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Leaders, followers, and equity risk premiums in booms and busts

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ABSTRACT

We study an investment problem in which two asymmetric firms face competition and the regime characterizing the economic condition follows a Markov switching process. We derive the value functions and investment thresholds of the leader and follower. The option value of regime uncertainty is found to be quite important for the investment decision of firms. We also show the relationship between the equity risk premium and the economic cycle that has not been done in previous studies, which proxy economic conditions by the level of demand or other state variables.

1. Introduction

The real options approach studies an investment problem in which the value of an investment opportunity is uncertain in the future and the cost of investment is somewhat irreversible. As Dixit and Pindyck (1994) point out, studying investment under competition is becoming important, not only because it enables us to analyze a more realistic situation, but also because competition is becoming fierce as a result of a globalizing economy and worldwide deregulation. In this background, many theoretical studies construct models with multiple firms in a real options framework to study the investment problem under competition.

Among them, Grenadier (1996) is regarded as a pioneering paper. He models a real estate market with two firms using a real options framework and claims that his model explains a US construction boom in the 1990s. Other important theoretical papers include Huisman and Kort (1999) and Nielsen (2002). Pawlina and Kort (2006) consider the case where two firms are asymmetric in their irreversible costs and present some theoretical results. Their model has three patterns of equilibrium: preemptive, sequential and simultaneous equilibria. Takashima et al. (2008) investigate an electricity market in which two firms are asymmetric in cost parameters and operating options. Kijima and Shibata (2005) and Bouis et al. (2009) extend these approaches to the framework of three or more symmetric firms. Nishide and Yagi (2016) introduce policy uncertainty to the preemption game. As seen above, the literature on real options in competitive environments is very extensive. For a more detailed literature review see, for example, Chevalier-Roignanta et al. (2011); Huisman et al. (2004) and Azevedo and Paxson (2014).

From another viewpoint, several studies introduce regime uncertainty within a real options analysis to capture economic cycles. As we observed in the global financial crisis after the failure of Lehman Brothers in September 2008, a change in regime can have a significant impact on economic circumstances. One example is the dislocations in the foreign exchange (FX) swap market between the US dollar and three major European currencies, which is empirically reported by Baba and Packer (2009). They report that almost all FX swap deviates from the covered interest rate parity after the Lehman failure, indicating a big effect caused by the change of economic conditions.

Theoretical papers that assume regime shifts within a real options framework include Chapter 9 of Dixit and Pindyck (1994); Guo et al. (2005); Hassett and Metcalf (1999); Pawlina and Kort (2005), and Nishide and Nomi (2009). Typically, regime uncertainty is modeled with parameters that describe the dynamics of the state variables following a Markov switching process. Among

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them, Driffill et al. (2013) study the investment decisions of a project with Markov-modulated geometric Brownian motions. They derive a simultaneous ordinary differential equation system that can calculate an investment threshold for each regime. Their main finding is that Markov switching risk causes a delay in the expected timing of the investment.

In this paper, we consider a situation where two asymmetric firms face an investment problem under competition with the market regime switching randomly. Specifically, we study the problem of investment timing where cash flow is defined by the demand shock and profit coefficient. In this paper, the key assumptions are that the coefficient is affected by the investment of the other firm, and that the dynamics of demand shock are modulated by a time-homogeneous Markov chain. The asymmetry of coefficients and investment costs enables us to investigate how a firm chooses its optimal timing, considering the firm's advantage or disadvantage in profits and costs. Investment timing is determined by its corresponding investment threshold: if a firm's investment threshold is lower (higher) and investment timing is earlier (later) than that of the other firm, the firm becomes the leader (follower). To the authors' best knowledge, this paper is the first attempt to combine a competitive real options model with a Markov switching regime. Our model not only extends previous studies to a more general and realistic setup, but also enables us to describe various patterns of competitive investment. In other words, we construct a theoretical model that produces a wide variety of strategies in a unified framework.

The major results of this study are as follows. Each finding or implication confirms that regime uncertainty is quite important for the investment decision of firms and the market equilibrium.

First, our model is flexible enough to produce a wide variety of results, such that a disadvantaged firm can be the leader even if the initial demand is low. Recall that, in previous studies, if both firms wait for investment due to low demand, only an advantaged firm has an incentive to invest earlier and always becomes a leader when the demand reaches a certain level. This means that existing theoretical studies cannot explain the fact that a less profitable firm sometimes enters a new and developing market before a more profitable firm, while our model can do so.

