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A jump-diffusion real option approach for hotel investment under uncertain lodging demand: the case of Macao

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Abstract

Purpose-One of the important characteristics of the hotel business is uncertainty of lodging demand, which can jeopardize hotel operation and ultimately even threaten a hotel's survival during an economic recession. This paper proposes an approach to determine optimal hotel investment issues under uncertain lodging demand.

Design/methodology/approach-Uncertainty of lodging demand is classified into two types: the impact of unexpected economic recession and the temporary imbalance between supply of hotel rooms and lodging demand. A jump–diffusion real option approach is proposed to analyze how these two types affect optimal investment timing and the potential value of new hotel projects. The case of hotel investment in Macao is used to illustrate the jump–diffusion real option approach.

Findings-The results of numerical analysis show that the uncertainty induced by temporary imbalance between supply of hotel rooms and lodging demand increases the threshold of investment and hotel value, while the uncertainty induced by unexpected economic recession has ambiguous effects on the value and optimal investment timing of new hotel projects.

Practical implications-The jump–diffusion real option approach increases managerial flexibility for managers when making investment decisions on new hotel projects, allowing greater value to be generated than is possible with the conventional discounted cash flow method.

Originality/value-The approach separates the impact of unexpected economic recession on lodging demand from that of 'normal' fluctuations in lodging demand, and it considers the impact of both types of uncertainty on hotel investment.

Keywords Hotel investment, Real option, Jump–diffusion model, Uncertain lodging demand

1 Introduction

The hotel business is characterized by a relatively inflexible supply of rooms or other units of accommodation but a high uncertainty of lodging demand (Baum & Mudambi 1995). Managers of hotel firms have to pay a fixed operating expenditure for rooms or other units of accommodation to keep the hotel operation running smoothly even in the absence of customers, in which case the hotel's revenue may not cover the operating cost. Uncertain lodging demand can jeopardize hotel operation, even ultimately threatening a hotel's survival during an economic recession (Chen & Yeh 2012). Therefore, it has become important for hotel managers to be able to manage uncertainty of lodging demand effectively and to enhance hotels' financial performance.

With the aim of dealing with the problem of uncertain lodging demand in an efficient manner, previous studies have focused on collecting more information about customer arrivals and implementing revenue management through strategies of room reservation. Based on the information system, revenue management can help hotel firms match supply and demand and maximize their revenue by dividing customers into different segments and charging different prices (Cross et al. 2009, Kimes 1989, Kimes & Wirtz 2003). Another approach emphasizes the effect of product variety on easing the demand uncertainty problem through reducing the expected costs associated with excess capacity, which has also been shown to be useful for hotel businesses facing uncertain lodging demands (Chen et al. 2011, Carlton & Dana 2008).

The existing approaches have been shown to be capable of partially handling the problem of uncertain lodging demand and enhancing hotel firms' financial performance. However, these approaches neglect the impact of an unexpected economic recession that may damage the entire hotel industry. The hotel business has been documented as being highly sensitive to economic fluctuations. For instance, Wheaton & Rossoff (1998) have demonstrated that the lodging demand in the U.S. hotel industry is very closely associated with fluctuations in GDP. Enz, Kosová & Lomanno (2011) found that the unexpected financial crisis in 2008 resulted in large falls in occupancy, price, and revenue per available room in the U.S. hotel industry. The global financial crisis has also been found to result in a significant contraction in international tourism and hospitality in Hong Kong (Song et al. 2011). In a period of economic recession, the total demand of the hotel industry will decrease and the decline in lodging demand is almost unavoidable by any hotel firm. In this case, revenue management and other similar strategies cannot help hotel firms avoid the negative impact of economic recession completely. This negative economic impact may result in absolute failure of these firms (Chen & Yeh 2012), with their losses including not only daily revenue but also the initial investment. One effective approach to dealing with this problem is to consider managerial flexibility and pay more attention to the investment stage.

