The influence of stock liquidity of energy enterprises on capital structure adjustment– –Based on a study of China's A-share listed energy enterprises

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Abstract. The transformation and optimization of energy enterprises can boost China's economic development. Studying the adjustment of the stock liquidity of energy enterprises to their capital structure will help enterprises realize their own value. Based on these, this paper explores the influence of stock liquidity on the capital structure of energy enterprises by constructing a fixed-effect step-back model based on static short-panel data, then draws the following conclusions：(1)The better the liquidity of the stock, the smaller the external financing cost of the enterprise; (2) It is more difficult for new energy enterprises to obtain equity financing, and the financing environment is worse;(3) The stock liquidity of traditional energy enterprises is more sensitive to the capital structure, and it is easier to adjust to the optimal capital structure; (4) In the field of new energy, the credit rating of enterprises with strong stock liquidity is higher, which is conducive to adjusting the capital structure through debt financing. Finally reasonable suggestions for the above conclusions are gave.

Keywords: Stock liquidity; Capital structure; Energy enterprises; Fixed effect.

1. Introduction

Under the goal of "double carbon", the transformation and optimization of energy enterprises is the "accelerant" of China's social and economic development. Although China's energy structure is constantly adjusted, traditional energy sources occupy the main position. To build a clean, low-carbon, and efficient energy system and help the development of new energy enterprises are the main direction of "carbon peaking" and "carbon neutrality". According to the equilibrium theory and the hypothesis of “economic man”, the capital structure will affect the enterprise value. Stock liquidity is a significant index to judge whether a country's stock market is prosperous or not, which affects the level of corporate governance and financing decision-making activities. Does the stock liquidity of China's energy companies have a significant impact on their capital structure? If so, is there a structural difference in factors such as factor industry, strength of stock liquidity, etc.? This paper is committed to solving the above problems, provide a theoretical basis for energy enterprises to adjust their capital structure, at the same time providing suggestions for the deployment planning of China's "double carbon" strategy, which helps it contribute solutions to global climate governance issues.

Based on the sampling method of combining stratified sampling and isometric sampling, this paper selects 56 Chinese energy enterprises listed on A-shares before 2013 as research objects. Firstly, a fixed effect stepwise regression model based on static short panel data is constructed. The impact of stock liquidity on capital structure is analyzed for a full sample. Secondly, the above model is tested from the perspective of model substitution and variable substitution. In the case of passing the test, the significance and sensitivity of the impact of stock liquidity on the capital structure of enterprises with different industries and different stock liquidity are studied based on sub-sectors and stock liquidity. Although the research direction of previous scholars is consistent with this paper, they have not delved into the energy field, most of the models used are based on dynamic panels or cross-sectional data . With this in mind, the innovations in this article are: (1) Multi-angle verification of the correlation between variables and the rationality of model design; (2) In-depth study of the degree and direction of impact of stock liquidity on capital structure of energy enterprises; (3) Build an

econometric model based on static panel data to control the influence of endogenousness on regression results while solving the problem of missing variables.

2. Literature review

According to the existing domestic research; Meng Henghong[1] tested empirically the effect of stock liquidity on capital structure and the intermediary effect of corporate governance, examined the effect of stock liquidity on corporate governance under different property rights. Xie Haifang, et al.[2] established a multiple regression model to empirically analyze the impact of capital structure of civil-military listed companies on stock liquidity, researched our country state-owned and the non-state-owned military and civil fusion listed company capital structure to the stock liquidity influence; Jinshuying et al.[3] confirmed that stock liquidity was significantly negatively correlated with the financing cost of listed enterprises. The capital structure adjustment of listed enterprises could effectively adjust the above relationship: the faster the capital structure adjustment, the more significant the negative impact of stock liquidity on equity, debt and weighted capital cost; Zhu Hongzhi et al.[4] took the domestic A-share market from 1999 to 2008 as the research object. Through the construction of univariate and multivariable regression models, he discussed the impact of stock liquidity measured by Amihud on the capital structure measured by book leverage ratio and market capitalization leverage ratio, lastly he came to the conclusion that stock liquidity is significantly negatively correlated with corporate financial leverage; Xu Sheng et al.[5]used panel data regression and other methods to study the impact of liquidity on the enterprise's capital structure. Theoretical analysis showed that the enterprise tend to use equity financing such as additional issuance and allotment. The empirical conclusion showed that the higher the liquidity of individual shares, the faster the adjustment of capital structure. Sheng Mingquan et al.[6] introduced the modified turnover rate as an indicator of stock liquidity, built a partial adjustment model to explore the impact of stock liquidity on the speed of capital structure adjustment, found that the speed of capital structure adjustment increased with the increase of stock liquidity; In recent years, there have been many studies on corporate stock liquidity and capital structure, but most of the research samples were the entire capital market in a certain period of time, or specific industries that did not involve the energy field. This paper will focus on the capital market of the energy industry, build an econometric model based on the multi angle verification of the correlation between variables and the rationality of the model design to deeply study the impact of the stock liquidity of energy enterprises on their capital structure. The conclusion is consistent with Li Hongxia and others[7] that the financing constraints of new energy enterprises are higher than those of traditional energy enterprises.

