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# Credit market equilibrium theory and evidence: Revisiting the structural versus reduced form credit risk model debate

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## Abstract

There are two competing paradigms for modeling credit risk: the structural and reduced form models. This paper applies our knowledge of credit market equilibrium to this debate. We show that credit markets have asymmetric information in the borrowing and lending relationship which influence equilibrium prices. Reduced form models are consistent with asymmetric equilibrium models, but structural models are not. This implies that structural models should not be used for pricing, hedging, or risk management.

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## Introduction

Two competing models for pricing and hedging credit risk exist: structural and reduced form models (see Jarrow (2009) for a review). A debate has raged in the academic literature and professional community for over 15 years as to which model is more appropriate for risk management. This paper uses the insights from our understanding of credit market equilibrium to help resolve this debate.

For at least 30 years it has been understood that the economic relationship between a borrower and a lender is characterized by asymmetric information: the borrower being better informed with respect to their ability and willingness to repay, and the lender being at a disadvantage. In understanding credit markets, this leads to the problems of adverse selection, moral hazard and their impact on credit market equilibrium (see Stiglitz and Weiss, 1981, Tirole, 2006).

Asymmetric information and the resulting equilibrium considerations are fundamental to our understanding of risk capital (Merton and Perold, 1993), debt and loan issuance (Ross, 1977, Myers, 1984, Leland and Pyle, 1977, Darrrough and Stoughton, 1986, Harris and Raviv, 1991, Sharpe, 1990, Pagano and Jappelli, 1993, Hauswald and Marquez, 2006), bank runs (Diamond and Dybvig, 1983), financial intermediation (Diamond, 1984, Holmstrom and Tirole, 1997), and credit rating agencies (see Millon and Thakor, 1985, Bolton et al., 2009, Jarrow and Xu, 2010). The empirical evidence supports the existence of

asymmetric information in credit markets, with both adverse selection and moral hazard being relevant and fundamental economic considerations (see, for example, Best and Zhang, 1993, Berndt and Gupta, 2009, Hyytinen and Vaananen, 2006, Sufi, 2007, Ross, 2010, Ivashina, 2009, Purnanandam, forthcoming, Titman and Wessels, 1988, Myers and Shyam-Sunder, 1999, Fama and French, 2002, Frank and Goyal, 2003).

Returning to the structural versus reduced form model debate, it is also well known that structural models assume symmetric information. Both the management and the market have the same information regarding the firm's asset value process. There is no adverse selection or moral hazard in these models. This is inconsistent with both the theory and evidence of credit market equilibrium. In contrast, as shown by Jarrow and Protter (2004), reduced form models are consistent with asymmetric information in credit markets.

These observations imply that structural models are not useful for pricing, hedging, nor risk management, due to their inconsistency with credit market equilibrium. Consequently, structural models are not useful for inferring default probabilities, computing Value-at-Risk (VAR) measures, nor for generating scenario analyzes in the determination of economic capital. Structural models are only useful as a stepping stone to our understanding of corporate contingent claims, in the same sense that frictionless markets are a precursor to understanding friction-filled markets. In contrast, reduced form models are useful for all of these practical endeavours.

In hindsight, recognizing these asymmetric credit market equilibrium considerations also better enables us to understand the direct evidence studying both structural and reduced form models. The empirical literature testing structural models generally finds them inconsistent with the term structure of bond yields (see, for example, Eom et al., 2004, Ericsson and Reneby, 2005, Jarrow et al., 2003, Schaefer and Strebulaev, 2008, Li and Wong, 2008), while those papers studying reduced form models find them consistent (see, for example, Duffee, 1999, Duffie and Singleton, 1997, Madan and Unal, 1998, Duffie et al., 2003, Jarrow et al., 2010, Jarrow et al., 2007, Berndt et al., 2010). This evidence is not surprising now, given our new insights in this regard.

An outline for this paper is as follows. Sections 2 Structural models, 3 Reduced form models briefly review the structural and reduced form models, respectively. Next, Section 4 reviews credit market equilibrium theory and evidence. Finally, Section 5 concludes with an analysis of how our understanding of credit market equilibrium affects the structural versus reduced form model debate.

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## Section snippets

### Structural models

The structural model for credit risk, sometimes called contingent claims modeling, was introduced by Merton (1974) and extended by Leland, 1994, Leland and Toft, 1996, Anderson and Sundaresan, 1996, among others. The defining characteristic of a structural model is given by two assumptions: one, the firm's asset value process trades and is known by both the firm's management and the market; and two, the liability structure of the firm is known by the market. *These are symmetric information...*

### Reduced form models

Reduced form models were introduced by Jarrow and Turnbull, 1992, Jarrow and Turnbull, 1995, and extended by Lando, 1998, Jarrow et al., 1997, Duffie and Singleton, 1999, Madan and Unal, 1998, among others. Reduced form models were introduced to modify the symmetric information assumptions underlying the structural model. The defining characteristic of a reduced form model is given by two assumptions: one, an exogenously given process for the firm's default time; and two, an exogenously given...

## Credit market equilibrium

The credit market borrower and lender relationship is characterized by asymmetric information. The borrower is better informed with respect to their ability and willingness to repay. The lender is at a disadvantage. In considering the pricing of the loan, the lenders being rational, will desire to price based on average risk. This leads to adverse selection in the market for credit (the lemons problem). Equilibrium may not exist, unless a costly signalling mechanism exists to differentiate the...

## Conclusion

This section relates the credit market equilibrium literature to the debate on the structural versus reduced form models. With respect to this debate, we draw four conclusions.

As noted in the previous section, the credit market equilibrium literature, both the theory and the empirical evidence, supports the existence and importance of asymmetric information in the determination of credit market equilibrium, and therefore, on risky bond prices and borrowing rates in loan markets. We also noted...

## Acknowledgment

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...Other approaches for options pricing that consider the presence of different sources of risk, such as liquidity and credit, are also worth noting. Sample works in this category include Ku *et al.* (2012), where the valuation framework of Leland (1985) in dealing with transaction costs is re-interpreted as an option-pricing problem under an incomplete-market

setting when liquidity risk is present; Jarrow (2011), on the other hand, argues that asymmetric information structure in fact plays an important role in the determination of credit market equilibrium, and hence affects the capital structure of a firm. Subsequent parts of this article are organized as follows: In Section 2, while the domestic and foreign forward interest rates are modeled by a MMHJM model, the exchange rate is assumed to follow a geometric Brownian motion, and the foreign stock prices are specified by a RSJD model....

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...Until recently, however, the broadly accepted conclusion was that structural models are not highly successful in this regard (Jones et al., 1984; Ogden, 1987; Lyden and Saraniti, 2001; Huang and Huang, 2003; Eom et al., 2004). Not surprisingly, the literature sometimes refers to the poor performance of structural credit risk models as a sort of 'stylized fact' (e.g. Jarrow, 2011). The theoretical completeness of structural models has raised a question, however: To what extent could this seemingly poor performance be a product of the estimation methods applied?...

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