

## **An internet banking system establishment with transaction rate uncertainty: a real options approach**

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### **Abstract**

This study investigates the entry threshold for providing a new transaction service channel via the real options approach, where the entry threshold is established by using an Internet banking system designed for the use of financial institutions under transaction rate uncertainty. This work is based on the assumption that an Internet banking system requires a limited replacement period of equipments or software upgrades, which will be charged as a fixed cost when the system is renewed following the replacement period. Additionally, the current paper discusses the differences between the real options approach and the conventional net present value method. Sensitivity analyses of related parameters are also conducted through numerical simulation. The results of the novel approach presented in this study provide a valuable reference for financial institutions to establish Internet banking systems.

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*Keywords : Internet banking, decision making, replacement planning, real options.*

### **1. Introduction**

Following the development of more technologically advanced and secure Internet services, financial institutions have begun introducing Internet banking systems (IBS) to complement their traditional service channels, namely counter tellers, automated teller machines, telephone

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banking, etc. Research (Hall et al. [7]) indicated that the average per transaction service charges by using these various service channels are US\$1.07 for counter tellers, US\$0.54 for automated teller machines, US\$0.27 for telephone banking, and US\$0.01 for Internet banking.

Moreover, the cost of establishing a single new branch for a commercial bank (US\$3.5M-5M) is around 2.5 times that of establishing an Internet banking service (US\$1.5-2.0M), while the costs of maintaining a new branch are over 50 times those involved in maintaining an Internet banking service. Consequently, the financial service industry tends to establish IBS to reduce operating costs and maintain competitiveness. Furst et al. [6] analysis indicated several differences between the profile banks that offer Internet banking and those that do not. For all but the smallest banks, Internet banks have better accounting efficiency ratios and higher returns on equity than non-internet banks. Centeno [2] pointed that consumer motivation to use Internet banking is a combination of factors such as speed, the convenience of remote access, whole day availability, and price incentives. Experience shows that consumers use the Internet as a complementary channel and continue to rely on branches and call centers. The role of branches and call centers is evolving to more advisory and selling functions. Bughin [1] analyzed and compared possible drivers of customer acquisition and conversion for European on-line banking in light of various theories of bank innovations. The econometric model is consistent with "pull" market features, playing a significant role but only for customer conversion. In contrast, banks' specific factors are the major drivers for on-line customer acquisition strategy, especially organizational link to on-line activities and bank size.

Miller and Park [9] conducted a comprehensive research on real options approach (ROA), focusing on decision making under uncertainty. Based on the observations in a risky world and the unstable cash flows associated with strategic investment projects, the future research on ROA can be conducted to determine the value of growth opportunities. Previous works have also identified the entry threshold in new markets by considering continuous stochastic or jump diffusion processes for decision making with various uncertainty variables. Courchane et al. [3] examined the optimal exercise of strategic options to adopt in Internet banking technology within a two-stage game, parameterized by the distribution of bank size, uncertainty over the profitability of investment, and empirical

tests of the results. Assume that the evaluation of an information system should be seen as a form of communication; Stamoulis et al. [12] adapted an approach that has been empirical to create a contingency model for evaluating an e-banking channel. The model comprised of five different perspectives, each of them having a corresponding set of metrics. These can be used to assess the business value along two viewpoints: (a) the internal view, where the channel is considered as a resource whose utilization must be maximized, and (b) the external view, where the channel is an interface to the bank's customer base whose usage should directly support customer relationship management.

This work thus presents a tentative IBS model for considering how ROA formulates and determines the entry threshold for instituting an IBS investment under Internet banking transaction rate uncertainty. This work derives the closed form analytic solution to entry threshold, and also clarifies, the differences between ROA and the net present value (NPV) method. The decision variables and Internet banking transaction rates follow the geometric Brownian motion (GBM). ROA thus enables financial institutions to establish IBS to reduce average costs and increase average net profits more effectively than the NPV method.

The rest of the paper is organized as follows. It first reviews relevant literature in Internet banking, real options and decision making, and discussion and planned behavior. It then describes how this study is conducted, together with the proposed model set by real options. Third, it reports the research findings for entry threshold and comparing different approach in NPV method. Forth, the numerical analysis is to simulate IBS entry decision by using the ROA and NPV methods. Finally, it concludes with a discussion and contribution in proposed model and traditional evaluation model.

