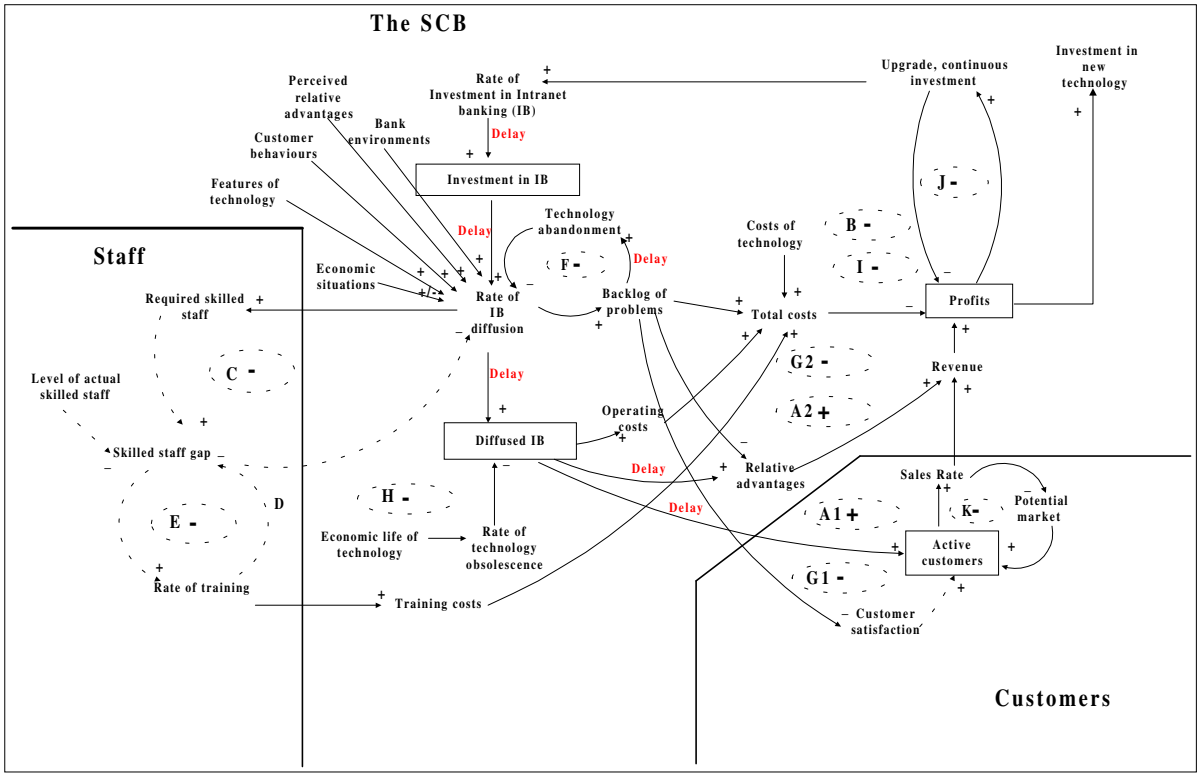
Source: Data derived from "Prospective Customers of Internet/ Intranet Banking" questionnaire and interview, 1998.

However, based on the two sources of information, the market potential of Intranet banking sounds promising due to two main reasons. Firstly, current non-adopters of this technology are clearly available in plenty. Secondly, the propensity to use this technology among people with the capability and affordability is high (more than 50 per cent). However, the rate of technology diffusion may not burgeon out. Bank staff revealed that an interest in this technology is dropping partly due to the economic crisis in Thailand. Before July 1997, many organisations were 'technological oriented'. They adopted technologies not only to gain benefits but also to reflect a good image and social status. Taking the above into consideration, innovative expensive technologies could be easily accepted in the future without difficulty in terms of organisational expenditures. However, at present, because of the current economic situation, even a subscription fee of baht 1,800 (i.e. AUD $ 90) per year is considered as an extravagant expenditure.

3.2 Influence Diagram

The derived information was initially analysed based on the qualitative system dynamics approach (Coyle, 1996; Wolstenholme, 1994). Figure 1 illustrates the influence diagram of Intranet banking, which depicts variables, system boundaries, and relationships among variables and feedback loops.

