SYSTEM DYNAMICS MODELLING OF INFORMATION AND COMMUNICATION TECHNOLOGIES: POLICY STUDIES IN THE BANKING INDUSTRY IN THAILAND

By

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ABSTRACT

This study aims to develop a holistic, dynamic model for information and communication technology (ICT) adoption and diffusion in a major bank in Thailand in order to identify the various policy variables affecting the adoption and diffusion of ICTs. The generic conceptual model of ICT adoption and diffusion was developed based on the system dynamics approach to identify and tackle the problems and fulfil bank objectives. The SD simulation model reveals the following issues. First, training is a vital factor for the success of technology diffusion. Second, a backlog of problems arising from technology diffusion decreases relative advantages and sales dramatically. Third, technology cannot bring as many customers as the bank expects due to the constraint of market potential. Fourth, excessive investment in new technology can be detrimental to the bank. Therefore, the bank has to determine the desired level of investment in new technology. Fifth, without substantial investment, the bank cannot harvest economic gains from investment in new technology.

1. Introduction

Thailand's economy is currently confronted with a major crisis originating in the property and financial sectors. While globalisation of the world economy through information and communication technologies (ICT) undoubtedly contributed to the flood of capital investment, which fuelled Thailand's 8% annual growth since 1988, the flight of this capital made the collapse (beginning in July, 1997) more severe, with 40% depreciation of the Baht and the local SET share index falling to a third of its highs. To prevent repetition of such damaging outcomes in the future, the ability of financial institution to adopt and diffuse ICT may be a necessary key to financial control mechanisms.

Since 1983, the banking Industry in Thailand has introduced and implemented numerous of information and communication technologies (ICT). The ICT investment commencing with the highly popular ATM transaction services has led the industry to the advent of the electronic banking period in Thailand (The Siam Commercial Bank (Pcl.), 1996). Adoption of ICT is initiated generally through equipment purchases. When this happens, relevant software applications are required. However, apart from such technological aspects, technology adoption and diffusion should focus on managerial and organisational processes and the social context, and should be adapted to local cultures, markets and circumstances (Bhatnagar, 1994; Gozlu, 1994).

Currently, bank executives have to make crucial decisions in regard to adopting new technologies, maximising utility and finding ways to promote widely those adopted fruitfully, as well as mitigating the degree of seriousness of problems deriving from technologies, and integrating those technologies to business performances. Consequently, this study aims to develop a holistic dynamic model for information and communication technology (ICT) adoption and diffusion, using one of the major banks in Thailand (i.e. the Siam Commercial Bank, Pcl. or SCB) as a case study. The model is proposed to identify the various policy variables affecting the adoption and diffusion of ICTs.

2. Current usage of information and communication technologies (ICT)

The study initially explores the current usage of information and communication technologies of the bank. The results reveal various types of technologies currently employ to service customers and facilitate work performance include ATMs, EFTPOS, smart cards, databases, data warehouse, video conferencing, internet, Intranet banking, network systems, for instance.

Although these technologies contribute to many advantages, the information from the data collection indicates critical problems confronting the bank such as rapid obsolescence of adopted technologies, selection of inappropriate technologies, low productive usage of those adopted, lack of capable employees, and high costs of technologies, coupled with unexpected performance and low acceptance from staff and customers.

Since adopting and diffusing technology are currently routine practice for decision-makers due to the rapid rate of technological evolution and intense competitive in the banking industry. Therefore, in order to provide a guideline on how to adopt and diffuse technologies productively, a generic conceptual model of ICT adoption and diffusion is proposed to capture key variables, detect constraints and purpose leverage strategic policies.

3. Research Questions

The information and communication technology (ICT) model developed is based on the qualitative and quantitative system dynamics approach (Coyle, 1996; Wolstenholme, 1994). The model aims to detect the results of the following research questions

3.1 How does training support impact on technology diffusion?

Apart from technical features, important factors influencing on the success and failure of technological implementation are organisational aspects such as training, top management support, interactions during implementation, user involvement, and motivated and capable users' attitudes (Kwon & Zmud, 1987; Manross & Rice, 1986). Since innovation can succeed only if end users have a full understanding of the technology, training is considered as a vital policy to provide knowledge, reduce levels of resistance, create skilled human resources and increase managerial potential (Madu, 1989). Generally, technology diffusion changes positively with the level of training support. When technology is diffused, it creates learning environments that convince more end users to attend training and more trained staff and active staff further enhance diffusion rate (Quaddus, 1996).

