Panel Threshold Effect Analysis between Capital Structure and Operating Efficiency of Chinese Listed Companies

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Abstract
This paper, aiming to test whether there exists an optimal debt ratio, employs panel threshold regression model to examine threshold effects of financial leverage on operating efficiency (and firm value) of Chinese listed firms. The findings are that there exists triple threshold effect and the coefficients are all positive and significant for four regimes. These results identify that the operating efficiency is positively related to debt level. However, the positive effect decreases when debt ratio increases since the results show that the lower the debt to asset ratio, the higher the impact coefficient. Our result is consistent with ‘Trade-off Theory of Capital Structure’ and ‘Agency Theory’ and provides an implication that financial managers should use financial leverage wisely to improve the operating efficiency in order to maximize the firm value and investors should refer to the debt ratio to make investment decisions. As corporate bond market hasn’t been well developed in China and firm’s debt financing mainly depends on commercial banks, our result is helpful for loan managers in banks.

Keywords: Capital structure, Financial leverage, Debt financing, Operating efficiency, Panel threshold effect

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1. Introduction
1.1 Capital Structure Theories
How can we get stable financing sources and minimize the capital cost? How can we run our business everlastingly and maximize the shareholders’ wealth? Financing strategy is always the most important decision for financial managers. Generally speaking, sources of corporate financing mainly come from equity and debt securities. The firm’s mix of different securities is known as capital structure. How to find the best combination that maximizes the firm value is the objective of capital structure theories.

Modigliani and Miller (1958)’s ‘capital structure irrelevance theory’ states that the firm’s overall market value and the WACC is independent of capital structure in a perfect market without taxation. However, the free-tax perfect market doesn’t hold in the real world. Modigliani and Miller(1963) proposed the modified ‘Capital structure relevance theory’, which analyzed the present value of interest tax shields at the corporate level and found that ‘the higher the debt ratio, the higher the firm value’. Miller (1977) extends the MM model to personal as well as corporate taxes, and introduced the ‘Miller theory’, which considered the relative tax advantage of debt over equity.

Nevertheless, over borrowing will lead to financial distress and even bankruptcy. ‘The trade-off theory’ balances the tax advantage of borrowing against the costs of financial distress and states there exists the optimal capital structure. The value of the firm with borrowing equals the value if all-equity –financed plus the present value of tax shield and minus the present value of costs of financial distress. Costs of financial distress can be broken down to bankruptcy costs and costs of financial distress short of bankruptcy. Bankruptcy costs include direct costs such as court fees and indirect costs reflecting the difficulty of managing a company undergoing the liquidation or reorganization. In financial stress short of bankruptcy, conflicts of interest between bondholders and stockholders may lead to poor operating and investment decisions. Jensen and Meckling(1976) analyze the agency costs led by the conflicts of interest among managers, shareholders and creditors during a financial stress and their implication for financing policy. Jensen (1986) finds that managers of firms with unused borrowing power and large free cash flows are more likely to undertake low-benefit or even value-destroying mergers so higher debt ratio can reduce agency cost and increase firm value.

Ross(1977) proposed ‘the signaling theory’, which states that ‘Information
Asymmetry’ exists between managers and investors so the increase of debt ratio will be taken as a positive signal to the investors and hence increase the firm value. Myers and Majluf (1984) proposed ‘the pecking-order theory’, which states that firms use internal financing when available and choose debt over equity when external financing is required. After that, Lakshimi and Myers (1999) and Chirinko and Anuja (2000) tested static tradeoff against pecking order theory.

Scholars have done a lot of research about the determinants of capital structure choice. Kim and Sorensen (1986) find that firms with higher insider ownership have greater debt ratios than firms with lower insider ownership. They also find that high-growth firms use less debt rather than more debt, high-operating firms use more debt rather than less debt, and firm size appears to be uncorrelated to the level of debt. Titman and Wessels (1988) state that the short-term debt ratio has a negative relationship with the firm size. Bergman and Callen (1991) states there exists negative relationship between the ratio of intangible assets to total assets and the debt ratio. Burgman (1996) states that the multinational corporate capital structure was influenced by political risk, foreign exchange rate risk and high agency cost. Erwan (2001) studies the relationship between asset liquidity and capital structure.