Figure 1. The Influence Diagram of Intranet Banking



The sub-system boundary of Intranet banking is divided into three sub-systems (i.e. the SCB, staff and customers). In this study, the SCB is defined as departments that are responsible for technical support and business policies of this technology. Staff comprises people who are responsible to provide services using Intranet banking to customers. Currently, there are 8 officials available to do so. The bank plans to train

their staff from branch offices by dividing them into 10 groups, with 500 people per group, in order to enhance their knowledge and capability to sell the technology to customers. Customers are subscribers to this technology. Currently, there are 2,000 subscribers. The bank expects to gain another 10,000 customers within 5 years, or an increase by 600 customers per year. However, these two figures appear inconsistent, because if customers were to increase by 600 per year, within five years there would only be 5,000 customers (including the current customers). Therefore, the analysis used 600 customers per year as a target rate of technology diffusion and 10,000 as a potential market of this technology.

The influence diagram of this technology comprises of 12 feedback loops.

Positive feedback loop A1: Generally, technology adoption drives technology diffusion (Fichman & Kemerer, 1994). Therefore, "Investment in Intranet banking" impels the bank to diffuse this technology to customers in order to obtain anticipated returns from the investment. Factors that drive the "rate of technology diffusion" are "perceived relative advantages", "customer behaviours", "economic situations", "bank environments" and "features of technology" (Gagnon & Toulouse, 1996; Herbig & Day, 1992; Manross & Rice, 1986; Preece, 1989; Rogers, 1983; Thompson, 1987b; Waema & Walsham, 1990; Wynekoop et al., 1992).

The bank diffuses this technology by selling *the SCB Cash Management* service to customers. "Active customers" bring about an increase in "sales", "revenue" (e.g. subscription fees and service fees) and "profits". Ultimately "profits" subsequently induce additional technological investment.

In general, the diffusion process is a time consuming process; therefore, time delays occur during the diffusion process as well as receipt of profits.

Positive feedback loop A2: Apart from sales, "diffused Intranet banking" also increase other "relative advantages". The explicit relative advantage is internal performance cost saving due to a decrease in physical visits to bank counters by customers. Sales and cost savings lead to increases in revenue and profits respectively. Eventually, profits encourage additional technological investment.

The feedback loops A1 and A2 are positive. That is, the more Intranet banking is diffused, the more increase in "sales", "relative advantages" and "profits" can be obtained

Negative feedback loop B: The bank spends resources for the provision of Intranet banking such as costs of technology, operating and maintenance costs. These costs decrease profits.

Negative feedback loops C and E: Diffusing Intranet banking, similar to other information technologies, requires an increase in the number of skilled staff to look after customers (Bezdek & Jones, 1990). Yet, successful diffusion is contingent upon levels of sufficient "actual skilled staff" (Kwon & Zmud, 1987; Madu, 1989). The difference between skilled staff available and those still required widens the skilled staff gap, and impels the bank to provide "training" or educational programs to fill it (Madu, 1989; Manross & Rice, 1986).

Negative feedback loop F: A backlog of problems can increase "the rate of technology abandonment" leading to a decrease in "the rate of technology diffusion" (Saeed, 1990). Intranet banking also has the potential to increase a backlog of problems. At present, a department in charge has to send staff to fix customers' problems at the rate of 2-3 cases per day. Most problems come from difficulty in connecting to the bank, sluggish response in transferring data and downed servers. A backlog of problems results in increased rate of technology abandonment, and subsequently decreases the rate of technology diffusion.

Negative feedback loops G1 and G2: Problems from technology usage may exert negative impacts on customer satisfaction, leading to the decrease in active customers and thus relative advantages.

Negative feedback loop H: Providing training programs to upgrade the quality and quantity of skilled staff results in increasing costs and decreasing profits (Farr & Sullivan, 1996; Goff, 1999).

Negative feedback loop I: The more the technology is diffused the higher and more various are the costs involved, from initial costs in feedback loop B such as training costs, and costs to resolve problems (Madu et al., 1991).

Negative feedback loop J: Profits from this technology induce the bank to additional investment and upgrading of the technology. Conversely, such investment may reduce the profits of the bank (Takac & Singh, 1992).