Therefore, the hypotheses regarding training support are :

H1 a: Training support increases the rate of technology diffusion.
H1 b: Training support increases relative advantages.
H1 c: Training support increases sales.

3.2 How does backlog of problems impact on technology diffusion?

Solving work problems and reducing uncertainty in problem solving are two main reasons for adopting information technology. However, whenever technology is diffused, a backlog of unsolved problems associated with technology itself and organisational aspects of adopters is created (Foschini, 1989; Gozlu, 1994; Rogers, 1983). For example, home banking which is in operation since the 70s, not only brings about a good return on investment but also gives rise to problems (e.g. abused information, business frauds, insecurity and unreliability, and increasing demand for higher capacity of hardware and software) (Global Banking Intelligence Corp., 1996). Therefore, if an organisation fails to solve a backlog of problems, it may create one kind of uncertainty in the minds of adopters leading to demoting further adoption and simultaneously promoting existing adopters to abandon technology use (Rogers, 1983; Saeed, 1990).

Thus, given a backlog of problems factor, the suggested hypotheses are:

H2 a: A backlog of problems decreases the rate of technology diffusion.
H2 b: A backlog of problem decreases relative advantages.
H2 c: A backlog of problem decreases sales.

3.3. How does market potential affect technology diffusion ?

Previous research indicates that early adoption of new IT applications leads to long-term competitive advantages (e.g. market share and income) (Dos Santos & Peffers, 1995). However, an organisation may hesitate to become involved in, or to postpone full implementation of a particular technology because of an obscure actual demand or market potential of a product deriving from technology use (Jirapinyo, 1997).

Market potential is physically reduced by sales in a period and increased by a flow coming from new potential customers and customers who repurchase due to product obsolescence (Maier, 1996; Milling, 1996). However, in reality, it is difficult to know market potential of a particular product because many potential customers or users may decide to wait for it to attain some initial success before entering the market. This delay occurs because early adopters will see few benefits from the product until it is used prevalently. A wait-and-see attitude of prospective customers may cause insufficient demand to launch the product successfully (Caskey & Sellon, 1996). Additionally, in a dynamic environment, short product life cycles, a sharp decline in prices and time to market also affect market potential (Maier, 1995).

In effect, although technology can be successfully diffused, economic gains are limited by the market potential. Therefore, the suggested hypothesis is:

H3: Despite successful diffusion market potential inhibits sales.

3.4. To what extent does investment in new technology affect economic returns on investment ?

Generally, a more costly technology is less likely to be adopted but once it is adopted, the large investment may highly motivate diffusion (Cooper & Zmud, 1990). In the recent past in Thailand, massive technological investment was not considered a serious issue due to the economic prosperity of the country. However, currently, there are increasing concerns regarding technological adoption and the overall gains in return for such investment because high investment not only brings many advantages but it also decreases profits (Takac & Singh, 1992; The Siam Commercial Bank's Staff, 1998). Additionally, excessive emphasis on technological aspects may persuade people to spend time and effort dealing with the technology instead of dedicating themselves to their actual work performances.

It is important that an organisation has to determine a balance between desired investment in new technology and economic returns from such investment. Therefore, the suggested hypothesis is:

> H4: The bank gains higher economic returns on investment from controlled technology expenditure than that from uncontrolled.

3.5 To what extent does the bank harvest economic gains from investment in new technology ?

In general, a positive relationship between relative advantages and technological adoption has been found (Kwon & Zmud, 1987; Rogers, 1983). However, economic gains from technological investment cannot be obtained synchronously. First, when new technologies are introduced, their potential may not be exploited fully because quite a few technologies are implemented based on a trial-and-error basis (Gagnon & Toulouse, 1996). Second, during the initial stages, advantages of technologies cannot be obtained or even precisely determined whereas short run costs are readily available (Gerwin, 1988). Third, technological investment requires an adaptation and learning process to combine environment, organisation, team, task and technology. Once the misalignments of these factors are corrected and end users eventually adopted, economic returns then will turn out fruitfully (Applegate, 1992).

Consequently, technologies have to be substantially invested together with minimum sufficient usage then advantages from the technology can be harvested. The hypothesis relating to this research question is:

> H5: Economic gains can be obtained after a new technology has been substantially invested.