The empirical research on the optimal capital structure includes: Castanias (1983) finds that ex ante default costs are large enough to induce the typical firm to hold an optimum mix of debt and equity. Brandley, et al. (1984) developed a theoretical model which highlights three firm-specific factors that influence the firm’s optimal capital structure: the variability of firm value, the level of non-debt tax shields, and the magnitude of the costs of financial distress. In the paper, Brandley, et al examines cross-sectional data and finds that firm leverage ratios are related inversely to earnings volatility. Altman (1984) compares the present value of expected bankruptcy costs with the present value of expected tax benefits from interest payments on leverage and concludes that the potential impact of bankruptcy costs on firm valuation and capital structure issues is very important. Leland and Toft (1996) examine the optimal capital structure of a firm that can choose both the amount and maturity of its debt. They find that short term debt does not exploit complete tax benefits but reduces agency cost compared to long term debt so the tax advantage of debt must be balanced against bankruptcy and agency costs in determining the optimal maturity of the capital structure. Philosophov (1999) develops a probabilistic Bayesian approach to assess the optimal debt to equity ratio, which affects both corporate returns and probabilities of bankruptcy to maximize the corporate value. Erik (2002) examines the debt ratios around the tender offers, and finds that the debt ratio may have to be
higher than optimal as predicted by the static trade-off model, in which tax benefits are traded off against financial distress costs in order to effectively deter takeovers.

However, there are still empirical evidences to support ‘Capital Structure Irrelevance Theory’. Flath and Knoeber (1980) finds that cross-sectional variation in capital structure was best explained by differences in operating risk, including that related to the regulatory process, and not by inter-industry differences in the tax advantage to interest, which were quite small. The general increase in interest as a percentage of EBIT that occurred between the earlier and later periods, was strongly related to the very great temporal increase in the tax advantage to interest that occurred between the two periods.

1.2 Chinese Stock Market and Financing Behavior of Listed Firms

There are two stock markets in China. One is Shanghai Stock Market; the other is Shenzhen Stock Market. They were established in 1990 and 1991 respectively. The establishment of stock markets was the demand of the economy reform. Open market brought severe competition and SOEs\(^1\) began to lose money. State owned banks encountered non-performing loans problems, operational difficulties and high risks, which cannot meet SOEs financing needs. One purpose of the establishment of stock markets is to stimulate the reform of SOEs. Therefore, most listed firms are SOEs, which have great influences on local economy. Having been used to get supporting from the government, managers of SOEs have no idea about the cost of capital. This free cash mentality is also related to the high uncertainty of transitional economy. In a trail-and-error process of economic reform, people cannot predict future according to their experiences. Having no clear expectations about the future, they tend to take into consideration only current cost and benefit in decision-making.

The development of the stock market is under strict regulation of the government. These regulations include quota restrictions and authorization system. Authorization system means that firms can go public only with the approval from the government. The quota system restricts the shares can be issued by a listed firm. Furthermore, government also restricts the issuing price.\(^2\) As a result, going public is peculiar right

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1 SOEs: State Owned Enterprises
2 Prior to Dec. 1996, quota system restricts the amount of shares can be issued in each province. The local government of province chooses the SOEs to go public, and report to CSRC for approval. In order to increase the number of firms to be listed, the local government always limits the size of the assets going public. In Dec. 1996, the quota system changed to restrict the number of firms to be listed. Restrictions on issuing price is based on a predetermined range of P/E, which is 15 to 20. The authorization system ceased to be effective in 2000. Restrictions on issuing price were also canceled in 2002.
to lucky firms. On the other side, corporate bond market has not been well developed which makes issuing corporate bonds very difficult for firms. All in all, Chinese firms have limited financing sources and access to stock market is a scarce resource.

Free cash mentality, limited financing resources induce the epidemic of ‘the thirst of capital’. We can find many symptoms of the epidemic, such as, many firms provide rights offering shortly after IPO, a lot of the money raised in listed firms is left unused, firms manipulate earnings in every way to meet the qualification of rights offering and etc. Referring to the capital structure, the debt ratio of Chinese listed firms is relatively low.

Though the long term ignores of capital cost and debt financing, Chinese listed firms should pay more attention to their capital structure and financing behavior. With the development of capital market, with the mature of investors, with the reform of Chinese government, if listed firms still pay no attention the capital cost and capital structure, they will be beaten in the open and severe competition. Chinese listed firms should find their optimal capital structure to reduce cost of capital and maximize firm value. Compared to equity financing, debt financing can bring tax shield to reduce the cost of capital. What’s more, increasing of debt financing can reduce agency cost and improve corporate governance. For Chinese investors, debt financing is a positive signal. Thus I predict debt financing can improve firm’s operating efficiency. However, on the other side, over borrowing can lead to financial distress and even bankruptcy. Hence, firms should carefully trade off costs and benefits of debt financing and find optimal debt ratio. This paper intends to examine the relationship between debt financing and operating efficiency.