Hotel project investment, as with investment by most firms, has two important characteristics: (1) the expenditure is irreversible and (2) the investment can be delayed (Pindyck 1991). The first characteristic makes managers more prudent when investing in a new hotel project, while the second provides hotel firms with an option to await more information and invest on favorable terms in the future, which lessens the negative effect of uncertainty on hotel management. This feature of investment deferral, as Myers (1977) pointed out, can be viewed as a 'real option', providing firms with greater managerial flexibility and value. Since the seminal work by Myers, option pricing theory has been widely used in evaluating investment issues in many fields. Few such studies, however, have analyzed the investment issue in the hotel industry except Cunill, Forteza & Miralles (2008), de Soto-Camacho & Vargas-Sánchez (2015), and Sewalk & Dai (2014). Cunill, Forteza & Miralles (2008) proposed a real option approach for valuing the growth strategy of the hotel industry under a high degree of uncertainty. Sewalk & Dai (2014) presented a simple binomial option approach to value the expansion capacity of hotel firms. de Soto-Camacho & Vargas-Sánchez (2015) proposed an explanatory model to explain the choice of entry mode of hotel firms within an international market under a dynamic real option approach.

In contrast with the previous literature, this paper considers uncertain lodging demand in hotel investment and separates the impact of unexpected economic recession on lodging demand, which has been shown by previous studies to have an important influence on hotel business, from 'normal' fluctuations in lodging demand. Here, 'normal' fluctuations are those due to temporary imbalances between supply of hotel rooms and lodging demand. In this paper, 'normal' fluctuations in lodging demand are assumed to follow a Wiener process (diffusion process) and the unexpected economic recession is assumed to follow a Poisson process (jump process). This paper proposes a jump–diffusion real option approach to analyze the effect of 'normal' fluctuations in lodging demand together with the impact of unexpected economic recession on the value and optimal investment time of a new hotel project. For simplicity, as previous studies did, we ignore the impact of other potential elements on the hotel investment.

This real option approach is illustrated through a case study of hotel investment in Macao. The simulated results show that the two types of uncertainty have ambiguous effects on investment in the new hotel project. The higher volatility of lodging demand induced by the temporary imbalance between supply of hotel rooms and lodging demand will increase the threshold of investment as well as the value of the new hotel project, while the higher probability of economic recession over finite intervals of time has ambiguous effects on the threshold of investment and the value of the new hotel. The simulated results also show that the jump–diffusion real option approach provides greater value for hotel firms than the conventional discounted cash flow (DCF) method, since it considers the option value of investment deferral, and it can also provide a more exact evaluation of a new hotel project than is obtained under the conventional real option approach that does not take account of the effect of economic recession. Generally, the jump–diffusion real option approach provides greater managerial flexibility and value for hotel firms, regardless of the ambiguous effects of the two types of uncertainty on hotel investment.

This remainder of the paper is organized as follows. Section 2 proposes a jump–diffusion model to evaluate the value and optimal investment time of a new hotel project under two types of uncertainty of lodging demand. In section 3, a case study of hotel investment in Macao is used to illustrate this approach. Section 4 concludes the paper.

2 Jump–diffusion model of hotel investment

2.1 Uncertainty of lodging demand and jump–diffusion process

The proposed model is based on a canonical real option model of investment.First, the uncertainty of lodging demand is described using a jump–diffusion process. In line with Merton (1976) and Dixit & Pindyck (1994), it is assumed that the lodging demand Q_t at date t is uncertain and follows a geometric Brownian motion (GBM) and Poisson jump process:

$$dQ_t = \mu Q_t\, dt + \sigma Q_t\, dW + Q_t\, dq \tag{1}$$

where μ and σ are the instantaneous drift rate and the volatility rate. The drift rate μ captures the expected percentage change of lodging demand, while the volatility rate σ represents the extent to which the lodging demand changes over time. dW is the increment of a standard Brownian motion, which captures the 'normal' fluctuations in lodging demand induced by temporary imbalances between supply of hotel rooms and demand, while dq is the increment of a Poisson jump process with mean arrival rate λ, which indicates that the unexpected economic impact occurs with probability $\lambda\, dt$ during a time interval dt. The Poisson jump process captures the influence of the unexpected impact of economic recession on lodging demand. dq in this study is assumed to be independent of dW, i.e., $E(dq\, dW) = 0$. It is further assumed that the lodging demand will fall by a fixed percentage ϕ (with $0 \leq \phi \leq 1$) of the current level once economic recession occurs. Thus,

$$dq = \begin{cases} 0 & \text{with probability } 1 - \lambda\, dt \\ -\phi & \text{with probability } \lambda\, dt \end{cases} \tag{2}$$

Given the probability of economic recession during the time interval dt and its impact level on lodging demand ϕ, as shown by Dixit & Pindyck (1994), the lodging demand following a jump–diffusion process has the following expected value:

$$E(Q_t) = Q_0 e^{(\mu - \lambda\phi)t} \tag{3}$$

where Q_0 represents the current lodging demand. Since

$$\frac{1}{Q_t}\frac{E(dQ_t)}{dt} = \mu - \lambda\phi$$

equation (3) implies that the expected percentage rate of change in lodging demand is $\mu - \lambda\phi$. Thus, the potential economic recession and its impact results in the expected lodging demand falling by $\lambda\phi$ in an interval of time dt.