## 2. Model with the real options approach

The NPV method requires future cash flow certainty. Normally, if  $NPV > 0$ , executing an investment project immediately is more profitable than executing it later or abandoning it. However, the NPV method may cause type I or II statistical errors<sup>†</sup> after implementing a project immediately or delaying it when future uncertainty affects

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<sup>†</sup>In NPV method, when the decision maker is done to invest for  $NPV > 0$ , it may cause the error decision because the NPV evaluation is wrong for predicating and calculating, that

decision variables so fast. Moreover, the NPV method ignores the certain considerations applied in real investment projects, such as whether the project is irreversible or partly irreversible, whether the investment environment involves high uncertainty, and whether projects can be deferred, altered, or shut down after starting, restarting, or being abandoned. In the outline of the proposed models, the following GBM is used to estimate the transaction rate of IBS. The remainder of this work introduces and tries to design an ROA based model.

The proposed model makes the following assumptions: transaction volume is fixed as  $M$  and remains constant regardless of service. Traditional transaction channels include counter teller services, telephone banking, automated teller machines, etc. For simplicity, the average service charge is assumed to be  $c_1$ . The rising popularity of the Internet has led to the emergence of numerous e-commerce businesses, and the trend to provide IBS based transaction services can be expected to continue. Datamonitor [4] provides the evidence of this growth trend with forecasts regarding numbers of online accounts in European banks accounts. Consequently, this study assumes that the transaction rate provided by IBS for following GBM in the proposed model is reasonable<sup>‡</sup>. Furthermore, average transaction costs decrease when a financial institution decides to introduce IBS, for which the major associated cost is a sizeable initial investment. Consequently, after establishing IBS, the transaction rate  $s(t)$  in IBS depends on GBM as follows:

$$\frac{ds(t)}{s(t)} = \alpha \cdot dt + \sigma \cdot dz(t), \quad (1)$$

where, the parameter  $\alpha$  denotes drift,  $\sigma$  represents volatility, and  $dz(t)$  during unit time  $dt$  is the increment of standard Wiener process with mean zero and volatility  $dt$ . From the initial condition  $s(0) = s_0$ , the easiest solution to Eq. (1) is  $s(t) = s_0 \cdot \exp \left\{ \left( \alpha - \frac{\sigma^2}{2} \right) \cdot t + \sigma \cdot z(t) \right\}$ .

After establishing IBS, the average cost of service charge  $AC(s)$  is

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is Type I error. On the other hand, when the decision maker gives up the investment for  $NPV < 0$ , it may make a mistake for misjudgment; similarly, Type II error will be arisen.

<sup>‡</sup>Following the GBM property, the drift draws the trend of growth rate and the volatility describes the change rate of growth. Hence, taking GBM to depict can match transaction rate well explained in Datamonitor's [4] investigation.

defined as:

$$AC(s) = (1 - s) \cdot c_1 + s \cdot c_2. \quad (2)$$

Here,  $c_2$  represents the average cost per transaction for IBS, which in reality satisfies  $c_1 > c_2$ . From Eq. (2), other relative service rates are assumed not to be influenced by providing traditional services after establishing IBS. Furthermore, besides technological innovations, timely equipment upgrade and replacement is essential for maintaining service quality in a competitive market. Consequently, IBS systems must be upgraded or replaced regularly, creating the need to consider a replacement schedule. This study assumes a limited planning period, in which IBS is replaced after  $N$  years of operations. Accordingly, this work designs a valuation model based on ROA and introduces the optimal service rate of IBS under the proposed model.

### 3. Entry threshold

The potential project strategic value,  $V_0(\pi_f)$ , and project strategic value,  $V_1(\pi_f)$ , are assessed before and after completing IBS respectively, as discussed below. A financial institution is assumed to run the service system indefinitely after the strategic manager makes their investment decision, and initial investment capital  $I$  is spent to introduce IBS. IBS is then assumed to operate for  $N$  years before being replaced. This work assumes a replacement period of  $N$  years, with the IBS having no salvage value on replacement. For simplicity, replacement cost  $I$  is fixed and constant and equals the initial investment capital. This work ignores the details of the replacement problem, but this simplification does not reduce its generality.

When a financial institution decides to introduce IBS, the NPV of total operating replacement cost  $I_T$  can be calculated as:

$$I_T = I \left( 1 + \frac{1}{(1+r)^N} + \frac{1}{(1+r)^{2N}} + \dots \right) = \frac{(1+r)^N}{(1+r)^N - 1} \cdot I, \quad (3)$$

where,  $r$  represents risk-free interest rate (discount rate).