3. Data sources and variable and model settings

3.1 Variable selection and data sources

Select China's energy enterprises listed on A-shares before 2013 as the research object, and conduct preliminary processing of data, mainly including: (1) Exclude enterprises with incomplete statistical years and enterprises with duplicate statistics; (2) Exclude ST enterprises; (3) Exclude variables with fewer observations. Finally, 56 energy enterprises (including 28 traditional energy enterprises and 28 new energy enterprises) are screened out by a combination of stratified sampling and isometric sampling. The sample information comes from the "2021 Global Top 500 Global New Energy Enterprises" and "2021 China Energy (Group) Top 500" published by China Energy News; the research data comes from the Guotaian database; the analysis software is Stata17.0.

3.2 Primary variable settings

3.2.1 Capital structure(cs)

Capital structure, also known as corporate leverage, is defined as the ratio of equity to debt or the combination of all liabilities and equity of a listed company and its proportional relationship.

Commonly used metrics are book financial leverage and market financial leverage. Since the price of energy stocks usually fluctuates more sharply, this paper finally selects the relatively stable book value method to measure the capital structure, which is calculated as: capital structure = book value of liabilities / total assets.

3.2.2 Stock liquidity(aatr)

Stock liquidity refers to how easy it is for investors to complete trading stocks at minimal cost and maximal speed. Among the many measurement indicators, the turnover rate can not only indicate the full degree and activity of stock turnover in a certain period of time, but also an important reference indicator to measure the size of the divergence between enterprises and investors. The turnover rate is positively correlated with stock liquidity. Learn from the improved turnover rate indicator proposed by Xu Sheng[5] and others to measure the liquidity of stocks. It is calculated as:

$$aatr_{it} = \sum_{n=1}^{end}(\frac{N_{itn}}{S_{itn}} \times 10^{-1}) \tag{1}$$

where N_{itn} is the total number of stock transactions on the Nth day of the t year of the enterprise i, S_{itn} is the corresponding total number of shares, and end represents the total number of days of the t year. For follow-up research, this paper reduces the liquidity indicator by a factor of ten.

3.3 Model Settings

In this paper, a multivariate regression model based on static short-panel data is constructed based on the research methods of Zhu Hongzhi[4] et al.. The following optimizations are carried out: (1) In order to avoid the influence of multicollinearity, the model fit is carried out by the stepwise regression; (2) In order to consider the individual heterogeneity in an all-round way, a fixed effect estimation quantity improvement model is selected. The general form of the model is as follows:

$$y_{it} = x_{it}^{'}\beta + z_i^{'}\delta + u_i + \varepsilon_{it}(i = 1,2,...,n; t = 1,2,...T) \tag{2}$$

where $x_{it}^{'}$ is the explanatory variable transpose matrix of the t year of the i individual; Matrix of regression coefficients with β as $x_{it}^{'}$; $z_i^{'}$ is the matrix of individual characteristics independent of the time dimension; u_i is an intercept term that represents individual heterogeneity .It is associated with an explanatory variable; ε_{it} is a stochastic error term that is independent and homogeneous and uncorrelative of u_i. In this article, the capital structure is taken as the explanatory variable, and the stock liquidity is the core explanatory variable. The above variables are renamed:

$$cs_{it} = aatr_{it}^{'}\beta + controls_{it}^{'}\gamma + z_i^{'}\delta + u_i + \varepsilon_{it}(i = 1,2,...,n; t = 1,2,...T) \tag{3}$$