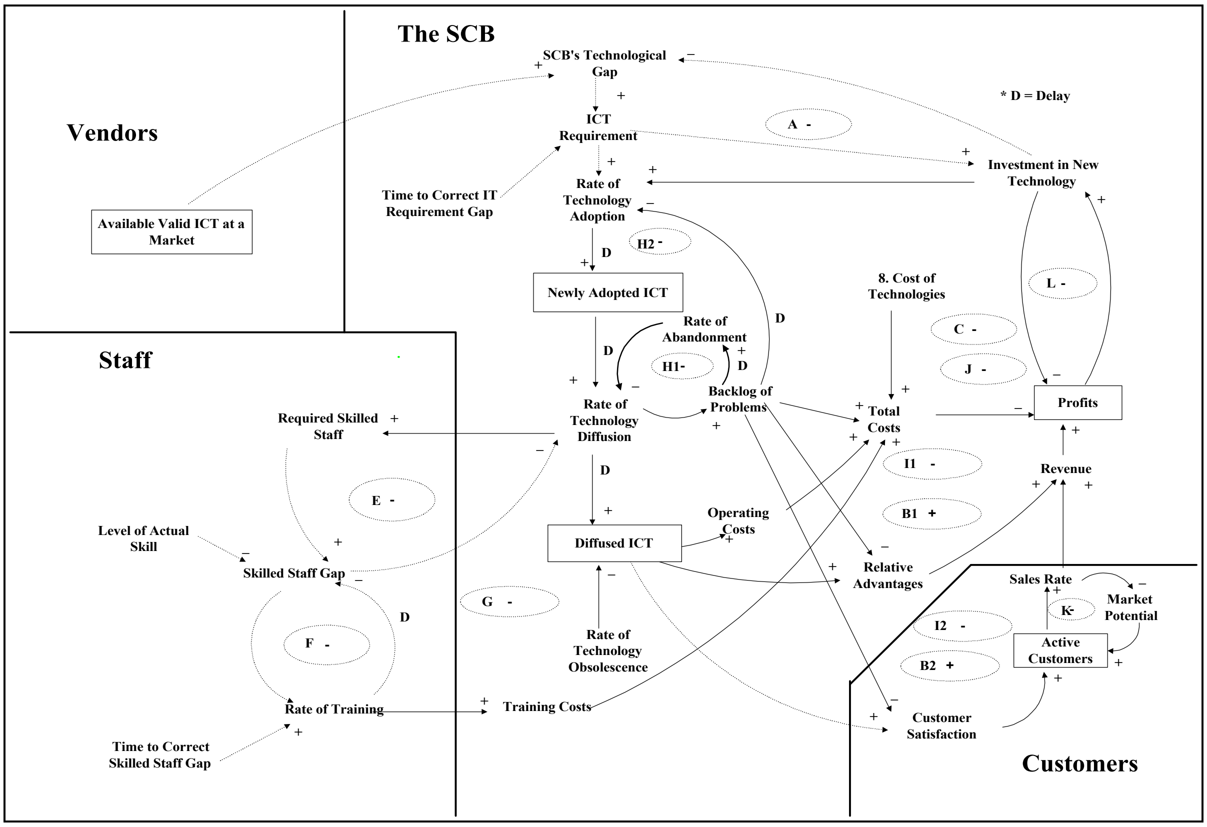
4. Information and Communication Technology (ICT) Model

The information and communication technology (ICT) model is developed in two stages using qualitative and quantitative system dynamics approach for the purpose of acquiring responses to the identified research questions.

4.1 ICT model based on qualitative system dynamics approach

Based on extensive literature reviews and interviewing the bank staff, the model divides organisation boundaries into four sub-sectors: the bank (i.e. technology group), bank staff, customers, and vendors. It emphasises four resources (i.e. technology, profits, staff, and customers), and captures main feedback loops, positive and negative, of the system (see Figure 1).

Figure 1. The influence diagram of the information and communication technology (ICT) model



According to Figure 1, the details of each feedback loop are as follows:

Negative Feedback loop A: Requirements in information and communication technologies (ICT) of the bank are inspired by the gap between available valid ICT on the market and a level of investment in new technology. The bank narrows its technical gap by increasing technological investment.