The additional net income,  $\pi_f$ , represents the cost savings achieved by financial institutions through introducing IBS (namely the difference between average per transaction service costs before and after

establishing IBS).  $\pi_f$  can then be expressed as:

$$\pi_f(s) = M \times (AC(0) - AC(s)) = M \times (c_1 - c_2) \times s.$$

When  $s \geq 1$  under the transaction rate following GBM, the constraint condition for the additional net income is bounded by  $\pi_f(s) = M \cdot (c_1 - c_2)$ . Establishing IBS is clearly superior to doing nothing if  $s \geq 1$  in a given instance. Furthermore, boosting potential project strategic value by the traditional NPV is considered a strategic NPV by the financial institutions able to provide IBS to their clients. The potential project strategic value  $V_0(\pi_f)$  before introducing IBS is the NPV derived from the average net incomes (net cash flows) from providing financial services, and the potential project value (capital gains) obtained from maintaining future operations (refer to Dixit and Pindyck [5] for a more detailed explanation).

The potential project strategic value of a firm which continues to operate in a financial institution,  $V_0(\pi_f)$ , is determined by using the excess operating incomes from the discounted value of the active operation in IBS. The mathematical presentation of  $V_0(\pi_f)$  is defined as follows:

$$V_0(\pi_f) = A\pi_f^{\beta_1}, \quad (4)$$

where parameter  $A$  can be determined. Meanwhile, the excess capital gains  $A\pi_f^{\beta_1}$  derived from the potential project strategic value are represented by the term on the right side of Eq. (4), which describes the excess operating incomes from active operations. The parameter  $\beta_1$  is defined as:

$$\beta_1 = \left( \frac{1}{2} - \frac{\xi}{\sigma^2} \right) + \sqrt{\left( \frac{1}{2} - \frac{\xi}{\sigma^2} \right)^2 + \frac{2r}{\sigma^2}}, \quad (5)$$

$\xi \equiv \alpha - \phi\rho_{\pi m}\sigma$ , where  $\phi$  denotes unit risk premium on the market ( $\phi = (r_m - r)/\sigma_m$ ,  $r_m$  represents expected market return,  $r$  is risk-free interest rate of return), and  $\rho_{\pi m}$  denotes the correlation coefficient between net profit gain and the portfolio of the total capital market. Furthermore, the project strategic value  $V_1(\pi_f)$  after establishing IBS represents current average excess operating income. That is, when financial institutions introduce IBS to provide Internet services, the discounted firm value  $V_1(\pi_f)$  from expected cash flows is considered in place of planned

operating period. The mathematical presentation is presented below:

$$V_1(\pi_f) = \frac{\pi_f}{r_a - \alpha}. \quad (6)$$

The risk adjustment factor in net excess income  $\pi_f$ ,  $r_a$ , is defined as  $r + \phi\rho_{\pi m}\sigma$ , while the risk-free interest rater is assumed to satisfy the condition  $r > (\alpha - \phi\sigma_{\pi m}\sigma)$ . If the IBS project continues indefinitely, the present value of the cash flows under the condition of the IBS project being undertaken as  $V_1(\pi_f)$  is given by Eq. (6). Before IBS investment, the value of the option to invest in the IBS project is  $V_0(\pi_f)$ , and firms are assumed to invest when IBS project value reaches a certain entry threshold, which is calculated by Eq. (4). That is, Eq. (4) is priced according to its potential value because it does not have any entry market, but in Eq. (6), IBS project value is calculated based on the cash flows of its realistic operating in the project invested. The following assumes that following an initial investment  $I$ , IBS can be immediately established and begin operating. Initial investment cost is an irreversible sunk cost associated with initiating an investment project. Furthermore, regarding replacement cost, financial institutions must invest replacement cost  $I$  following IBS replacement period. This investigation applies transaction rate  $s$  to receive the Internet banking service in the proposed model to optimize threshold  $s^*$  for introducing IBS, and this is the same as the consideration for optimizing net additional incomes  $\pi_f^*$  after establishing IBS. The optimal solutions for seeking threshold are presented mathematically as follows:

$$V_0(\pi_f^*) + I_f = V_1(\pi_f^*); \quad (7)$$

$$V_0'(\pi_f^*) = V_1'(\pi_f^*). \quad (8)$$

Equation (7) is termed the value matching condition, while Eq. (8) is termed the smooth pasting condition and the superscript “'” represents the partial differential with respect to  $\pi_f$ . Simple manipulation of Eqs. (7) and (8) yields the following results:

$$A = \frac{(\pi_f^*)^{1-\beta_1}}{\beta_1} \cdot \frac{1}{r_a - \alpha}; \quad (9)$$

$$\pi_f^* = \left( \frac{\beta_1}{\beta_1 - 1} \right) (r_a - \alpha) I_T. \quad (10)$$

