

消費者首次購買之實質選擇權價值分析

The Real-Option Value Contained in Consumers' Initial Purchase

羅烈明¹ Lieh-Ming Luo

輔仁大學 金融與國際企業學系

Department of Finance and International Business, Fu Jen Catholic University

楊宜興 Phil Yihsing Yang

台中教育大學 事業經營研究所

Department of Creative Design and Management, National Taichung University of Education

李慧慈 Sandra H.T. Lee

中興大學 財務金融學系

Department of Finance, National Chung Hsing University

蔡偉澎 Wei-Pen Tsai

輔仁大學 金融與國際企業學系

Department of Finance and International Business, Fu Jen Catholic University

摘要：對消費者而言，由於首次購買之產品認知價值通常具有高度不確定性，故鑲嵌於首次購買的選擇權價值應不可忽略。本文針對鑲嵌於消費者首次購買的選擇權價值建構一個評價模式。在本文中，鑲嵌於消費者首次購買之實質選擇權包括二項：重複購買之買權與退款保證之賣權。由於此二項選擇權具有互斥性，因而形成一個有趣的評價問題。本模型同時考慮兩項具互

¹ Corresponding author: Department of Finance and International Business, Fu Jen Catholic University, New Taipei City, Email: lmluo@mail.fju.edu.tw.

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斥性的選擇權，並同時考慮了兩項主要風險：即價值估算風險與損壞風險，因而增加了模型建立的困難。除了理論模式之推導，本研究亦提供評價模式之數值分析，進一步釐清模型中各項行銷變數間的關聯。本研究之評價模式說明了上述二項選擇權價值如何產生，以及二者如何相互影響。尤其，當廠商針對新發售的產品，或新開發的特定市場，擬定產品訂價時，本模型可幫助決策者更能掌握上述二項實質選擇權所能提供的附加價值，對於消費者首次購買的產品之訂價能提供有用的參考。

關鍵詞：首次購買；實質選擇權；重複購買；退款保證；產品定價

Abstract: In this paper, we propose a model to evaluate the real options embedded in consumers' initial purchase. Due to high uncertainty of perceived value for initially-purchased products, the real-option values contained in those products would be substantial, and thus should be considered. We fairly value the two real options about consumers' initial purchase, i.e., the repeat-purchase call option and the Money-Back Guarantee put option. The mutually exclusive relationship between the two options leads to an interesting valuation issue. When applied to products involving two types of risks, i.e., valuation risk and breakage risk, mutual exclusion of the aforementioned two options makes model calibration rather challenging. The model expresses how these real options can create added-value for consumers and their interaction effects. In addition to model derivation, this study also conducts numerical analysis to illustrate effects of several factors on the options value. The research can broaden the understanding of consumers' perceived value for initial purchases, and thereby can help management to improve product-pricing decision making, especially in the case of developing a new product or a new market.

Keywords: Initial purchase; Real options; Repeat purchase; Money-back guarantee; Product pricing

1. Introduction

Firms typically need to stimulate consumers' initial purchase to increase

their sales or market share, especially when they attempt to penetrate into a new market or to put a new product on sale. However in consumers' initial purchase, consumers usually encounter higher uncertainty about a product they wish to buy because of no prior product-using experience. Although the uncertainty about an initial purchase may decrease perceived product value, the higher uncertainty also implies more real-options values obtained in the purchase for consumers. As we've already known, more real-options values could be created in a higher uncertain situation. So the options value contained in an initially-purchased product would be substantial, and thereby should be considered. As emphasized by Meyer, Zhao and Han (2008), consumer decisions to adopt a newly-experienced product or service for gaining access to novel functions might be viewed as analogous to risky investments in options: By purchasing the product, the consumer is not acquiring a known stream of benefits, but rather a flexible stream whose value depends on what is learned about the utility of the product. Therefore, consumers' purchase of a product may not only involve its present perceived value, but also its possible future value. Especially with a product that is entirely new or an initial purchase, the uncertainty about its post-purchase values (the future value) would be rather high and thus affect the purchase decision making. Unlike the literature on initial purchase, which pays little attention to the added value of the embedded real options (e.g., Eskin, 1973; Kalwani and Silk, 1980; Kuan *et al.*, 2008.), this work emphasizes that option value as a crucial determinant of consumers' product evaluation. The results of this study can help management to clarify how the options values contained in consumers' initial purchase are created, and how to utilize them in improving marketing activities, especially in pricing.

Retailing industries often used money-back guarantees (MBG) offers as a mechanism to reduce consumers' perceived risk. MBG can be regarded as one real option embedded in a new or an initially purchased product. Consumers can sell back a product to retailers at a predetermined price (return it for a refund) with MBG. As Heiman *et al.* (2002) proposed, MBG is treated as a put option and evaluated with an option-pricing approach. MBG could reduce the consumers' perceived risk as to the product's value and then enhance the consumers'

perceived product value (Mann and Wissink, 1988, 1990; Davis *et al.*, 1995; McWilliams, 2012). The second real option we consider here is the repeat-purchase option like a call option that can enable buyers to repurchase a product in the future at a predetermined price if the post-purchase product value can fulfill consumers' expectation. For any repurchase situation or a standardized product, the repeat-purchase option cannot create a significant value since the future product value is almost certainly predictable. However, this option value cannot be ignored in such an initial purchase due to involving high risk. In summary, then, an initial purchase can comprise at least both the repeat-purchase call option and MBG put option values. And the study concentrates on the valuation of the aforementioned two options contained in initial purchase.