Positive feedback loop B1 and B2: Investment in new technology activates the bank to diffuse the technology in order to maximise relative advantages and customer satisfaction. Customer satisfaction is the vital factor for generating active customers, which leads to accelerating sales rates and profits. Ultimately, profits attract the bank to technological expansion.

Negative feedback loop C: Massive expenditure (e.g. costs of technology and operational costs) is accommodated throughout the processes of adopting and diffusing new technology. Certainly, the costs reduce prospective profits.

Negative feedback loop E and F: New technology usage requires an increase in both the number of skilled staff and levels of skill of actual staff. Failing to upgrade levels of skilled staff widens the gap between the actual skilled staff and those required. Therefore, providing training is necessary to fill the gap.

Negative feedback loop G: Fulfilling quality and quantity of skilled staff via training results in increasing costs and subsequently decreasing profits.

Negative feedback loop H1 and H2: Once technology is integrated in work performances and services, a backlog of problems begins to accumulate. If end users or customers are annoyed or disappointed, they will abandon that technology use, Additionally, the bank may also hesitate to adopt additional technologies.

Negative feedback loop I1 and I2: A backlog of problems exerts negative impacts on both relative advantages and customer satisfaction. These impacts may completely or partially offset the positive gains from previous feedback loops (Loop B1 and B2).

Negative feedback loop J: Apart from costs of technology and operating costs, disparate costs (e.g. training costs, maintenance costs and costs from backlog of problems) continue to accumulate with the diffusing process.

Negative feedback loop K: Although the bank deploys technology to increase customers, the numbers of customer cannot be increased beyond market potential.

Negative feedback loop L: The bank has to find the balance between technological investment and profits in order to arrive at the desirable level of technological expenditure because excessive investment can reduce the bank's profits.

4.2 ICT model based on quantitative system dynamics approach

The qualitative conceptual model identified by the above feedback loops is then quantified and simulated using the *Ithink* software (Richmond, Peterson, & Charyk, 1994). Each feedback is added to the simulation until the whole system is complete. This incremental technique enhances understanding in terms of the impacts of each feedback loop, detecting errors and tracing the logical concepts.

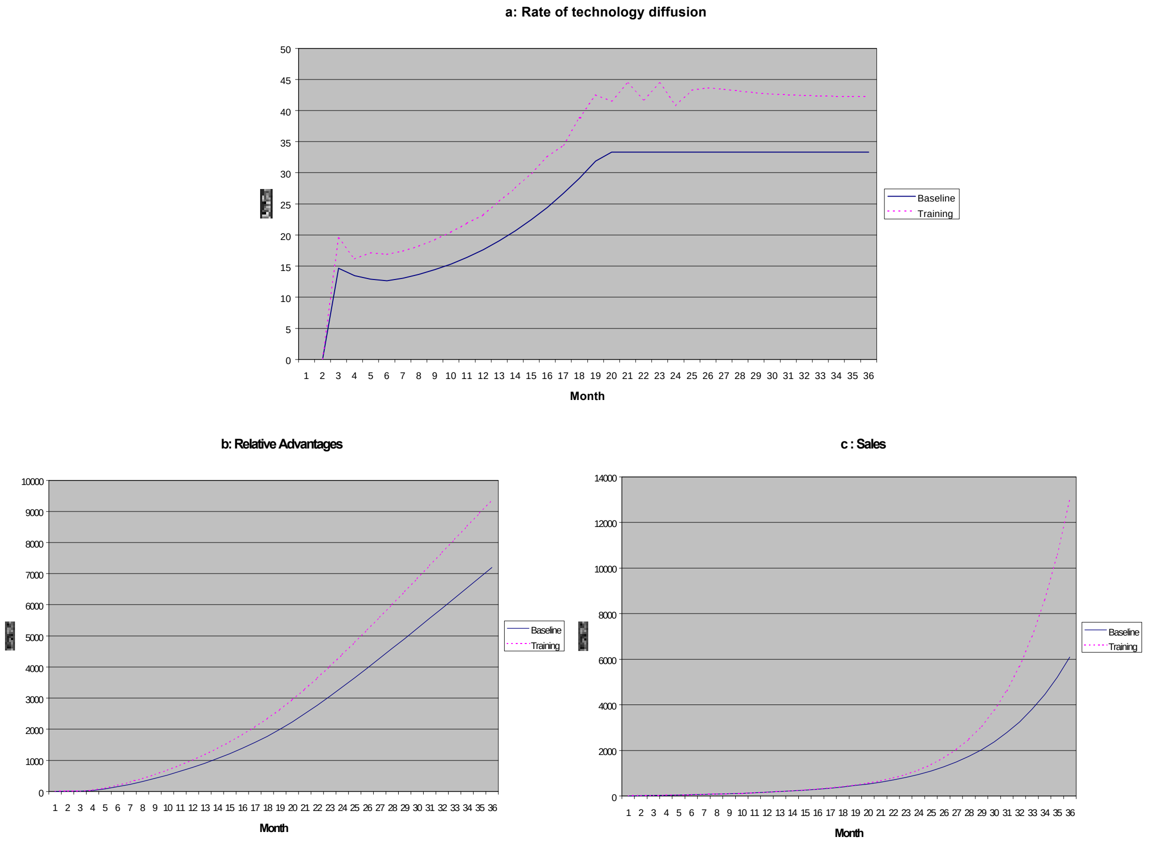
Initially, the feedback loops are simulated incrementally from loop A to loop C in order to identify the behaviours of significant variables (e.g. rate of technology diffusion, relative advantages and sales). The simulation results up to loop C are considered as baseline results and are used to compare with other results deriving from subsequent incremental simulation.