From equation  $\pi_f(s) = M \cdot (c_1 - c_2) \cdot s$ , Eqns. (9) and (10) can be rearranged to express the threshold for  $s^*$  as follows:

$$A = \frac{(M \cdot (c_1 - c_2) \cdot s^*)^{1-\beta_1}}{\beta_1} \cdot \frac{1}{r_a - \alpha}; \quad (9a)$$

$$s^* = \frac{\beta_1}{\beta_1 - 1} \cdot \frac{r_a - \alpha}{c_1 - c_2} \cdot \frac{I_T}{M}. \quad (10a)$$

The necessary condition for Eq. (10a) with  $s^*$  confirms that the value must be between zero and one. Otherwise, the solution is infeasible in Eq. (10a), meaning introducing IBS is impossible. Generally, IBS is unreliable initially, and thus the normal condition is  $s < 1$ . Introducing the GBM for  $s$  is reasonable in the proposed model. Subsequently, the total replacement cost for the average charge on a per transaction basis  $I_T/M$  must comply with the restriction:

$$\frac{I_T}{M} \leq \left( \frac{\beta_1 - 1}{\beta_1} \right) \cdot \left( \frac{c_1 - c_2}{r_a - \alpha} \right). \quad (11)$$

Equation (11) indicates that the total replacement cost shared on a transaction basis,  $I_T/M$  must be below or equal to the ratio of the excess service charge per transaction provided by the IBS,  $c_1 - c_2$ , as well as the risk adjustment factor  $r_a - \alpha$ , a ratio that is multiplied by  $(\beta_1 - 1)/\beta_1$ . Given transaction rate  $s < s^*$ , financial institutions delay investing in an IBS project until transaction rate  $s$  reaches the threshold  $s^*$ , after which initial investment cost  $I$  is inputted, followed by replacement cost  $I$  for the end of the replacement period, when IBS is run immediately. Potential and actual project strategic value,  $V_0(\pi_f)$  and  $V_1(\pi_f)$  respectively, are thus represented as follows:

$$V(\pi_f(s)) = \begin{cases} A\pi_f^{\beta_1}, & \pi_f < \pi_f^* \\ \frac{\pi_f}{r_a - \alpha}, & \pi_f \geq \pi_f^*. \end{cases} \quad (12)$$

Shackleton and Worjakowski [10] introduce the random optimal stopping time for the Merton-type Real Options problem as follows: operating income follows GBM when  $\tau$  is the random optimal stopping time, and the probability density function  $\phi(\tau)$  is

$$\phi(\tau) = \ln \frac{\pi_f^*}{\pi_f} / (\sigma \sqrt{2\pi\tau^3}) \exp \left\{ - \left( \frac{1}{\sigma} \ln \frac{\pi_f^*}{\pi_f} - \theta\tau \right)^2 / 2\tau \right\},$$

where the parameters are denoted as follows:  $\pi_f$  denotes the profit in the present horizon,  $\pi_f^*$  represents the entry threshold profit,  $\sigma$  is the GBM standard, and the parameter  $\theta \equiv \alpha/\sigma - \sigma/2$  can be defined, in which  $\alpha$  denotes average GBM growth rate. Given this optimal stopping time result, it is realized to exclude that the unrealistic problem of  $s_t > 1$ . That is, if the finite entry time from present as the entry threshold is finite, the probability of  $s_t > 1$  can be ignored in this imaginary problem.

The following section compares the valuation of project value and subsequent use of ROA to derive the threshold mentioned above by using traditional NPV with risk adjustment.