Chinese scholars have done some empirical research about the relationship between the capital structure and firm value. Wang (2003) applied multiple regression analysis and concluded that debt financing has positive impact on firm value. Nevertheless, when I used the same method but different sample, completely different result is found. Accordingly, I thought it is better for us to use non-linear method than linear regression to study the relationship between capital structure and operating efficiency. This paper applies panel threshold regression model developed by Hansen (1996) to test whether there exists an optimal debt ratio. When debt ratio is below the threshold value, it has a positive relationship with firm’s operating efficiency, which means, at this time, managers can increase firm’s operating efficiency and firm value by increasing debt ratio. Contrarily, when debt ratio is above the threshold value, a negative relationship exists. If managers increase the debt ratio, operating efficiency
and firm value will decrease.

The rest of this paper is organized as follows. Section 2 describes the data resource and variables selection. Section 3 introduces panel threshold regression model, including empirical model, estimation method, testing process, asymptotic distribution of threshold estimate and etc. Section 4 presents empirical results and analysis. Section 5 concludes.

2. Data Resource and Variables Selection

This study analyzes a sample consisting of 821 A-shares listed firms traded on the SHSE and SZSE over December 1998-December 2002 interval. It is panel data. The total number of observations is 4105. Firms which were listed after 1998 are not included in the sample. All financial data we uses in this paper comes from CSMAR.

We choose ROA (Return on asset) as dependent variable. As we know, Tobin Q is a good indicator of firm value. However, Tobin q cannot well assess Chinese listed firm value because of the peculiar features of Chinese stock market. With the exception of a few listed firm that do not involve state ownership, all Chinese listed firms are restructured SOEs. For the government to have an effective control over state assets and SOEs, shares of a firm are typically split into state shares, legal-entity shares, and tradable shares, with the restriction that state and legal-entity shares cannot be traded publicly. State shares are those owned by the central or local government. Legal-entity shares are those held by domestic legal entities, such as listed companies, SOEs, banks, etc. So it is difficult for us to evaluate the market value of non-tradable shares. What’s more, the market value of debt and replacement cost is also difficult for valuation. Therefore, we choose the accounting indicator ROA to evaluate the firm’s operating efficiency and firm value. To fix notation, let \( v \) be the ratio of return on asset.

The independent variable is debt ratio, which is computed by ‘book value of total liabilities’ divided by ‘book value of total assets’. In this paper, debt ratio is also the threshold variable. Let \( d \) be debt ratio.

Table 1. Descriptive summary of ROA and Debt Ratio.

<table>
<thead>
<tr>
<th></th>
<th>Minimum</th>
<th>25%</th>
<th>Medium</th>
<th>75%</th>
<th>Maximum</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Debt ratio</td>
<td>0.005535</td>
<td>0.306142638</td>
<td>0.42795837</td>
<td>0.5547367</td>
<td>13.58267</td>
<td>0.453161</td>
</tr>
<tr>
<td>ROA</td>
<td>-13.0837</td>
<td>0.014648006</td>
<td>0.04189124</td>
<td>0.0674998</td>
<td>0.812518</td>
<td>0.023634</td>
</tr>
</tbody>
</table>
3. Model
This paper applies Panel Threshold Regression Analysis developed by Hansen (1999) to test the threshold effect for panel data.

3.1 Threshold Autoregressive Model
Tong (1978) proposed Threshold Autoregressive model, thereafter, this non-linear time series model becomes very popular for economic and financial research.

When we estimate Threshold Autoregressive Model, first we should test whether there exists threshold effect. If we accept the null hypothesis, the threshold effect doesn’t exist. Again, the existence of nuisance will make the testing statistic follow non-standard distribution, which was called ‘Davies’ Problem³. Hansen (1999) suggests that a bootstrap method to compute the asymptotic distribution of testing statistics in order to test the significance of threshold effect. Furthermore, when the null hypothesis doesn’t hold, which means, the threshold effect does exist, Chan (1993) proves that OLS estimation of threshold is super consistent, and then derive the asymptotic distribution. However, nuisance influences this distribution and make it non-standard. Hansen (1999) uses simulation likelihood ratio test to derive the asymptotic distribution of testing statistic for a threshold.

