The Real Option Approach to Adoption and Discontinuation of Management Accounting Innovation: The Case of Activity-Based Costing

Shu Feng[1]

Department of Economics
Boston University
270 Bay State Road
Boston, MA 02215
USA
Tel: (857)-204-8979
Fax: (617)-552-0431
Email: fengshu@bu.edu

Chun-Yu Ho

Department of Economics
Boston University
270 Bay State Road
Boston, MA 02215
USA
Tel: (857)-204-0416
Fax: (617)-552-0431
Email: chunyu@bu.edu

[1] Corresponding Author.

We would like to thank Alison Kirby Jones and Jianjun Miao for their helpful comments and suggestions.

The Real Option Approach to Adoption and Discontinuation of Management Accounting Innovation: The Case of Activity-Based Costing

Current Version: October 2005

Abstract

This paper employs real option approach (ROA) to study the decision of ABC adoption and discontinuation under uncertainty. The general idea behind is that investing in ABC system is an option-rights as in financial American call option. The proposed model takes the total annual number of production of a firm as the primary decision variables. The added annual net profits after establishing ABC are considered in deciding the optimal threshold for adoption or discontinuation. Moreover, the difference between the ROA and the net present value (NPV) method is compared. We found that the optimal entry threshold for adoption obtained by the ROA is higher than that obtained by the NPV method. Conversely, the optimal exit threshold for discontinuation obtained by the ROA is less than that obtained by the NPV method. Thus, ROA is more conservative than the NPV method. The difference between these two methods is primarily driven by the option value of waiting before implementing the entry/exit project in the ROA.

Keywords： Activity based costing; Management accounting innovations; Real option theory; Investment under uncertainty

1. Introduction

The activity-based costing (ABC) has been attracting widespread attention in the field of management accounting. Cooper and Kaplan (1991) argue that ABC provides cost data for improving production mix, process improvement, pricing and other managerial decision. The ABC approach measures the costs of objects by first assigning resource costs to the activities performed by the organization, and then using causal cost drivers to assign activity costs to products, services, or customers that benefit from or create demand for these activities. This approach captures the economics of the production process more closely than traditional unit-based cost systems, which track the marginal cost more closely than the unit cost. It reduces the difference between information available to the firm and information required for decision making and hence to achieve better decision and higher profitability.

The activity-based costing literature highlights three potential operational benefits: lower costs, improved quality, and reduced manufacturing cycle time. First, as in Carolfi (1996), ABC systems provide detailed information on the value-added and non-value-added activities performed by the organization, the costs associated with these activities, and the drivers of activity costs. This information allows managers to reduce costs by designing products and processes that consume fewer activity resources, increasing the efficiency of existing activities, eliminating activities that do not add value to customers, and improving coordination with customers and suppliers. Moreover, Carolfi (1996) argue that increased information about activities and cost drivers is also expected to enhance quality improvement initiatives by identifying the activities caused by poor quality and the drivers of these problems. As indicated in Cooper et al. (1992), ABC systems can help justify investments in quality improvement activities that might otherwise be considered uneconomic, and improve the allocation of resources to the highest valued improvement projects by highlighting the costs of quality-related non-value-added activities. Finally, many non-value-added activities such as counting, checking, and moving increase the duration of a process or are driven by the amount of time a product takes in an activity. By identifying activities that cause non-value-added time, Kaplan

(1992) argues that ABC can assist in justifying investments in cycle time reduction and provide the detailed information needed to minimize delays.

Despite the vast literature[2] in ABC, there is little discussion on the adoption of ABC.[3] A notable exception is Bjørnenak (1997) which conducts a survey which incorporating data from 75 of the largest manufacturing companies in Norway. The results show that cost structure is significant for ABC adoption. Companies have knowledge of ABC are more likely to adopt the system. Also, it indicates a diffusion process that takes a contagious form and points out the importance of institutional influence.

This paper contributes the literature by using real option approach[4] (ROA) to study the decision of ABC adoption under uncertainty. There are evidences that managers are using ROA to evaluate project. According to Busby and Pitts (1997), they conducts a survey of senior finance officers in the largest U.K. firms assessing how, in the absence of an easily implementable normative model, firms think about real options during investment appraisal. The results show that real options often occurred and were generally significant in determining how decision-makers regarded an investment proposal. Graham and Harvey (2001) survey a large representative set of US firms and find that a quarter of them incorporate the real options of a project when evaluating it. Using the Dutch data,

---

[2] The analytical studies focus on the use of ABC information for strategic decisions rather than for operational improvement. In contrast to claims by ABC proponents, analytical studies suggest that the cost data provided by ABC systems need not be more "accurate" than the costs reported by traditional unit-based systems. See Noreen (1991), Banker and Potter (1993), Datar and Gupta (1994), Christensen and Demski (1997), and Bromwich and Hong (1999).

[3] There is a related literature on management accounting innovation. Dunk (1989) argue that lag in organizations may be due to the perceived greater complexity and lesser relative advantage, compatibility, trialability and observability of administrative (e.g., accounting) innovations as compared with technical innovations. Foster and Ward (1994) argue that perpetual accounting lag theory is derived from the organizational failure framework and markets and hierarchies theory. The theory asserts that operation of an internal labor market within a hierarchical organization inhibits management accounting innovation.

[4] The real options studied in the literature include operating options in McDonald and Siegel (1985), the option to wait and undertake an investment later in McDonald and Siegel (1986) and uncertainty from future interest rates in Ingersoll and Ross (1992). On the empirical study, Pindyck and Solimano (1993) examine the relationship between uncertainty and investment. They use measures of economic and political instability to proxy for uncertainty about the marginal profitability of capital and inflation to proxy economic uncertainty. They find that inflation is inversely correlated with investment. Excellent surveys on real options and option pricing literature are provided by Amran and Kulatilaka (1999) and Broadie and Detemple (2004) respectively.

Verbeeten (2005) shows that the firm's usages of sophisticated capital budgeting practices include real option approach is increasing with the financial uncertainty and firm size. Firms in financial services and building, construction and utility industry are more incline to use complex capital budgeting practices.

The proposed model takes the total annual number of production of a firm as the primary decision variables. The added annual net profits after establishing ABC are considered in deciding the optimal threshold for adoption or discontinuation. Moreover, the difference between the ROA and the net present value (NPV) method is compared. We found that the optimal entry threshold for adoption obtained by the ROA is higher than that obtained by the NPV method. Conversely, the optimal exit threshold for discontinuation obtained by the ROA is less than that obtained by the NPV method. Thus, ROA is more conservative than the NPV method. The difference between these two methods is primarily driven by the option value of waiting before implementing the entry/exit project in the ROA.