2.2 Threshold and optimal time of hotel investment

This subsection presents the real option approach to hotel investment given a lodging demand following geometric Brownian motion and a Poisson jump process. Consider a risk-neutral hotel manager who plans to invest in a new hotel with lifetime m and initial investment cost I. For simplicity, it is assumed that the average consumption P of each customer is constant. Once the hotel begins to operate, the firm should pay a constant cost C each period to keep it running smoothly. Then, at any time t, when investment in the hotel is complete and the hotel begins to operate, the expected value of the new hotel project can be calculated as follows:

$$\begin{aligned} V_t &= E\left[\int_t^{t+m} (PQ_s - C)e^{-r(s-t)}\,dt\right] \\ &= \frac{PQ_t[1-e^{-(r-\mu+\lambda\phi)}]}{r-\mu+\lambda\phi} - \frac{C(1-e^{-rm})}{r} \end{aligned} \tag{4}$$

where r is the risk-adjusted discount rate and must satisfy $r > \mu - \lambda\phi$, otherwise investment in the hotel will never occur (Dixit & Pindyck 1994).

Before carrying out the new hotel investment, the hotel firm can either make the investment immediately or wait. The choice depends on whether the value of the new hotel project is greater than the sum of the direct investment cost and the opportunity cost of immediate investment (Dixit & Pindyck 1994). If this condition is satisfied, then immediate investment is the optimal choice for the hotel firm; otherwise, waiting is better. Theoretically, the waiting time is infinite. Thus, for the hotel firm, the problem can be interpreted as determining the optimal exercise date t^* of an American call option with the infinite expiration to maximize the following profit function:

$$F(Q) = \operatorname{Max} E[(V_t^* - I)e^{-rt^*}, 0] \tag{5}$$

Using Bellman's equation and Ito's lemma, the solution for $F(Q)$ can be obtained from the following differential equation:

$$\tfrac{1}{2}\sigma^2 Q^2 F'' + \mu Q F' - (r+\lambda)F + \lambda F[(1-\phi)Q] = 0 \tag{6}$$

where $F' = \partial F/\partial Q$ and $F'' = \partial^2 F/\partial Q^2$. In addition, $F(Q)$ should also satisfy the following boundary conditions:

$$F(0) = 0 \tag{7}$$

$$F(Q^*) = \frac{PQ_t(1-e^{-(r-\mu+\lambda\phi)})}{r-\mu+\lambda\phi} - \frac{C(1-e^{-rm})}{r} - I \tag{8}$$

$$F'(Q^*) = \frac{1-e^{-(r-\mu+\lambda\phi)}}{r-\mu+\lambda\phi} \tag{9}$$

The boundary condition (7) implies that there is no option value if the lodging demand is zero, in which case the hotel firm will not make any investment. The boundary condition (8) is the value-matching condition. It implies that once the lodging demand reaches the critical value Q^*, the hotel firm will exercise the option and invest immediately, in which case the NPV of the new hotel project is the difference between the present value of the total future cash flow and the initial investment cost I. The boundary condition (9) is the smooth-pasting condition, which ensures that $F(Q)$ is continuous and smooth at the critical value Q^*, otherwise firms could obtain more by exercising the option at a different point.

The general solution of equation (6) is of the form $F(Q) = AQ^\beta$, where A is a constant to be determined and β is the root of the equation. Given the general solution, β can be obtained from the following characteristic equation:

$$\tfrac{1}{2}\sigma^2\beta(\beta-1) + \mu\beta - (\lambda+r) + \lambda(1-\phi)^\beta = 0 \tag{10}$$