Hansen (1999) proposes to use two-stage OLS method to estimate the panel threshold model. On the first stage, for any given threshold ($\gamma$), we compute the sum of square errors (SSR) separately. On the second stage, we find the estimation of $\gamma$ by minimization of the sum of squares. At last, we can use the estimation of threshold to estimate the coefficient for every regime and do analysis.

3.2 Threshold Model Construction
In this paper, we want to examine whether threshold effect exists between the financial leverage and firm’s operating efficiency. According to ‘Trade-off Theory of Capital Structure’, when debt ratio increases, the interest tax shield increases; however, on the other side, costs of financial distress increase to counteract the positive effect of debt ratio to firm value. Thus I hypothesize that there exists an optimal debt ratio, and try to use threshold model to estimate this ratio which can help us understand the relationship between financial leverage and operating efficiency as

well as help financial managers, loan managers and investors make decisions.

So we set up single threshold model as follows.

\[ v_i = \mu_i + \alpha_1 d_i I(d_i \leq \gamma) + \alpha_2 d_i I(d_i > \gamma) + \varepsilon_i \tag{1} \]

Where \( v_i \) represents the ratio of return on assets; \( d_i \), the threshold variable, represents the ratio of debts to assets; \( \mu_i \), the fixed effect, represents the heterogeneity of companies under different operating conditions; \( I(\cdot) \) is the indicator function. The errors \( \varepsilon_i \) is assumed to be independent and identically distributed (iid) with mean zero and finite variance \( \sigma^2 \); \( i \) represents different companies; \( t \) represents different periods.

Another compact representation of (1) is to set

\[ \alpha = (\alpha_1, \alpha_2)' \]

and \( d_i = \begin{bmatrix} d_i I(d_i \leq \gamma) \\ d_i I(d_i > \gamma) \end{bmatrix} \) so that (1) equals

\[ v_i = \mu_i + \alpha' d_i(\gamma) + \varepsilon_i \tag{2} \]

The observations are divided into two ‘regimes’ depending on whether the threshold variable \( d_i \) is smaller or larger than the threshold \( \gamma \). The regimes are distinguished by differing regression slopes, \( \alpha_1 \) and \( \alpha_2 \). We will use known \( v_i \) and \( d_i \) to estimate the parameters \( \gamma \), \( \alpha \) and \( \sigma^2 \).

### 3.3 Estimation

Note that taking averages of (2) over the time index \( t \) produces

\[ \bar{v}_i = \mu_i + \alpha' \bar{d}_i(\gamma) + \bar{\varepsilon}_i \tag{3} \]

where \( \bar{v}_i = \frac{1}{T} \sum_{t=1}^{T} v_i \), \( \bar{\varepsilon}_i = \frac{1}{T} \sum_{t=1}^{T} \varepsilon_i \), and

\[ \bar{d}_i(\gamma) = \frac{1}{T} \sum_{t=1}^{T} d_i(\gamma) = \begin{bmatrix} \frac{1}{T} \sum_{t=1}^{T} d_i I(d_i \leq \gamma) \\ \frac{1}{T} \sum_{t=1}^{T} d_i I(d_i > \gamma) \end{bmatrix} \]

Taking the difference between (2) and (3) yields

\[ v_i^* = \alpha' d_i^*(\gamma) + \varepsilon_i^* \tag{4} \]

where \( v_i^* = v_i - \bar{v}_i \), \( d_i^*(\gamma) = d_i(\gamma) - \bar{d}_i(\gamma) \), \( \varepsilon_i^* = \varepsilon_i - \bar{\varepsilon}_i \)

Let
\begin{align*}
v_i^* &= \begin{bmatrix} v_{i1}^* \\ \vdots \\ v_{iT}^* \end{bmatrix}, \\
d_i^*(\gamma) &= \begin{bmatrix} d_{i1}^*(\gamma) \\ \vdots \\ d_{iT}^*(\gamma) \end{bmatrix}, \\
e_i^* &= \begin{bmatrix} e_{i1}^* \\ \vdots \\ e_{iT}^* \end{bmatrix}
\end{align*}

\[
v^* = \begin{bmatrix} v_1^* \\ \vdots \\ v_n^* \end{bmatrix}, \\
D^*(\gamma) = \begin{bmatrix} d_1^*(\gamma) \\ \vdots \\ d_n^*(\gamma) \end{bmatrix}, \\
e^* = \begin{bmatrix} e_1^* \\ \vdots \\ e_n^* \end{bmatrix}
\]

denote the stacked data and errors for an individual, with one time period deleted. Then let \( V^*, D^*(\gamma) \) and \( e^* \) denote the data stacked over all individuals.