The general idea behind is that investing in ABC system is an option-rights. It can be assimilated to the purchase of a financial American call option, where the investor pays a premium price in order to get the right to buy an asset for some time at a predetermined price (exercise price/strike price), and eventually different from the spot market price of the asset (spot price). Analogously, the firm, in its investment decision, tries to get the maximum firm's current value of future discount payoff (a premium price), which gives her the right to use the capital, the cost of setting up the ABC system (exercise price), now or in the future, in return for the firm's value worth a spot price. The value of the option to adopt the ABC system is "An option on an option", if we think of the firm's value as a derivative asset and take the profit flow as being the underlying asset. (In this case the time horizon of the option is infinite). Taking into account this options-based approach, the calculus of profitability cannot be done simply applying the net present value rule to the expected future cash flows of the operation, but consider the following three characteristics of the investment decision. First, there is uncertainty about future payoffs from the investment. Second, the investment can be delayed. Third, the investment is at least partially irreversible. The three characteristics imply that the opportunity cost of investment includes the value of the option to wait that is extinguished when an investment decision is taken. Therefore, the investment decision is affected by the determinants of the value of this option and consequently, an appropriate identification of the optimal exercise strategies for real options plays a crucial role in the maximization of a firm's value.

The article is organized as follows. Section 2 presents the model. Sensitivity analysis is discussed in section 3. In section 4, numerical example is given in which we calibrate the model to the data and then simulate it. Section 5 concludes and discusses the applicability of the model to other management accounting innovation.

2. Model

2.1. Assumptions

ABC system provides more accurate information on cost for each product line. It enables to the accounting number proxy the marginal cost more closely than the traditional unit-based cost. Consequently, the firm can approach the profit maximization point closer than before since it produces at a level closer to marginal cost equal to marginal revenue. If the marginal cost is not accurate, it is difficult to get to that point by using the rough information. Therefore, it is expected that the net profit after adopting ABC exceed that from before. That is $D - F \geq 0$ where D is average net profit after adopting ABC system, which is average revenue minus average cost for each product. F is average net profit from traditional unit-based cost system, which is average revenue minus average cost for each product. Hence, the profit provides firms an incentive to establish ABC system. However, the total demand of product produced by the firm fluctuates with the economic environment. In the long term, the production is expected to grow owing to the economic growth. Accordingly, this study assumes that the firm's annual number of production, N, follows a geometric Brownian motion (GBM). Consequently, the motions of N is described as follows

$$\frac{dN}{N} = \alpha_N dt + \sigma_N dz_N \tag{1}$$

The parameters α_N and σ_N are the drift and volatility of N, respectively, and dz_N denotes the increment of a Wiener Process. From the above assumptions, a firm can increase net profits after establishing ABC system. The added annual net profit π after using ABC is

$$\pi = (D-F)\, N \tag{2}$$

By Ito's Lemma (1951),

$$d\pi = \frac{\partial \pi}{\partial N} dN + \frac{1}{2!}\frac{\partial^2 \pi}{\partial N^2} dN^2 \tag{3}$$

After some manipulation:

$$\frac{d\pi}{\pi} = \alpha_N dt + \sigma_N dz_N \equiv \alpha dt + \sigma_N dz_N \tag{4}$$

where $\alpha \equiv \alpha_N$. Eq. (4) shows that the stochastic process of π also follows a GBM with drift α and volatilities σ_N.

2.2. Adoption decision

Generally, the investment project is worth assessing only when the added annual net profit, π, from adopting ABC can break even or cross over the sum of initial investment and maintenance cost of ABC. This model assumes that the ABC is completed T_I years after the initial investment decision is made. No cash flow, π, is produced during this period. After the using of the ABC, we assume that a firm will spend C annually to update and maintain the ABC operation forever. Assume this expense can support the ABC system operating forever. Thus, the value of the project after ABC is established, $V_1(\pi)$, can be obtained by

$$V_1(\pi) = E[\int_0^{\infty} \mathrm{e}^{\text{-rs}} (\pi(\mathrm{t}+\mathrm{s}) - \mathrm{C})\, \mathrm{ds} \,|\pi(\mathrm{t}) = \pi] = \frac{\pi}{\mathrm{r} - \alpha} - \frac{C}{\mathrm{r}} \tag{5}$$

where r is a specified discounted rate, which is the required rate of return for capital investment. This study assumes r-$\alpha > 0$, then the positive value of $V_1(\pi)$ holds.

When firm decides to invest in the system, it immediately incurs the setup cost I, which is the initial invested capital to establish the ABC system. Moreover, this investment project does not yield immediate cash flow during the period T_{I} for setting up ABC system. τ denotes the remaining time before ABC completion. The value of the project during the ABC establishment period U_{I} (π, τ) is obtained as follows

$$U(\pi,\tau) = \mathrm{E}[\mathrm{e}^{\text{-r}\tau} V_1(\pi(\mathrm{t}+\tau) \,|\, \pi(\mathrm{t}) = \pi] = \frac{\pi \mathrm{e}^{-(\mathrm{r}-\alpha)\tau}}{\mathrm{r} - \alpha} - \frac{C\mathrm{e}^{\text{-r}\tau}}{\mathrm{r}} \tag{6}$$

The potential value of this project before investment, $V_0(\pi)$, is obtained by dynamic programming with a specified discount rate r (Dixit and Pindyck, 1994). The value of the project at time t can be expressed as the present value of its continuation value beyond t+dt. That is

$$V_0(\pi) = \mathrm{E}[\mathrm{e}^{\text{-rdt}} V_0(\pi + d\pi)]$$

Expanding the right-hand side using Ito's Lemma, we have

$$V_0(\pi) = \alpha\pi V_0^{'}(\pi) + \frac{1}{2}\sigma^2\pi^2 V_0^{''}(\pi)dt + (1 - rdt)V_0(\pi) \tag{7}$$

and the volatility σ^2 is defined as follows $\sigma^2 \equiv \sigma_N^2$. Simplifying, dividing by dt in Eq. (7), the second order homogenous ordinary differential equation can be obtained

$$\frac{1}{2}\sigma^2\pi^2V_0^{''}(\pi)dt+\alpha\pi V_0^{'}(\pi)-rV_0(\pi)=0 \tag{8}$$

