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# Optimal capital structure and credit spread under incomplete information☆

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ABSTRACT

This paper builds a novel learning model by incorporating information incompleteness to extend the traditional capital structure tradeoff theories. We find that myopic agents without learning will make a more conservative debt policy, which provides an alternative explanation for the long-standing under-leveraged puzzle. Also, we find learning under incomplete information additionally generates premiums on corporate-debt yield spread. Overall, this paper extends capital structure literature from the perspective of learning under incomplete information and contributes to explain the under-leveraged nature of most firms.

## 1. Introduction

Since the seminal irrelevance theorem of Modigliani and Miller (1958), the challenge of the "under-leverage puzzle is broached by Miller (1977): in expectation, default losses for firms seem disproportionately small compared to tax benefits of debt. Graham (2000) also documents clearly this puzzle. He estimates the capitalized tax benefits of debt to be as high as 5% of the firm value, which is much larger than conventional estimates for the present values of default losses. Many financial economists have devoted much effort to exploring the economic mechanism behind the under-leverage puzzle from various angles: dynamic financing option (Goldstein, Ju, & Leland, 2001; Ju, Parrino, Poteshman, & Weisbach, 2005; Strebulaev, 2007; Sundaresan, Wang, & Yang, 2015), the negative effects of the illiquidity on firm's leverage choice (Chen, Miao, & Wang, 2010; Morellec, 2001), and macroeconomic risk (Chen, 2010; Chen & Manso, 2010), as well as the extent of CEO ownership and length of CEO tenure (Strebulaev & Yang, 2013).

We have learned much from these studies, but virtually few literatures have taken the view of incomplete information to look into

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the under-leverage puzzle. All previous models implicitly assume that the expected rate of return on a firm's cash flow is constant and observable (complete information), and that the firm's asset value is the expected discounted value of its future cash flow for a given expected return. However, the expected rate of return is definitely unknown and unobservable in reality (incomplete information). Traditional real business cycle models require that the productivity of a firm depends on macroeconomic variables, but knowing the growth rate of a firm's operating profit may be unrealistic in many situations.[1] For example, Harchaoui and Lasserre (1995) study copper investment and find that the current estimate for the annual growth rate of the price of copper varies within their sample from as low as 0.7% to as high as 4.3%. Under these circumstances, it is unreasonable to assume that estimated and actual growth rates are the same for a firm. Klein (2007) and Bolton et al. (2013) show that the uncertainty of growth rates has very important effects on firm's investment, financing and risk management.

Indeed, very few studies have tried to address the following related questions in the context of *incomplete information* by integrating the incomplete information and optimal capital structure in a unified framework: How should the equity holder price the equity value and the debtholder value the coupon bond* What is the optimal default decision when the firm's operating cash flow is lower than the payoff to the debtholder* What financing strategy and leverage choice are required to construct the optimal capital structure under incomplete information* How is it linked to the empirical facts* How do we calculate the credit spreads and tax advantage to risky debt when the expected return of a firms cash flow is not observable* Does there exist a credit spread premium when the agents do not update their beliefs by using the dynamic information* Is it important to estimate parameters dynamically*.

We address these questions by establishing a quantitative model of default, valuation, optimal capital structure, credit spread, and tax advantage of debt for firms under incomplete information. Our model builds on a recent classic study by Goldstein et al. (2001), mainly by adding unobservable expected return of a firm's cash flow. In particular, some recent studies argue that parameter uncertainty has significant effects on the firm's capital structure and credit spread. For example, Korteweg and Polson (2012) investigate the impact of parameter uncertainty on the corporate bond credit spread by using data for 4206 firm-years between 1994 and 2004, and find that the parameter uncertainty can explain up to half of the credit spread that is typically attributed to liquidity, taxes and jump risk. An empirical study by Lu, Chen, and Liao (2010) shows that corporate bond investors charge a significant risk premium on both information uncertainty and information asymmetry. Guo (2013) explores the information risk and ambiguity about the probabilistic structure of the process driving the fundamental value of credit securities. Boyarchenko (2008) shows that ambiguity shifts will induce CDS premia and under-valuation of equity based on the data of financial institutions. Thus, our paper is also trying to provide structural and theoretical support for the empirical evidences of high credit spread and low leverage under the classical capital structure model by incorporating incomplete information. Our incomplete information model predicts that myopic agent without updating the information dynamically will choose lower leverage, which further sheds light on the important role of incomplete information that plays in leverage decision.

As a first step in this research, it is necessary for us to assume that the expected rate of return on the cash flow cannot be observable, but is known to be a random variable that can take only two different values, either high or low. All agents (equityholder and debtholder) can update their belief on the expected growth rate by observing the realization of the value of cash flow. This case is called incomplete or partial information in previous studies. In contrast to prior research, a special feature of our study is that simply by utilizing the incomplete information generated by the cash flow, we derive the values of equity/debt and study how much effect the uncertainty of the expected rate of return has on the optimal capital structure, default decision, and the valuation of credit spread.

To achieve this goal, we categorize our model into two sub-models, which correspond to the complete and incomplete information cases, respectively. Following Goldstein et al. (2001), we obtain the closed-form solutions if the expected rate of return is observable. For the incomplete information model, we first obtain the filtering estimation of the belief process and then derive the partial differential equations (PDEs) that are satisfied by various valuations and optimal capital structures under incomplete information. In general, it is not possible to obtain closed-form solutions of the PDEs, thus we use the finite differences method to solve the problem numerically. Specifically, based on insights from Song, Yang, and Yang (2013), we successfully obtain explicit solutions to the PDEs under a special case in a reasonable parameter region.

To understand the effects of the information structure and dynamic processing on the capital structure and credit spread, we provide the solutions for both the dynamic learning and non-updating cases under incomplete information. The numerical results show that the non-updating firm prefers conservative financing strategy by taking low leverage, and by comparing it with the dynamic learning case, we find there exists significant credit spread premium for bearing the information risk. Moreover, our comparative statics analysis shows that the effects of the parameters behave differently under incomplete information.

**Related literatures:** The present study is related to several research areas in finance. First, the present study is related closely to Leland (1994, 1998), and Goldstein et al. (2001), who solve the optimal (dynamic) capital strategy of a firm and investigate the implications of optimal leverage ratios and the magnitude of the tax benefits to debt. The fundamental difference between their studies and our investigation is that they did not consider the uncertainty of expected return or consider the effects of incomplete information.

Actually, there exists many literature about capital structure argue that information structure has very important effects on the firm decisions and valuations. For example, Giesecke and Goldberg (2004) build a structural credit model based on incomplete information. They compare their model with traditional structural models, such as Merton (1974) and Black and Cox (1976), and find

[1] See Jermann (1998), Tallarini (2000), Bolton, Chen, and Wang (2013).