Among them, $controls_{it}^{'}$ is the transposition matrix of other control variables in the t year of enterprise i, including a series of factors that may potentially affect the capital structure of the enterprise. The variable settings are summarized in Table 1:

Table.1. Model variable settings for the impact of stock liquidity on capital structure

Varibale name	Varibale meaning	Measurement basis
year	Statistical year	2013-2021
ind	Industry	0 = conventional energy; 1 = new energy
cs	Capital structure	Liabilities/Total assets
aatr	Stock liquidity	Annual turnover rate
gro	Growth	Stock market capitalization/Total assets
size	Enterprise size	The natural logarithm of total assets
pro	Profitability	EBIT/total assets
mc	Mortgage capacity	(Net fixed assets + Inventory) / Total assets
bmr	Book-to-market ratio	Shareholders' equity/Market capitalization of the enterprise
ndts	Non-debt tax shield	(Depreciation of fixed assets + Depreciation of oil and gas assets + Depreciation of productive biological assets) / Total assets
ogpm	Operating gross margin	Gross profit/Net operating income

4. Empirical analysis

4.1 Descriptive statistics

Table 2 summarizes the descriptive statistical results of each variable, the results shows that: (1) The average and median of capital structure of enterprises are not much different in quantity, it indicates that the data is highly centralized. Traditional financial theory shows that The capital structure of the enterprise is optimal in the range of 0.4-0.6.The overall control of the proportion of equity financing and debt financing of energy enterprises is better; (2) The average and median values of stock liquidity are quite different in value and the standard deviation is high, indicating that the degree of dispersion of the indicator is large. It is necessary to conduct heterogeneity analysis; (3) Although the sample size of some variables is slightly lower than the total sample size, the panel data is a strong balance panel. It indicates that the existence of missing values does not affect the balance of panel data; (4) Except for stock liquidity and enterprise size, the standard deviation of the remaining variables is lower than 0.2, indicating that the stability of the variables is better.

Table.2.Descriptive statistics of energy enterprises

Variable name	Number of observations	Average	Median	standard deviation	Minimum	Maximum
cs	504	0.5504	0.5524	0.1569	0.0196	0.9792
aatr	504	0.3649	0.3032	0.2629	0.0029	1.7411
gro	504	0.0011	0.0007	0.0012	0.0001	0.0170
size	504	23.4516	23.2328	1.3884	18.9272	28.6243
pro	504	0.0463	0.0475	0.0623	-0.6632	0.2265
mc	501	0.4119	0.3958	0.1654	0.0055	0.8620
bmr	501	0.3324	0.3190	0.1387	0.0090	0.7477
ndts	503	0.0253	0.0231	0.0156	0.0003	0.0968
ogpm	503	0.2488	0.2340	0.1446	-0.1299	0.9994

4.2 Correlation analysis

Prior to the regression analysis of the model, the pearson correlation coefficient and the spearman correlation coefficient were used to analyze the correlation of each numerical variable. The results of

the correlation analysis are shown in table 3, where the lower left is spearman correlation coefficient , upper right is pearson correlation coefficient. It shows that there is a significant correlation between capital structure and liquidity at the confidence level of α=0.05, it is two-factor verified. Other variables also have a significant correlation with each other. Preliminary explanation is that the variable setting is appropriate, and the overall construction of the model is reasonable.

Table.3. Correlation analysis of numerical variables

	cs	aatr	gro	size	pro	mc	bmr	ndts	ogpm
cs	1	0.12*	-0.22*	0.21*	-0.27*	0.27*	-0.55*	-0.01	-0.46*
aatr	0.13*	1	0.10*	-0.24*	-0.10*	0.001	-0.30*	-0.15*	-0.11*
gro	-0.41*	0.20*	1	-0.44*	0.11*	-0.24*	-0.36*	-0.24*	0.26*
size	0.24*	-0.25	-0.55*	1	0.07	-0.04	0.26*	0.29*	-0.20*
pro	-0.31*	-0.11*	0.30*	0.01	1	0.01	0.09*	-0.01	0.28*
mc	0.21*	-0.02	-0.16*	-0.07	0.04	1	-0.08	0.40*	-0.25*
bmr	-0.62*	-0.32*	-0.34*	0.19*	0.04	-0.06	1	0.20	0.10
ndts	-0.05	-0.16*	-0.23*	0.13*	0.14*	0.52*	0.22*	1	-0.17*
ogpm	-0.38*	-0.12*	0.25*	-0.12*	0.39*	-0.23*	0.17*	-0.15	1

Note: * respectively indicates that the regression results are significant at 5% confidence levels.