The general solution form is represented as $A\beta^{\pi}$, which when substituted into Eq. (8) yields the quadratic equation for β, as follows

$$\frac{1}{2}\sigma^2\beta(\beta-1)+\alpha\beta-r=0 \tag{9}$$

The two roots of Eq. (9) are

$$\beta_1=[\frac{1}{2}-\alpha\sigma^2]+\sqrt{(\frac{1}{2}-\alpha\sigma^2)^2+\frac{2r}{\sigma^2}}$$

$$\beta_2=[\frac{1}{2}-\alpha\sigma^2]-\sqrt{(\frac{1}{2}-\alpha\sigma^2)^2+\frac{2r}{\sigma^2}} \tag{10}$$

Assume $r > \alpha$, thus $\beta_1 > 1$ and $\beta_2 < 0$. The general solution of Eq. (8) can be written as

$$V_0(\pi) = A_1\pi^{\beta 1} + A_2\pi^{\beta 2} \tag{11}$$

If π equals zero, then the potential value of the project, $V_0(\pi)$, is also zero. This condition implies that the coefficient A_2 must equal zero. Thus, the potential value of the project before investment is

$$V_0(\pi) = A_1\pi^{\beta 1} \tag{12}$$

Suppose that π_I is the optimal entry threshold for the investment project. The firm should defer the adoption of ABC system when π is less than π_I. On the other hand, the firm should begin to invest I and establish the ABC to provide a new measure of cost reporting for managerial use when π increases to equal π_I. Following the value matching and smooth pasting conditions (see Dixit and Pindyck, 1994), we have

Value matching condition:

$$V_0(\pi_I) + I = U_I(\pi_I, T_I) \tag{13}$$

Smooth pasting condition:

$$V_{0\pi}(\pi_I) = U_{I\pi}(\pi_I, T_I) \tag{14}$$

Here, the smooth pasting condition ensures that π_I is the entry threshold that maximizes the potential value $V_0(\pi)$ (Dixit, 1993). Substitute Eqs. (6) and (12) into Eqs. (13) and (14) to solve the optimal entry threshold, π_I, and the coefficient of the potential value, A_1. After some manipulations, we obtain

$$\pi_I = \left(\frac{\beta_1}{\beta_1 - 1}\right) r - \alpha r [C\mathrm{e}^{-\alpha T_I} + rI\mathrm{e}^{-(r-\alpha)T_I}] \tag{15}$$

$$A_I = \pi_I \left(\frac{1-\beta_1}{\beta_1}\right) rI\mathrm{e}^{-(r-\alpha)T_I} - \alpha \tag{16}$$

where T_I is the period for establishing the ABC system. Substituting Eq. (3) into Eq. (15), then the optimal entry threshold N_I is obtained

$$N_I = \frac{\pi_I}{D-F} = \left(\frac{\beta_1}{\beta_1 - 1}\right) \frac{r-\alpha}{r} \frac{[C\mathrm{e}^{-\alpha T_I} + rI\mathrm{e}^{-(r-\alpha)T_I}]}{D-F} \tag{17}$$

In the NPV method, the NPV of a project is the sum of the present value of the expected cash flow of the project and the salvage value at the end of the life of the project, minus the initial investment cost. Typically, the NPV can be estimated at the time of decision-making. The decision rule for the NPV method is described as follows. If NPV > 0, then the investment project should be executed immediately, otherwise the project should be abandoned. That is, the NPV method requires the present value of the expected cash flow (π-C) after establishing ABC to exceed or equal the system setup cost, I. When the following inequality is satisfied, the firm should invest in the project immediately.

$$E\left[\int_{t_0}^{\infty}\left(\pi(t)-c\right)e^{-rt}dt\middle|\pi(t_0)=\pi\right]\geq 1 \tag{18}$$

After some manipulations, we obtain the optimal entry threshold π_I^0 using the NPV method.

$$\pi_I^0=\frac{r-\alpha}{r}\left[Ce^{-\alpha T_1}+rIe^{(r-\alpha)T_1}\right] \tag{19}$$

Substituting Eq. (3) into Eq. (19) produces the optimal entry threshold N_I^0 using the NPV Method

$$N_I^0=\frac{r-\alpha}{r}\frac{\left[Ce^{-\alpha T_1}+rIe^{(r-\alpha)T_1}\right]}{D-F} \tag{20}$$

Comparing the optimal entry threshold obtained by the ROA, N_I, in Eq. (17) with Eq. (20) obtains the following result

$$N_I=\frac{\beta_1}{\beta_1-1}N_I^0 \tag{21}$$

The restriction on $\beta_1 > 1$ leads to $\beta_1/(\beta_1 -1) > 1$, and thus the required optimal entry threshold obtained by the ROA is higher than that obtained by the NPV method. The difference between the two methods arises mainly because of the option value of waiting before implementing the investment project. Since it considers the managerial flexibility by including the option value in its calculations, the ROA method is more conservative than the NPV method in supporting entry decision in the face of uncertainty. Thus, the ROA is superior because it gives more accurate decision rule.

2.3. Discontinuation decision

If the added annual profit π from the ABC system cannot break even or cross over the maintenance cost of ABC system, the ABC system adopted firm should consider discontinuing the ABC system. We assume that the terminating project requires a period T_E to terminate the business completely and cash flow (π-C) will still occur during this period. Additionally, the exit cost E is incurred at the end of the period T_E. If a firm stops using the ABC system, a business loss ratio η, which is a constant, occurring in the annual number of production N will not return to the traditional system, due to weaken customer's confidence on managerial ability to achieve profit maximization for the firm. This variable proxy the opportunity cost for the management to abandon the ABC system in additional to exit cost, E. Based on the above assumptions, the potential value before terminating the project, $V_{E1}(\pi)$, is obtained as follows:

$$V_{E1}(\pi) = E[e^{-r\,dt} \times V_{E1}(\pi + d\pi)] + (\pi - C)\,dt \qquad (22)$$

Expanding the right-hand side of Eq. (22) by Ito's Lemma and dividing by dt produces the second order ordinary differential equation, as follows:

$$\frac{1}{2}\sigma^2\pi^2 V''_{E1}(\pi) + \alpha\,\pi\, V'_{E1}(\pi) - r\, V'_{E1}(\pi) + (\pi - C) = 0 \qquad (23)$$