Unfortunately, a solutions for β cannot be obtained analytically. Therefore, it must be found numerically. Again, the numerical solution for β should be greater than one to ensure that the critical value Q^* is greater than zero. Given the general solution form for $F(Q)$, solving equation (6) with the boundary conditions (7)–(9) yields

$$Q^* = \left\{ \frac{(r-\mu+\lambda\phi)[C(1-e^{-rm})+Ir]}{rP(1-e^{-(r-\mu+\lambda\phi)m})} \right\} \frac{\beta}{\beta-1} \tag{11}$$

$$A = Q^{*(1-\beta)} \frac{P(1-e^{-(r-\mu+\lambda\phi)m})}{\beta(r-\mu+\lambda\phi)} \tag{12}$$

and

$$F(Q) = \begin{cases} AQ^{\beta}, & Q < Q^* \\ \dfrac{PQ(1-e^{-(r-\mu+\lambda\phi)})}{r-\mu+\lambda\phi} - \dfrac{C(1-e^{-rm})}{r} - I, & Q \geq Q^* \end{cases} \tag{13}$$

Equations (11)–(13) provide the solution for the critical lodging demand Q^*, the solution for the constant value A, and the option value of the new hotel project. Q^* in equation (11) is the threshold of new hotel investment, and is such that only when the lodging demand is equal to or higher than Q^* can the new hotel project be triggered. In the case that the lodging demand is lower than Q^*, the optimal strategy for the hotel firm is to wait, and its value is AQ^{β}, which is equal to the option value of waiting. In contrast to the DCF method, in which the value of the hotel project is zero if it cannot be accepted, here there is a positive value even if the new hotel project option is not exercised. Therefore, the waiting opportunity provides more value for the new hotel project.

From equation (13), the lodging demand Q' that makes the NPV of the new hotel project equal to zero is

$$Q' = \frac{(r - \mu + \lambda\phi)[C(1 - e^{-rm}) + Ir]}{rP(1 - e^{-(r-\mu+\lambda\phi)m})} \tag{14}$$

Obviously, Q' is always smaller than the critical value of lodging demand Q^*, given $\beta > 1$. This indicates that the uncertainty and irreversibility require a higher lodging demand to trigger new hotel investment in the real option approach than in the DCF method.

3 A case study of hotel investment in Macao

3.1 The hotel industry in Macao

This section presents an illustration of the approach proposed in section 2 through a case study of hotel investment in Macao. In this case, the goal of the hotel firm is to decide the optimal investment timing to lessen the influence of uncertain lodging demand, which is caused both by 'normal' fluctuations in lodging demand and the impact of unexpected economic recession, on the value of a new hotel project.

Macao is a small economy driven by tourism. For many years, the hotel industry has been an important part of Macao's economy. According to information from the Statistics and Census Bureau of Macao, the average revenue of the hotel industry has been about 6.3% of Macao's GDP in the past five years. As of 2014, there were 66 hotels in Macao, more than 10% of which were built in the previous five years. Since the Macao government released rights to gambling operations in 2002 and signed the CEPA (Closer Economic Partnership Arrangement) with mainland China in 2004, the hotel industry in Macao has experienced respectable growth. However, two economic recessions have also damaged the hotel industry heavily. In 2009, the global financial crisis resulted in the growth rate of lodging demand falling by 11.5% and that of total revenue in the hotel industry by nearly

46.4%. More recently, Macao experienced another wave of economic recession. As of 2014, these growth rates had fallen by 11.7% and 5.2%, respectively. Despite the great volatility in lodging demand and the revenue of the hotel industry, many new hotel projects in Macao are still being built or planned. How can managers determine whether it is a good time to build a new hotel? The predicament of the hotel industry in Macao provides an opportunity to illustrate the real option approach numerically.

3.2 Data collection and descriptive statistics

Data on the hotel industry were collected from the Statistics and Census Bureau of Macao. Since there are many types of hotel in Macao, and the investment expenditure, occupancy rate, operational cost, and business pattern of each type of hotel are very different, this paper focuses on the investment issue for five star hotels, which are the main type in Macao, with most newly built hotel projects being of this type.

Quarterly data were collected from the first quarter of 2008 to the second quarter of 2015. The total number of lodgers of the five star hotels is used to measure the quarterly lodging demand. The growth rate of lodging demand is calculated as

$$G = \ln\left(\frac{Q_t + 1}{Q_t}\right) \tag{15}$$

Given the natural logarithmic growth rate of lodging demand, the average growth rate of lodging demand (the drift rate) can be calculated as

$$\bar{\mu} = \frac{1}{n}\sum_{i=1}^{n} G_i \tag{16}$$

where i is the number of data. The volatility of the lodging demand can be calculated as

$$\sigma = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}(\mu_i - \bar{\mu})^2} \tag{17}$$

Since geometric Brownian motion requires that growth rate of lodging demand follow a normal distribution, the Shapiro–Wilk and Shapiro–Francia tests are used to check this. Table 1 reports the descriptive statistics result and the normality test result. Both test results cannot reject the null-hypothesis, implying that the growth rate of lodging demand in the sample is normally distributed and can be used in the real option approach.