When the MBG put option and repeat-purchase call option co-exist for a given product, someone may wonder how interactively they influence consumers' perceived product value. The study attempts to evaluate those embedded real options using a conventional option pricing method from the consumer value-based viewpoint. Particularly, the two options are mutually exclusive: consumers can use the repeat-purchase call option only if they do not return the product and are satisfied with it after the initial purchase; if they return it for a refund, the repeat-purchase call option automatically ceases. In other words, if one of the two options is excised, it cannot be possible to excise the other one in such an initial purchase case. This relationship between the two options makes model calibration rather challenging and thus leads to an interesting product-valuation issue. Our proposed model is proposed to resolve such the valuation problem.

Real-options approaches have been applied in various areas of management, such as R&D project evaluation (McGrath, 1997; McGrath and MacMillan, 2000; Luo *et al.*, 2008), human resource management (Malos and Campion, 2000), flexibility in multinational operations (Reuer and Leiblein, 2000), and joint venture evaluation (Kogut, 1991; Chi, 2000). When applying that approach to analogous marketing issues, the underlying assumptions must be carefully specified. A typical real-option approach assumes that an underlying asset follows a specific stochastic process. For example, a gold-mining project embeds several

types of real options such as abandonment, deferment and expansion. The real-option approach typically treats gold's market price as the underlying following a specific stochastic process. Analogously, the MBG put option and repeat-purchase call option can be thought of as a contingent claim on consumers' perceived product value after purchase. Thus the underlying variable ought to be the post-purchase product value, which varies over time due to many stochastic factors. For example, consumers' perceived value may increase when they find that the product has additional functions; or decrease when they unexpectedly find some inconvenience in use. Applying stochastic processes to express the uncertainty of consumers' product valuation is one distinguishing feature of this work. The proposed model can evaluate consumers' benefits from both the MBG put option and repeat-purchase call option in the initial purchase on the basis of this stochastic process setting.

Few studies model marketing tools as financial options. For example, MBG is treated as a put option for consumers (Heiman *et al.*, 2002); Leasing is viewed as a call option enabling consumers to buy at a predetermined price (Grenadier, 1995; Miller, 1995). As those researches with limitations in which the underlying asset of focus options is non-tradable and thus feasibility of replicating portfolio could be a problem, the present study also encounters with the same limitations in applying the option pricing approach. We concentrate in valuing real options embedded in initially purchased products from a consumer value-based perspective. We use a quantitative model to evaluate those real options and clarify the relations among key factors through numerical analysis, illustrating what factors can influence consumers' value-conception and thereby expressing how they can influence their purchase behaviors. Understanding the value-creation effect of options helps to show how consumers evaluate a new or an initially purchased product, thus improving firms' pricing decisions for consumers' new purchases.

In the remainder of the paper, we first develop a theoretical valuation framework for the MBG put option and repeat-purchase call option, in which the post-purchase product value to consumers is treated as a stochastic evolution. Next, simulation analysis are conducted to demonstrate the relationship among

the relevant parameters in our model, followed by the conclusion with discussions and management implications.

2. The Valuation Framework

Consumers will be uncertain about how much value a product offers before purchasing it. And even after purchase, they cannot estimate the value exactly. They must keep evaluating the product sequentially. To understand its true value, that uncertainty in valuation after purchase comes from various risk sources: product performance, experiences in use, others' comments, and so on. Basically, the consumer perceived value of products is not a salvage value but a whole valuation result for a product, so it comprises the utility value gained from past consumption and the expected utility value from future consumption. The consumers' product valuation will reflect these positive or negative influences, and hence will change stochastically over time. This risk is henceforth called *valuation risk*. In addition, consumers may face another critical risk, the probability that the product may break (henceforth called *breakage risk*). When the product breaks, consumers' product valuation will depart from the situation of normal valuation, shifting downward to a specific value, depending on the cumulative utility of using the product up to that time. To evaluate the product appropriately, the both risks should be taken into account.

2.1 Set-up of Post-Purchase Perceived Product Value

Suppose that a consumer initially purchases a product at time 0 and product use will last T years. The post-purchase product value is assumed to follow a stochastic evolution. Consider a discrete model in which each year is divided into n periods of equal length, and the total number of periods is $N = T/\Delta$ with identical length period $\Delta = 1/n$. The product value at the end of the t -th period is denoted by V_t , for $t = 0, 1, 2, \dots, N$ and could be set up as a binomial tree, as proposed by Cox, Ross and Rubinstein (1979) (abbreviated CRR model). This discrete model is often used in the literature in pricing financial options or real

options. The model has an important property that it can converge asymptotically to the Black-Scholes model (Black and Scholes, 1973) as $N \rightarrow \infty$ and hence can be viewed as an approximation of that model. As a typical CRR model setting with a fixed volatility coefficient σ , this process is accompanied by an upward multiple, $u = \exp(\sigma\Delta^{0.5})$, and a downward multiple, $d = 1/u$. Thus V_t will become either uV_t (for up) or dV_t (for down) in the next period, for $t = 0, 1, 2, \dots, N-1$. As is generally assumed throughout the literature on capital budgeting with a real-options approach, without exception we must assume a complete market to use risk-neutral valuation (e.g., Majd and Pindyck, 1987; Copeland and Antikarov, 2001).

