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Counterparty effects on capital structure decision in incomplete market

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ABSTRACT

This paper builds a static contingent-claim model that allows for examining the optimal capital structure with the joint arguments of counterparty default risk and market incompleteness. A first-passage-time model with jump default barrier is adopted to capture the counterparty effects on the pricing of defaultable claims. Following the framework of Jarrow and Yu (2001), the jump in primary firm's bankruptcy barrier is designed as the loss on capital resulted from secondary firm's bankruptcy. The relevance of market incompleteness in the context of claim-pricing is considered using "good-deal asset price bound" method by Cochrane and Saa-Requejo (2000). We show that the effects of counterparty's default clearly diminish the uses of debt, which indirectly explains the so-called under-leveraged puzzle. We further find that counterparty effects on capital structure are sensitive to market incompleteness and firm's characteristics, such as tax rate and bankruptcy cost rate.

1. Introduction

Since the seminar work by Modigliani and Miller (1958), there is a vast literature on corporate finance that devotes to explaining the central anomaly related to firm's financing decision: low leverage-use (so-called underleveraged puzzle). The issues on such a subject explored by prior research include agency costs (Jensen and Meckling, 1976; Leland, 1998; Myers, 1977), information asymmetries (Myers and Majluf, 1984), asset illiquidity (Morellec, 2001), empirical test (Ju et al., 2005), and macro-economic risk (Chen, 2010; Hackbarth et al., 2006). A consensus view underlying these works is that bankruptcy costs derived from standard structural model are too small to offset the value of tax shields, and thus, other cost-factors must be introduced into trade-off analysis to explain observed capital structures. Motivated by this idea, the paper intends to address the central question on capital structure theory from the arguments of counterparty defaults.

The reason of why this study puts a special focus on counterparty's default risk is sketched as follows. In view of credit contagion and clustering of default during the credit crises, many of the studies hold that the standard credit models without considering counterparty effects (e.g., Merton, 1974) will under-predict a firm's default risk and mis-estimate the value of derivatives on defaultable assets, such as credit default swap. To overcome this modeling restriction, a class of works on the counterparty risk has been motivated. Jarrow and Yu (2001) pioneer in pricing the default-risky securities with counterparty risk using reduced-form model, proposed by Jarrow and Turnbull (1995). Except for Jarrow and Yu, subsequent works on the pricing of credit default swap that particularly focus on the risk accompanied by counterparty defaults include Brigo and Tarenghi (2005), Turnbull (2005), Walker (2006), Duffie and Zhu (2009), and Leung and Kwok (2005, 2009). Kraft and Steffensen (2007) develop a unifying framework to capture credit contagion. Thompson (2007) and Chang and Yu (2009) make the application on insurance contract pricing. Jorion and Zhang (2009) offer the empirical evidence on credit contagion via direct counterparty effects. The above-mentioned literatures provide an important implication that the effects of counterparty's defaults are crucial for measuring the credit risk. Because of a strong linkage between firm's leverage and default risk, this paper thus develops a capital structure model combined with the impacts of counterparty's default.

It is noteworthy that the existing counterparty-related credit models mainly are of intensity-based approach. These models cannot be applied in capital structure problem due to the underlying assumption that the default is irrelevant with firm's value and capital structure. For this reason, the modeling spirit of paper must follow firm-value based approach. However, substantial empirical tests have found the evidence of asset illiquidity (see, e.g., Strebulaev, 2003; Gibson and Mougeot, 2004; Martineza et al., 2005; Eisfeldt, 2007; Khandani and Lo, 2009). In addition, for levered firms, the free disposition of assets will likely be restricted by their bond protective

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covenants (see, Morellec, 2001). If the asset non-tradability or illiquidity does exist, it is impossible to perfectly replicate the focus payoff associated with claims on underlying assets using the continuous trading strategies. In other words, no-arbitrage based pricing argument in a continuous-trading economy fails, and the complete market-assumption becomes inappropriate. To overcome this problem, the paper adopts Cochrane and Saa-Requejo's (2000) "good-deal" price bound method when modeling the dynamic of asset value. Such method is featured by "stochastic discount factor". Imposing relevant constrains on the discount factor, the pricing of uncertain payoff can be undertaken in incomplete market or situations where the purely preference-free approach suffers the breakdown; such as thin trading or non-tradable circumstances (see Section 2.1 for more detailed introduction).

This paper captures the counterparty effects by establishing a first-passage-time model with jump default barrier under primary–secondary framework. Specifically, an upward jump accompanied by counterparty's default is imposed on the primary firm's bankruptcy-triggering threshold. Based on this framework, the paper develops a static contingent claim model for primary firm's capital structure decision. The model considers a common case where the primary firm (like parent company) may offer the secondary firm (like subsidiary) a credit guarantee against default promising their collateral demands for defending joint interests. Once the secondary firm bankrupts, the obligation of primary firm will be expanded to lead to a higher bankrupt potential. The optimization of primary firm's capital structure here is determined by the tradeoff between traditional levered benefits (i.e., tax shields minus bankruptcy costs) and the capital loss in counterparty's default. The values of contingent claims involved in the financing decision will be derived using the martingale method.

The remainder of paper is structured as follows. Section 2 makes a brief review to "good-deal" price bound method, and builds first-passage-time model with jump default barrier. Section 3 extends Section 2 to make an application on capital structure theory. The numerical analysis is given in Section 4. Lastly, Section 5 concludes.

2. Preliminaries

In this section we firstly make a review to Cochrane and Saa-Requejo's (2000) method particularly for asset pricing in incomplete markets, and then establish a first-passage-time model with jump default barrier under primary–secondary framework.