Table 1: Descriptive statistics and normality test for the growth rate of the lodging demand

Mean	Standard deviation	Shapiro–Wilk test		Shapiro–Francia test	
		Statistic	Sig.	Statistic	Sig.
2.5%	0.072	0.970	0.550	0.977	0.667

The expected rate of return r of the new hotel project is calculated using the capital asset pricing model introduced by Lintner (1965), Mossin (1966), and Sharpe (1964). Data are collected on the betas of the six largest hotel firms in Macao and the average return of the Hang Seng index is obtained from the Bloomberg database. The expected returns of each hotel firm are then calculated, and their mean is taken as the expected rate of return of the new hotel project. Finally, the calculated quarterly expected rate of return r is found to be 2.7%. Investment information about the new hotel project is obtained from the annual reports of the six largest hotel companies, and the average expenditure per room of the hotel project is taken as the hotel investment data. According to recent annual reports of the six largest hotel firms, it is assumed that the new hotel project has 1700 rooms (about 8% market share according to the present total number of rooms of the five star hotels in Macao) and that the total investment expenditure I is 3500 million U.S.

dollars.

According to statistics from the Statistics and Census Bureau of Macao, the average personal consumption in a five star hotel is 1060 U.S. dollars, and the quarterly operating cost of a five star hotel with 1700 rooms is taken to be 42 million U.S. dollars, based on the average operating expenditure of a five star hotel. The lifetime of the new hotel project, m, is taken to be 280 quarters (70 years). Finally, the mean arrival rate of economic recession λ in a quarter is taken as 0.05 and the impact level of economic recession on lodging demand ϕ as 0.3. Later, these values will be changed to investigate how variations in the probability of economic recession and in the impact level affect the threshold of investment. The parameters used in this illustration are summarized in Table 2.

Table 2: Parameters for illustration

Parameter	r	μ	σ	ϕ	λ	m	P ($)	C (million$)	I (million$)
Value	2.7%	2.5%	0.072	0.3	0.05	280	1060	42	3500

3.3 Effect of uncertainty of lodging demand on threshold and hotel value

Figure 1 shows the relation between the 'normal' volatility rate of lodging demand and the threshold of investment, for a probability of unexpected economic recession $\lambda = 0.05$ and an impact level $\phi = 0.3$. As can be seen, for a greater volatility of total lodging demand, a higher critical value Q^* is required to trigger new hotel investment. As pointed out by Dixit & Pindyck (1994), uncertainty and irreversibility lead to a wedge between the critical value Q^* and the total lodging demand Q' under which the NPV of the hotel investment equals zero. Higher volatility of lodging demand is associated with a larger wedge, thereby resulting in a greater expected return rate before irreversible investment in the hotel project. Thus, as the volatility of lodging demand increases, the threshold of investment also increases.

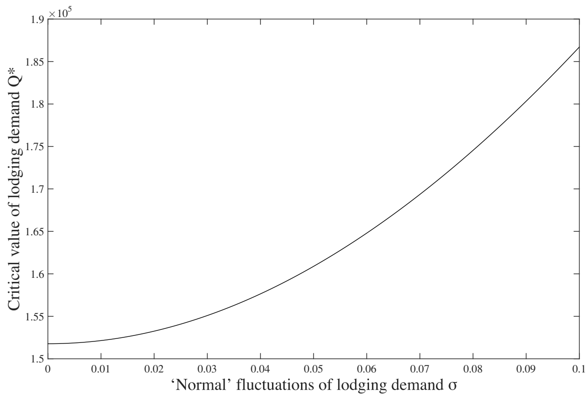

Figure 1: The effect of volatility rate of lodging demand on threshold. The parameters are $r = 2.7\%, \mu = 2.5\%, \lambda = 0.05, \phi = 0.3, C = 42, P = 1060, I = 3500$, and $m = 280$.