As stated above, the proposed evaluation model for an initial purchase or a new product mainly considers valuation risk and breakage risk. Valuation risk can be described by a stochastic process of post-purchase product value, set as a binomial lattice. First consider a simple case taking only the valuation risk into account. If no real-options value is incorporated, the expected consumers' perceived value can be estimated as

$$V_0 = E^Q[(1+r)^{-N\Delta}V_N | I_0] \quad (1)$$

where E^Q is the conditional expectation operator with respect to the risk-neutral probability measure of CRR model, and I_t denotes the information filtration at time t . Note that we also can utilize the valuation method of Constantinides (1978) to resolve the problem for this case. Based on the method, the risk-free interest rate r could serve as a discount factor for pricing an asset after the transformation of the expected rate of V_t . This approach could achieve the same results as conventional option pricing approach can do, especially for the valuation of non-financial assets.

Whereas the *valuation risk* affects the product's perceived value and consumers' behaviors (whether to exercise the options or not), the breakage risk determines the moment when the product value departs from the stochastic evolution of normal valuation. To describe breakage risk, two possible states of

consumers' evaluation status in each period are specified: one is to keep going if the product performs normally, and the other one is to stop valuation if broken. Let the probability of product breakage within the t -th period be denoted by b_t for $t=1, 2, \dots, N$. b_t would increase with time in a general case, but still depends on products' characteristics. The breakage probability distribution can be inferred from consumers' subjective judgments or consumption experiences. As mentioned, the perceived product value reflects the cumulative utility of the product before breakage. By this reasoning, the perceived product value will be proportional to the time period that buyers have used the product (called consumption time). That is, if the product is broken at time t , consumption time would be $t\Delta$ (note that entire duration of product use is $T = N\Delta$). Basically, the price is the historic cost of the product and could be regarded as original consumer perceived value. Once the product is broken, the expected future utility value as of that time would become zero and the perceived product value merely can contain the utility value gained from past consumption. Therefore, the perceived product value should be a function of consumption time and price P when breakage happens. On the basis of this argument, we set the perceived product value as $G_t = (t/N)P$ if the product is broken at time t . However, it is still possible that V_t can be smaller than G_t . That relationship between V_t and G_t will depend on consumption experience during the consumption time. Thus, It follows that consumers' perceived product value will turn to $\min(V_t, G_t)$ if product breakage occurs at time t . To simplify analysis, we assume that the perceived value of the product is determined at the end of each sub-period: $\min(V_t, G_t)$ at the end of the t -th period (i.e., at time t) if the product is broken during the t -th period, $t = 1, 2, \dots, N$, or V_t if it can still can perform normally.

Assume that a consumer purchases a product at a price P . Before taking both the BMG put option and the repeat-purchase call option into account, we consider a basic situation with no options. The estimated value of the initial-purchase product is termed *basic value*, denoted by U^b . Incorporating the aforementioned two types of risks, the basic value can be written:

$$U_0^b = \sum_{t=1}^N b_t E^Q[(1+r)^{-t\Delta} \min(V_t, G_t) | I_0] + (1 - \sum_{t=1}^N b_t) E^Q[(1+r)^{-N\Delta} V_N | I_0] \quad (2)$$

where $(1 - \sum_{t=1}^N b_t)$ is the probability that the product still can work normally (not broken) at the end of the use duration (i.e., at time $t = N$).

2.2 Real Options Embedded in Initial Purchase

The MBG put option permits product return for a refund. The repeat-purchase call option allows future re-purchase at the original price when a product's life expires. Once the MBG put option is exercised, the repeat purchase call option disappears. Due to the mutually exclusive relationship, the valuation for combination of the two options cannot be derived by simple adding-up.

2.2.1 Repeat-Purchase Call Option

First consider only the repeat-purchase call option. The exercising time of the option is the end of product use (i.e., at time $t = N$). We assume that the consumer can purchase the product at the same price (say at time $t = N$). First, consumers' optimal behavior for exercising the repeat-purchase call option should be explored. The repeat-purchase decision is based on a rational choice. Consider the situation where the product does not break throughout its normal life, and works normally to time $t = N$. A rational consumer will compare the perceived product value of as time N , V_N , and the cost of obtaining a replacement, P . The consumers' receivable benefit from the repeat-purchase call option is $\max(V_N - P, 0)$ at time $t = N$. Based on the option pricing properties, the value of the repeat-purchase call option can be derived as $E^Q[(1+r)^{-N\Delta} \max(V_N - P, 0) | I_0]$ ². Incorporating the repeat-purchase call option into the valuation model, the fair product value perceived by consumers, denoted

² According to the option-pricing theory, the fair value of the focus asset in the underlying process, Y_f that has payoffs, f_t , at time t for $t=1, 2, \dots, N$, can be calculated based upon all information at time 0, I_0 , as: $Y_f = E^Q[\sum_{t=1}^N (1+r)^{-t\Delta} f_t | I_0]$

by U_0^c , can be written as

$$U_0^c = \sum_{t=1}^N b_t E^Q [(1+r)^{-t\Delta} \min(V_t, G_t) | I_0] \\ + (1 - \sum_{t=1}^N b_t) E^Q [(1+r)^{-N\Delta} (V_N + \max(V_N - p, 0)) | I_0] \quad (3)$$

Therefore, the value of the repeat-purchase call option can be obtained by $(U_0^c - U_0^b)$.