#### 4. Different approach comparisons

This section discusses the similarities and differences of the risk adjusted traditional NPV method and the ROA valuation model, and demonstrates the sensitivity analysis for important parameters. For the threshold,  $s_0^*$ , the results obtained by using estimated data for the risk adjusted traditional NPV method are determined for decision making, assuming a static and certain environment. That is, if the following equation is satisfied, the investment project can be implemented by using the traditional NPV method. Namely,

$$I_T \leq E \left[ \int_0^\infty e^{-r_a t} s(t) M(c_1 - c_2) dt \mid s_0 = s_0^* \right].$$

Following some manipulation, we obtain:

$$I_T < \frac{M \cdot s_0^* \cdot (c_1 - c_2)}{r_a - \alpha}. \quad (13)$$

Equation (13) illustrates the decision making for traditional NPV, in which total operating net incomes by risk adjustment must exceed the present value of the total replacement cost following IBS introduction. With some simple manipulation, the IBS will be optimized if the threshold  $s_0^*$  satisfies the following condition:

$$s_0^* \geq \frac{r_a - \alpha}{(c_1 - c_2)} \left( \frac{I_T}{M} \right). \quad (14)$$

Equation (14) provides the thresholds  $s_0^*$  for the traditional NPV method following risk adjustment, which only considers the excessive service charge  $c_1 - c_2$  adjusted by the risk adjusted discount rate  $r_a - \alpha$ , and the net value of total replacement cost shared on a per transaction basis  $I_T/M$ . If the conditions above cannot be matched, delaying investment in IBS is more profitable than investing immediately. Comparing Eqs. (14) with (10) in the previous section, the difference between ROA and the traditional NPV method following risk adjustment is as follows:

$$\frac{s^*}{s_0^*} = \frac{\beta_1}{\beta_1 - 1}. \quad (15)$$

The difference between ROA and the traditional NPV method, as displayed in Eq. (15), reveals the benefits achieved by avoiding the risk of waiting to implement the project through applying ROA, specifically the provision of additional value under transaction rate uncertainty. The analysis results for Eq. (15) are similar to those discussed in the models presented in Dixit and Pindyck [5]. Furthermore, the risk adjusted difference in the project strategic value derived from using the ROA and traditional NPV methods is  $\beta_1/(\beta_1 - 1)$ , meaning this value is produced by waiting to invest in ROA but not in the traditional NPV method. The ROA method definitely is more conservative than the traditional NPV method in valuation criterion.

## 5. Numerical analysis

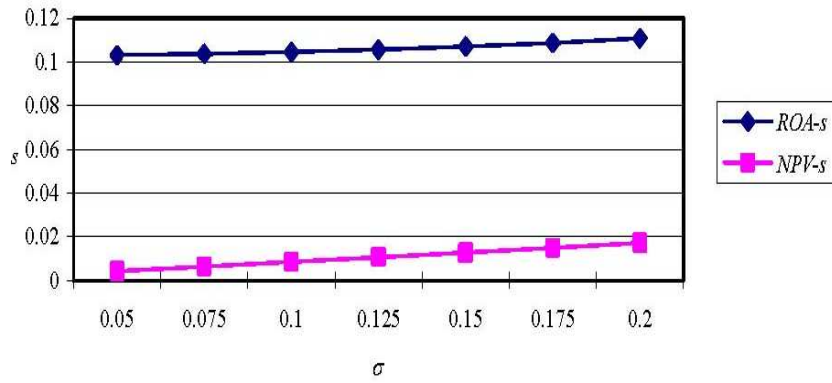
This section presents a more comprehensive discussion of the ROA and NPV methods, and builds on the previous results to simulate IBS entry decision by using the ROA and NPV methods. Datamonitor [4] forecasts that between 2000 and 2003, the number of online bank accounts in Europe will grow by 34% annually. The number of online bank accounts thus is expected to grow from 14.3 million in 2000 to 34.2 million in 2003. Furthermore, the penetration of population using Internet by such services is expected to increase from 9.7% in 2000 to 13.4% in 2003. The example presented here involves data partially derived from Hall et al. [7], and

Datamonitor [4], supplemented with various assumptions as presented below.