5. Results

The simulation model reveals the following issues.

5.1 Research question1: Loop E, F and G are added to the baseline simulation for the purpose of capturing the impacts of training support which is set up to bridge the gap of insufficient technical skill. The derived results are then compared with those of the baseline to answer the research question 1, *How does training support impact on technology diffusion?*

Figure 2: Impacts of training support on technology diffusion



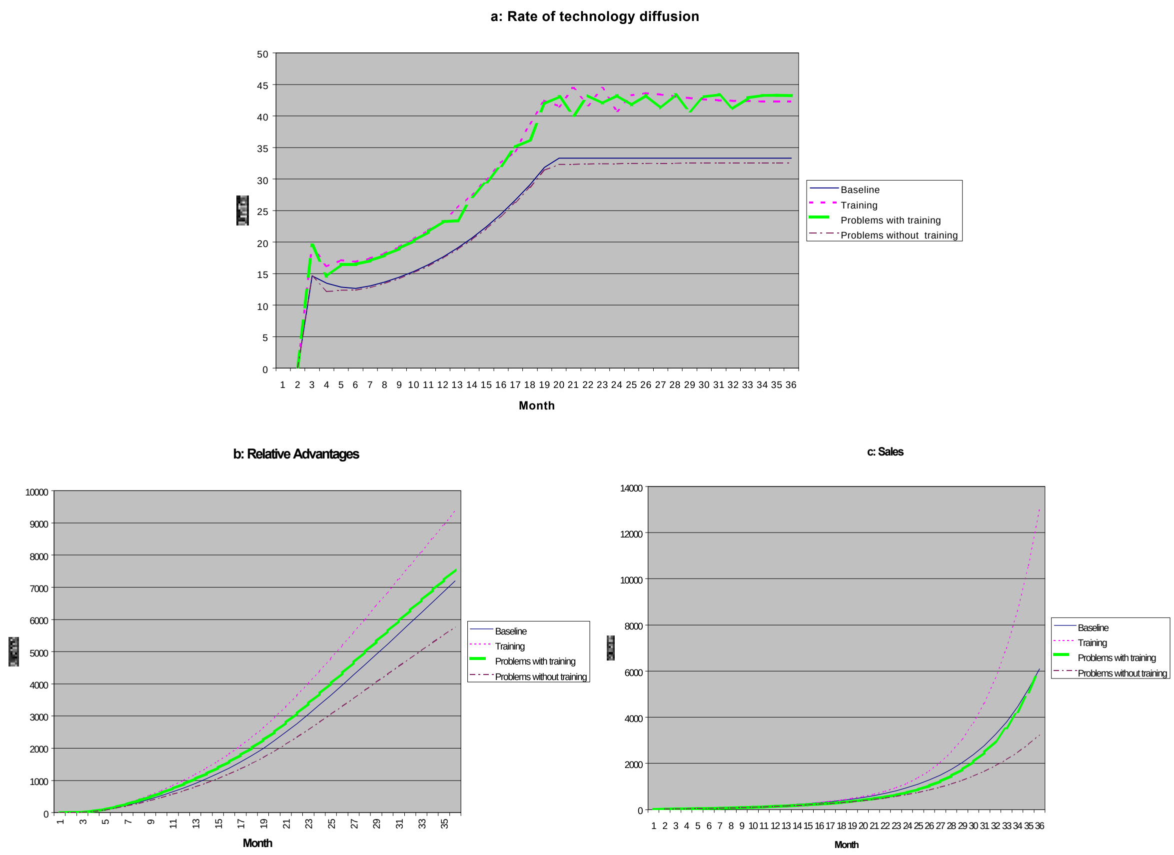
According to Figure 2a, the rate of technology diffusion supported by training is higher than the baseline for the whole periods of time. Additionally, despite an increase in training costs, the bank still gains more relative advantages and sales (Figure 2b and 2c.).