\[
V^* = D^*(\gamma)\alpha + e^*
\]

For any given \( \gamma \), the slope coefficient \( \alpha \) can be estimated by ordinary least squares (OLS). That is,

\[
\hat{\alpha}(\gamma) = (D^*(\gamma)'D^*(\gamma))^{-1}D^*(\gamma)V^*
\]

The vector of regression residuals is

\[
\hat{e}^*(\gamma) = V^* - D^*(\gamma)\hat{\alpha}(\gamma)
\]

and the sum of squared errors is

\[
SSE_1(\gamma) = \hat{e}^*(\gamma)'\hat{e}^*(\gamma) = V^* (I - D^*(\gamma)(D^*(\gamma)'D^*(\gamma))^{-1}D^*(\gamma))V^*
\]

Chan (1993) and Hansen (1999) recommend estimation of \( \gamma \) by least squares. This is easier to achieve by minimization of the concentrated sum of squared errors (7).

Hence the least squares estimators of \( \gamma \) is

\[
\hat{\gamma} = \arg \min SSE_1(\gamma)
\]

Once \( \hat{\gamma} \) is obtained, the slope coefficient estimate is \( \hat{\alpha} = \hat{\alpha}(\hat{\gamma}) \). The residual vector is

\[
\hat{e}^* = \hat{e}^*(\hat{\gamma})
\]

and residual variance

\[
\hat{\sigma}^2 = \hat{\sigma}^2(\hat{\gamma}) = \frac{1}{n(T - 1)}\hat{\sigma}^* (\hat{\gamma})\hat{e}^*(\hat{\gamma}) = \frac{1}{n(T - 1)}SSE_1(\hat{\gamma})
\]

where \( n \) indexes the number of sample, \( T \) indexed the periods of sample.

### 3.4 Testing for a threshold

This paper hypothesizes that there exists threshold effect between the debt ratio and operating efficiency. It is important to determine whether the threshold effect is statistically significant. The null hypothesis and alternative hypothesis can be
represented as follows

\[
\begin{align*}
H_0 : \alpha_1 &= \alpha_2 \\
H_1 : \alpha_1 &\neq \alpha_2
\end{align*}
\]

When the null hypothesis holds, the coefficient \( \alpha_1 = \alpha_2 \), the threshold effect doesn’t exist. When the alternative hypothesis holds, the coefficient \( \alpha_1 \neq \alpha_2 \), the threshold effect exists between the debt ratio and operating efficiency.

Under the null hypothesis of no threshold, the model is

\[
v_{it} = \mu_i + \alpha'_i d_{it}(\gamma) + \epsilon_{it}
\]

After the fixed-effect transformation is made, we have

\[
V_{it}^* = \alpha'_i d_{it}^*(\gamma) + \epsilon_{it}^*
\]

The regression parameter is estimated by OLS, yielding estimate \( \hat{\alpha}_i \), residuals \( \tilde{\epsilon}^* \), and sum of squared errors \( SSE_0 = \tilde{\epsilon}^{*'} \tilde{\epsilon}^* \).

Hansen (1999) suggests that we use the F Test Approach to test the existence of threshold effect, and use the sup-Wald statistic to test the null hypothesis.

\[
F = \sup F(\gamma)
\]

\[
F(\gamma) = \frac{(SSE_0 - SSE_1(\gamma))/1}{SSE_1(\hat{\gamma})/n(T-1)} = \frac{SSE_0 - SSE_1(\hat{\gamma})}{\sigma^2}
\]

Under the null hypothesis, some coefficients (e.g. the pre-specified threshold \( \gamma \)) do not exist, therefore, the unisance exists. According to Davies’ problem (1977,1987), the F statistic becomes non-standard distribution. Hansen (1996) shows that a bootstrap procedure attains the first-order asymptotic distribution, so p-values constructed from the bootstrap are asymptotically valid. Treat the regressors and threshold variable \( d_{it} \) as given, holding their values fixed in repeated bootstrap samples. Take the regression residuals \( \hat{\epsilon}_{it}^* \), and group them by individual:

\[
\hat{\epsilon}_{i}^* = (\hat{\epsilon}_{i1}^*, \hat{\epsilon}_{i2}^*, \ldots, \hat{\epsilon}_{iT}^*)
\]

