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Product market competition and credit risk

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ABSTRACT

This study theoretically and empirically investigates effects of product market competition on credit risk. We first develop a real-options-based structural model in a homogeneous oligopoly and show that credit spreads are *positively* related to the number of firms in an industry. The disparity of firm size in an industry is relevant to both product market competition and credit risk, and we therefore extend the model to an asymmetric duopoly case. In particular, we demonstrate that credit spreads of relatively small (large) firms within an industry are *positively* (*negatively*) related to Herfindahl-Hirschman index, and the relative firm size in an industry is an important determinant of credit risk. The models' implications are empirically scrutinized by a reduced-form hazard model and generally supported. By performing out-of-sample analyses, the results demonstrate that firm size together with the interaction terms between intra-industry firm size dummies and competition intensity can effectively predict default.

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1. Introduction

The recent global financial crisis has impacted financial markets around the world, emphasizing the importance of correctly forecasting credit events. The unprecedented scale of corporate defaults has drawn the attention of both academics and practitioners to examine the prediction of defaults and to explore the causes of default clustering. In prior literature, some researchers have indicated that industry characteristics can affect default probabilities. Jorion and Zhang (2007) and Lang and Stulz (1992) documented significant intra-industry contagion effects of bankruptcies through event studies. Jorion and Zhang (2007) empirically showed that intra-industry credit contagion can be captured in credit default swaps (CDS), and further provided evidence that the change in CDS spreads is significantly related to the industry Herfindahl-Hirschman index (HHI). It means that the extent of co-movement in firms' credit quality within an industry can be determined by the intensity of competition, and this in turn explains part of the correlation of credit risk and the phenomenon of clustered defaults. However, the prevailing credit risk models rarely consider this industry effect. This motivates us to fill the gap in the literature by first building a structural model to theoretically illuminate the relationship between industry competition and credit risk, and then empirically exploring the effect of product market competition on credit risk and default prediction.

Since the seminal papers of Merton (1974) and Leland (1994), many structural credit risk models have shown that a firm's capital structure is an important determinant of credit risk. Mauer and Sarkar (2005) and many others clearly demonstrated that a firm's financing and investment decisions are interdependent. Moreover, Grenadier (2002) and Aguerrevere (2009) built real options models to analyze the effect of product market competition on a firm's investment and operational decisions. Accordingly, this paper develops a simple structural model to analyze a firm's optimal operational and financing decisions in a symmetric oligopolistic market and scrutinizes the relationship between product market competition and credit spreads.

Several research works on real options have shown that product market competition has a significant impact on firms' investment and operational decisions (Grenadier, 2002; Aguerrevere, 2009). Recently, Akdogu and Mackay (2012) theoretically and empirically demonstrated that under- and over-investment can be rational when framed in a strategic competitive setting. Research on the effect of competition on other issues of corporate finance has been relatively sparse, but recently more attention has been paid to this issue. For example, Mackay and Phillips (2005) focused on aggregate financial leverage, Grullon and Michaely (2007) investigated payout policy, Giroud and Mueller (2008) explored corporate governance, and Morellec and Nikolov (2009) and Fresard (2010) looked at firms' cash holdings. Valta (2010) examined how the

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intensity of competition affects the cost of bank loans and provides evidence that banks rationally take into account the industry structure and competition when pricing financial contracts. As far as we know, however, no study in the literature addresses the linkage between product market competition and credit risk.

Some real options models use regression approach to test the implications of the models. Since the main subject of the paper is to investigate the influence of product market competition on credit risk, instead of regression analysis, we employ the reduced-form approach. Different from the regression analysis, reduced-form models can further provide estimates of default probabilities, and recent empirical research in this field has greatly improved the accuracy of default forecasting. In addition, structural-form models assume that valuation of any corporate security can be modeled as a contingent claim on the underlying value of the firm, implicitly assuming that firm value contains sufficient information about the probability of bankruptcy, but Bharath and Shumway (2008) indicated that this is unlikely to be the case. They empirically employed a reduced-form hazard model approach and showed that the implied default probability of the Merton model is not a sufficient statistic for default prediction. Therefore, in addition to proposing a theoretical structural model, we empirically analyze the model's implications by the well-known reduced-form approach – the hazard model.