Therefore, it can be concluded that training is a vital factor for technology diffusion and all the three hypotheses are supported. That is, training support increases the rate of technology diffusion, relative advantages and sales.

5.2 Research question 2: As can be seen in Figure 1, a backlog of unsolved problems directly affects rates of technology adoption and diffusion, consumes costs for resolving problems and possibly reverses relative advantages and customer satisfaction from positive to negative outcomes. The entire feedback loops (from Loop A to Loop J) are then simulated to detect the impacts of the backlog of problems.

According to Figure 3a, a backlog of problems, without training support, decreases the rate of technology diffusion. However, the result is not significantly different from that of the baseline because the percentage of a backlog of problems that the bank has currently confronted is low (The Siam Commercial Bank's Staff, 1998). Figures 3b and c reveal that relative advantages and sales do decrease because of the impacts of a backlog of problems.

Figure 3: Impacts of a backlog of problems on technology diffusion

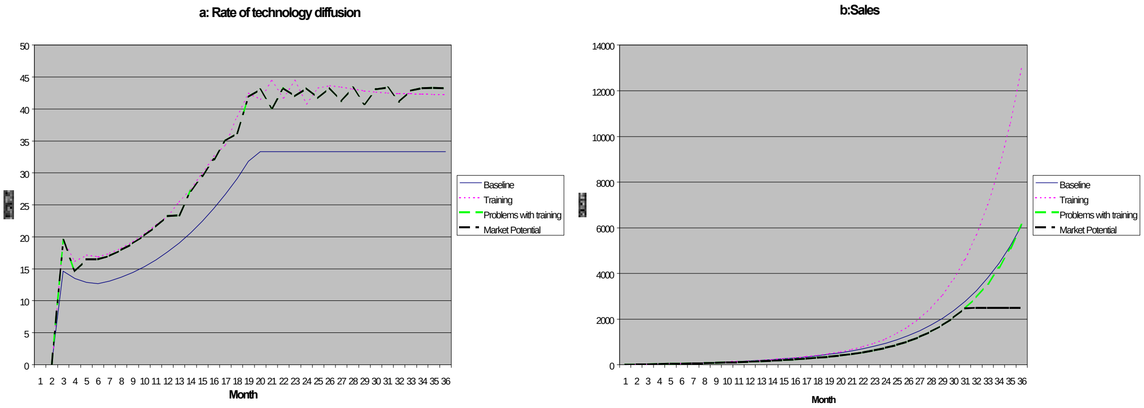


In effect the end results reveal that a backlog of problems exerts impacts on technology diffusion. All three hypotheses are supported; that is, a backlog of problems decreases a rate of technology diffusion, relative advantages and sales. It is interesting to observe that, apart from sales, the rate of technology diffusion and relative advantages, given the training factor, are still higher than those from the baseline because of the more powerful influences of training support.

5.3 Research question 3: A feedback loop K is added in order to observe the influence of market potential on sales. As can be seen from Figure 4a and b, although the rate of technology diffusion is similar to those of previous simulations, sales increase until the market potential is completely absorbed.

Therefore, it can be concluded that technology cannot increase sales beyond market potential, although it can be successfully diffused.