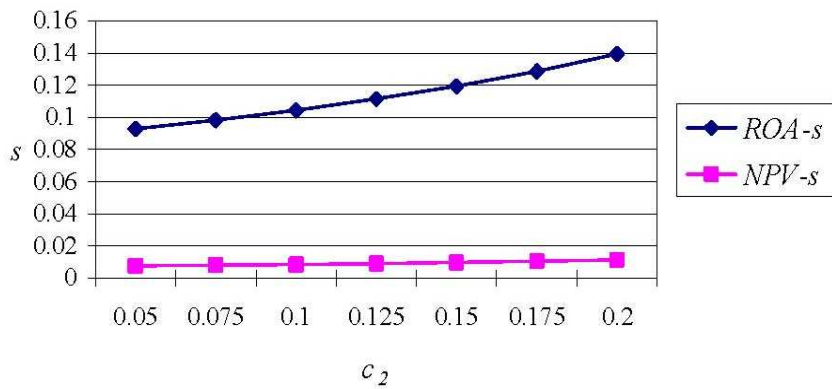
The parameters are set as  $\alpha = 0.3$ ,  $\sigma = 0.1$  per year respectively. Furthermore, specific discount rates of  $r = 0.3$  and  $\xi \equiv \alpha - \rho_{\pi m}\sigma = -0.275$  are calculated, assuming  $\pi = 0.5$  and  $\rho_{\pi m} = 0.5$  and  $r_a = (r + \phi\rho_{\pi m}\sigma) = 0.325$ . Thus, following some manipulation,  $\beta_1 = 1.0894$ . The establishment cost of IBS is one to two million U.S. dollars, depending on the functions provided by financial institutions, transaction capacity unit time, IBS transmission speed, etc. This investigation assumes setup cost  $I = 1$  million, while replacement period  $N = 5$  years, consistent with a typical case as explained above. Average per transaction income is estimated for traditional transaction channels, where  $c_1$  is US\$0.5, average per transaction service charge  $c_2$  is US\$0.1, and transaction volume  $M$  is US\$10 million annually. The ratio of  $s^*/s_0^* = 12.184$  is obtained below. This work finds the following results. The entry threshold for the proposed model exceeds that for the NPV method. The two methods differ mainly in the transaction rate uncertainty, which is ignored by the NPV method but considered by the ROA. The entry threshold  $s_0^*$  required for investment by the ROA thus exceeds that for the NPV method. Consequently, the ROA is more conservative than the NPV method in supporting entry decisions given transaction rate uncertainty, and hence is superior to the NPV method from flexible management viewpoint of decision making now or never. Hence, this flexible feature of ROA is valuable for decision makers in re-valuing IBS project value.

Figure 1 displays the entry thresholds  $s^*$  for ROA and  $s_0^*$  for NPV method, as functions of volatility parameter  $\sigma$ . Entry thresholds  $s^*$  and  $s_0^*$  both increase with  $\sigma$ . Here, entry threshold clearly increases with volatility  $\sigma$ . Consequently, ROA is more sensitive than NPV method to volatility, and thus ROA is more conservative than NPV method in supporting IBS entry decisions given high transaction rate uncertainty.

Figure 2 illustrates that the entry thresholds,  $s^*$  and  $s_0^*$ , both increase with IBS transaction cost,  $c_2$ . This phenomenon occurs because higher IBS transaction costs reduce expected profit flow, meaning a higher threshold  $s^*$  or  $s_0^*$  is required before investing in IBS. Furthermore, the zone of  $(s^*, s_0^*)$  increases with  $c_2$ , meaning that the influence of IBS transaction cost  $c_2$  on entry threshold with the IBS model exceeds that with the NPV method.