Figure 2 shows the effect of economic recession on the threshold, given a 'normal' volatility rate of lodging demand $\sigma = 0.072$. As can be seen, the critical value Q^* first decreases and then increases as the probability of economic recession λ increases. An unexpected economic recession is another kind of uncertainty that has been well documented to have an important influence on the total number of tourists and therefore an impact on lodging demand. However, in contrast to 'normal' fluctuations in lodging demand, the uncertainty driven by unexpected economic recession has two effects on the threshold. First, it reduces the expected growth rate of lodging demand (from μ to $\mu - \lambda\phi$), which reduces the value of future investment opportunities. Therefore, immediate investment (meaning a smaller threshold), rather than waiting, is the better strategy for managers. Second, it makes future lodging demand more uncertain, in which case cautious managers need a higher threshold to trigger investment in the new hotel project. When the probability of economic recession is sufficiently small, the net effect is strong, and an increase in λ leads to a drop in the critical value Q^*, whereas when the probability of economic recession is higher than a specific value, an increase in λ leads to a rise in Q^*.

From figure 2, by comparing the critical values Q^* for $\phi = 0.1, 0.2$, and 0.3, respectively, but for the same probability of economic recession λ, it can be seen that the impact level

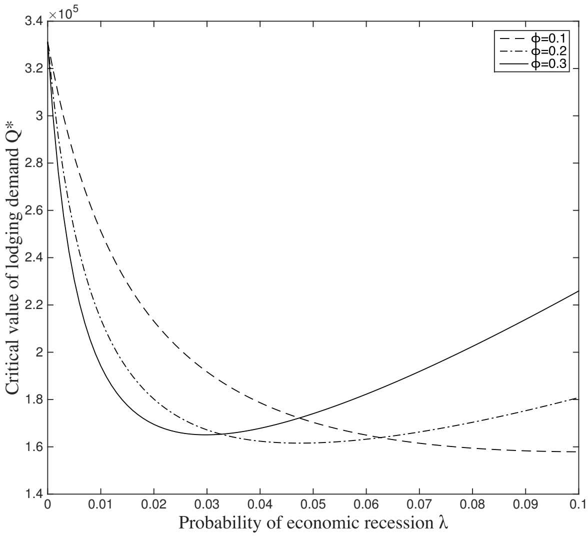

Figure 2: Effect of economic recession on threshold. The parameters are $r = 2.7\%, \mu = 2.5\%, \sigma = 0.072, \phi = 0.1, 0.2, 0.3, C = 42, P = 1060, I = 3500$, and $m = 280$.

ϕ has a similar effect on the threshold as that of λ. When ϕ is small, an increase in its value leads to a decrease in the value of the future investment opportunity, and therefore a relatively small threshold can trigger investment in the new hotel project. However, when ϕ is above a specific level, an increase in its value results in any economic recession having a more negative impact on the hotel business, and therefore a greater lodging demand is needed to trigger investment in the new hotel project.

The threshold of investment and the value of the new hotel project found using the jump–diffusion real option method (considering economic recession) will now be compared with those found using the diffusion-only real option method (without considering economic recession) and the conventional DCF method.

The analysis commences with a comparison of the critical values of lodging demand Q^*. In Macao, as already mentioned, the present volatility rate of lodging demand is 0.072, indicating that, with the jump–diffusion real option method, only when the quarterly total lodging demand reaches 0.174 million can the new hotel investment be started. With the

DCF method, Q^* is 0.082 million according to equation (14). The uncertainty in lodging demand makes the threshold of investment increase by 112%. However, with the diffusion-only real option method, where the impact of unexpected economic recession is neglected, the threshold of investment reaches 0.332 million, higher than that with the jump–diffusion real option method by 91%. As already mentioned, the impact of unexpected economic recession reduces the value of future investment opportunity, and therefore a lower lodging demand can trigger investment in a new hotel project.

