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Production efficiency uncertainty and corporate credit risk: Structural form credit model perspectives

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ABSTRACT

This study investigates the effect of production efficiency uncertainty (PEU) on firm credit risk from structural form credit model perspectives (e.g. asset volatility) by employing 4376 American manufacturing firms' bond observations from the year 1997 to 2008. We find that PEU is positively related to firm credit risk when controlling for well-known credit risk determinant variables. We also find that booming economic conditions weaken the PEU effect. Finally, our empirical results are robust for the firm-fixed effect issue and the minimum required observations in estimating production efficiency.

1. Introduction

A firm's production efficiency is crucial for a firm's value creation process.[1] Firms with higher production efficiency usually have higher outputs with the same inputs and therefore have better operating performance. Kahn (1987) and other studies find that the variance of production exceeds the variance of sales with demand uncertainty and show that production variations substantially influence a firm's inventory flow, cash flow and its asset value distribution.[2] That is, a higher degree of uncertainty in production efficiency increases the variations of a firm's operating cash flows and may cause the firm's asset value distribution more volatile, which raise firm default probability and credit risk (Merton, 1974). In addition, according to Lambert et al. (2007), accounting information with less precision (more variation) increases the assessed variance of a firm's asset value. Since production efficiency cannot be fully detected by outside investors, the assessed effects of production efficiency on the accounting information present measurement errors. The uncertainty in production efficiency limits investors' ability to predict a firm's operating performance because of less precise (more

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[1] Production efficiency is defined as the ability to produce goods (outputs) with fewer resources (inputs).

[2] Kahn (1987) proposes a production counter-smoothing hypothesis to explain the stylized fact of inventory behavior. Blinder (1986) and West (1986) also have similar arguments.

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volatile) accounting information. Therefore, production efficiency uncertainty (PEU thereafter)[3] may increase the variation of the assessed asset value distribution which contributes to the increase in firm credit risk (Merton, 1974).[4] However, few existing studies consider the PEU effects into corporate credit models or investigate its effects on bond yield spreads.[5] To address this issue, this study employs American manufacturing firms' bond observations to examine the effects of PEU on firm credit risk. This investigation also contributes to the line of literature exploring the determinants of corporate bond yield spreads (a proxy for firm credit risk),[6] which is an important topic in credit risk management.

Most existing studies are on the relation between a firm's production efficiency (rather than PEU) and its credit risk. The literature of exploring production efficiency effects on credit risk can be roughly classified into two categories. One is to examine the relation between production inefficiency and business failure (later denoted as PIE_BF category); the other is to explore the linkage between productivity level and corporate capital structure (later denoted as PL_CS category). The PIE_BF category emphasizes the importance of production inefficiency for firm failure predictions. Becchetti and Sierra (2003) employ an inefficiency measure derived by a stochastic frontier approach to predict firm bankruptcy and find that production inefficiency is a significant ex-ante indicator of business failures.[7] In addition, because an enhancement in production efficiency improves a firm's operating cash flows and reduces its cash flow volatility (Mackay and Phillips, 2005; Maksimovic and Zechner, 1991),[8] a firm with higher production efficiency may have lower credit risk, according to structural form credit model, other things being equal.

The works of the PL_CS category, beginning with Brander and Lewis (1986, 1988) and Maksimovic (1988), focus more attention on the relation between product market decisions and capital structure. Kovenock and Phillips (1995) show that firms with low productivity plants in highly concentrated industries are likely to recapitalize and to increase debt financing (or equivalently, higher financial leverage). Miao (2005) provides a competitive equilibrium capital structure model considering industry dynamics, and shows that a firm's financing, investment, entry, and exit decisions are subject to its production efficiency.[9] Among the above studies, few of them investigate the PEU effects on firm credit risk.