2.2.2 MBG Put Option

MBG is thought of as a put option, a contingent claim in the stochastic valuation process described above. Consumers can exercise this option when their valuation is lower than a determined level. Assume the MBG duration is T_k ($T_k < T$) containing $k (= T_k/\Delta)$ sub-periods. During that period the consumers can return the product at the purchase price if they find that its value does not remain at an expected level.

We consider two cases of returning the product. In the first case the product breaks during the MBG duration, and consumers return it immediately. The benefit of returning would be $\max(p - c, \min(V_t, G_t))$ if the breakage occurs at time t , where c is the total return cost. In the second case, the product performs normally during the MBG duration. MBG provisions allow consumers to exercise the option early if they are not satisfied with the product. It is an American-type put option, but we treat it as a European option for this case, partly because the European option has a closed-form solution and the American option does not. And there is no significant difference between the two when the contract duration is not long (usually less than 90 days, i.e., $T_k < 0.25$)³. Moreover, since this paper aims to provide an easily-applied model to investigate the MBG option value,

³ The numerical test is being done for comparing American-type put option value with European-type one. For a rather extreme case with MBG duration = 90 days, setting volatility coefficient $\sigma = 40\%$, American-type put option value is larger than European type about 0.5%; fixing $\sigma = 40\%$, for a general case with MBG duration = 7 days, the difference between both option types can be mere 0.14%. Consequently, it's verified the difference between both is very small within our discussion scope.

using the European option model is preferable and will get no loss of generality. According to the option-pricing property, the European put option is exercised only at the end of MBG duration as to achieve its maximum value. So the maximum value of the option can be obtained by fixing the time of exercising it as the due date (i.e., at time $t = k$).

To determine the possible benefits of the MBG put option at time k , we need to know consumers' optimal decision behavior. A rational consumer will compare the value of retaining the product with the value of returning it. If the former is lower than the latter, the MBG put option will be exercised, and vice versa. The consumer deciding to exercise the MBG put option will receive the value of $P-c$. If the consumer decides to retain the product at time k , the product value at time k may be written as

$$U_k^b = \sum_{t=k}^N b_t E^Q[(1+r)^{-(N-k)\Delta} \min(V_t, G_t) | I_k] + (1 - \sum_{t=k}^N b_t) E^Q[(1+r)^{-(N-k)\Delta} V_N | I_k] \quad (3)'$$

The payoff of the MBG put option at time k would be as $\max(p-c, U_k^b)$.

Putting the two possible cases together, the perceived value of a product accompanied by MBG can be estimated in the valuation framework. The fair product value perceived by consumers, denoted by U_0^p , can be written as

$$U_0^p = \sum_{t=1}^k b_t E^Q[(1+r)^{-t\Delta} \max(p-c, \min(V_t, G_t)) | I_0] \\ + (1 - \sum_{t=1}^k b_t) E^Q[(1+r)^{-k\Delta} \max(p-c, U_k^b) | I_0] \quad (4)$$

Therefore the value of MBG put option can be obtained by $(U_0^p - U_0^b)$.

2.2.3 Combination of Both Options

Now both the MBG put option and repeat-purchase call option are

considered jointly. Again, when time of use reaches the option exercise time of MBG (at time k), a rational consumer compares the value of owning the product (containing a repeat-purchase call option) and of returning it. If the consumer decides to retain the product with the repeat-purchase call option at time k , the product value at time k may be written as

$$U_k^c = \sum_{t=k}^N b_t E^Q[(1+r)^{-(N-k)\Delta} \min(V_t, G_t) | I_k] \\ + (1 - \sum_{t=k}^N b_t) E^Q[(1+r)^{-(N-k)\Delta} (V_N + \max(V_N - p, 0)) | I_k] \quad (4)'$$

Thus, given consumers' optimal behavior, the payoff of the MBG put option at time k becomes $\max(p - c, U_k^c)$. While incorporating both the MBG put option and the repeat-purchase call option, the fair product value perceived by consumers, denoted by U_0^{c+p} , can be written as

$$U_0^{c+p} = \sum_{t=1}^k b_t E^Q[(1+r)^{-t\Delta} \max(p - c, \min(V_t, G_t)) | I_0] \\ + (1 - \sum_{t=1}^k b_t) E^Q[(1+r)^{-k\Delta} \max(p - c, U_k^c) | I_0] \quad (5)$$

Consequently, the value of the combined options can be obtained by $(U_0^{c+p} - U_0^b)$.

3. Illustrative Examples

This section is devoted to implementing the numerical analysis to illustrate consumers' valuation of initial-purchase products. The work examines the effect of changes of some relevant parameters on consumers' perceived values, i.e., U^b , U^c , U^p , U^{c+p} .