With the jump–diffusion real option method, as shown in figure 3, the value of the new hotel project is always higher than or equal to that with the DCF method. When lodging demand is more than 0.174 million (the threshold in the jump–diffusion model), investment in the new hotel project is triggered, and the value of the project with the jump–diffusion real option method is now equal to that with the DCF method. However, when lodging demand is less than 0.174 million, the value of the project with the jump–diffusion real option method is higher than that with the DCF method, even though there will not be investment in the project. The difference is the value of the waiting option. In other words, the decision to wait for a favorable investment time when lodging demand is uncertain provides more value for the new hotel project. In contrast, if the impact of unexpected economic recession is not taken into account by the model, the value of the new hotel project may be misestimated. Whether there is underestimation or overestimation depends on how economic recession affects the critical value of lodging demand. In the present case, the value of the new hotel project with the diffusion model is significantly overestimated. The main reason for this is that the total effect of economic recession is not large enough to make cautious managers require a greater threshold to trigger investment. On the contrary, an unexpected economic recession and its effect on lodging demand reduce the value of future investment opportunity and hence result in a large fall in the value of the waiting option. Therefore, the jump–diffusion real option approach can provide a

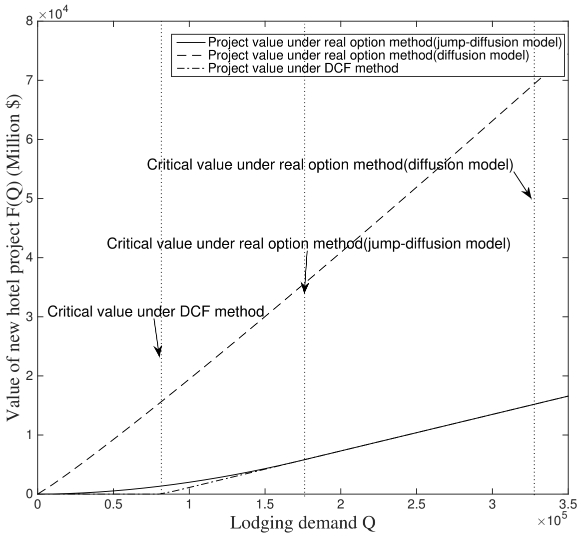

Figure 3: Comparison of the real option method and the DCF method. The parameters are $r = 2.7\%, \mu = 2.5\%, w = 0.072, \phi = 0.3, \lambda = 0.05, C = 42, P = 1060, I = 3500$, and $m = 280$.

relatively accurate assessment of investment timing and the value of a new hotel project when potential economic recession has an important effect on hotel business.

4 Conclusions

The hotel business is characterized by inflexible supply of rooms or other units of accommodation but uncertain lodging demand, which has an important influence on firms' financial performance. It is important for hotel managers to be able to handle uncertainty of lodging demand and enhance firms' financial performance. To deal with the problem of uncertain lodging demand, most previous studies have paid particular attention to the operational stage of hotel management and have emphasized the reduction of this uncertainty through effective collection of information on arrival of customers. In contrast, this study has considered managerial flexibility and has paid more attention to the investment stage. In particular, it has proposed a real option approach to determine the optimal timing of hotel investment and evaluate project value under uncertain lodging demand. To analyze the effect of uncertainty on hotel investment exactly, the impact of unexpected economic recession, which has been proved by previous studies to have an important influence on the hotel business, has been separated from the 'normal' fluctuations in lodging demand. Based on the work of Dixit & Pindyck (1994), a jump–diffusion model has been proposed to analyze how both types of uncertainty of lodging demand influence the optimal timing of investment and the value of new hotel projects.

Through a case study of new hotel investment in Macao and numerical analysis, it has been shown that the 'normal' fluctuations in lodging demand require a higher threshold to trigger investment in a new hotel project, while the effects of the probability of economic recession as well as its impact level on the threshold are ambiguous. A lower probability of economic recession and a higher impact level on lodging demand will first reduce the opportunity cost of immediate investment and thereby reduce the threshold, while, as the probability of economic recession increases, a higher threshold is required to trigger investment. In comparison with the conventional DCF method, the jump–diffusion real option approach provides more value for hotel firms, since it considers the option of investment deferral. It also provides a more exact evaluation of new hotel projects than can be obtained using the conventional real option approach in which the effect of economic recession is ignored. Overall, the jump–diffusion model for hotel investment has been shown to be effective in helping managers handle the uncertain lodging demand induced by temporary imbalances between supply of hotel rooms and lodging demand together with the impact of unexpected economic recession, as well as enhancing hotel firms' financial performance through increasing managerial flexibility during the investment stage.

In this study, we do not consider potential uncertainties such as political instability as well as elements including managers' experiences and location of the establishment, which are crucial for the success of hotel investment. Nevertheless, since the main purpose of the study is to propose a new approach for hotel investment, further discussion on the influence of aforementioned uncertainties and elements could be considered as an interesting direction for future research.

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