Treat the sample \( \{\hat{\epsilon}_1^*, \hat{\epsilon}_2^*, \ldots, \hat{\epsilon}_n^*\} \) as the empirical distribution to be used for bootstrapping. Draw a sample size of \( n \) from the empirical distribution and use these errors to create a bootstrap sample under \( H_0 \). Using the bootstrap sample, estimate the model under the null (12) and alternative (4) and calculate the bootstrap value of the likelihood ratio statistic \( F(\gamma) \) (14). Repeat this procedure a large number of times and calculate the percentage of draws for which the simulated
statistic exceeds the actual. This is the bootstrap estimate of the asymptotic p-value for \( F(\gamma) \) under \( H_0 \). The null of no threshold effect is rejected if the p-value is smaller than the desired critical value.

\[
P = P(\tilde{F}(\gamma) > F(\gamma) \mid \zeta)
\]

where \( \zeta \) is the conditional mean of \( \tilde{F}(\gamma) > F(\gamma) \).

### 3.5 Asymptotic distribution of threshold estimate

Chan (1993) and Hansen (1999) have shown that when there is a threshold effect \( \alpha_1 \neq \alpha_2 \), \( \hat{\gamma} \) is consistent for \( \gamma_0 \), and that the asymptotic distribution is highly non-standard. Hansen (1999) argues that the best way to form confidence intervals for \( \gamma \) is to form the ‘no-rejection region’ using the likelihood ratio statistic for tests on \( \gamma \). To test the hypothesis

\[
\begin{aligned}
H_0 : \gamma &= \gamma_0 \\
H_1 : \gamma &\neq \gamma_0
\end{aligned}
\]

We construct the testing model

\[
LR_i(\gamma) = \frac{SSE_i(\gamma) - SSE_i(\hat{\gamma})}{\hat{\sigma}^2}
\]

Hansen (1999) points out that when \( LR_i(\gamma_0) \) is too large and the p-value exceeds the confidence interval, the null hypothesis is rejected\(^4\). Besides, Hansen (1999) indicates that under some specific assumptions\(^5\) and \( H_0 : \gamma = \gamma_0 \),

\[
LR_i(\gamma) = d\zeta
\]

as \( n \to \infty \), where \( \zeta \) is a random variable with distribution function

\[
P(\zeta \leq x) = (1 - \exp(-\frac{x}{\sqrt{2}}))^2
\]

The asymptotic p-value can be estimated under the likelihood ratio. According to the proof of Hansen(1999), the distribution function (18) has the inverse

\[
c(\alpha) = -2\log(1 - \sqrt{1 - \alpha})
\]

from which it is easy to calculate critical values. For a given asymptotic level \( \alpha \), the null hypothesis \( \gamma = \gamma_0 \) rejects if \( LR_i(\gamma) \) exceeds \( c(\alpha) \).

---

\(^4\) Note that the statistic (16) is testing a different hypothesis from the statistic (14) introduced in the previous section. \( LR_i(\gamma_0) \) is testing \( H_0 : \gamma = \gamma_0 \) while \( F(\gamma) \) is testing \( H_0 : \alpha_1 = \alpha_2 \).

3.6 Multiple thresholds Model
If there exist triple thresholds, the model is

\[
v_{it} = \begin{cases} 
\mu_i + \alpha_1 d_{it} + \epsilon_{it} \cdots \text{if } d_{it} \leq \gamma_1 \\
\mu_i + \alpha_2 d_{it} + \epsilon_{it} \cdots \text{if } \gamma_1 < d_{it} \leq \gamma_2 \\
\mu_i + \alpha_3 d_{it} + \epsilon_{it} \cdots \text{if } \gamma_2 < d_{it} \leq \gamma_3 \\
\mu_i + \alpha_4 d_{it} + \epsilon_{it} \cdots \text{if } d_{it} > \gamma_3 
\end{cases}
\]  
(20)

where threshold value \( \gamma_1 < \gamma_2 < \gamma_3 \). This can be extended to multiple thresholds model \(( \gamma_1, \gamma_2, \gamma_3, \cdots, \gamma_n )\).