3.1 Simulation Analysis

We first consider the volatility of post-purchase perceived product value. Suppose the price (p) is \$100, and consumers can receive \$100 as a full refund. Assume the total sacrifice (s) of buying the product is equal to \$100 (p), and the total return cost (c) is fixed at \$2. Thus the exercise price of MBG put option equals \$98 ($p-c$). The original expected value (V_0) is set to \$105, where the breakage risk and all embedded options are not yet taken into account. The specification would be reasonable, in that a consumer receives an added-value of \$5 in purchasing the product. We set the products' use duration at one year (i.e., $T = 1$). In the discrete model setting, each year is divided into 52 sub-periods, of one week each. MBG duration (T_m) is typically less than one year, i.e., $T_m < 1$, set $T_m = 12/52$ (12 weeks). For simplicity, the likelihood of product breakage is assumed to be indifferent in each time period; hence let b_t constant for each t . In this case, we fix b_t to 0.02% and assume an annual risk-free interest rate of 2%. According to the relationship of Equations (2) to (5), all else being equal, we estimate all consumers' perceived product values, including U^b , U^c , U^p and U^{c+p} , with different options types for various degrees of volatility ($\sigma = 5\% \sim 40\%$). The numerical results, as shown in Figures 1a and 1b, illustrate the value-creating effects of the repeat-purchase call option, the MBG put option, and the combination of both.

Figure 1a
The Product Value with Different Real-Options Types for
Various Valuation Risk Levels

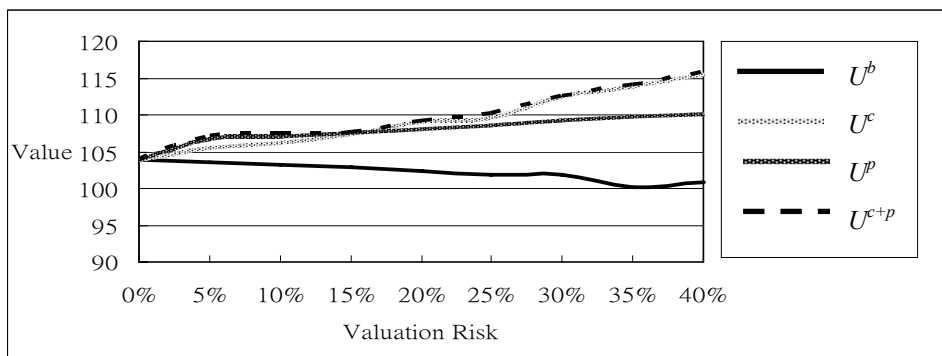
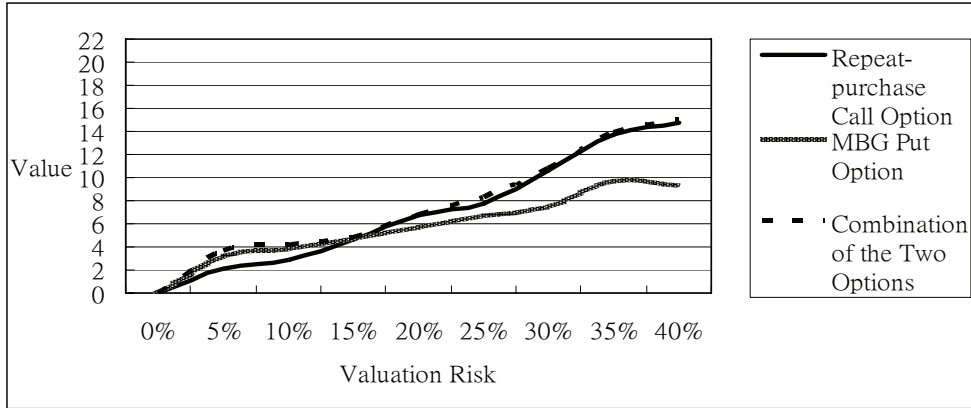


Figure 1b
The Value of Different Types Real-Options for Various Valuation Risk Levels



Next, we test the effect of the breakage risk level. We focus on the impact of the breakage risk on the real-options value, selecting different values of b_t ranging from 0.01% to 0.5%. All else being equal, we estimate the product's value with various values of b_t . The results are exhibited in Figures 2a and 2b.

Figure 2a
The Product Value with Different Real-Options Types for Various Breakage Risk Levels

