Real options and contingent convertibles with regime switching

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ABSTRACT

We consider a firm with no assets in place but an option to invest in a project. The investment is irreversible but delayable in a regime-switching economy. The firm issues equity, straight bonds (SBs) and contingent convertibles (CoCos). We provide the closed-form prices for the firm's securities and the pricing and timing of the option. Our numerical analyses discover that issuing CoCos instead of SBs induces much less agency cost of debt. The agency cost is higher in a boom economy than in recession but the difference is small. There is a unique CoCos' conversion ratio such that the agency cost arrives at the minimum value zero. The inefficiencies arising from asset substitution and debt overhang are much more significant in recession than in boom. Only if the conversion ratio is not too small, the two inefficiencies disappear during boom periods. While the effects of the conversion rate on optimal capital structure and firm value and those of supervision and jump intensity on optimal CoCos' coupon are ambiguous and weak, the stricter the supervision or the longer the economy remains in recession, the less the option value and the optimal SBs' coupon.

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1. Introduction

In the recent financial crisis, many firms have experienced financial distress, under which they were not able to raise significant new funds from the market through a conventional approach. To solve such kind of problems, contingent convertibles (CoCos) have drawn much attention of researchers and regulators. As a matter of fact, since CoCos were first issued by Lloyds Banking Group in November 2009, they have been widely welcomed by banks of many countries over the world. The amount of CoCos issued increases in a surprising speed. For example, according to the statistics reported by a journalist of the Chinese journal of Moneyweek on December 29, 2014, the banks in China have stepped up issuance: from nothing in 2012 to RMB 358.35 bn yuan of CoCos by December 2014.

On the other hand, since CoCos are invented, a great number of papers studying them have been published in the literature. It is well known that unlike traditional debt, CoCos can bring tax shields without incurring extra bankruptcy costs. However, all the studies on CoCos do not take into account business cycle, let alone business cycle in a real options model. We do not know if CoCos increase or reduce the inefficiencies from asset substitution and debt overhang in a regime-switching economy. How about the agency cost of debt in the option to invest in a project if CoCos are issued? What effect does the CoCos' conversion ratio have on shareholders' wealth, and is there a unique conversion ratio that maximizes shareholder wealth? Is this the same conversion ratio that eliminates agency cost? What is the optimal capital structure

with both straight debt and CoCos in a regime-switching economy? What effects on them the CoCos' conversion ratio and switching intensity of the economic regime have? How does the optimal level of straight debt depend on the existence and level of CoCos? Naturally, if the optimal capital structure has a non-zero amount of CoCos, it would show that the firm would voluntarily issue CoCos and hence they likely add the firm value; However, if the optimal capital structure contains zero CoCos, it means CoCos are not really necessary, and the only reason for their existence is external constraints. In this paper, we aim to answer these questions, where the modeling of regime changes makes the technical analysis much more complicated. A new challenge is to determine the investment thresholds and default thresholds, which directly depend on the economy states and we must therefore solve a series of complicated free-boundary problems.

Our contributions. We provide an investment-based explanation for introducing CoCos into a firm's capital structure in addition to traditional equity and straight bonds (SBs) under a regime-switching model. The firm has no assets in place but is initially endowed with a perpetual option to invest in a project at any time by incurring an irreversible sunk cost. We model the firm's investment behavior as a real option under the firm- and equity-value-maximizing policies respectively. To highlight the effects of CoCos and business cycle on investment, the agency cost of debt and the inefficiencies arising from asset substitution and debt overhang, we take capital structure as given and draw a comparison between two given capital structures: One includes CoCos and the other not. To make the comparison reliable, the total coupon rates of debt in the two capital structures are the same. We provide closed-form prices for the firm's securities and the pricing and timing of the option. Our numerical analyses discover that issuing CoCos instead of SBs induces much less agency cost of debt. The agency cost is higher in a boom economy than in recession though the difference is small. There is a unique CoCos' conversion ratio such that the agency costs arrive at the minimum value zero, which maximizes shareholders' wealth only if the debt remains fairly priced. Generally speaking, rational buyers of CoCos would anticipate the agency costs in advance and force the seller (shareholders) to bear all the agency costs by increasing borrowing cost or paying less for the same CoCos, of which the agency costs are positive. We find that the inefficiencies arising from asset substitution and debt overhang are much more significant in recession than in boom. If the conversion ratio is high enough, the two inefficiencies disappear during boom periods. The firm would voluntarily issue CoCos to maximize its value. Their issuing amount is much larger in boom than in recession. While the effects of the conversion rate on optimal capital structure and firm value and the effects of supervision and jump intensity on optimal CoCos' coupon are ambiguous and weak, the stricter the supervision or the longer the economy remains in recession, the less the option value and the optimal SBs' coupon. These conclusions provide implications for security design.

Literature review. Our paper is related with business cycle. Recently, a vast literature is dedicated to the effect of business cycle. For example, Chen (2010) and Bhamra et al. (2010) incorporate the business cycle into a consumption based asset pricing model. Arnold et al. (2013) consider an irreversible growth option. Guo et al. (2005) examine an irreversible investment problem with regime switching for an all-equity firm. However, to the best of our knowledge, there are no papers on business cycle taking CoCos into account.

Our paper is linked to the research line on real options and the contingent capital theory. In their seminal work, Brennan and Schwartz (1985) use option pricing theory to fix the value and the optimal production policies of a natural resource investment. Mauer and Sarkar (2005) examine the impact of a shareholder–bondholder conflict over the optimal investment policy and provide a measure of the agency cost of debt. Lyandres and Zhdanov (2014) study an expansion problem with equity financing for a firm having issued SB and ordinary convertible bond instead of CoCo. After the recent financial crisis, the academic literature on CoCos is burgeoning, where the majority of the theoretical contributions focus on the valuation of CoCos, capital structure after issuing them and how to design CoCos to reduce their inefficiencies. For instance, McDonald (2013) proposes a form of CoCos with conversion triggered by an exogenous barrier on the equity price and a financial index. Sundaresan and Wang (2015) provide a condition that the conversion ratio must satisfy in order for a unique equilibrium to exist and present a design that mitigates the problem of multiple equilibria. However, all the papers in the literature on real options do not take into account CoCos and all papers on CoCos are silent on how CoCos impact on investment by a real options approach, except Song and Yang (2015) and Tan and Yang (2016). However, the latter does not take business cycle into account. In particular, our research explains that business cycle is an important determinant of the CoCos' effects on investment and their inefficiencies arising from asset substitution and debt overhang.

The structure of the paper is as follows. Section 2 lays out model setup. Section 3 first explicitly derives security prices, the pricing and timing of the option to invest in a project under a given capital structure. Then, based on the proceeding computations, we discuss optimal capital structure. Section 4 provides numerical analyses. Section 5 concludes.

2. Model setup

Let $(\Omega; \mathcal{F}; \mathbb{P})$ be a probability space on which a standard Brownian motion B and a two-state continuous-time Markov chain L are defined. The Markov chain L is right-continuous with values in $\{0, 1\}$ without loss of generality. We suppose the process L, starting at $i \in \{0, 1\}$, remains there for an exponentially distributed length of time with its parameter being λ_i, and then jumps to state $j \in \{0, 1\}(j \neq i)$, i.e. λ_i represents the jump intensity from state i to state j. The exponentially distributed inter-regime times are independent, and independent of Brownian motion B.

Consider a firm who has an opportunity to undertake an irreversible but delayable investment by entailing a fixed sunk cost $I > 0$ and then obtain a continuous stochastic cash flow X. Time is continuous and infinite, and labeled by $t \in (0, \infty)$. The