The general and particular solution to this equation is

$$V_{E1}(\pi) = B_1\pi^{\beta 1} + B_2\pi^{\beta 2} + \frac{\pi}{r-\alpha} - \frac{c}{r} \qquad (24)$$

The last two terms in Eq. (24) are the present value from the ABC system when it keeps operating forever, and the first two terms are the option value associated with exiting the project. The likelihood of exit in the near future becomes extremely small as π goes to ∞, so the value of the exit option should go to zero as π becomes very large. Hence, the coefficient B_1 corresponding to the positive root β_1 should be zero. This leaves

$$V_{E1}(\pi) = B_2\pi^{\beta 2} + \frac{\pi}{r-\alpha} - \frac{c}{r} \qquad (25)$$

From the assumptions, a firm loses ηNF profits forever when it does not use the ABC system. And the firm still has cash flow (π-C) during period T_E. The value of the exit after terminating the ABC system,

$$V_{E0}(\pi) = \frac{\pi}{r-\alpha}\left(e^{(r-\alpha)T_E} - 1\right) - \frac{\eta F}{D-F}\frac{\pi}{r-\alpha} - \frac{c}{r}(e^{rT_E} - 1) \tag{26}$$

Denote τ as the time required to achieve a complete exit after deciding to terminate the ABC system. The value of the exit project during the period T_E, $U_2(\pi, \tau)$, is obtained as follows

$$U_2(\pi, \tau) = E[e^{-r\tau} V_{E0}(\pi(t+\tau)) \,|\pi(t) = \pi] \tag{27}$$

Substituting Eq. (25) into Eq. (26) obtains

$$U_2(\pi, \tau) = \frac{\pi}{r-\alpha}\left(e^{(r-\alpha)(T_E-\tau)} - e^{-(r-\alpha)\tau}\right) - \frac{\eta F}{D-F}\frac{\pi}{r-\alpha}e^{-(r-\alpha)\tau} - \frac{c}{r}(e^{r(T_E-\tau)} - e^{-r\tau}) \tag{28}$$

Suppose that π_E is the optimal exit threshold for discontinuing the project. The firm should continue to use the ABC system and defer the exit project when π is higher than π_E. On the other hand, the firm should begin to spend E and implement the exit project immediately when π reduces to π_E. Because the exit cost E is charged at the end of the period T_E, we obtain Eqs. (29) and (30) from value matching and smooth pasting conditions.

Value matching condition:

$$U_2(\pi_E, T_E) + E \cdot e^{-rTE} = V_{E1}(\pi_E) \tag{29}$$

Smooth pasting condition:

$$U_{2\pi}(\pi_E, T_E) = V_{E1\pi}(\pi_E) \tag{30}$$

Substituting Eqs. (25) and (26) into Eqs. (29) and (30) to solve the optimal exit threshold, π_E, and the coefficient of the potential value B_2, we obtain:

$$\pi_{\mathrm{E}}=\left(\frac{\beta_2}{\beta_2-1}\right)\left(\frac{r-\alpha}{r}\right)\left(\frac{D-F}{D-\left(1-\eta\right)F}\right)\left(C-rE\right)e^{-\alpha T_E} \tag{31}$$

Substituting Eq. (3) into Eq. (31) can obtain the optimal exit threshold N_{E}.

$$N_{\mathrm{E}}=\frac{\pi_E}{D-F}=\left(\frac{\beta_2}{\beta_2-1}\right)\left(\frac{r-\alpha}{r}\right)\left(\frac{D-F}{D-\left(1-\eta\right)F}\right)\left(C-rE\right)e^{-\alpha T_E} \tag{32}$$

According to the NPV method, when the sum of the value before implementing the exit project and the exit cost is less than the value after implementing the exit project, a firm should implement the exit project immediately. That is

$$\frac{\pi_E{}^0}{r-\alpha}-\frac{c}{r}+E\cdot e^{rT_E}\le\frac{\pi_E{}^0}{r-\alpha}\left(1-e^{-(r-\alpha)T_E}\right)-\frac{\eta F}{D-F}\frac{\pi_E^0}{r-\alpha}e^{-(r-\alpha)T_E}-\frac{c}{r}(1-e^{-rT_E}) \tag{33}$$

From Eq. (29), the optimal exit threshold by the NPV method is obtained:

$$\pi_E{}^0=\left(\frac{r-\alpha}{r}\right)\left(\frac{D-F}{D-(1-\eta)F}\right)\left(c-rE\right)e^{-\alpha T_E} \tag{34}$$

From Eq. (30), the optimal exit threshold, $N_E{}^0$, by the NPV method for the exit project is

$$N_E{}^0=\frac{\pi_E{}^0}{D-F}=\left(\frac{r-\alpha}{r}\right)\left(\frac{1}{D-(1-\eta)F}\right)\left(c-rE\right)e^{-\alpha T_E} \tag{35}$$

Comparing the optimal exit threshold obtained by the ROA, N_{E}, in Eq. (28) with Eq. (31), we obtain

$$N_E = \frac{\beta_2}{\beta_2 - 1} N_E^0 \tag{36}$$

The restriction on $\beta_2 < 0$ leads to $0 < \beta_2/(\beta_2 - 1) < 1$. This result means that the required optimal exit threshold obtained by ROA is less than that obtained by the NPV method.

3. Sensitivity Analysis

This section addresses how related parameters influence the optimal entry threshold, N_I, for adoption and the optimal exit threshold, N_E, for terminating the ABC system. **Table 1** lists the results of the sensitivity analysis.

On the cost side, a reduction in annual maintenance cost (C) or cost of installation (I) implies that the optimal entry threshold decreases and more firms are willing to adopt ABC system. Similarly, more firms will be inclined to retain ABC system given declining annual maintenance costs. Additionally, increasing the net profit of traditional unit-based cost system (F), the incentive for firms to adopt (or retain) ABC system thus is decreased. On the other hand, if reduction in the operating costs becomes more significant with the improvements in ABC. Hence, the cost of ABC reduces and net profits from ABC (D) increase. Firms thus have increased incentives to establish (or retain) ABC system, and consequently the optimal entry threshold (or the optimal exit threshold) declines. Exit costs (E) include the cost of scrapping ABC system and layoff of related staff. If exit costs increase, more firms will be willing to retain ABC system. Hence, the optimal exit threshold declines with rising exit costs. A similar result occurs in the case of the business loss ratio η. If the business loss ratio increases, then more firms would be unwilling to terminate ABC system since the opportunity cost is increased. Thus the optimal exit threshold declines with business loss ratio η.