Following Pawlina and Kort (2006), we analyze the conditions for the occurrence of this type of equilibrium. The second result is the finding that a preemptive equilibrium, which represents a competitive situation among firms, is more likely to occur in a boom than in a bust. This result is most remarkable when the intensity of regime transition takes a moderate value. Intuitively, uncertainty of the demand evolution is higher in a bust and both the leader and follower have an incentive to wait for investment, resulting in a sequential or simultaneous equilibrium. The second result says that this situation is less likely to happen when the transition probability is extremely high or low. As we discuss later, this implies that both firms take the option value of regime uncertainty into consideration.

Third, unlike other previous studies such as Carlson et al. (2014), the equity risk premium can be non-monotonic with respect to the level of demand between the leader's and the follower's investment thresholds.[1] The reason is that both firms take the possibility of a regime change into account in our model. More specifically, potential investment caused by a sudden regime change vanishes the option value, and the risk premium in a bust changes the shape drastically at that point. Therefore, the risk premium in a bust is non-monotonic and has a kink.

Fourth, we show that the firm's beta in a bust is higher than that in a boom. Aguerrevere (2009) finds that when the demand is low, firms in competitive industries are riskier, whereas firms in concentrated industries are riskier when demand is high. At first glance, our study replicates the result of Aguerrevere (2009). However, our study does not show the negative relationship between the beta and economic growth. Many empirical papers such as Chen (1991) and Hoberg and Phillips (2010) suggest that the time-varying beta is negatively associated with economic growth rate or market returns, not the absolute level of state variables. In other words, our result with regime switching model theoretically describes the relationship in a more precise way than in Aguerrevere (2009). Intuitively, a lower economic growth rate reduces the investment opportunity due to a decrease in the option value. Thus, assets in place amount to a relatively large fraction of the firm value when the economic growth rate is low. In addition, assets in place in competitive market become riskier because firms' cash flows are more sensitive to demand dynamics. This result corresponds to the results of Chen (1991) and Hoberg and Phillips (2010), that is, there exists a negative relation between beta and the rate of economic growth.

The remaining part of the paper is organized as follows. In the next section, we concisely review the model and the results of Pawlina and Kort (2006) as a benchmark case. Section 3 presents our model that introduces a Markov regime switching process. In Section 4, we implement a numerical analysis and show how each firm chooses its investment threshold depending on the regime. Following the analysis in Pawlina and Kort (2006), we examine the conditions and types of equilibrium that occur in each regime in Section 5. Additionally, we show the effect of regime uncertainty on the investment decisions of both firms and the market equilibrium. We discuss how effectively our model explains the behavior of a firm's beta in relation to the economic cycles in Section 6. Section 7 provides some concluding remarks. The appendices following Section 7 present the glossary of the notation used in the paper, and supplementary results.

2. The model

2.1. Cash flow and market settings

Consider a situation where two firms compete in a product market. The demand shock in the market is denoted by P_t. Superscript $i \in \{1, 2\}$ denotes the identity of a firm. Each firm has a single investment opportunity to increase its profit. Prior to making an investment, firm i generates the cash flow $D_{00}^i P_t$. We assume that P_t follows a stochastic differential equation as

$$\mathrm{d}P_t = \mu_{\epsilon(t)} P_t \mathrm{d}t + \sigma_{\epsilon(t)} P_t \mathrm{d}z_t,$$

with initial value $P_0 = P$. Here, the expected growth rate μ and the volatility σ depend on $\epsilon(t)$, the regime at time t. We assume that there are only two regimes in the economy, so that we have

$$(\mu_\epsilon, \sigma_\epsilon) = \begin{cases} (\mu_1, \sigma_1), & \text{if } \epsilon = 1, \\ (\mu_2, \sigma_2), & \text{if } \epsilon = 2. \end{cases}$$

The key assumption is that the regime $\{\epsilon(t)\}$ follows a stationary Markov chain as

$$1 \to 2, \quad \text{with intensity } \lambda_1,$$
$$2 \to 1, \quad \text{with intensity } \lambda_2.$$

In later discussions, we regard regime 1 as a good state (boom) and regime 2 as a bad one (bust).

Suppose that firm i currently receives the instantaneous cash flow $D_{00}^i P$ and considers an investment in the new technology. The

[1] Lambrecht et al. (2015) show that a decrease in demand level increases a firm's stock beta due to operating leverage in downturns as in Carlson et al. (2004). However when the firm switches between different procurement options, the firm's beta exhibits non-monotonic behavior, as is shown in this paper.