Impact of Registration System Reform on IPO Pricing Efficiency in China's Capital Market

Based on Stochastic Frontier Analysis

Jiayi Lyu(✉)

Department of Business, Nankai University, Tianjin 300000, China
2012028@mail.nankai.edu.cn

Abstract. Since 2019, China's registration-based reform has continuously advanced, leading to a more market-oriented approach to IPO pricing. However, there is little agreement on whether IPO pricing efficiency has improved. As a result, this research compiles IPO data from 354 businesses listed in the GEM and 119 companies listed in the STAR market to assess IPO pricing efficiency before and after registration system reform using the stochastic frontier model. According to the study, GEM's IPO pricing efficiency was 80.83% in the first year after the registration system was implemented and increased to 84.75% in the following year. This was lower than it had been before the registration system reform but higher than the IPO pricing efficiency of the STAR market. This essay examines the institutional investors, information disclosure, and IPO inquiry process as causes of the reduction in efficiency and makes three recommendations that are each comparable to each.

Keywords: IPO · Pricing efficiency · Stochastic frontier analysis

1 Introduction

The 'securities issuance registration system' has been tested by the sci-tech innovation board (STAR market) in 2019. The growth enterprise market (GEM) implemented a registration system in 2020, further boosting registration reform. The Beijing stock market, which was established in 2021, thereafter adopted the registration system, increasing the scope of the registration system reform. "Capital market reform will be further promoted with the full implementation of the stock issuance registration system as the main target," the China Securities Regulatory Commission (CSRC) stated at the 2022 system work conference. Full implementation of the stock issuance registration system in China's capital market is becoming a general trend.

The price of new shares is left to the market with the establishment of more market-oriented policies. What effect does this have on the efficiency of IPO pricing? What is the difference between the GEM and the STAR market? What are the existing system's flaws in terms of IPO pricing? The discussion of these topics may help people better grasp the impact of the IPO registration system reform, give a point of reference for improving the securities issuance registration system, and enhance relevant IPO research in China's stock market.

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Pricing efficiency research has long been an essential component of capital market efficiency research. Mao Zongping and Chuan Wen (2004) proposed two IPO measurement standards: absolute price efficiency and relative price efficiency [1]. The degree of match between the issue price of new shares and the closing price on the first day is referred to as absolute price efficiency. The closer the distance between the two prices, the greater the price efficiency. Many academics use the first-day underpricing rate to assess the impact of IPO pricing, however, this approach is predicated on the idea that the secondary market is effective and that the first-day IPO's closing price can accurately capture the company's intrinsic worth. The effectiveness of the Chinese stock market, however, has never been universally agreed upon. As a result, some researchers, like Cao Fengqi and Dong Xiuliang (2006), thought that the relative efficiency criteria are more suited to gauge the effectiveness of IPO pricing [2].

The degree of connection between the issue price of new shares and other factors influencing IPO pricing is referred to as relative price efficiency. The challenge of this approach is determining the real intrinsic value of new shares. The Stochastic Frontier Model (SFM) is commonly employed in domestic and international calculating research. Using the stochastic frontier analysis approach, Hunt and others (1996) were the first to utilize the SFM in assessing IPO price efficiency in the US stock market [3]. Based on the model, Liu qiangqiang and colleagues (2016) created an index to assess the efficiency of production technology - EFF value, that is, the degree to which the issue price deviates from the intrinsic value, to compare the efficiency of IPO pricing more intuitively [4]. The SFM has also been refined using the Bayesian technique by Jin et al. (2020) [5]. Scholars then keep enhancing and polishing the model, as well as conducting much empirical research.

As the STAR market is an emerging market segment and the GEM was established earlier and had been under an approved system until 24 August 2020, this paper will select pricing data from the GEM before and after the registration system for longitudinal comparative analysis and further explore the impact of the registration system reform on the pricing efficiency of China's capital market through a cross-sectional comparison with the STAR market. For the quantitative measurement of IPO pricing efficiency, this paper will use a stochastic frontier model to calculate the IPO pricing efficiency using a combination of all relevant influencing factors.