Our main hypothesis for the effect of PEU on corporate bond yield spreads is mainly based upon the asset volatility perspective of structural form credit models (Merton, 1974). As previously mentioned, this study introduces Kahn (1987) and Lambert et al. (2007) as the theoretical foundations for the hypothesis development. Since production variance is important for a firm's inventory behavior (Kahn, 1987), production efficiency uncertainty increases the variations of a firm's inventory flow, cash flow, and asset value distribution. In addition, PEU makes a firm's accounting information less precise, which therefore increases the assessed variance of the firm's asset value distribution according to Lambert et al. (2007). Based upon the above discussions, greater PEU causes a firm's asset value distribution more volatile and ambiguous, which increases a firm's asset value volatility (or assessed volatility) and therefore its credit risk (or bond yield spreads) according to structural form credit model.

Many studies employ total factor productivity (TFP hereafter) as a proxy for a firm's production efficiency. According to the input–output model, TFP is defined as the portion of total outputs unexplained by factor inputs used in production (Solow, 1956, 1957). In other words, TFP represents the production innovation (efficiency) created in the stage from production to sales. Following previous studies, this work employs TFP as the proxy for production efficiency and firstly uses the volatility of TFP to be the proxy for PEU in the following empirical investigations. Regarding the estimation methods of TFP, many researches employ Cobb–Douglas function as the production function to describe the relation between sales outputs and factor inputs. Most previous studies use either plant-level or firm-level methods in estimating TFP. McGuckin and Pascoe (1988), Maksimovic and Phillips (2002), and Schoar (2002) estimate plant-level TFP by using data from Longitudinal Research Database (LRD).[10] On the other hand, Brynjolfsson and Hitt (1995, 1996), Lichtenberg (1995) and others adopt firm-level TFP estimation. Since it is difficult to obtain the LRD plant-level data, this study follows Brynjolfsson and Hitt (2003) to identify firm-level factor input variables and estimates TFP by the model specification of Schoar (2002).

This study empirically examines whether or not PEU significantly influences corporate bond yield spreads (firm credit risk) when controlling for well-known yield spread determinant variables, including leverage ratio, equity volatility, maturity, coupon, issuance amount, industrial concentration level, R&D intensity, information asymmetry, cash flow volatility and credit rating, by employing a sample consisting of 1297 manufacturing firm-year data, which accounts for 4376 annual bond observations from 1997 to 2008. This

[3] This study employs the variation (volatility) of production efficiency to be a proxy for production efficiency uncertainty (PEU).

[4] Among the structural form credit models of Merton (1974) and Duffie and Lando (2001), a firm's asset returns, asset volatility, default threshold, and incomplete accounting information are four core determinants of its credit risk.

[5] In credit risk literature, firm bond yield spreads represent the required premium of credit risk. Therefore, this study employs firm bond yield spreads as a measure of firm credit risk.

[6] Several extant studies explore the effects of firm or bond characteristics on bond yield spreads, including equity volatility (Campbell and Taksler, 2003), external liquidity risk (Longstaff et al., 2005; Warga, 1992), information asymmetry and information uncertainty (Güntay and Hackbarth, 2010; Liao et al., 2009; Lu et al., 2010; Yu, 2005), tax effect (Liu et al., 2006; Qi et al., 2010), internal liquidity (Chen et al., 2011) , institutional ownership (Wang and Zhang, 2009), real earnings management uncertainty (Chen et al., forthcoming) and so on. In addition, Tang and Yan (2010) also show that market conditions have significant impacts on bond yield spreads.

[7] Murillo-Zamorano and Vega-Cervera (2001) also employed parametric and non-parametric frontier methods to measure the productive efficiency in the industrial sector.

[8] Maksimovic and Zechner (1991) and Mackay and Phillips (2005) document that firms at the technological core of an industry experience lower cash flow risks and use less debt than firms at the technological fringe.

[9] Many empirical studies examine the relation between capital structure and firm entry, exit, investment and output decisions, such as Chevalier (1995a,b), Phillips (1995), Kovenock and Phillips (1997), Maksimovic and Phillips (1998), Zingales (1998), Lang et al. (1996), Mackay and Phillips (2005).

[10] The LRD database is maintained by the Center for Economic Studies at the Bureau of the Census and provides complete plant-level data of each plant's shipments, investments and labor inputs (the number of employees).