Negative feedback loop K: Market potential is one of the factors that impacts on an innovation diffusion processes (Maier, 1995). Since this technology relates directly to customers, the market potential is important to indicate the future level of sales and anticipated relative advantages. The bank is able to increase sales, however, once the market is completely saturated, sales and profits decrease.

4. MODELLING THE DIFFUSING PROCESS USING QUANTITATIVE SYSTEM DYNAMICS

Although the qualitative model provides holistic perspectives, it may not suffice for analyses of the impacts of interaction between the feedback loops. Therefore, the model of Intranet banking was then elaborated based on a quantitative system dynamics approach.

Parts of the derived data were scattered, unrelated and conflicting with each other. The inconsistent data are common due to the fact that people in charge can give only piecemeal data, rather than holistic data about the system. The examples of the conflicting data are as following.

> *"The bank wants to increase the customer base by 600 people per year within 5 years."*
>
> *"The economic life of this technology is 3 to 5 years."*
>
> *"The potential market of this technology is about 10,000."*
>
> *"The revenue target is 20 per cent increase per year."*
>
> *"The bank invests in this technology baht 2 million per year."*

"The bank will train staff, 10 group with 500 people per group."

The above data are inconsistent. First, if the bank increases by 600 customers per year it will take 16 years to absorb a potential market (10,000 customers) but the economic life of this technology is only 3-5 years. Second, the revenue target of the bank is 20 per cent per year. If the bank aims at an increase in 600 customers per year, it means that the rate of increase in customers is decreasing from 30 per cent for the first year to 12 per cent per year at the end of the fifth year. Third, the bank spends baht 2 million per year for investment in this technology and intends to provide a massive training. However, the interviewees did not identify that this amount of investment and trained staff could help the bank to increase the target revenue of 20% per year.

Therefore, an incremental approach was employed to develop a quantitative system dynamics model to find a complete model at a present state and to validate consistency among the data. The model was then used as a baseline model in order to explore strategic policies to detect leverage points that may increase the rate of technology diffusion and profits and promote "system learning" (Senge, 1992). The results from these four simulations- focusing the rate of technology diffusion, time to gain 5,000 customers, and time to absorb the potential market- are presented in Table 4.

Table 4. Comparison of Simulation Results using an Incremental Approach

	Rate of technology diffusion	Time to acquire 5000 customers (months)	Time to absorb the potential market (months)
Base run 1 (Using a diffusion target)	50	73	200
Base run 2 (Using a growth rate of diffusion)	33-217	61	103
Base run 3 (Adding a backlog of problems)	33-145	98	144
Base run 4 (Adding training)	28-364	60	93

4.1 Base Run 1: Using a Diffusion Target

The first simulation used a target of the bank endeavouring to diffuse this technology for 600 subscribers per year (i.e. 50 per month) as a rate of technology diffusion. The simulation aimed to use the interview data without any attempt to link the variables. That is, there is no linkage between investment in technology and technology diffusion, between investment in technology and profits, and between staff and technology diffusion.

Findings: The results of this simulation revealed that the bank gained 5,000 customers within 73 months and took 200 months to absorb a potential market (10,000 prospective customers). The results did not accord with reality because the economic life of this technology is projected at only 60 months (see Table 4).

4.2 Base Run 2: Using a Growth Rate of Diffusion

This simulation was undertaken using the current customers (2,000 customers) as diffused technology with a 20% per year growth rate of diffusion instead of highlighting a constant customer target (i.e. 50 subscribers per month). The rate of technology investment, the rate of technology diffusion, and profits were linked.

Findings: The rate of technology diffusion was increased from 50 to 217 customers per month. The bank gained 5,000 subscribers within 61 months and absorbed the potential market within 103 months.

4.3 Base Run 3: Adding a Backlog of Problems

The data from interviewing bank officials indicated that the rate of technology abandonment of Intranet banking is 2-3 per cent per year. Additionally, the bank has to send staff to solve customers' problems, averaging three cases a day. Therefore, the base run 3 exerts impacts from a backlog of problems on the rate of technology diffusion and the rate of technology abandonment. The basic assumption is that the more customers perceive problems in technology usage, the more they abandon using it, and the harder the task for the bank staff to convince new customers to use it. There were two main changes in this simulation. That is, a backlog of problems decreases the rate of technology diffusion but increases the rate of technology abandonment.