2 Measuring and Samples

2.1 Stochastic Frontier Model

Aigner et al. (1977) first developed the stochastic frontier model to assess manufacturers' production efficiency [6]. The calculations produced by the stochastic frontier are comparatively steady and examine the output as a single variable while taking the influence of random elements on the output into account, not affected by outliers. After discovering that the productivity measure and the IPO pricing efficiency measure share many characteristics, Hunt et al. (1996) took the initiative to apply the model to the study of the IPO pricing efficiency of the US stock market.

The stochastic frontier model is used to estimate the optimal price of the intrinsic value of the IPO firm, that is, the effective frontier. The IPO price is seen as the output, and the fundamental variables impacting the IPO pricing are viewed as the input of each element. The efficiency loss in selecting the issue price, which allows us to assess the pricing effectiveness of IPOs, is the difference between the actual issue price and the ideal pricing.

2.2 Model with Stochastic Upper Bounds for IPO Pricing

A stochastic upper frontier model of IPO price is built using the concept of stochastic production frontier analysis:

$$y_i = f(x_i, \beta) * TE_i * exp(v_i) \tag{1}$$

Among them, y_i represents the ith manufacturer's actual output, $f(x_i, \beta)$ represents the matching theoretical output, β is the parameter to be evaluated, and x_i represents the input. TE_i is the ith manufacturer's technical efficiency and $0 \leq TE_i \leq 1$. $TE_i = 1$ means there is no efficiency loss. $Exp(v_i)$ is a random shock that takes random disturbances from outside variables into account. Assuming that $f(x_i, \beta) = \exp(\beta_0)x_1^{\beta} \ldots x_k^{\beta_k}$ (subject to Cobb-Douglas distribution) is useful for quantitative analysis, the logarithm of formula (1) is as follows.

$$lny_i = \beta_0 + \sum\nolimits_{k=1}^{n} \beta_k lnx_k + lnTE_i + v_i \tag{2}$$

Let $u_i = -ln(TE_i)$, where TE_i is the production technology's inefficiency. Since $0 \leq TE_i \leq 1$ then $u_i \geq 0$; let $\varepsilon_i = v_i - u_i$, which means the compound disturbance term, where v_i is the random disturbance in the general sense term, assuming $v_i \sim N\left(0, \sigma^2\right)$ and independent of u_i; u_i is the technical invalidity term to measure the difference between actual output and frontier surface, which can be set as half-normal distribution, truncated normal distribution, or other distribution. Here it is set to a half-normal distribution. The integrated formula is as follows:

$$lny_i = \beta_0 + \sum\nolimits_{k=1}^{n} \beta_k lnx_k + \varepsilon_i \tag{3}$$

A maximum likelihood estimation (MLE) is necessary to estimate the technically incorrect term u_i since the mixed disturbance term $\varepsilon_i = v_i - u_i$ is not distributed asymmetrically. The corresponding value of β is obtained after the MLE, so that the price frontier value $\mathrm{E}(P_i|u_i = 0, x_i)$ can be obtained. Also, efficiency can be defined as the ratio of the expected value of the actual issuance price to the expected value of the theoretical issuance price (the price frontier value). The pricing efficiency value is derived as follows:

$$TE = exp(-u) = \frac{E(P_i|u_i, x_i)}{E(P_i|u_i = 0, x_i)} \tag{4}$$

When $u_i = 0$, the efficiency is the highest, indicating that there is no system inefficiency and that the difference between the real and theoretical issue prices is caused only by random mistakes. When $u_i > 0$, the mechanism is inefficient, and the difference between the actual issue price and the theoretical maximum issue price includes the technically invalid item u_i. The individual's price efficiency may be calculated using the IPO pricing stochastic upper bound model. The efficiency value has a value range of [0, 1]. The pricing efficiency value increases as the inefficiency error u_i decreases, suggesting that the real issue price approaches the theoretical ideal price.

Battese et al. (1995) proposed the following relationship for evaluating inefficiency states [7]:

$$\gamma = \frac{\sigma_u^2}{\sigma_v^2 + \sigma_u^2} \tag{5}$$

Among these, σ_v^2 stands for the variance of random interference items and σ_u^2 stands for the variance of technically invalid items. γ stands for the proportion of technical invalid items error to the overall error, and its value ranges from [0,1]. If γ is near 0, it means that random mistakes are mostly to blame for the discrepancy between the IPO price and the ideal boundary. At this time, the effect of MLE is not better than the ordinary least square (OLS) method. If γ is close to 1, it indicates that the presence of technical invalid term error primarily causes the gap between IPO pricing and the optimal boundary, and MLE is better at this time. Close to 1 in the stochastic upper bound model implies that the IPO issue price is underpriced; close to 1 in the stochastic lower bound model shows that the IPO issue price is overpriced.