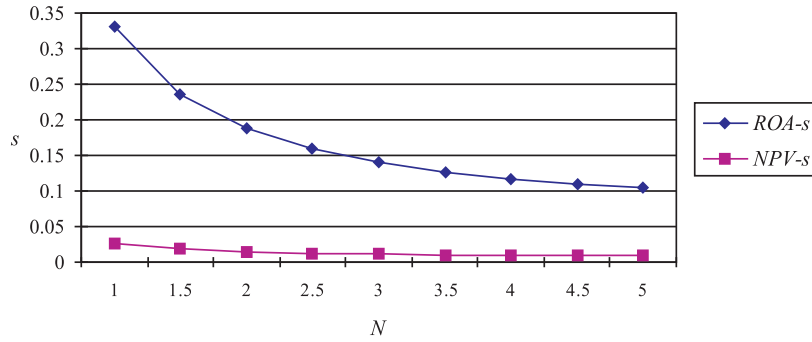


**Figure 1**  
Entry threshold as a function of  $\sigma$



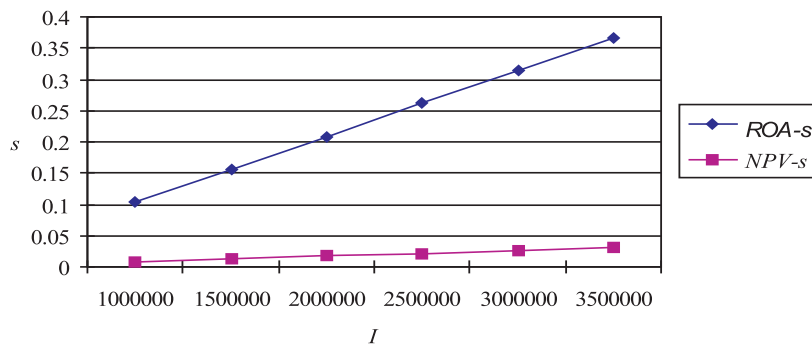
**Figure 2**  
Entry threshold as a function of  $c_2$

Figure 3 indicates that the entry thresholds decrease with increasing replacement period  $N$ . Higher replacement period  $N$  accelerates the establishment of IBS by a financial institution and reduces the required entry thresholds. Furthermore, the zone of  $(s^*, s_0^*)$  decreases with increasing  $N$ , and the impact of IBS replacement period  $N$  on entry threshold in the ROA model is less than in the NPV method.



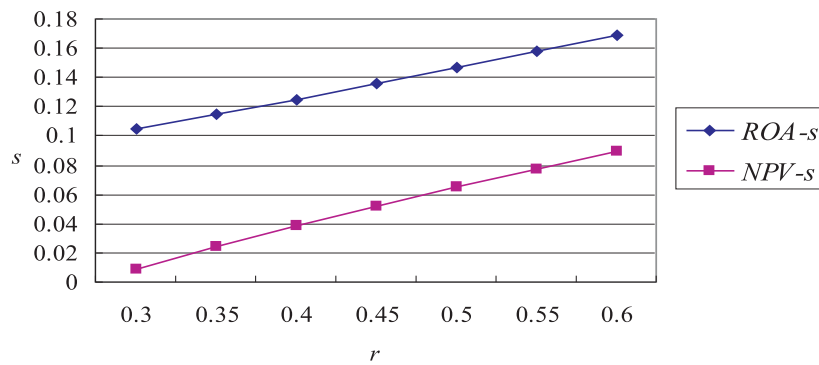
**Figure 3**  
Entry threshold as a function of  $N$

Required IBS specifications differ among financial institutions and setup cost  $I$  differs accordingly. In general, higher setup costs are associated with higher maintenance costs. Figure 4 plots setup costs against entry thresholds. Moreover, the zone of  $(s^*, s_0^*)$  increases with  $I$ , meaning that the influence of initial investment cost  $I$  on the entry threshold of the IBS model exceeds that of the NPV method.



**Figure 4**  
Entry threshold as a function of  $I$

Figure 5 illustrates the relationship between IBS thresholds and risk free interest rate  $r$ . Increases in  $r$  also lead to increases in the thresholds of the ROA or NPV method.



**Figure 5**  
Entry threshold as a function of  $r$

## 6. Concluding remarks

Previously, investment decision makers have neglected risk adjustment when determining tangible financial value and waiting time in calculating intangible project value. This flawed approach to investment decision valuation derives from assuming a static and certain situation during financial analysis and planning. Employing the improved methods for assessing IBS establishment considered herein and assuming a limited replacement period for running an Internet Banking service reduce average service cost and optimize the threshold for establishing IBS. The techniques presented here thus can help decision makers in assessing IBS. The NPV method may incur type I or II statistical judgment errors. Traditional NPV (included risk adjustment NPV) methods suffer potential losses from adjustment errors, and it is difficult to avoid downside investment risk. Consequently, this work introduces ROA to achieve management flexibility and deal with the uncertainty of the service market. The analytical results of this paper are summarized as follows: given an IBS transaction charge for customers consistent with GBM and considering the methods for reducing average cost, the assessment of potential project value from waiting and actual project value from cash flows as determined by the ROA differs from those determined by using the traditional NPV method, which only considers static cash flows. Consequently, present strategic value can be determined by subtracting strategic NPV with a flexible value from that with an inflexible value. Comparing the risk adjustment factor of the traditional NPV method with

that of ROA and examining the parameters via sensitivity analysis, the parameters with a threshold can be easily obtained.

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