Findings: A backlog of problems decreased the rate of technology diffusion from 217 to 145 persons per month. Furthermore, the bank took a longer time to gain 5,000 customers (from 61 to 98 months), and to absorb the potential market (from 103 to 144 months).

4.4 Base Run 4: Adding Training

This simulation included a staff sector into the previous simulation. The assumption under this simulation is that if the bank has more skilled staff, the rate of technology diffusion should be increased by an accelerator factor. The accelerator factor was calculated from the derived data. Suppose the current accelerator factor is 1. At the end of training the accelerator factor will be up to 1.5.

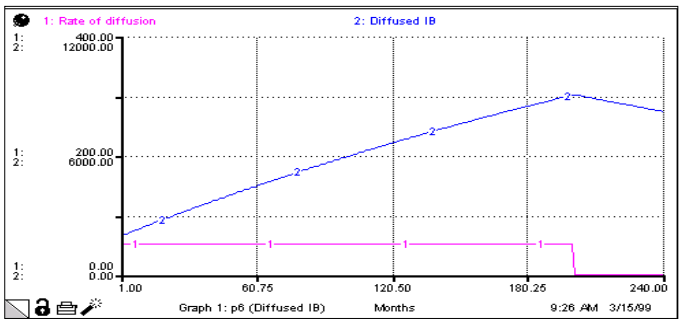
Findings: Training increased the rate of technology diffusion from 145 to 364 customers per month. Therefore, the bank gained 5,000 customers within 60 months and absorbed the potential market within 93 months.

The comparison of each simulation is illustrated in Figure 2. The rate of technology diffusion from the base run 1 is constant at 50 customers per month. The rate of technology diffusion increases up to 217 in the base run 2 because of the growth rate of technology diffusion that the bank tries to achieve, and the relationships between technological investment, technology diffusion and profits. A backlog of problems (base run 3) decreases the rate of technology diffusion whereas training (base run 4) enhances it.

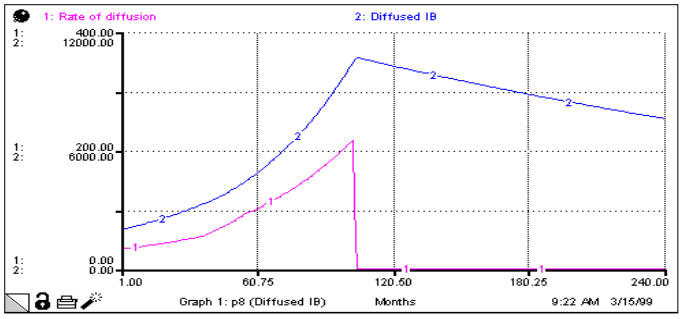
The patterns of diffused Intranet banking follow an S shape, with different slopes however. According to Figure 2 b, it takes approximately 50 months for this technology to take off, and 103 months to absorb the whole market. However, when the problems are accommodated (Figure 2c.), the slope of the diffused technology is more elastic. That is, the bank is able to gradually diffuse the technology. The bank takes a longer time (i.e. more than 120 months) to gain the highest diffused technology but without the ability to absorb all the prospective customers (only 8,400 out of 12,000 persons). Once the bank provides training (Figure 2d.), diffused technology increases more rapidly compared to other scenarios. The potential market is then saturated within only 66 months.

Figure 2. Comparison of the Rate of Technology Diffusion and Diffused Intranet Banking between Different Scenarios

