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Investment under regime uncertainty: Impact of competition and preemption☆

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ABSTRACT

In this study, we analyze the investment-timing problem and introduce a model of two firms competing for investment preemption, each of which knows in advance the time at which the economic condition that will have an impact on the investment changes. We qualitatively show how two firms strategically optimize their investment timing, taking into account competition and preemption.

1. Introduction

In a seminal study of the real options literature, McDonald and Siegel (1986) consider a monopolistic firm's decision on an investment and show that the investment should be delayed compared to the case of the net present value (NPV) criteria if the firm actually considers irreversibility. This result is due to the fact that the decision to not invest immediately allows for flexibility in whether the firm invests in the future or withdraws from an investment project. In the literature, the value of this flexibility is called an *option value* as its structure is very similar to an option derivative.

On the other hand, the so-called *bad news principle* proposed by Bernanke (1983) is widely regarded as one of the most important propositions in modern investment theory. In his study (p.91), he states that,

> "Given the current return, the willingness to invest in the current period depends only on the severity of bad news that may arrive. Just how good is the potential future good news for the investment does not matter at all."

Nishide and Nomi (2009) extend McDonald and Siegel (1986) to examine the case in which the parameters describing the dynamics of the state variable (hereafter, the set of parameters of the regime) change at a prespecified time and the time of regime change is known in advance to a monopolistic firm that considers an investment. Nishide and Nomi (2009) show that as the time to the regime change approaches, the investment threshold of the firm converges to the highest value for the possible future regimes, meaning that the bad news principle holds for the time prior to the regime change. The intuition is that at the time near the regime change, the firm can observe which regime occurs if waiting for a short period of time, while immediate investment could cause a big loss if a bad regime emerged.

However, the results may be different when competition among firms is considered, because a first mover or an investment leader can achieve some preemptive payoff.

In this study, we consider the investment timing of two identical firms in a situation in which the time of a regime change is predetermined. Our

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model can be applied to an actual case in which the time of a regime change can be estimated. For instance, economic policies are often revised when a new president is elected and everyone knows the election date. In fact, future uncertainty after a specific event could significantly impact an investment decision. A typical example of this is the large decrease in foreign direct investment (FDI) in Indonesia in 2004. During that year, the country faced an unprecedented amount of political activity, with legislative elections in April and the country's first direct presidential poll in July, which led to a two-thirds decrease in FDI. Some observers conclude that this decrease was due to foreign investors' concern about the possible occurrence of turmoil ahead of the elections.[1] To examine the effect of such a policy change on an investment decision, it is assumed that the regime change can only transpire at a prespecified and predetermined time.

Several studies empirically examine the relationship between economic conditions and investment behavior in the industry, especially the effect of economic policy on investment. They include Knack and Keefer (1995), Alesina and Perotti (1996), Servén (1997), and Lensink (2002). Recently, Julio and Yook (2012) show that during election years, relative to non-election years, firms reduce investment expenditure by an average of 4.8%, thereby controlling growth opportunities and economic conditions. Moreover, Ghosal and Loungani (1996) document that the negative relationship between investment and uncertainty is more noticeable in competitive industries than in non-competitive ones. This implies that it is important to simultaneously study the effects of competition and regime uncertainty on irreversible investment decisions.

This simultaneous study is not new in the theoretical literature. See, for example, Nielsen (2002), Grenadier (2002), Joaquin and Khanna (2001), Weeds (2002), Pawlina and Kort (2006), Bouis et al. (2009), Mason and Weeds (2010), Boyer et al. (2012), and Thijssen et al. (2012), and Goto et al. (2015). However, these studies consider time-homogenous models while our model is time inhomogeneous. We come back to the related literature at the end of Section 4.

The main contribution of this study is to show how two firms strategically optimize their investment timing, taking into account competition, preemption, and regime uncertainty. In particular, we effectively show how a leader firm optimally chooses its optimal investment timing. Just prior to the regime change, a leader firm is unwilling to invest if the ex-post regret for a bad regime is large compared to the degree of preemption. In an extreme situation in which investment loss is sufficiently large in a bad regime and its probability is non-negligible, a leader firm should be reluctant to invest and conforms to the bad news principle, although being a leader entails preemptive cash flows.

The remainder of this paper is organized as follows: Our model is described in Section 2. Section 3 derives the value functions and investment thresholds of the two firms in the model. In Section 4, we numerically calculate the value functions to analyze the optimal investment strategies. Finally, we present our concluding remarks in Section 5.