2.3 Model with Stochastic Lower Bounds for IPO Pricing

In line with the concept of stochastic cost boundary analysis, the following is presented for the stochastic lower boundary model for IPO pricing:

$$lnP_i = \beta_0 + \sum\nolimits_{k=1}^{n} \beta_k lnx_k + v_i + u_i \tag{6}$$

In contrast to the stochastic upper bound model, the sign before u_i has changed. When the real issue price is systematically greater than the estimated theoretical issue price, the difference between the two appears as residual bias. The cost efficiency formula is currently as follows. The efficiency value has a value range of $[1, +\infty]$. The inefficiency decreases as the value decreases, and the real issue price approaches the theoretical minimum price.

$$TE = \exp(u) \tag{7}$$

2.4 Empirical Model and Variable Definition

Referring to past relevant literature and taking data availability into account, the influencing indicators of IPO price are chosen from elements such as the company's intrinsic worth, risk factors, market and macro-environmental factors, as indicated in Table 1 [8–10].

After replacing numerous influencing elements according to formula (3), the model is formed as follows:

$$\begin{aligned} lnP_i = \beta_0 + \beta_1 ln(PE) + \beta_2 ln(ROE) + \beta_3 ln(EPS) + \beta_4 ln(TA) \\ + \beta_5 ln(NUM) + \beta_6 ln(LEV) + \beta_7 ln(FEE) + v_i - u_i \end{aligned} \tag{8}$$

Table 1. Influence Indicators on IPO Pricing

Variable types	Variable names	Variable Symbols	Variable definitions
Response variable	Issue price	Pi	IPO price
Explanatory variables	Initial price-to-earnings ratio	PE	P/E Ratio of IPO
	Return on equity	ROE	Return on equity in the year before listing
	Earnings per share	EPS	Earnings per share after deducting non-recurring gains and losses for the year before listing
	Debt to asset ratio	LEV	Debt to asset ratio in the year before listing
	Total assets	TA	Total assets at IPO
	Number of IPO	NUM	The number of IPO of listed companies
	Issuance fee	FEE	Total issuance fee

2.5 Sources of Samples and Data

The IPO and financial data of listed businesses in the GEM and the STAR market selected for this article are mainly obtained from the Wind database. The research interval selected is from 1 June 2019 to 1 June 2020 before the GEM registration system reform, from 1 September 2020 to 1 June 2021 in the first year after the reform, and from 1 June 2021 to 1 June 2022 in the second year after the reform on the GEM; and from 1 June 2021 to 1 June 2022 after the registration system reform on the STAR market.

The final sample companies are: 54 companies listed on the STAR market prior to the reform, 113 companies in the first year following the reform, 187 companies in the second year, and 119 companies listed on the STAR market. Companies with missing key data have been eliminated from the sample.

3 Empirical Results

The existence and skewness of unilateral systematic errors should be tested before using the stochastic frontier model for analysis.

Table 2 summarizes the results of the stochastic frontier model applicability test for the four sample groups. It is discovered that the value of γ is near 1, indicating that it is mainly the presence of the technical invalid term error that leads to the gap between IPO pricing and the optimal frontier. At this point, MLE is employed to better estimate the effect, demonstrating that the stochastic frontier model is appropriate.

Figures 1, 2, 3, 4 show the histograms of residual distributions derived by OLS regression for each of the four samples. The residuals of the four groups of data may

Table 2. Results of Stochastic Frontier Model Applicability Testing

There is no inefficiency term	There is an inefficiency term	Before the GEM reform	8.31	1	5.41	0.90	Reject H0
		The first year after the GEM reform	29.84	1	5.41	0.97	Reject H0
		The second year after the GEM reform	27.44	1	5.41	0.88	Reject H0
		After the reform of STAR market	33.58	1	5.41	0.97	Reject H0