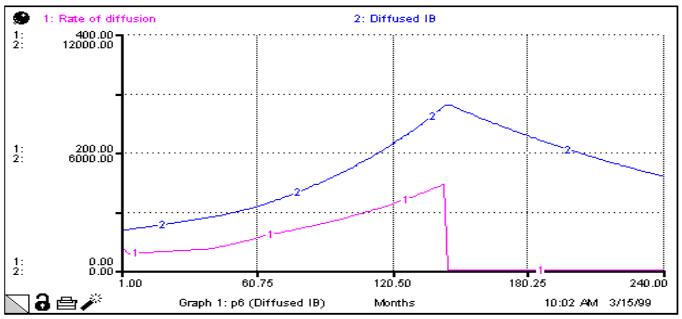
a. Base run 1: using a diffusion target



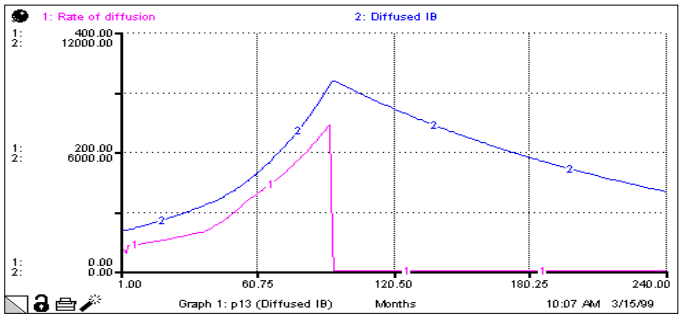
b. Base run 2: using a growth rate of diffusion



c. Base run 3: adding a backlog of problems



d. Base run 4: adding training



5. STRATEGIC POLICY ANALYSIS

The policy analysis aims to observe impacts of strategic policies and detect the leverage policies that may increase the rate of technology diffusion of Intranet banking and the profits from use of this technology. The base run 4 is used for policy analyses.

The SCB bank officials identified these following strategic policies to increase the rate of technology diffusion (See Table 5).

1. **Supportive training factor.** Training is an instrument in creating knowledge workers and enhancing their levels of understanding (Madu, 1989; Manross & Rice, 1986; Quaddus, 1996). This policy is divided into three sub policies including increase in co-operation between IT people and users, increase in perceived relative advantages and decrease in perceived complexity. It is believed that if the bank increases the supportive training factors, technology can be diffused faster, leading to an increase in profits.

2. **Marketing strategies.** Since this technology serves customers directly, marketing strategies are important to increase the rate of technology diffusion and profits. This policy is divided into two sub policies, increasing customer satisfaction/acceptance and increasing promotional advertising (Bee, 1988; Feichtinger, 1992).

3. **Positive organisational environments.** Organisational environments can promote or demote the rate of technology diffusion. The bank staff indicated that an important factor in driving technology development is support from top executive managers.

4. **Decreased the backlog of problems.** Staff and customers can easily accept technology, which contains positive features. Therefore, if the backlog of problems is decreased, the bank may increase the rate of technology diffusion and concurrently decrease the rate of technology abandonment.

Table 5 also indicates the level of actual performance (i.e. the level of current perceptions of staff) towards each strategic policy. The lowest score is 1, which indicates the lowest performance, whereas the highest one is 7 which is used as the level of desired performance. The level of actual performance (1 to 7) was transformed to a zero to 1 scale value in order to facilitate simulation using ITHINK software (Richmond et al., 1994).

Table 5. List of Strategic Policies of Intranet Banking

Policy	Level of actual performance (Average Weight- 1 low and 7 high)	Level of desired performance (Average Weight- 1 low and 7 high)	Value used in ITHINK (Average Weight- 0 low and 1 high)
1. Supportive training factor			
- Increased co-operation between IT people and users	3.89	7	From 0.55 to 1.00
- Increased perceived relative advantages	6.09	7	From 0.87 to 1.00
- Decreased perceived complexity (Make it easy to use)	4	7	From 0.57 to 1.00
2. Changing marketing strategies			
- Increased satisfaction/acceptance	6	7	From 0.85 to 1.00
- Increased advertising	4	7	From 0.57 to 1.00
3. Positive organisational environments			
Increased management support	6.14	7	From 0.87 to 1.00
4. Decreased backlog of problems	2-3 cases per day	Less then 1 case	From 0.33 to 0.00