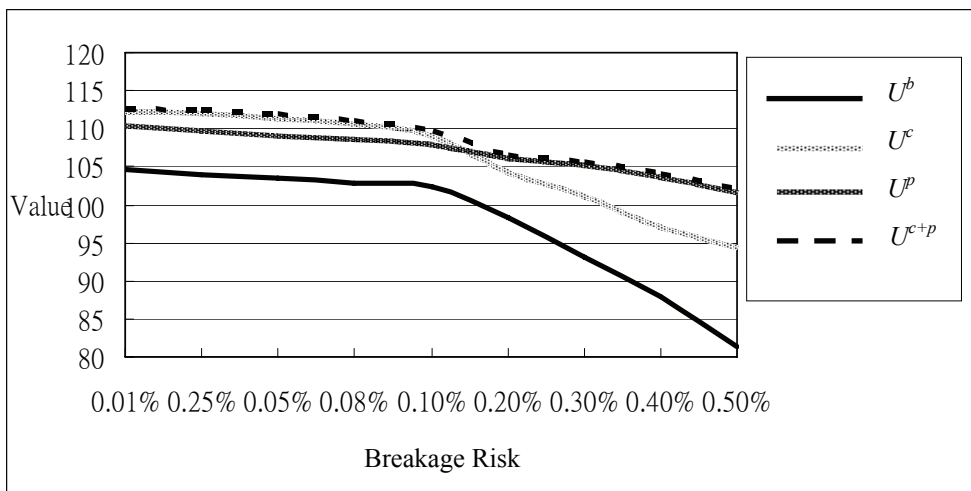
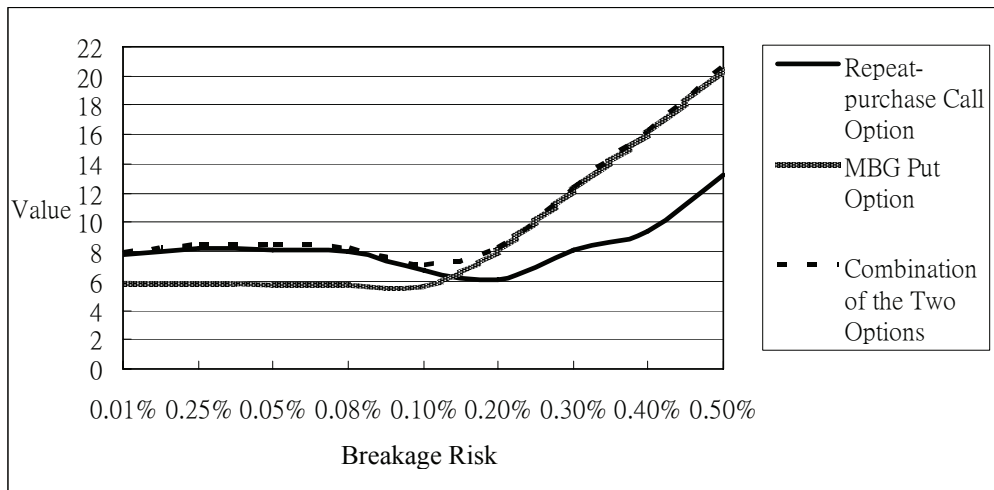


Figure 2b
The Value of Different Types Real-Options for
Various Breakage Risk Levels



According to option pricing theory, the value of the repeat-purchase call option increases with product use duration (T), and that of the MBG put option also increases with MBG duration (T_m). We still fix MBG duration to 12 weeks and concentrate on the effect of product use duration, using the relevant parameters described above. To test the effect of product use duration (T), we estimate all the product's values embedding various options types with various magnitudes of T ranging from 0.4 to 2 (years). The results are presented in Figures 3a and 3b.

Lastly, we examine the effect of product price level (P) on real-options value. The return cost (c) is the same. Consumers' perceived product values are estimated with different option types for various price levels ranging from \$20 to \$200. The numerical results are illustrated in Figures 4a and 4b.

Figure 3a
The Product Value with Different Real-Options Types for Various Use Durations