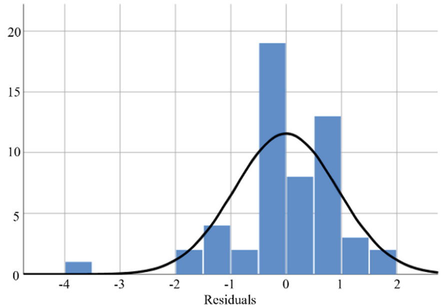

Fig. 1. Histogram of residuals before the GEM reform

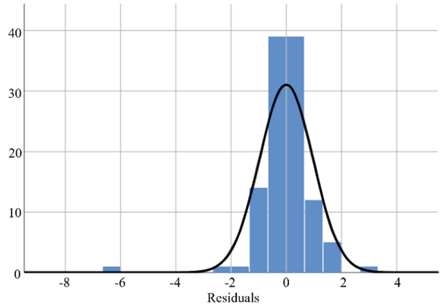

Fig. 2. Histogram of residuals in the first year after the GEM reform

be shown to be skewed to the left, suggesting that the issue price of new shares is underpriced. As a result, the model developed in this study should be the stochastic frontier model of the production function, also known as the stochastic upper frontier model of IPO pricing.

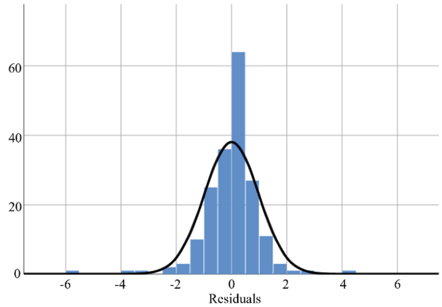

Fig. 3. Histogram of residuals in the second year after the GEM reform

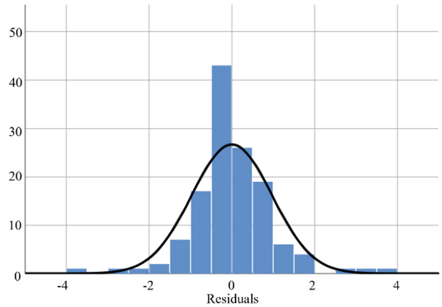

Fig. 4. Histogram of residuals after the STAR market reform

3.1 Empirical Results and Analysis

According to the statistics in Table 3, IPO price efficiency of GEM reached 92.66% before the registration reform but dropped to 80.83% in the first year following the reform and marginally rebounded to 84.75% in the second year. The average price effectiveness of IPO in the STAR market is 82.12%, which is somewhat lower than the pricing efficiency of the GEM in the same period.

Table 3 also provides information on each variable's impact on the pricing of new shares. The issuance price-earnings ratio has a positive influence on the issuance price from the perspective of the company's intrinsic value at 1% significance level; in terms of profitability, the return on equity is positively correlated with the issue price at 10% and 1% significance level respectively, indicating that the higher the yield, the stronger the profitability, and the higher the pricing; at the same time, the earnings per share has a positive influence on the pricing at 1% significance level, demonstrating that investors are particularly concerned about the impact of earnings per share on the profitability of the company.

In terms of risk, the asset-liability ratio is negatively connected with issue pricing in the GEM, which implies that the higher the asset-liability ratio, the higher the risk investors must accept, and hence the lower the price. However in the STAR market, it seems that the asset-liability ratio is not a significant factor of pricing.

Table 3. Results of four sets of sample data using MLE regression

		Before the GEM reform	The first year after the GEM reform	The second year after the GEM reform	After the reform of STAR market 2021.6–2022.6
Variables	Parameter	coefficient	coefficient	coefficient	coefficient
Constant term	beta 0	-1.4399**	-3.4920***	-2.5369***	-3.4382***
Ln(PE)	beta 1	0.8847***	0.6472***	0.8556***	0.8087***
Ln(ROE)	beta 2	0.0736*	0.1897*	0.1809***	0.1485***
Ln(EPS)	beta 3	0.7423***	0.4437***	0.6970***	0.6935***
Ln(LEV)	beta 6	-0.1221***	-0.1174**	-0.1157***	-0.0059
Ln(TA)	beta 4	0.1085***	0.2206**	0.2152***	0.1887***
Ln(NUM)	beta 5	-0.2521***	-0.5590***	-0.3064***	-0.2967***
Ln(FEE)	beta 7	0.1832***	0.4938***	0.0851**	0.2248***
σ2		0.0115***	0.1142***	0.0687***	0.1006***
γ		0.8972***	0.9720***	0.8803***	0.9713***
mean efficiency		92.66%	80.83%	84.75%	82.12%
Number of samples		54	113	187	119

Note: ***, **, * represent parameters that are at significant levels of 1%, 5%, and 10% respectively.

