



Real option with liquidity constraints under secondary debt illiquidity risk market



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ABSTRACT

We incorporate the illiquidity risk subjects to the secondary debt markets into the real option framework with liquidity financing constraints. Our model shows that the investment threshold and optimal leverage no longer monotonically increase in project risk but are up to internal liquidity, and illiquidity risk will make the firm care more about the liquidity constraints. The optimal coupon shows a “U-shaped” function of internal liquidity. The optimal debt pricing depends on either coupon payment or project value, which bases on the internal liquidity. Finally, our model gives an alternative explanation for the long-time unexplained findings of the relationship between leverage and liquidity in empirical studies.

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1. Introduction

Most of the former literature, dating from classic papers like Leland (1994) and Leland and Toft (1996), to recent papers like He and Xiong (2012), are mainly based on the liquid unconstrained firm structure, which implies there are no liquidity constraints for firms to finance. As we know, when the firms need to finance with shares or debts, there would be requirements for them to provide the collaterals. Clementi and Hopenhayn (2002) claim that the maximize value of the debt shouldn't be higher than the collateral value. So the amount of debts to be issued should depend on the collateral value. For the equity, some constraints also exist. Boyle and Guthrie (2003a) show that the maximum amount of equity to be issued to outside investors should be part of the project value.¹ Anyway, the financial constraints should be taken into consideration when we set up the model.

Lyandres (2007) and Hirth and Uhrig-Homburg (2007) highlight the importance of capital market frictions to investment for constrained firms. Based on this mind, we continue discussing the effects of capital market friction by adding an illiquidity risk cost to the firms' finance cost. We follow He and Xiong (2012) to set the illiquidity risk on the secondary debt

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¹ This constraint can be caused by information asymmetric problem from Akerlof (1970).

markets. When liquidity deteriorates, a trade cost will be generated for bond selling. Besides, in order to discuss the liquidity constraints, we assume that the firm possesses an initial cash stock, an existing asset and the project rights to invest. Because the illiquidity risk will produce illiquidity risk cost for the firms' finance, it will affect the retaining cash flow and aggravate the liquidity constraints.

With the settings shown above, we find that the internal liquidity will significantly change the firm's behaviors. The investment threshold and optimal leverage no longer monotonically change in project diffusion volatility, but depends on internal liquidity. The optimal coupon shows "U-shaped" in internal liquidity. The optimal debt to be issued is determined by firm's unleveraged value when internal liquidity is low, and by optimal coupon once internal liquidity is high enough. Furthermore, the optimal leverage and credit spread show an inverse "U-shaped" function of internal liquidity, and the leverage shape gives an alternative explanation for the unexplained relationship between leverage and internal liquidity in empirical findings. Finally, the illiquidity risk cost will aggravate liquidity constraints and make the firm more cautious.

Our model relating to the literatures combine the topic of liquidity and real option researches. Leland (1994) provides the analysis framework for optimal capital structure by setting up the endogenous default boundary and obtaining the analytical solution for the security pricing. He and Xiong (2012) extend the illiquidity risk subjects to the secondary debt markets to analyze the credit risk. Besides, Boyle and Guthrie (2003a) introduce the dynamic model about liquid constrained firm which can choose the timing of its investments. Bolton et al. (2014a) and Bolton et al. (2014b) enrich the real option approach with liquidity constraints and point out that liquidity is very important in considering investment and financing decision. Liu and Yang (2015) highlight the importance of illiquidity and compensation structure on the investment decision of Private Equity.

The remainder of this paper proceeds as follows. Section 2 provides the model settings. Section 3 presents the valuation of all the securities. Section 4 depicts the effects of various factors by comparative static analysis. Section 5 concludes. All proofs are shown in the Appendices.

2. Model setup

A firm owns the rights to invest the project and has the option to invest at any time. Once the firm exercises this option, it will pay a fixed cost I and receive a cash flow $\{P_t: 0 \leq t < \infty\}$. The project's cash flow $\{P_t\}$ follows a geometric Brownian motion (GBM) process under physical measure P :

$$dP = \mu^P P dt + \sigma P dZ_t^P, \quad (1)$$

where μ^P is the drift rate, σ is the constant cash flow volatility, and $Z_t^P: 0 \leq t < \infty$ is a standard Brownian motion, representing random shocks to the firm's project asset value. At the same time, the project also follows a GBM process under risk neutral measure Q (Goldstein et al., 2001):

$$dP = \mu P dt + \sigma P dZ_t^Q, \quad (2)$$

where μ is the drift rate, σ is the constant cash flow volatility, and $Z_t^Q: 0 \leq t < \infty$ is a standard Brownian motion, representing random shocks to the firm's project asset value.

In addition to the project rights, the firm has a cash stock of X_t , and some existing assets with perpetual life and market value G . These existing assets can generate a dynamic cash stream $v dt + \phi d\eta$ while G remains constant all the time, where v is the drift rate, ϕ is the volatility, and η is a standard Brownian process with $dZ^P d\eta = \rho dt$. As the firm is a liquid constrained firm, the firm won't pay any dividends before invest into the new project.² For the firm's own cash stock X_t , we assume it is invested in riskless securities with earning the risk-free rate r . Under these settings, the cash stream generated by the existing assets can increase or reduce the firm's cash stock X . Therefore, prior to invest into the project, the cash stock X follows the process:

$$dX = rX dt + v dt + \phi d\eta. \quad (3)$$

At each time, the investors can trade existing shares $E(P)$ and issue debts $D(P)$ to fund the investment cost for the project. Hence the firm's investment is possible at time t if and only if

$$I \leq X_t + G + \alpha E(P_t) + D(P_t), \quad (4)$$

for some constant $0 \leq \alpha < 1$. The right hand of Eq. (4) contains three sources of capitals: two internal capitals: cash stock X_t , existing asset G , are frictionless cash when be used. The outside funding capacity financed by debt and equity, bearing the constraints as it is constrained by external markets. The friction α in Eq. (4) is related to the constraint about the firm's ability or willingness to finance cash from outside equity investors.

The constraint of equity can be caused by the asymmetric information problem provided by Akerlof (1970). The friction α will impose restrictions on the firm's investment choice. For (X_t, P_t) such that $X_t + G + \alpha E(P_t) + D(P_t) < I < E(P_t) + D(P_t)$, though the investment payment $E(P_t) + D(P_t) - I$ is positive, the firm's financial situation doesn't allow it to invest. The lower X is, the more likely this is going to happen. Reversely, as X becomes extremely high, the financing constraint becomes trivial.

² This assumption is universal in the private funds. Because the firm needs to prepare funds for the later project investment, it must hoard cash.

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