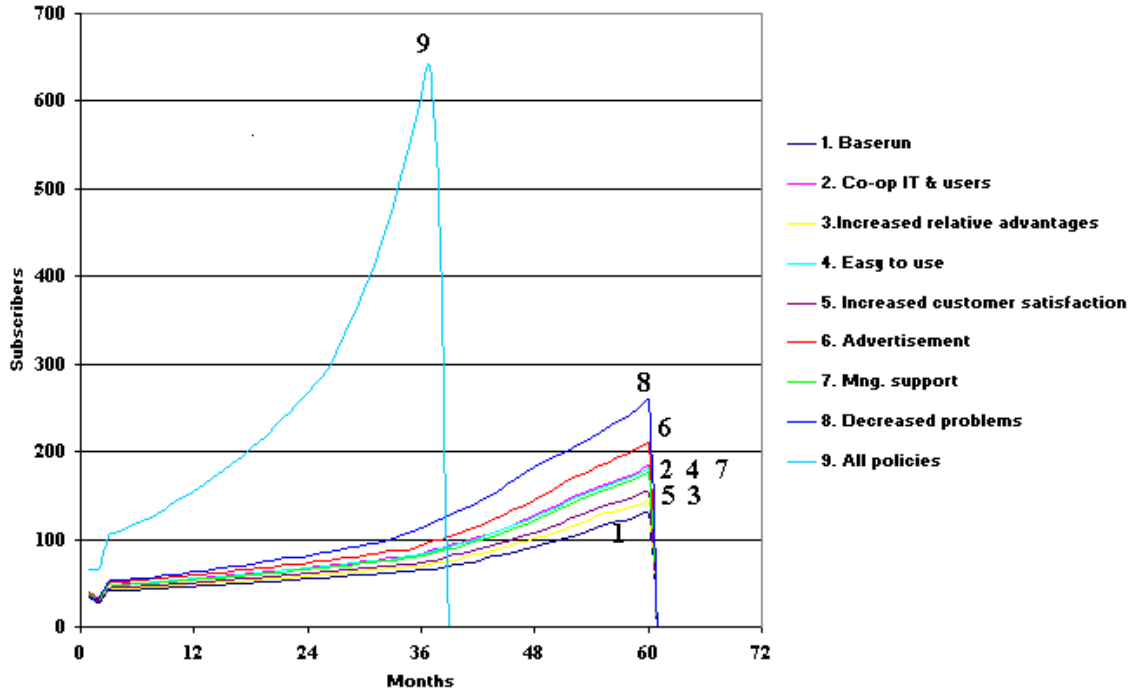
Source: Data derived from "Policy Analysis" questionnaire and interview, 1998

Each strategic policy was additionally simulated from a baseline model. The end results of each strategic policy are compared in Table 6. The comparison patterns of diffused technology and the rates of technology diffusion from different policies are also illustrated in Figure 3.

Table 6. Comparison of the Impacts of Exerting Strategic Policies

Policy	Rate of technology diffusion (within 60 months)	Time to absorb the potential market 12,000 customers (months)	Profits within 60 months (1,000 Baht)
Baseline simulation	28-128	60	22,086
Increased co-operation between IT people and users	32-181	52	27,160
Increased perceived relative advantages	29-142	58	23,473
Decreased perceived complexity (Make it easy to use)	32-178	52	26,917
Increased satisfaction/acceptance	35-153	56	24,526
Increased advertising	34-209	49	29,137
Increased management support	32-173	53	26,438
Decreased backlog of problems	33-256	42	38,744
All policies	66-638	21	83,505

Figure 3: Comparison of Rate of Technology Diffusion from Different Policies



Leverage policies are the policies that absorb the potential market within the shortest time due to the limitation of the economic life of technology (60 months). *Decreasing the backlog of problems* (42 months), *increasing promotional advertising* (49 months), *increasing co-operation between IT people and users* (52 months), *decreasing perceived complexity* (52 months) and *increasing management support* (53 months) are five main policies that may drive the rate of technology diffusion. If the bank combines all the policies and undertakes them effectively, the ideal rate of technology diffusion will increase from 128 to 638 subscribers, and decrease the time to absorb market from 60 months to 21 months (Table 6, and Figure 3).