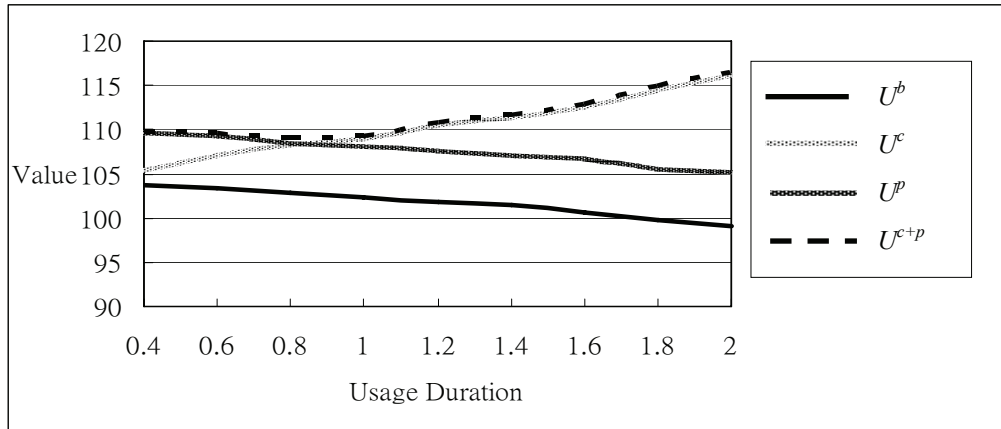


Figure 3b
The Value of Different Types Real-Options for Various Use Durations

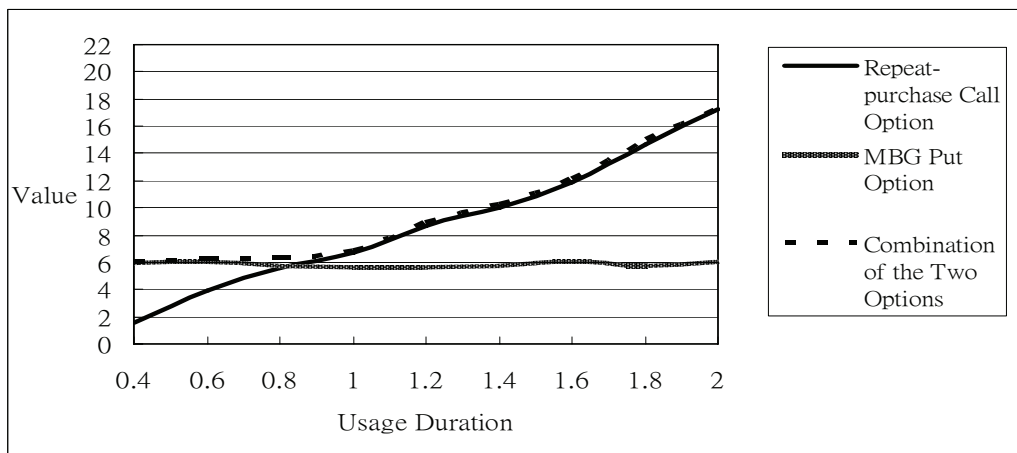


Figure 4a
The Product Value with Different Real-Options Types for
Various Price Levels

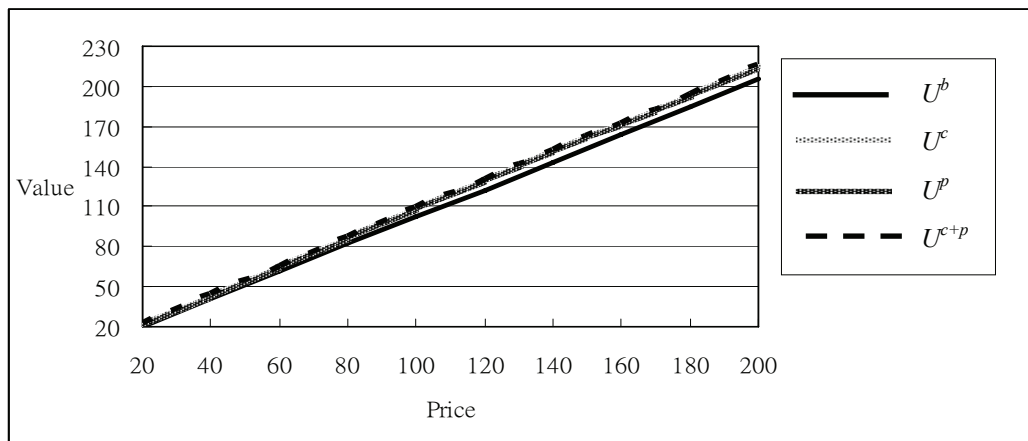
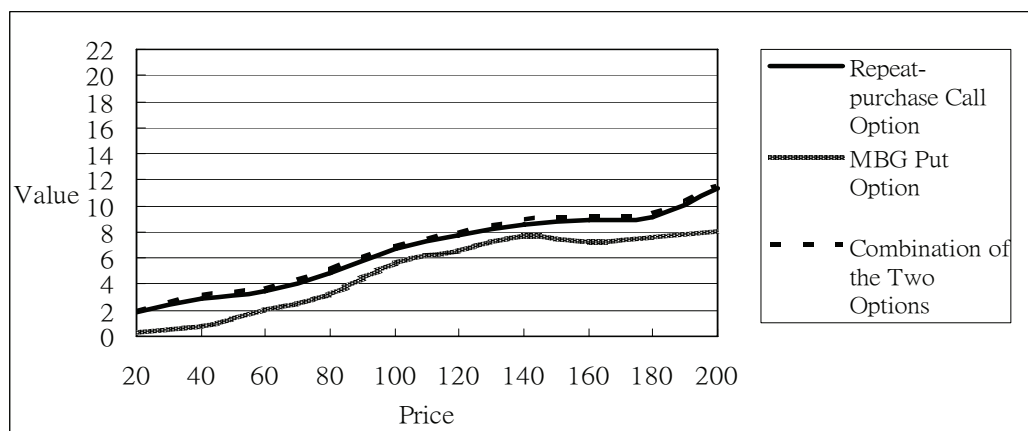


Figure 4b
The Value of Different Types of Real Options for
Various Price Levels



3.2 General Discussion

The illustrative examples reveal some interesting phenomena about the real-options values embedded in initial-purchase products. As is seen in Figures 1a and 1b, the valuation risk, i.e., the volatility of post-purchase perceived value, negatively affects the basic value of a product (U^b), since higher valuation-risk can lower consumers' product valuation. Moreover, higher volatility would augment the negative effect of the breakage since the value-increasing possibilities of high volatility would be offset by the breakage risk. On the other hand, the values of all types of real options (i.e., U^c , U^p and U^{c+p}) increase with volatility, which coincides with the prediction of the option-pricing theory. However, we find that the value-creating effect of volatility on the value of the repeat-purchase call option is larger than on the MBG put option. Note also that the value of the combined two options is not their sum. Instead, repeat-purchase call option value would trend to dominate MBG put option value as volatility gets greater. By contrast, the MBG put option value may tend to dominate the repeat-purchase call option in the very-low volatility cases. This phenomenon may result from the interaction between option expiration time and degree of volatility. The repeat-purchase call option typically has the longer time to expiration. Because the volatility in the stochastic process can increase with time so as to cause the perceived value to fluctuate more, the value-creating effect of the repeat-purchase call option is greater. In contrast, due to the shorter time to expiration for the MBG put option, this augmented effect of volatility on option value is relatively small. In other words, the value source of MBG is mainly the guarantee of product value, not on value-creation opportunities. Even so, we notice that all values of various real-option types consistently increase with volatility.