2. Model setup

In this section, we set up our model, which extends that of Nishide and Nomi (2009) to the case of competition between two firms. The definitions of strategy spaces and equilibrium in this setting are also presented.

2.1. Market structure

Suppose that two identical, risk-neutral firms consider whether to invest in a project. To earn cash flow from the project, each firm must pay an irreversible cost, denoted by K. When one of the two firms invests, it earns an instantaneous cash flow, given by D_1P, where P denotes the industry-wide demand shock. After both firms invest, each firm receives the cash flow D_2P. To describe a preemptive situation in which a leader firm earns more profit, owing to less competition, we assume the inequality $D_1 > D_2$. We define the *degree of preemption* of a leader's investment by the ratio D_1/D_2. In summary, the instantaneous cash flow from the project is written as

$$1_{\{t \geq \tau_F\}} D_2 P$$

if the firm is a follower, and

$$1_{\{\tau_L \leq t < \tau_F\}} D_1 P + 1_{\{t \geq \tau_F\}} D_2 P$$

if it is a leader, where τ_F and τ_L are the investment times of the follower and leader, respectively.

The demand shock P and risk-free interest rate r are subject to a regime change. Contrary to a time-homogeneous setting, as in Hassett and Metcalf (1999), Guo et al. (2005), or Goto et al. (2015), the time of the regime change is predetermined and known in advance by both firms. Some examples for the applications of our model are a presidential election, which can affect economic policy, and bilateral trade negotiations that have an explicit deadline. In such situations, both firms should consider not only the potential future economic conditions but also the time remaining before the regime change (see, Nishide and Nomi, 2009, for a detailed discussion,).

Let $\hat{T}$ be the calendar time of the regime change. For $t < \hat{T}$, the demand shock of the project follows the geometric Brownian motion

$$\mathrm{d}P(t) = \mu_0 P(t)\mathrm{d}t + \sigma_0 P(t)\mathrm{d}z(t),$$

where μ_0 is the expected growth rate of demand, σ_0 is its volatility, and $z(t)$ is a standard Brownian motion that describes randomness. The risk-free rate (discount factor) before $\hat{T}$ is assumed to be a constant, r_0.

A regime change occurs at time $\hat{T}$. Suppose that there are S possible states after $\hat{T}$, and let q_s be the probability of state s, $s = 1, \ldots, S$. When state s is realized, the demand shock $P(t)$ satisfies the stochastic differential equation as

$$\mathrm{d}P(t) = \mu_s P(t)\mathrm{d}t + \sigma_s P(t)\mathrm{d}z(t),$$

and the risk-free rate $r(t)$ is equal to a constant r_s for $t \geq \hat{T}$. We impose the inequality $r_s > \mu_s$ to guarantee that the problem is well posed. If we denote the state at time t by $s(t)$, it is given by

$$s(t) = \begin{cases} 0 & \text{for } t < \hat{T}, \\ 1 & \text{for } t \geq \hat{T} \text{ with probability } q_1, \\ \vdots & \\ S & \text{for } t \geq \hat{T} \text{ with probability } q_S. \end{cases}$$

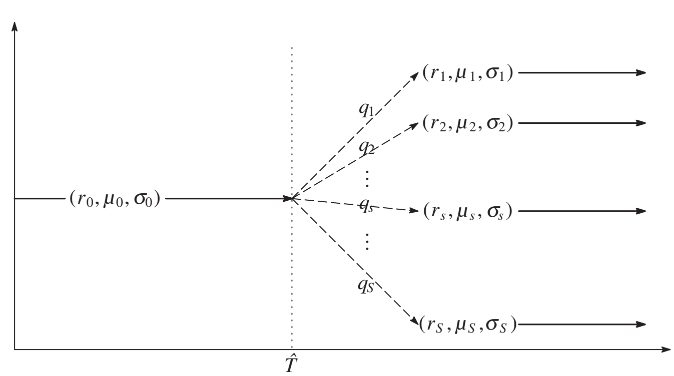

Fig. 1. Structure of a regime change. Both firms know in advance the time of the regime change $\hat{T}$, the possible regimes after $\hat{T}$, and their respective probabilities.

[1] BBC news article dated March 29, 2004: http://news.bbc.co.uk/2/hi/business/3577883.stm.