4.3 regression analysis

For the preliminary regression of the model (3), the regression results are shown in Table 4. Table 4 shows all the control variables that affect the capital structure of enterprises in the case of overcoming multicollinearity, where stock liquidity has a significant negative impact on capital structure at the confidence level of α = 0.01. This is consistent with the findings of Zhu Hongzhi[4] et al. When other control variables remain unchanged, the capital structure decreases by an average of 0.045 units for every 1 unit increase in stock liquidity. With the rise of stock liquidity, the equity financing cost of enterprises has decreased. The cost of debt financing has risen relatively, resulting in a downward adjustment of the capital structure, which is also consistent with the theoretical analysis of JiangZhou and Zheng Zhuqing[8].

Table.4. Results of the stepwise regression of the fixed effect model of energy enterprises

Variable	Regression coefficients	Standard errors	t-value	P-value	LCL	UCL
aatr	-0.0452	0.0139	-3.25	0.001	-0.0725	-0.0179
Control variables	YES	YES	YES	YES	YES	YES

Note: (1) R2=0.479, Overall P-value=0.0000.

(2) “YES” indicates that it is in line with expectations (the same below). If readers are interested in more information, please contact the author.

4.4 Robustness examination

In order to ensure the accuracy of the above conclusions and avoid the influence of endogenousness on the regression results, this paper uses variable substitution and model substitution as the basic ideas for robustness testing, mainly including: (1) Use clustering robust standard error to re-regress the model; (2) Adopt a random effects model and perform a Hausman test with the original model; (3) Use the system GMM to estimate the parameters; (4) Select the Zero Returns indicator instead of the annual turnover rate to measure stock liquidity, the metric is the ratio of zero yield days to the number of trading days in the year; the larger the value, the lower the stock liquidity. For ease of analysis, this article takes a negative value. The specific results of the robustness test are shown in Table 5.

As can be seen from Table 5, among the test results, stock liquidity has a significant negative impact on the capital structure. The regression coefficient estimates of other control variables are consistent in direction and most of them pass the significance test. In addition, the P-value of the

Haussmann test is extremely small, indicating that there are systematic differences in the regression coefficients, it is better to select the fixed-effects model. In summary, the robustness test results are not significantly different from the regression results of model (3), which further shows that the model has good fitting effect and high reliability.

Table.5. Test results generated by energy enterprises through variable and model substitution

Variable	Standard errors	Random effects	SGMM	Zeros liquidity indicator
cs lags one period			0.393*** (0.000)	
aatr	-0.045*** (0.002)	-0.039*** (0.006)	-0.332** (0.040)	-0.745*** (0.000)
Control variables	YES	YES	YES	YES
R2	0.479	0.586		0.498
Overall P-value	0.0000	0.0000	0.0000	0.0000
P-value of Hausman test		0.0000		

Note: P value in parentheses; ***, **, *respectively indicates that the regression results are significant at 1%, 5%, and 10% confidence levels (the same below).

4.5 Heterogeneity analysis

This paper is committed to studying the impact of stock liquidity on the capital structure of enterprises in the energy industry, combined with the analysis of Tables 1 and 2, finally grouping the whole sample based on industry and stock liquidity. In terms of industry, 56 energy enterprises are divided into 28 traditional energy enterprises and 28 new energy enterprises; As for stock liquidity, according to the 33.3% and 66.7% quantiles, the enterprise's stock liquidity is divided into weak, medium and strong three grades. The results of the heterogeneity analysis are shown in Table 6.