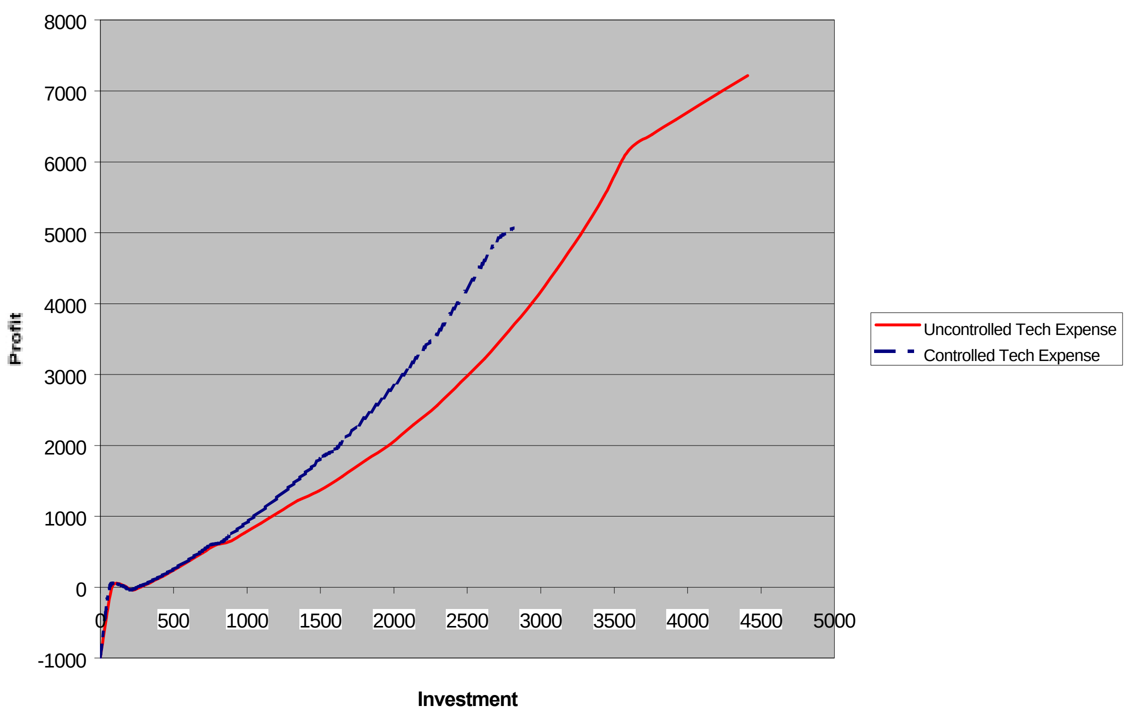
Figure 4: Impacts of market potential on sales



5.4 Research question 4: Investment in new technology to eliminate technological gap or catch up with technological evolution cannot be infinitely increased because technology expenditure relates directly to profits of an organisation.

Loop L is added to the simulation to observe the impacts of the bank's control of technological investment based on the amount of its profits.

Figure 5: Impacts on profits of controlled investment in new technology



According to Figure 5, with the same amount of technological investment, profits deriving from controlled technology expenditure are higher than those without control. Hypothesis H4 is therefore supported.

5.5. Research question 5: The simulation results of comparing investment in new technology with profits in figure 5 also reveal that, the bank cannot gain any profits from its technological investment at the initial period. Profits increase after the bank has spent substantial money for technology investment. Hypothesis H5 is therefore supported.

6. Conclusions

The ICT model informs the following issues. First, training support has the potential to accelerate the rate of technology diffusion and economic gains whereas a backlog of problems hinders them. Second, market potential constrains an increase in economic returns although technology is successfully diffused. Third, it is important to determine the balance between the desired investment in new technology and its prospective outcomes because massive investment in new technology does not always bring a good return on that investment. Fourth, economic gains from new technology are obtained after an organisation has spent substantial resources on technology investment.

This model enables bank officials to understand the present state and constraints of technology adoption and diffusion. This can be further used for policy analysis and forward planning to mitigate the constraints and re-design the system behaviours. Since existing and potential banking technologies are abundant, the model can be initially used to gain holistic understanding before applying any particular technologies or tailoring for specific organisations.

Apart from interviewing data, this proposed conceptual model attempts to include numerous variables based on literature review. However, in reality, relatively few variables are taken into account by bank staff. Additionally, complete data are hard to obtain due to their physical properties (e.g. implicit, intangible and unclassified). Therefore, for future research, this conceptual model will be elaborated into two specific technologies (i.e. Intranet banking and data warehousing technology) using only variables that the bank has considered in order to improve the model to fit with reality.

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