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Influence of investor subjective judgments in investment decision-making

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ABSTRACT

By extending the results of previous literature, this study contributes to propose a fuzzy stochastic model for valuing the option to invest in an irreversible investment. The proposed model can provide reasonable ranges of option value, which investors can use to either exercise the option to invest or to delay investment. According to the right and left values of the triangular fuzzy number, investors can interpret the optimal difference based on their individual subjective judgments regarding volatility of future investment values. Finally, in this study two fuzzy goal examples are used to illustrate that the permissible fuzzy option values of pessimistic investors are relatively narrow to optimistic investors.

1. Introduction

An investment opportunity resembles a financial call option. Investors have the right but not the obligation to pay an exercise price in return for an asset. Exercising the option is irreversible because investors cannot retrieve the exercise price (e.g., the investment expenditure is unrecoverable). When an investor makes irreversible investment expenditure, they abandon the right to wait for new information that might affect the timing of their investment decision (McDonald and Siegel (1986); Dixit & Pindyck, 1994; Moore, 2000; Korkeamaki & Moore, 2004). The option falls in value when market conditions turn out to be worse than expected. The lost option value is a potentially large opportunity cost that cannot be ignored in calculating the investment cost. Additionally, this opportunity cost is much more sensitive to volatility in the future investment value (Caballero, 1991). Investors become either more optimistic or more pessimistic in response to changing economic conditions. Optimistic investors perceive low riskiness of future cash flows and thus exercise the option to invest. Meanwhile, pessimistic investors perceive high riskiness of future cash flows and thus delay their investment. The option insight helps explain why investment behavior varies with economic conditions.

One of the most basic option pricing approaches is the continuous-time model of irreversible investment, which was first developed by McDonald and Siegel (1986). This model considers the problem of the optimal time to pay a sunk cost in return for a project whose future value evolves according to the geometric Brownian motion. Future project values thus evolve over time, since the information arrives over time. The investor observes the future values sometimes rising and falling deterministically, or sometimes moving randomly and unpredictably. Because future values are unknown, investing carries an opportunity cost. Hence, the optimal investment rule is to invest when future values at least equal a critical value that exceeds sunk cost (Dixit & Pindyck, 1994; Pindyck, 1991). For reasonable parameter values, they demonstrate that this critical value may be

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two or three times the sunk cost. Researchers using real option approaches to discuss firm investment decisions include: Abel (1983), Caballero (1991), Caballero and Pindyck (1996), Nakamura (2002), Boyle and Guthrie (2003), Wong (2006, 2009), and Xie (2009).

In contrast to the model of McDonald and Siegel (1986), which assumes constant volatility, the main contribution of this study is to apply fuzzy set theory to the McDonald and Siegel (1986) model to establish the fuzzy approach to real option valuation. The proposed model can provide reasonable ranges of option value, which investors can use to either exercise the option to invest or to delay investment. Because the McDonald and Siegel model provides only a single investment threshold, this study uses fuzzy volatility to replace the corresponding crisp values. In the fuzzy approach to real option valuation, investors make investment decisions based on the right and left values of the triangular fuzzy number and interpret the optimal difference based on their individual subjective judgments regarding volatility of future investment values. Finally, this study uses two examples of fuzzy goals to illustrate the relative narrowness of the permissible fuzzy option values of pessimistic investors to optimistic investors.

Researchers have thus far made substantial efforts and achieved significant results regarding the significant effect of subjective judgments regarding riskiness on the decision to invest (e.g., Brennan, 1979; De Bondt, 1993; Mankiw & Zeldes, 1991; Stapleton & Subrahmanyam, 1984). These studies show that subjective judgments affect investor investment decisions. Additionally, researchers have examined subjective judgments regarding option pricing (Detemple & Murthy, 1994; Harris & Raviv, 1993; Robinstein, 1973, 1994; Shefrin & Statman, 1994).

The remainder of this study is organized as follows. Section 2 introduces the basic model originally developed by McDonald and Siegel (1986). Section 3 applies fuzzy set theory to the McDonald and Siegel model to set up the fuzzy approach to real option valuation. Section 4 illustrates numerical examples to assess the accuracy of approximation to the McDonald and Siegel model, and computes the fuzzy goal using a constant absolute risk aversion utility to capture investor risk preference. Finally, Section 5 presents concluding remarks.

2. Basic model

In this basic model, a firm must decide when to invest in a project. Assumes that the investment cost I is known and fixed, but the value of the investment V_t follows a geometric Brownian motion with the form,

$$dV_t = \mu_V V_t dt + \sigma_V V_t dz_V, \tag{1}$$

where $\mu_V \geq 0$ denotes the instantaneous expected rate of the return, $\sigma_V \geq 0$ represents the instantaneous standard deviation, and dz_V is the increment of a Wiener process. Eq. (1) implies that the current investment value is known, but that future values evolve according to the lognormal distribution and have a variance that increases linearly over time. Thus, while fresh information is continuously becoming available (the firm observes changing V), the future value of the investment is always uncertain.

Since V_t evolves stochastically, the optimal investment rule is to invest when V_t is at least as large as an investment threshold V^* that exceeds I. The following introduces some Propositions, which enable us to value the option to invest using dynamic programming.

Proposition 1. Because the investment opportunity $F_B(V_t)$ yields no cash flows when the investment is undertaken, the only return from holding it is its capital appreciation. Hence, at the point for which it is not optimal to invest, the Bellman equation is

$$\rho F dt = E_t(dF), \tag{2}$$

where E_t denotes the expectation at time t and ρ represents a discount rate. Eq. (2) indicates that over a time interval dt, the total expected return on the value of the option to invest, $\rho F dt$, equals its expected rate of capital appreciation, $E_t(dF)$.

Proof. The truth of the above proposition is self-evident, but for further detail see Malliaris and Brock (1982).

Proposition 2. If we try the function $F_B(V_t) = AV_t^{\beta_1}$ as the solution, then the optimal investment threshold V^*, β_1, and $F_B(V_t)$ can be solved after imposing the appropriate boundary conditions, including the initial, value-matching, and smooth-pasting conditions. The solutions can be presented as follows:

$$V^* = \frac{\beta_1}{\beta_1 - 1} I, \tag{3}$$

$$\beta_1 = \frac{1}{2} - \frac{\mu_V}{\sigma_V^2} + \sqrt{\left(\frac{\mu_V}{\sigma_V^2} - \frac{1}{2}\right)^2 + 2\frac{\rho}{\sigma_V^2}}, \tag{4}$$

$$A = \frac{1}{\beta_1}\left(\frac{\beta_1}{\beta_1 - 1} I\right)^{-(\beta_1 - 1)} = \frac{1}{\beta_1}(V^*)^{-(\beta_1 - 1)}, \tag{5}$$