Both parameters in the stochastic process for the annual number of production affect the adoption/discontinuation decision. The parameter α represents the drift in the trend of annual number of production, which can be interpreted as the long run trend of demand.

An increase in the trend makes the optimal entry threshold (and the optimal exit threshold) decline, which implies that more firms would be willing to adopt (or retain) ABC system. On the other hand, the entry and exit results for firm's annual number of production volatility (σ) differ. Increased volatility implies increased uncertainty of firm's annual number of production and firms require more time to obtain enough information for making decisions on entering or retaining ABC system. This implies that firms will keep holding the option and defer entering or exiting the ABC system. Increased volatility decreases the incentive to adopt ABC system but increase the incentive to retain an existing one. Therefore, an increase in the volatility increases the threshold of entry but decreases the threshold of exit. It indicates that firms in growing and stable industries are more likely to adopt the ABC system. Empirical test for this implication of the model is left for the future research.

The relationship between threshold for entry/exit and discounted rate r is unclear. If the discounted rate r increases, which makes the interest charge for entry/exit rise, more firms would not be willing to adopt/terminate ABC system. Conversely, shorter period for entry/exit reduces the interest charges for entry/exit, meaning more firms will be willing to adopt/terminate ABC system. These two interactions simultaneously influence the optimal entry/exit threshold. Thus, the relationship between the optimal entry/exit threshold and discounted rate is unclear.

The effect of the time period for entry (T_I) on the optimal entry threshold (N_I) is also unclear. The reasons are similar to the descriptions of the above paragraph for the relationship between discounted rate and the optimal entry threshold. However, a rise in the time period for exit (T_E) decreases the optimal exit threshold. The relationship between N_E and T_E differs from the relationship between N_I and T_I. Because the exit cost E is charged at the end of time period T_E, no interest charge rE exists during the exit period. However, cash flow (π-C) still occurs during the exit period. Hence, more firms would be willing to retain the ABC system if the exit time period increases.

4. Numerical Example

This section simulates the adoption and discontinuation decision of ABC system for a firm with the proposed model mentioned in the previous section. Numerical analysis is conducted using the following parameters. Using 1929 to 2005 quarterly data of Real GDP from Bureau of Economic Analysis, we get $\alpha_N = 0.0084$ and $\sigma_N = 0.0099$. Discount rate is calibrated to $r = 0.01$ which is equal to average inflation adjusted return of U.S. T Bills during the period 1929-2005. Hence, $\beta_1 = 14.74$, and β_2 =-13.74 are calculated from Eq. (10). Since the setup cost is large relative to the maintenance and termination cost, we assumes set up cost *I*, maintenance cost *C,* and exit lump-sum cost *E* and the average net profit ABC system exceed the traditional unit- based cost system (D-F) have the ratio relationship, E = C = 0.1*I, E/(D-F)= C/(D-F)=0.1*I/(D-F)=50000, in order to emphasis the costs in the decision making process. Additionally, this investigation assumes that the business loss ratio in *N* as $\eta = 0.5$, which implies (D-F)/[D-(1- η)F] = 2. It is the state variable that we use to proxy the profitability of the firms. The time lags for entry and exit project are $T_I = 0.5$ years and $T_E = 0.5$ years, respectively.

From these baseline parameters, the entry and exit thresholds for the decision of adopting and discontinuing the ABC system are listed as **Table 2**. The drift parameter is at its mean value and we take two level of volatility level around the mean to perform the sensitivity analysis on the entry/exit threshold.

The numerical example illustrate that the entry threshold for adopting a new ABC system is consistently higher for ROA approach than the NPV approach. It is due to the former method incorporates the uncertainty of demand from output market into consideration. The entry threshold from ROA approach is 7% - 8% higher that from NPV approach. The entry threshold is increasing with the volatility parameter but the threshold from NPV does not. On the other hand, the ROA provides a lower exit threshold than the NPV method since it needs lower realization of output level in order to make the adopters give up the ABC system. It is 7% - 9% lower than that from NPV approach. The exit threshold is decreasing with the volatility parameter to show the waiting option is higher when uncertainty is higher. Therefore, the ROA method is more conservative than the NPV method in supporting entry/exit decisions under uncertainty. **Figure 1 and 2** extends the example by allowing a range of drift parameter. **Figure 1** shows that the entry threshold from both approaches are decreasing with the drift parameter since higher trend growth in demand make the producer more likely to incur a fixed cost to adopt the ABC system. However, as the trend growth rate increase, the entry threshold from ROA do not go to zero but converge to a positive level of output because trend growth does not eliminate the waiting option derived from the uncertainty. Similarly, **Figure 2** shows that exit threshold from both approaches are decreasing with the drift parameter since the higher trend growth in demand make the producer less likely to abandon the system. Similar to the case of adoption, slow growth in demand does not make the producer abandon the ABC system because they are willing to wait and collect more information before making the discontinuation decision. **Figure 3 and 4** indicate that the decision rule discussed before is valid in a wider range of parameter space in which the trend growth can take positive and negative rate whereas the volatility can be varied from 0.02 to 0.2. The impact from trend growth is stronger than that from volatility. Despite the demand uncertainty affects the adoption and discontinuation decision, it shows that the trend growth in demand in product market is more important in determining the decision.

Table 3 shows that if the period T is required to completely adopt or discontinue the ABC system. If we allow the time required increased from 0 to 2 years, then both optimal entry and exit thresholds decreases with time required. The average annual rate of decrease in N_I and N_E is about -0.373% and -0.418%, respectively.`

Since the specification requirements of ABC system differ among firms, the setup costs I differ among firms. More complicated system requires more capital in setting up and maintaining the system. Generally, setup costs are associated with maintenance costs. Hence, we assume the maintenance cost C is 10% of the setup cost I. **Table 4** compares the entry/exit thresholds for the maintenance cost-to-value added ratio of C/(D-F) at 100,000, 50,000 and 20,000.