2.1. A review of "good-deal" asset pricing bound

For a levered firm, the assets usually are illiquid or non-traded, because the debt covenants may restrict the disposition of assets (see, Morellec, 2001). As a result, the payoffs associated with claims on these types of assets cannot be perfectly replicated. Thus the traditional no-arbitrage arguments are not applied in this case. To address the problem, Cochrane and Saa-Requejo (2000) propose "good-deal" asset pricing bound method. They show that, in incomplete market, the claims on illiquid assets will be traded at a range of price, rather than single price. The tightness of price bound relies on the degree of underlying assets' illiquidity. We now give a brief introduction to the theory of illiquid-asset pricing.

Let x be a focus payoff associated with contingent claim on reference firm's illiquid assets V, and Λ be the stochastic discount factor with a fixed upper bound on its volatility $\mathcal{A}^2>0$. Following Cochrane and Saa-Requejo (2000) and Hung and Liu (2005), to exclude high Sharpe ratio and arbitrage opportunities, some restrictions need to be imposed on the discount factor. Imposing the positive, volatility, and white noise constrains on the unique discount factor and trying all kinds of combinations of non-binding and binding constrains, this yields the lower good-deal price bound for contingent claim issued by reference firm, $\underline{C}_x$, shown by the following equation:

$$\underline{C}_x(0) := \min_{\Lambda} \mathrm{E_P}\left(\int_0^\infty x(t,V(t))\Lambda(t)/\Lambda(0)dt \,|\, \mathcal{H}_0\right) \equiv \mathrm{E_P}\left(\int_0^\infty x(t,V(t))\underline{\Lambda}(t)/\underline{\Lambda}(0)dt \,|\, \mathcal{H}_0\right) \tag{2.1}$$

$$s.t.V(0) = \mathrm{E_P}(V(t)\Lambda(t)/\Lambda(0)\,|\,\mathcal{H}_0);\ \Lambda(t)>0;\ dt^{-1}\mathrm{E_P}\left((d\Lambda(t)/\Lambda(0))^2\,|\,\mathcal{H}_0\right)\le\mathcal{A}^2;$$
$$m\times Cov\left(d\Lambda(t)/\Lambda(t), dB_A^{P'}(t)\right) = Cov\left(d\Lambda(t)/\Lambda(t), dB_B^{P'}(t)\right)^{1};\ \forall t\in[0,\infty],$$

where $\mathrm{E_P}(\cdot)$ is the expectation operator under physical measure P; $\mathcal{H}_0$ denotes the collection of information on the white noises dB_B^P and dB_A^P; and $m\in[0,\infty]$ is a constant parameter. Similarly, the upper good-deal bound $\overline{C}_x$ can be derived from the corresponding maximum.

The good-deal price bound method is useful in modeling the financing decision of a firm with illiquid or non-traded assets. It helps us derive the value of contingent claims involved with capital structure problem, such as tax benefits, bankruptcy costs, firm's debt, and equity. The optimization of leverage is achieved by choosing a debt level that maximizes firm's total value.

2.2. A first-passage-time model with jump default barrier

Consider a primary–secondary framework in the continuous-time economy. For brevity, let firm A play the primary firm and B the secondary firm. Assume that there is a complete probability space (Ω, $\mathcal{F}$, P), rich enough to support the value processes of non-traded firm i assets $V^i=\{V^i(t);\ 0\le t<\infty\}$ and corresponding twin securities $S^i=\{S^i(t);\ 0\le t<\infty\}$ for $i=A, B$.[2]

Also assume that there is a finite time span [0, T], where $T\in\Re^+$ is valid for both firm A and B. Denote by $\tau^i:\Omega\to\Re^+, i=A,B$ the first passage F-stopping times for firms A and B respectively. Each random time means the first moment in the finite interval [0, T] that the underlying assets' value falls below its predetermined bankruptcy triggering threshold and can be defined as

$$\tau^A := \inf\left(t\in[0,T] : V^A(t)\le F^A + 1_{(\tau^B\le t)}d\right), \tag{2.2}$$

$$\tau^B := \inf\left(t\in[0,T] : V^B(t)\le F^B\right), \tag{2.3}$$

with the convention: $\inf\phi=+\infty$. In Eqs. (2.2) and (2.3), $F^i>0$, $i=A, B$ can be served as debt's par value of firm i. The jump term d is assumed to be a predetermined fraction of B's promised repayment, reflecting an increment in A's debt obligation accompanied by B's default. The size of jump interprets the intensity of counterparty risk. A natural implication behind jump default barrier is: since A may use its assets as the collaterals for B's liabilities to defend common interests, B's default will transfer a portion of its own obligation into A. And the likelihood of A's default will be greater after B goes bankrupt.

The dynamics under this real measure P of non-traded firm i assets' value and of the price of corresponding tradable twin security are given by

$$dV^i(t)/V^i(t) = \left(\mu_V^i-\delta_V^i\right)dt + \sigma_{V_Z^i}\,dZ_i^P(t) + \sigma_{V_W^i}\,d\,W_i^P(t) \tag{2.4}$$

and

$$dS^i(t)/S^i(t) = \left(\mu_S^i-\delta_S^i\right)dt + \sigma_{S^i}\,dZ_i^P(t), i=A,B \tag{2.5}$$

[1] Hung and Liu (2005) impose this constraint on discount factor to assume that the impact of white noise dB_B^P on discount factor is m times greater than white noise dB_A^P.

[2] Cochrane and Saa-Requejo (2000) state that, once the purely preference-free approach breaks down, one may be unable to trade continuously and to achieve the perfect hedge. If so, there still exists a tradable asset in the market that can be used for approximately hedging non-traded underlying asset. Such assets used for approximate hedge are termed "twin securities" in Hung and Liu (2005).