Figure 4. Comparison between Profits from Different Policies

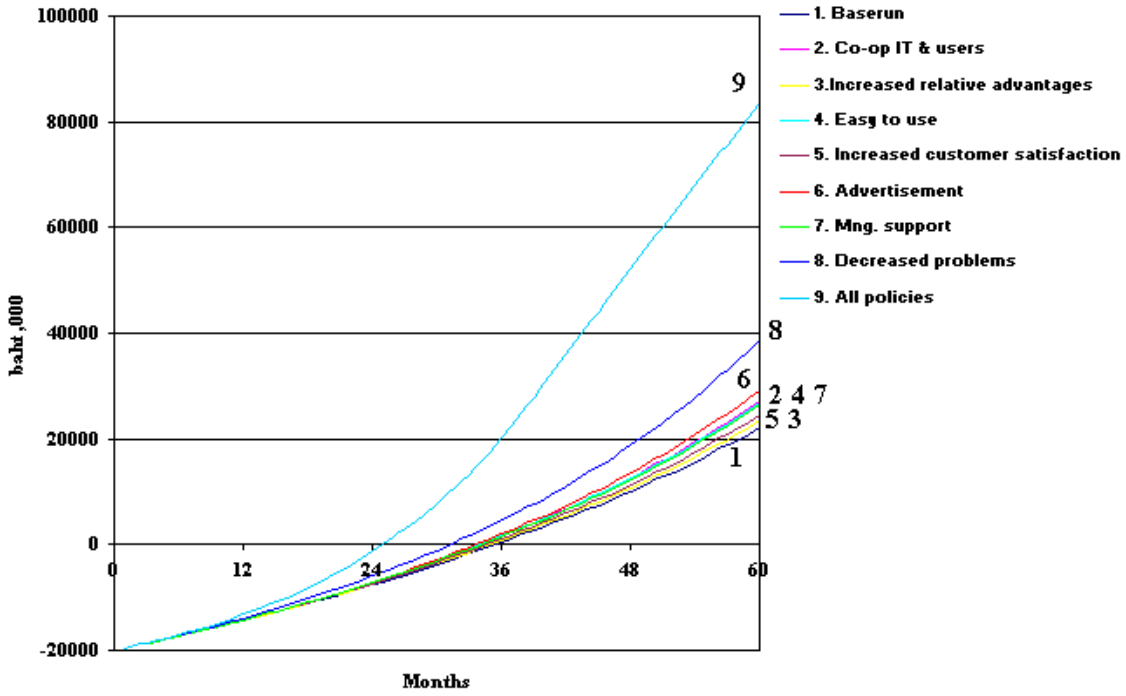


Figure 4 illustrates the comparison between profits based on each strategic policy. Those fore-mentioned policies (i.e. increasing advertising, decreasing the backlog of problems, increasing co-operation between IT people and users, decreasing perceived complexity, and increasing management support) are five main strategic policies that may increase profits of the bank. It can be observed that an increase in advertisement provides substantial profits because currently the actual performance of advertising is rather low. Ideally, if the bank combines all the policies, the profits may increase from baht 22 million within 60 months to baht 83 million.

6. CONCLUSION

Although currently the level of acceptance in using Intranet banking in Thailand is not high, it is believed that potential adopters of this technology maybe ubiquitous in the long run in the same way as those who use ATM machines. The analysis of the model pointed out that training, decreasing the backlog of problems from the technology, co-operation between IT people and users, making the technology easy to use and support from executives are the main issues that the bank should consider. Additionally, since this technology is employed to service customers, marketing such as promotional advertising is necessary to boost the rate of technology diffusion in order to absorb the market potential before the technology becomes obsolete, due to the limitations of its economic life.

The proposed Intranet banking model is however constrained by limitations, in that it may not be a suitable vehicle for accurate predictions because of the potential unreliability of information gathered. This incompleteness of data is due to a variety of reasons, in the main based on the “human factor”. For example, inconsistencies in data derived from the fact that bank staff responsible for validating data was unable to devote sufficient time or interest to it because of other demands of work. Data were

also scattered and potentially biased because of respondents' varying perceptions. Finally, not all parts of the data especially costs and benefits could be recorded or classified because of the properties of data (e.g. un-categorisation, implicity and un-quantification), and confidentiality. Therefore, if an organisation requires an accurate forecasting model, provision of accurate information and full co-operation between the model analyst and stakeholders of the organisation are a must. Nevertheless, at the least, this model analysis may be useful as a basic guideline for promoting the learning and understanding of the people involved. That is, bank staff is able to "play" with it by adding more variables (e.g. economic situation, competitors), changing the relationships between variables, as well as adding other strategic policies as they see fit.

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