The optimal entry and exit threshold increase more than proportional with the ratio. Given the stochastic environment, the waiting option is more valuable for the firm when maintenance cost is relative large since the firm want to wait for longer for a higher realization of output level in order to make sure the new system break even. Once the system is established, the firm is more likely to abandon the system when the maintenance cost is relatively high since it is less probable for the project to break even. **Figure 5 and 6** show that the influence from time to completion is relatively small compare to that from maintenance cost to value added ratio. Although the time to completion affects the adoption and discontinuation decision, the maintenance cost to value added ratio is still the main determining in decision making.

5. Concluding Remarks

This paper establishes a decision model for evaluating whether to adopting or discontinuing the ABC system using the ROA. The proposed model takes the total annual number of production of a firm as the primary decision variables. The added annual net profits after establishing ABC are considered in deciding the optimal threshold for adoption or discontinuation. Moreover, the difference between the ROA and the NPV method is compared. We found that the optimal entry threshold for adoption obtained by the ROA is higher than that obtained by the NPV method. Conversely, the optimal exit threshold for discontinuation obtained by the ROA is less than that obtained by the NPV method. Thus, ROA is more conservative than the NPV method. The difference between these two methods is primarily driven by the option value of waiting before implementing the entry/exit project in the ROA.

The ROA approach can be applied to other adoption and discontinuation decision for other management accounting innovation, for instance Residual Income measure and Balanced Score Card. For the case of Residual Income, firms perceived more benefit are more likely to adopt Residual Income measure to evaluate manager. Garvey and Milbourn (2000) argue that the adopter of Residual Income should have higher correlation between Residual Income and stock price. Lovata and Costigan (2002) use organization strategy is a determinant for the decision of adoption. Firm uses costleadership strategy is more likely to adopt Residual Income than those use differentiated product strategy. However, the perceived benefit may not be realized once the new measure is used. Lin (2005) investigate the discontinuation decision of firm on Residual Income and find out that discontinuing firm experience less correction in investment, i.e less realized benefit, than continuing firm. However, in the studies mentioned, there is no consideration from the view of ROA approach. Exploring the implications from ROA can deepen our understanding on the firm's decision.

The model in this paper assesses the adoption and discontinuation decision separately. When a firm considers adopting a new management accounting practice, it has an option of adopting the practice, and also has the option of discontinuing the practice after having using it. The current model can be extended to the case that a firm exercises an option to adopt a new management accounting practice and own another option to discontinue the practice and revert to the original practice. Therefore, two interlinked option pricing problems must be solved simultaneously. Such an adoption and discontinuation decision model for further research will provide a more thorough understanding on the life cycle of management accounting practices.

References

Amran, M. and N. Kulatilaka (1999) *Real Options: Managing Strategic Investment in an Uncertain World*. Boston, Harvard Business School Press.

Anderson, S. W. and S. M. Young (1999) "The Impact of Contextual and Procedural Factors on the Evaluation of Activity Based Costing Systems," *Accounting, Organizations and Society*, October: 525–59.

Banker, R. D., and G. Potter (1993) "Economic Implications of Single Cost Driver Systems," *Journal of Management Accounting Research*, Fall: 15–31.

Bjørnenak, T. (1997) "Diffusion and accounting: the Case of Norway," *Management Accounting Research*, 8 (1), 3–17.

Bromwich, M., and C. Hong (1999) "Activity-Based Costing Systems and Incremental Costs," *Management Accounting Research*, March: 39–60.

Broadie, M. and J.B. Detemple (2004) “Option Pricing: Valuation Models and Applications,” *Management Science*, September: 1145–1177.

Busby, J. and C. Pitts (1997) “Real Options in Practice: An Exploratory Survey of How Finance Officers deal with Flexibility in Capital Appraisal,” *Management Accounting Research*, 8, 169–186.

Carolfi, I. A. (1996) “ABM Can Improve Quality and Control Costs,” *Cost & Management*, May: 12–16.

Christensen, J. and J. S. Demski (1997) “Product Costing in the Presence of Endogenous Subcost Functions,” *Review of Accounting Studies*, 65–87.

Cooper, R. (1988) “The Rise of Activity-Based Costing-Part One: What is an Activity-Based Cost System?” *Journal of Cost Management*, Summer: 45–53.

Cooper, R. and R. S. Kaplan (1991) *The Design of Cost Management Systems*, Englewood Cliffs, NJ: Prentice Hall.

Cooper, R., R. S. Kaplan, L. Maisel, E. Morrissey and R. Oehm (1992) *Moving From Analysis to Action: Implementing Activity-Based Management*. Montvale, NJ: Institute of Management Accountants.

Datar, S. M. and M. Gupta (1994) “Aggregation, Specification and Measurement Errors in Product Costing,” *The Accounting Review*, October: 567–91.

Dixit, A. (1993) *The art of smooth pasting*. Gmbh: Harwood Academic Publishers.

Dixit, A. and R. Pindyck (1994) *Investment Under Uncertainty*. Princeton University Press.

Dunk, A. S. (1989) “Management Accounting Lag.” *Abacus*, September: 149–55.

Graham, J.R. and C.R. Harvey (2001) “The Theory and Practice of Corporate Finance: Evidence from the Field,” *Journal of Financial Economics*, 60, 187-243.

Garvey, G. and T. Milbourn (2000) “EVA versus Earnings: Does It Matter Which Is More Highly Correlated with Stock Returns?” *Journal of Accounting Research*, 38 (Supplement): 209-245.

Ingersoll, J. and S.A. Ross (1992) “Waiting to Invest: Investment and Uncertainty,” *Journal of Business*, 65, 1-29.

Lin, T. (2005) “Residual Income-based Compensation: Investment Activities and Discontinuation Decision,” National Chung Cheng University, *mimeo*.

Lovata, L. and M. Costigan (2002) “Empirical Analysis of Adopters of Economic Value Added,” *Management Accounting Research*, 13: 215-228.

Ito, K. (1951) “On Stochastic Differential Equations,” *Memoirs of American Mathematical Society*, 1–51.

Kaplan, R. S. (1992) “In Defense of Activity-Based Cost Management,” *Management Accounting*, November: 58–63.

McDonald, R. and D. Siegel (1985) “Investment and the Valuation of Firms When There is an Option to Shut Down”, *International Economic Review*, 26, 331-349.

McDonald, R. and D. Siegel (1986) “The Value of Waiting to Invest”, *Quarterly Journal of Economics*, 101, 707-727.

Noreen, E. (1991) “Conditions Under Which Activity-Based Cost Systems Provide Relevant Costs,” *Journal of Management Accounting Research*, Fall: 159–68.