4. Empirical Results
This paper applies the threshold theory proposed by Hansen (1999) and hypothesize that debt ration and operating efficiency have asymmetric nonlinear relationship. First let us test whether there exist the triple thresholds effect. We test single threshold, double threshold and triple threshold effect respectively. The models are as follows.

\[
v_{it} = \begin{cases} 
\mu_i + \alpha_1 d_{it} + \epsilon_{it} \cdots \text{if } d_{it} \leq \gamma \\
\mu_i + \alpha_2 d_{it} + \epsilon_{it} \cdots \text{if } d_{it} > \gamma 
\end{cases}
\]

\[
v_{it} = \begin{cases} 
\mu_i + \alpha_1 d_{it} + \epsilon_{it} \cdots \text{if } d_{it} \leq \gamma_1 \\
\mu_i + \alpha_2 d_{it} + \epsilon_{it} \cdots \text{if } \gamma_1 < d_{it} \leq \gamma_2 \\
\mu_i + \alpha_3 d_{it} + \epsilon_{it} \cdots \text{if } d_{it} > \gamma_2 
\end{cases}
\]

\[
v_{it} = \begin{cases} 
\mu_i + \alpha_1 d_{it} + \epsilon_{it} \cdots \text{if } d_{it} \leq \gamma_1 \\
\mu_i + \alpha_2 d_{it} + \epsilon_{it} \cdots \text{if } \gamma_1 < d_{it} \leq \gamma_2 \\
\mu_i + \alpha_3 d_{it} + \epsilon_{it} \cdots \text{if } \gamma_2 < d_{it} \leq \gamma_3 \\
\mu_i + \alpha_4 d_{it} + \epsilon_{it} \cdots \text{if } d_{it} > \gamma_3 
\end{cases}
\]

The dependent variable \( v_{it} \) represents ROA, the indicator of operating efficiency. The independent \( d_{it} \) represents debt ratio, in this paper \( d_{it} \) is also threshold variable.

This paper follows the bootstrap method to get the approximation of F statistic and then calculate the p-value. Table 2 presents the empirical results of test for single threshold, double threshold, and triple threshold effects. Through 200 bootstrap replications for each of the three bootstrap tests, we find that the test for a single threshold is highly significant with a bootstrap p-value of 0.03, the test for a double threshold is also significant with a p-value of 0.06, and the test for a triple threshold is statistically significant with a p-value of 0.02. The p-value is least for the test of a triple threshold effect, therefore we conclude that there exists a triple threshold effect.
between the debt ratio and operating efficiency.

**Table 2 Tests for threshold effects**

<table>
<thead>
<tr>
<th>Test</th>
<th>$F$</th>
<th>P-Value</th>
<th>(10%, 5%, 1% critical value)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single threshold</td>
<td>19.446401</td>
<td>0.03</td>
<td>(11.34, 14.4, 20.68)</td>
</tr>
<tr>
<td>Double threshold</td>
<td>10.198337</td>
<td>0.06</td>
<td>(9.14, 10.78, 15.28)</td>
</tr>
<tr>
<td>Triple threshold</td>
<td>10.127469</td>
<td>0.02</td>
<td>(6.9, 8.63, 10.96)</td>
</tr>
</tbody>
</table>

••• denotes significance at the 10%, 5%, 1% level respectively.

When there exists a triple threshold effect between the debt ratio and operating efficiency, all observations are split into four regimes. Table 2 represents the threshold estimates and Table 4 represents the regression slope estimates, conventional OLS standard errors, and White-corrected standard errors for four regimes.

**Table 3 Threshold estimate**

<table>
<thead>
<tr>
<th>Estimate</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\hat{\gamma}_1$</td>
<td>0.21654495</td>
</tr>
<tr>
<td>$\hat{\gamma}_2$</td>
<td>0.35053867</td>
</tr>
<tr>
<td>$\hat{\gamma}_3$</td>
<td>0.51936048</td>
</tr>
</tbody>
</table>

**Table 4 Regression estimates: triple threshold model**

<table>
<thead>
<tr>
<th>Coefficient estimate</th>
<th>OLS Se (6.3)</th>
<th>White Se (2.75)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\hat{\alpha}_1$</td>
<td>0.88791656***</td>
<td>0.14039845(6.3)</td>
</tr>
<tr>
<td>$\hat{\alpha}_2$</td>
<td>0.51746028***</td>
<td>0.06845810(7.65)</td>
</tr>
</tbody>
</table>
\[ \hat{\alpha}_3 = 0.34217229^{***} \quad 0.040440677(8.5) \quad 0.13830329(2.474) \]
\[ \hat{\alpha}_4 = 0.25437742^{***} \quad 0.016846981(15.1) \quad 0.10603472(2.399) \]

1. \( ^{***} \) denotes at the significance of 1% level.
2. \( \hat{\alpha}_1 \) is the coefficient estimate for \( d_u \leq \hat{\gamma}_1 \), \( \hat{\alpha}_2 \) is the coefficient estimate for \( \hat{\gamma}_1 < d_u \leq \hat{\gamma}_2 \), \( \hat{\alpha}_3 \) is the coefficient estimate for \( \hat{\gamma}_2 < d_u \leq \hat{\gamma}_3 \) and \( \hat{\alpha}_4 \) is the coefficient estimate for \( d_u > \hat{\gamma}_3 \).
3. The value inside [ ] is t-value.