Total assets are positively correlated with the issue price at significance levels of 1% and 5% in different time periods, suggesting that the larger the firm's asset size, the greater its capacity to withstand risks and the higher its price. However, the initial number of new shares issued by the firm is adversely connected with the IPO pricing at 1% significance level. This might be explained by the fact that the new share issue price will be suitably decreased as the number of new shares issued increases in order to ensure that the new shares can be fully sold within the sales period.

In terms of issuance fees, they are positively correlated with issue prices at 1% and 5% significance levels before and after the GEM reform respectively, and at 1% significance level for the STAR market, which might due to that the higher the issuance fees, the higher the costs incurred by underwriters for due diligence, and the greater the role played by underwriters in the reasonable valuation of IPO, raising the pricing level of new shares.

3.2 Discussion

Why did the price efficiency of new shares on the GEM drop after the registration system reform? This essay believes that there are mainly the following reasons:

Firstly, during the first year of the GEM registration-based system's deployment, some offline investors concentrated on strategy rather than research, and "grouped quotes" in pursuit of additional money. This is a manifestation of the dysfunctional

IPO inquiry mechanism under the registration system, where institutional investors take advantage of the IPO inquiry loophole to benefit from speculation. The lower the issue price, the greater the share price increase after listing, and the more lucrative such gains. However, such conduct undermines market efficiency while also harming the interests of issuers, underwriters, secondary market investors, and other stakeholders.

Secondly, at the early stages of the registration system's deployment, Chinese institutional investors are not yet mature enough, underwriters' pricing power is limited, and moral risks are high. The sponsorship and follow-on system to minimize moral hazard of the brokerage companies has not yet significantly impacted their capital limits, and the reputational mechanism of the lead underwriter has not served as an effective disciplinary tool.

Last but not least, the cost of information disclosure in China is high, but the degree of difference is low, resulting in low information disclosure quality. Listed firms ignore investor requirements in their relentless pursuit of regulatory compliance. For instance, annual reports of publicly traded businesses are becoming increasingly lengthy, burying crucial information behind a mountain of unnecessary data. The supplied material is not easily readable, making it more difficult for investors to receive useful information.

4 Conclusion

In this paper, data related to IPO companies before and after the GEM registration system reform and after the STAR market reform are selected to measure and compare the efficiency of IPO pricing in different periods and sectors using the stochastic frontier model. The empirical results show that in the first year of the registration system, the GEM did not establish a sound market discipline mechanism, resulting in a high degree of IPO price suppression and a decline in pricing efficiency. In the second year, after the relevant institutional regulations were improved and the enquiry mechanism was optimized, pricing efficiency improved accordingly.

In the long run, IPO pricing efficiency will further improve as market efficiency increases. At the same time, the efficiency of the STAR market has increased from 77.57% at the beginning of the reform to 82.12%. In comparison, the pricing efficiency of the STAR market is still lower than that of the GEM, indicating that there is still much room for improvement in the STAR market as an emerging sector.

In addition, the number of listed companies has grown consistently after the registration system reform was put into place in the GEM, demonstrating that these changes resulted in a lower listing threshold, significant policy flexibility, and a highly inclusive market that gave access to the capital market to more businesses focused on technological innovation. This is conducive to improving access to finance, reducing financing costs, and enhancing the quality of economic development.

Based on the aforementioned study, this article makes the following conclusions in order to better play the role of the registration system reform: (1) Strengthen the relevant IPO system reform, further optimize and improve the inquiry mechanism, such as the introduction of a competitive bidding mechanism in the offline inquiry section of new shares, which could really touch the vital interests of the inquiry agencies and fundamentally regulate the quotation behavior; (2) Increase efforts to cultivate institutional investors, enhance the awareness of intermediaries and their professional capabilities, and improve the quality of information disclosure, guided by the differentiated needs of investors; (3) Regulators need to accelerate the transition from ex-ante to ex-post supervision, improving the ecology of the capital market.

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