Pindyck, R.S. and A. Solimano (1993) “Economic Instability and Aggregate Investment,” *NBER Macroeconomics Annual*, 8, 259-319.

Verbeeten, F. (2005) “Do Organization Adopt Sophisticated Capital Budgeting Practices to deal with Uncertainty in the Investment Decision? A Research Note,” *Management Accounting Research*, 16: *forthcoming*.

Table 1: Influence of related parameters on N_I and N_E

	r	α	σ	D	F	C	I	T_I	E	T_E	η
N_I	($\pm$)	(-)	(+)	(-)	(+)	(+)	(+)	($\pm$)			
N_E	($\pm$)	(-)	(-)	(-)	(+)	(+)			(-)	(-)	(-)

(+) Monotonically increasing; (-) monotonically decreasing; ($\pm$) unclear.

Table 2: The entry/exit threshold for ROA and NPV method

	Entry Model	Exit Model
	N_I	N_E
ROA with σ_N =0.0099	9470.06939	3701.096
ROA with $\sigma_{N=}$0.0420	9604.84616	3649.162
NPV with σ_N =0.0099	8827.43315	3970.536
NPV with σ_N =0.0420	8827.43315	3970.536

Table 3: Entry/exit threshold values for Time to Completion, T

Entry Model		Exit Model	
T_I	N_I	T_E	N_E
0	9506	0	3717
0.5	9470	0.5	3701
1	9435	1	3686
1.5	9400	1.5	3670
2	9365	2	3655

Table 4: Entry/Exit thresholds values for Maintenance Cost-to-Value Added Ratio

Entry Model		Exit Model	
C/(D-F)	N_I	C/(D-F)	N_E
100,000	18940	100,000	7402
50,000	9470	50,000	3701
20,000	3788	20,000	1480