The estimated model from empirical research is as follows:
\[
\nu_u = \mu_u + 0.89d_uI(d_u \leq 0.22) + 0.52d_uI(0.22 < d_u \leq 0.35) + 0.34d_uI(0.35 < d_u \leq 0.52) + 0.25d_uI(d_u > 0.52) + \varepsilon_u
\]

\( \hat{\gamma}_1 \), \( \hat{\gamma}_2 \) and \( \hat{\gamma}_3 \) split the observations into four regimes. In the first regime, where the debt ratio is below 22%, the estimate of coefficient \( \hat{\alpha}_1 \) is 0.89, which means, when the debt ratio is increased by 1%, ROA will be increased by 0.89%. In the second regime, where the debt ratio is above 22% but below 35%, the estimate of coefficient \( \hat{\alpha}_2 \) is 0.52, which implies, ROA will be increased by 0.52% by 1% increase of debt ratio. In the third regime, where the debt ratio is above 35% but below 52%, the estimate of coefficient \( \hat{\alpha}_3 \) is 0.34, that is, when debt ratio is increased by 1%, ROA will be increased by 0.34%. In the fourth regime, where debt ratio is above 52%, the estimate of coefficient \( \hat{\alpha}_4 \) is 0.25, that is, ROA will be

Figure 1. Confidence interval construction in triple threshold model.
increased by 0.25% by 1% increase of debt ratio. According to table 4, the estimates $\hat{\alpha}_1, \hat{\alpha}_2, \hat{\alpha}_3, \hat{\alpha}_4$ are all significant under the 1% level under the consideration of both homogenous standard errors and heterogeneous standard errors.

From empirical research we find that the increase of debt ratio can improve the operating efficiency of firms thus increase firm value. This finding is consistent with the proposition MM (1963). On the other side, costs of financial distress increase as the debt ratio increase gradually, which counteracts the positive effect of debt ratio to operating efficiency. Our finding $\hat{\alpha}_4 < \hat{\alpha}_3 < \hat{\alpha}_2 < \hat{\alpha}_1$ is consistent with this view. This result can also be explained by agency theory. On one hand, higher debt ratio means less free cash flow for managers to manipulate, which can reduce agency cost and increase firm’s operating efficiency. On the other hand, when the debt ratio is too high which leads to financial distress, the conflicts between creditors and shareholders will increase the agency costs and reduce the operating efficiency. Therefore, we conclude that if financial managers use financial leverage deliberately, operating efficiency will be improved and firm value will be increased.

5. Conclusions
The paper applies panel threshold regression model to examine whether financial leverage affects operating efficiency thus affects firm value of Chinese listed firms. We intend to test whether there exists an optimal debt ratio, which leads to the asymmetric relationship between the debt ratio and operating efficiency.

Under the consideration of the special features of Chinese stock market, we choose ROA as the indicator of the operating efficiency of the firms to test threshold effect based on their debt to asset ratio. We find that there exists triple threshold effect and the coefficients are all positive and significant for four regimes. Our results identify that the operating efficiency is positively related to debt level, with ‘very low debt’ firms having a higher coefficient. but the positive effect decreases when debt ratio increases. When debt ratio increases, the interest tax shield increases; however, on the other side, costs of financial distress increase to counteract the positive effect of debt ratio to firm value. As Chinese listed firms prefer equity financing and their debt to asset ratios are relatively low, the benefits of interest tax shield are higher than costs of financial distress. This result can also be explained by agency theory. On one hand, higher debt ratio means less free cash flow for managers to manipulate, which can reduce agency cost and increase firm’s operating efficiency. On the other hand, when the debt ratio is too high which leads to financial distress, the conflicts between
creditors and shareholders will increase the agency costs and reduce the operating efficiency.

Our results indicate that financial managers should use financial leverage wisely to improve the operating efficiency in order to maximize the firm value and investors should refer to the debt ratio to make investment decisions. As corporate bond market has not been well developed in China and firm’s debt financing mainly depends on commercial banks, our result is helpful for loan managers in banks.

References
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