Figures 2a and 2b basically express how consumers' subjective expectation of breakage risk can affect the real-options value in the initial-purchase situation. As observed from Figures 2a and 2b, the breakage risk has a negative effect on the basic value (U^b). The breakage risk also has a negative effect on all real-options values (U^c , U^p and U^{c+p}), particularly more significant on the

repeat-purchase call option (U^c). The main reason is that a higher breakage risk would reduce likelihood of exercising those real options and thereby cause the decrease in option value. In particular, the likelihood of exercising the repeat-purchase call option would be reduced to a larger extent for the higher breakage-risk cases because a longer time to expiration would increase the probability of breakage. As for MBG put option value, its negative effect tends to be slight. In the combination of the two options, the repeat-purchase call option tends to dominate when breakage risk is very low, while the MBG put option tends to dominate when breakage risk is relatively high.

Figures 3a and 3b show that all values of those options can be affected by the product use duration (T) to varying degrees. First, the basic value (U^b) decreases with product use duration, since the cumulative probability of product breakage would increase with T . The MBG put-option value (U^p) tends to decrease with T . However, the repeat-purchase option value (U^c) obviously increases with T because of longer time to expiration. Even this effect would be offset partly by the negative effect of the breakage risk. We can notice that the effect of T on the repeat-purchase call option is more positive, and on MBG put-option value is negative but less. Moreover, when the two options are considered together, the repeat-purchase call option may dominate in long use duration and the MBG put option when use duration is short.

The effects of the price (p) on those real-option values are also obvious, as shown in Figures 4a and 4b. All product values increase as p increases, as do all options values. The outcome agrees with intuition. In most cases, the value-creation effect of p on repeat-purchase call option is larger than on the MBG put option, and would predictably increase with longer use duration. As shown in Figures 3a and 3b, the repeat-purchase call option would be more affected by use duration than the MBG put option. From Figures 4a and 4b, we can observe the relationship between the various options and the price levels.

4. Conclusions

Levy *et al.* (2004) point out that pricing optimization is currently one of the important topics in retail industry and retailers must carefully consider certain key factors, such as customers and competition, to develop and implement an appropriate pricing strategy and sales tactics. Our model can serve as reference for the optimal pricing decision. An initial purchase characterized by high uncertainty may be exposed to risk, but consumers may also receive unexpected extra value from the purchase experience. For example, a consumer making the first purchases of a specific brand will gain a new chance to understand the brand more. Especially for the experienced goods, people can realize what their true value is only if they have used the products for a certain period of time. Once consumers make sure that the products or services can fulfill their expectation or need, they will repeat exercising the call options to make more extra value. Thus, the embedded option value could be considerable for consumers in an initial purchase either on a new product or brand. As shown in the numerical results, the added values of both options are substantial in the consumers' initial purchase. Accordingly, firms need to appropriately apply those embedded options to achieve a better pricing decision. In particular, jointly offering the two options can create a significant added value for consumers. The value-creation effect comes from the fact which consumers not only can hedge the down-side risk by the MBG put option, but also can fully capture the up-side potential value by the repeat-purchase call option. Nevertheless, as we generally can observe in practice, retailing firms often adopt a price-reducing policy or offer discount coupons to attract more consumers to the first-time purchase. That is because consumers often over-augment the negative effect of risks for a newly purchasing. A price-reducing policy typically suffers a lot of costs. The embedded real-option values allow firms to appropriately set a fair price without sacrificing a great cost. As indicated in the numerical analysis, applying MBG to the initial purchase can enhance significantly consumers' perceived value, including a put option value and a call option value. If firms can appropriately make use of MBG, the risk of

the new purchase, which consumers are typically averse to, may be transformed into a real-options value. However, the optimal pricing decision still should depend on the key parameters, such as consumers' risk perception, use duration, price level, and so on.

This study proposes an applicable model for evaluating the real option value embedded in consumers' initial purchase. With the proposed model, we analyze the structure of those option values for various product types, and explore the effects of relevant parameters on product value. The numerical results can offer a comprehensive understanding of how the real option value is produced in a first purchase, and thereby allow product pricing from a consumer value-based viewpoint. The real-option approach can show how consumers can gain the benefit by capturing potential value as well as mitigating risk exposure, and can guide firms to clarify what determines the real-option values contained in initial purchases. The results also can be applied to pricing of some other service products, which typically carry high uncertainty.

Future research could focus on empirical studies on related marketing variables. In addition more options embedded in a product could be considered; for example, warrants could be seen as another type of put option and product exchange guarantees as a switch option. The limitations of our research include the parameter assumption regarding the stochastic process and product value, which also appears in a typical real-option model, for example, on the valuation of deferred and abandoned options for a project. Due to that managers typically cannot observe historical data of the volatility parameter, they probably couldn't obtain very accurate estimations. Hence applications of this model have to rely on the judgment of senior management or on some heuristic approaches. Real assets (or real projects) typically have more complicated features than financial assets when the option-pricing approach is applied.

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