The early reduced-form models for default prediction employ approaches like discriminant analysis (Altman, 1968) or binary response models such as logit and probit regressions (Ohlson, 1980; Zmijewski, 1984). Shumway (2001) argued that these models are inconsistent, because their single-period static features do not adjust period for risk. The hazard model proposed by Shumway (2001) can incorporate time-varying covariates and was later adopted by Chava and Jarrow (2004), Hillegeist et al. (2004), Figlewski et al. (2006), Agarwal and Taffler (2008), and many others. However, most of the prior reduced-form models did not consider the industry effect, with only a few exceptions like Chava and Jarrow (2004) that revealed the importance of introducing industry effects in the hazard rate estimation. Nonetheless, they merely consider variables such as industry dummies and their interaction terms with accounting ratios, which only demonstrate industry differences as well as the degrees of importance of accounting variables for different industries. If default intensities are different across industries with otherwise identical firm-specific characteristics, it is of interest to investigate the determinants behind the industry effect through the perspective of product market competition.[1]

Theoretically, we first build a structural model in a homogeneously oligopolistic industry. We show that credit spreads are *positively* related to the number of firms and the effect is significantly amplified when the firm size is small. The number of firms cannot capture the relative size distribution of the firms in an industry while HHI can. Since the relative firm size in an industry is relevant to both HHI and credit risk, we extend our model to an asymmetric duopolistic industry case, demonstrating that credit spreads of relatively small firms are *positively* related to HHI, while those of relatively large firms are *negatively* related to HHI. The effect of HHI on credit spreads is amplified when the firm size is small, and a firm's relative size in an industry is an important determinant of credit risk. For empirical analysis, we provide evidence supporting our theoretical models' predictions through the reduced-form hazard model. We further perform an out-of-sample default prediction accuracy analysis, incorporating the characteristics of product market competition. The results demonstrate that considering firm size together with interaction terms between the intra-industry firm size dummies and competition intensity can effectively predict default.

The major contributions of our paper are summarized as below. We theoretically and empirically examine the effects of product market competition on credit risk, and further identify that the number of firms and HHI in an industry, measuring different dimensions of market competition, can lead to the opposite impacts. This undoubtedly makes contributions to the literature and practice of pricing, measuring and forecasting credit risk with consideration of market competition.

The remainder of this paper is organized as follows. Section 2 describes our models and hypotheses. Section 3 presents the empirical methodology and data. Section 4 reports the empirical results of the hazard model and the out-of-sample prediction accuracy analysis. Finally, Section 5 draws conclusions.

2. Models and hypotheses

In this section we first develop a structural model that employs the symmetric Cournot-Nash equilibrium in order to model firms' interactions and propose testable hypotheses that demonstrate how credit spreads are related to the number of firms. We then introduce the asymmetric Cournot-Nash equilibrium in a duopoly and propose hypotheses that particularly show the relationships between the two firms' credit spreads and the Herfindahl-Hirschman index (HHI). Finally, we provide numerical illustrations of our models and develop testable hypotheses.

2.1. Homogeneous oligopoly model

For simplicity, all agents are assumed to be risk-neutral and thus all expected cash flows can be discounted at a constant risk-free rate r.[2] Consider a homogeneous oligopolistic industry with n infinitely-lived symmetric firms producing $q(t)$ units of output at total cost $TC(q(t)) = a_0 + a_1 q(t)$, where a_0 denotes fixed cost and $a_1 q(t)$ is variable costs. Assume that the produced output cannot be stored, i.e. output always equals demand. The industry inversed demand function is thus given by:

$$P(X(t), t) = X(t) Q(t)^{-1/\gamma}, \tag{1}$$

where $Q(t) = \sum_{i=1}^{n} q_i(t)$, γ is elasticity of demand, and $X(t)$ is the industry demand shock governed by $dX(t) = \mu X(t)dt + \sigma X(t)dW(t)$.. We further assume $X(0) = x_0 > 0$ and $r - \mu > 0$. Industry production capacity is exogenously given by K, where each symmetric firm owns capacity $k_i = k = K/n$.

Similar to the set-up of Aguerrevere (2009), at time t, any firm i in the industry makes its optimal production decision $q_i^*(t) = \arg\max_{0 \leqslant q_i(t) \leqslant k} P(t) q_i(t) - TC_i(q_i(t))$, which leads to the symmetric Cournot Nash equilibrium given by:

$$q_i^*(t) = \begin{cases} \frac{1}{n}(X(t)/(a_1 A(n,\gamma)))^{\gamma}, & \text{if } X(t) \leqslant SW, \\ k, & \text{if } X(t) \geqslant SW, \end{cases} \tag{2}$$

where $A(n,\gamma) = n\gamma/(n\gamma - 1) \equiv A$ and $SW = a_1 A K^{1/\gamma}$. When the industry demand is lower than the switching point SW, the firm will produce below its full capacity (k). On the other hand, the firm will produce at its full capacity when the demand is high enough.[3]

We can now define the firm i's instantaneous after-tax operating net profits as: $\pi_i^*(X(t), K) = (1 - \tau)(P(t) q_i^*(t) - TC_i(q_i^*(t)))$.

[1] For example, among others, Duffie et al. (2007), Figlewski et al. (2006), and Duan (2010) incorporated macroeconomic variables into their reduced-form models.

[2] Alternatively, we could assume there is a tradable asset that spans the risks the firms face.

[3] We assume that the firm is unable to adjust its capacity, thereby allowing us to focus on the firm's bankruptcy decision.

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