Figure 1: Entry Threshold from ROA and NPV Approach

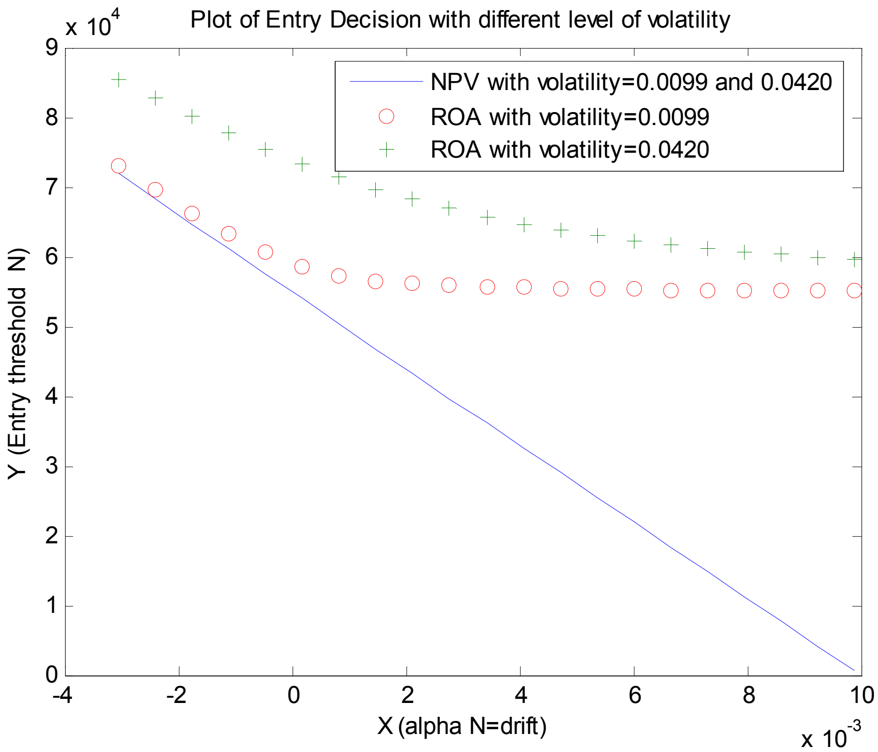

Figure 2: Exit Threshold from ROA and NPV Approach

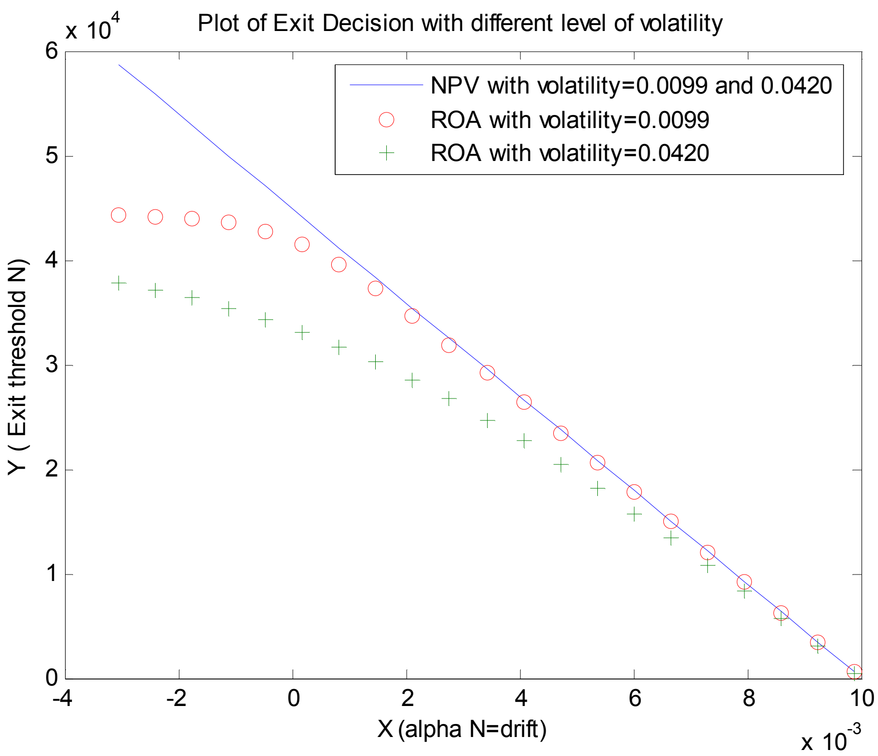

Figure 3: Entry Threshold from ROA Approach with different Drift and Volatility

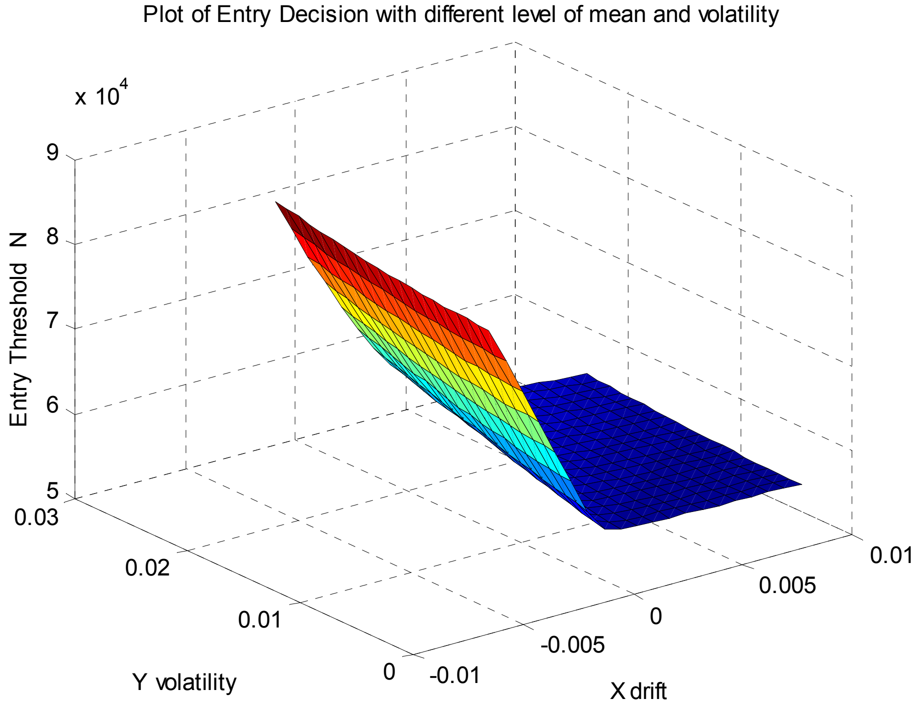

Figure 4: Exit Threshold from ROA Approach with different Drift and Volatility

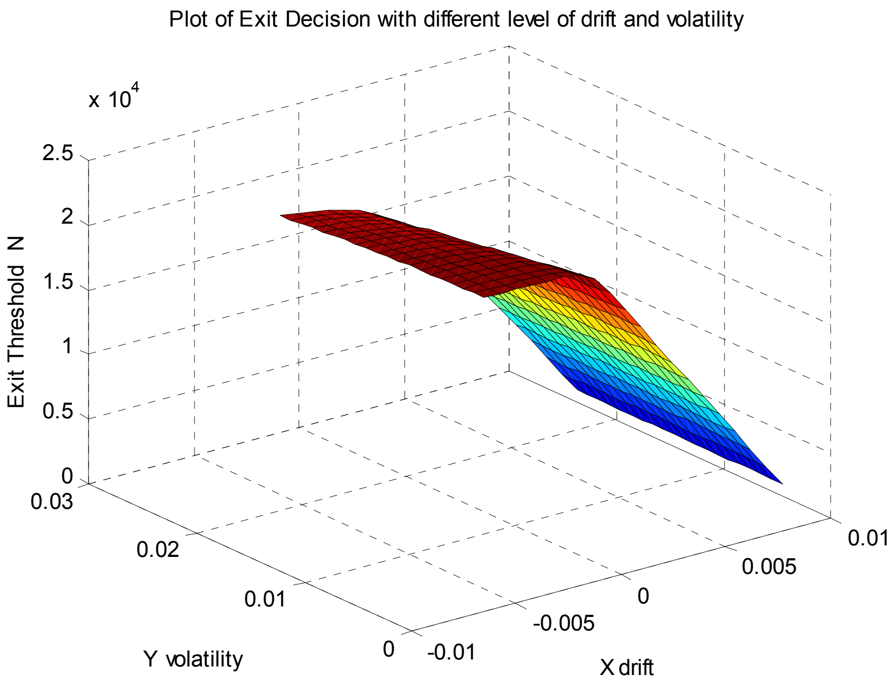

Figure 5: Entry Threshold from ROA Approach with different Maintenance Cost to Value Added Ratio and Time to Completion

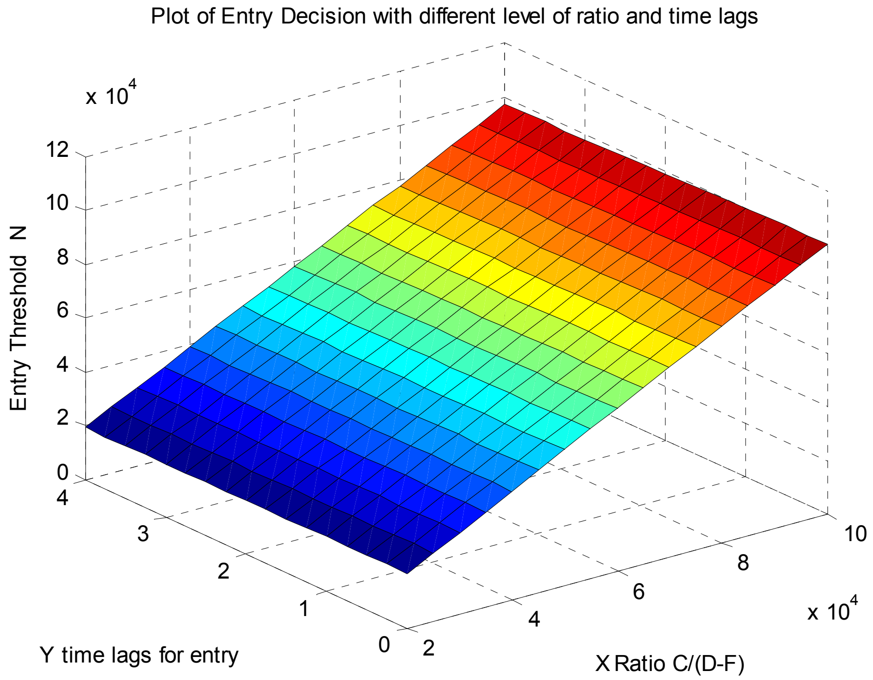

Figure 6: Exit Threshold from ROA Approach with different Maintenance Cost to Value Added Ratio and Time to Completion