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Macroeconomic conditions and a firm's investment decisions [☆]

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ABSTRACT

We propose a model of a firm's reversible investment decision with macroeconomic conditions based on optimal switching of a diffusion regime. The switching costs and the cash flow generated from the firm depend on a business cycle alternating via a Markov chain, and the triggers of investment and disinvestment in each state are determined endogenously. Provided the investment costs are cyclical due to high wages and rents in a boom, the investment tends to be delayed in boom, while the disinvestment is likely to be made earlier in terms of the level of switching triggers. This result shows us that the 'hysteresis' of investment is a rigorous phenomenon that does not change dramatically depending on business cycle. Yet, the business cycle may still amplify and propagate the exogenous shocks from macroeconomic conditions as far as the persistence of business cycle is concerned. In particular, the investment is deferred and the disinvestment occurs earlier when recession lasts longer and boom ends soon.

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1. Introduction

A real option based approach has been adopted in numerous works to illustrate the firm's investment decision. Most of the existing literature on real options implicitly assumes that an option can be

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exercised under the same conditions all the time. In the real world, however, the investment environment changes frequently by exogenous shocks such as business cycle, and the exercise of the firm's option is greatly affected by them. The necessity of researches with varying investment costs has been pointed out in a number of papers. For instance, [Pindyck \(1993\)](#) has noted that sometimes the cost of an investment is more uncertain than the future payoff. Meanwhile, a majority of papers on real options assume the investment to be irreversible, but the disinvestment of a firm is a common thing in the real world (e.g., [Abel and Eberly \(2002\)](#)²), and thus the firm's option of disinvesting also needs to be integrated in the framework.

In the present paper, we propose a model in which a firm has options of reversible investment with varying investment conditions. To be more specific, the firm optimally switches between two diffusion regimes, and the switching costs and the firm's instantaneous operating profit depend on the state of the economy, which switches via a Markov chain. The triggers of investment and disinvestment in each state are determined endogenously. Provided the investment costs are cyclical due to high wages and rents in a boom, the cyclicity of the costs and cash flow affects the firm's investment decision in opposite directions, but the effect of the former is predominant over that of the latter, which leads to the countercyclical investment. Thus, the firm invests earlier in a downturn of the economy while the disinvestment is advanced in an upturn of the economy. That is, the discrepancy between the triggers of investment and disinvestment does not change dramatically depending on business cycle, and this implies that the 'hysteresis' of investment, noted by [Dixit \(1989\)](#), is a rigorous and consistent phenomenon. Meanwhile, the business cycle may still amplify and propagate the exogenous shocks as far as the persistence of the business cycle is concerned. The comparative statics show that the investment is deferred and the disinvestment gets earlier when recession lasts longer and boom ends soon.

Many attempts have been made to illustrate the firm's option with varying costs. [McDonald and Siegel \(1986\)](#) assumed that investment costs follow a geometric Brownian motion (GBM). As noted by [Elliott et al. \(2009\)](#), however, a diffusion process is not suitable for modeling investment costs. [Pindyck \(1993\)](#) considered the uncertain cost of investment by letting the expected cost to completion follow a controlled diffusion process. [Elliott et al. \(2009\)](#) postulated that the investment costs change depending on the state of the economy, which switches via a Markov chain, and this assumption coincides with ours. Yet, they supposed that a firm has only one growth opportunity without any asset-in-place, and thus could not consider the reversibility of investment. [Du and MacKay \(2010\)](#) investigated both entry and exit options with state varying costs, but examined them separately; that is, an idle firm with an opportunity to invest and an active firm holding an option to exit are discussed individually. Furthermore, they assumed that the diffusion regime changes exogenously. In contrast, we integrate the on-going firm's options of investing and disinvesting with the endogenous switching of diffusion regimes.

A number of papers have been devoted to a firm's negative investment. [Dixit \(1989\)](#), one of the monumental works that pioneered real options theory, examined the options to enter and exit the market under uncertainty. [Abel and Eberly \(1997\)](#) further considered adjustment costs and reversibility of investment, and derived closed-form solutions for the trigger and the firm value with the investment modeled via Cobb–Douglas production function. [Zervos \(2003\)](#) derived the form of the optimal investment strategy that differs depending on the abandonment cost and cash flow. [Vath and Pham \(2007\)](#) provided us a great insight of modeling investment via optimal switching of diffusion regimes, and the present model extends this idea to more general case in which the switching cost varies depending on macroeconomic condition.

Numerous works have adopted a Markov chain to model exogenous shocks from macroeconomic conditions. For instance, [Guo et al. \(2005\)](#) examined an irreversible investment of a firm with regime switching. [Chen \(2010\)](#) and [Bhamra et al. \(2010\)](#) incorporated the business cycle into a consumption-based asset pricing model. In these papers, a Markov chain is adopted to

² In their empirical analysis, 80% of firms in the samples sold capital in at least one year, and these years accounted for a half of all observations. Moreover, the authors noted that the figures might have been a result of the purchase and sale of capital in the same sample period, which would increase the frequency of the disinvestment even more.

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