In terms of industries, the regression results are shown in columns 4 and 8: the stock liquidity of new energy enterprises and traditional energy enterprises is significantly negatively correlated with the capital structure at the confidence level of α=0.1. The regression coefficient estimate for the former is -0.027 and the latter -0.035. It shows that the stock liquidity of traditional energy enterprises is more sensitive to capital structure: when improving the liquidity of the same unit, it can reduce more debt financing and reduce debt pressure. In contrast, new energy enterprises cannot effectively obtain financing from the stock market, reflecting the high degree of information asymmetry between enterprises and investors, excessive borrowing will increase the debt risk of enterprises and there is downward pressure on credit ratings.

In terms of stock liquidity, the regression results are shown in columns 1-3 and 5-7: as far as the traditional energy industry is concerned, the regression coefficients at all levels are not significant, indicating that the correlation between the stock liquidity and the capital structure after stratification is not high; As far as the new energy industry is concerned, with the rise of stock liquidity, its negative impact on capital structure has become more and more significant, indicating that the liquidity of individual stocks of highly liquid enterprises is more closely related to the capital structure. Since the regression results of column 1 are not significant, this paper only considers the cases of columns 2 and 3. Medium-liquid firms are significantly more sensitive to capital structure than highly liquid firms. Studies have shown that corporate credit rating is an important factor influencing their capital structure[9], while the relationship between institutional investors and commercial credit financing is positively regulated by stock liquidity[10]. The stronger the stock liquidity, the stronger the ability of the enterprise to adjust the credit rating of the enterprise, which further affects its capital structure making the debt ratio relatively high, has a positive impact on the expansion of reproduction of the enterprise.

Table.6.Regression results of energy enterprises grouped on the basis of industry and liquidity

Variable	New energy industry liquidity				Traditional energy industry liquidity			
	Weak (1)	Medium (2)	Strong (3)	Total (4)	Weak (5)	Medium (6)	Strong (7)	Total (8)
aatr	0.107 (0.461)	-0.256** (0.034)	-0.080*** (0.003)	-0.027* (0.097)	-0.172 (0.216)	-0.090 (0.573)	-0.027 (0.403)	-0.035* (0.076)
Control variables	YES	YES	YES	YES	YES	YES	YES	YES
mc	0.233*** (0.005)	0.306*** (0.000)	0.026 (0.737)	0.176*** (0.000)	0.104 (0.218)	0.192 (0.175)	-0.144 (0.109)	0.067 (0.190)
Overall P-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

5. Research conclusions and policy implications

5.1 Research conclusions

This paper takes 56 A-share enterprises listed in China's energy industry before 2013 as samples to analyze the impact of stock liquidity on the capital structure, and obtains the following conclusions: (1) Stock liquidity has a significant negative impact on the capital structure of energy enterprises. which indicates that the better the stock liquidity; the smaller the external financing cost of the enterprise; (2) Compared with traditional energy enterprises, the stock liquidity of new energy enterprises is less sensitive to their capital structure adjustment. This shows that the information asymmetry between the latter and investors in the stock market is quite different, the difficulty of obtaining equity financing is higher and the financing environment is worse; (3) The stock liquidity of traditional energy enterprises is more sensitive to the capital structure. It is easier to adjust to the optimal capital structure; (4) New energy enterprises with high stock liquidity, the impact of their stock liquidity on capital structure adjustment is more significant and less sensitive. This shows that in the field of new energy, enterprises with strong stock liquidity have a higher credit rating, which is conducive to adjusting the capital structure and expanding reproduction through debt financing.

5.2 Policy implications

In view of the above four research conclusions, this paper gives one-to-one corresponding policy implications: (1) Regulators need to regulate the trading mechanism of the capital market, eliminate the unfavorable factors of stock liquidity, reduce the cost of capital structure adjustment, create a positive market environment for energy enterprises. (2) The state should vigorously develop green finance, provide government subsidies and financing guarantees, reduce the financing constraints of new energy enterprises. (3) Traditional energy enterprises with weak stock liquidity try to avoid excessive debt, actively participate in the carbon market, achieve safe carbon reduction, vigorously promote green and low-carbon transformation and development; (4) New energy enterprises with strong liquidity should beware of debt risks and reasonably control the scale of debt financing. Other new energy enterprises should improve the internal control system and improve the quality of information disclosure of enterprises, so as to alleviate problems such as information asymmetry, improve credit level, enhance stock liquidity, reduce equity financing costs, and optimize capital structure.

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