# Does Stock Liquidity Enhance Small and Medium-Sized Enterprises Innovation?--Evidence from the China's Neeq Market

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**Abstract:** For small and medium-sized enterprises with relatively low liquidity, does the improvement of stock liquidity affect enterprise innovation? This paper uses the data of China's NEEQ companies from 2013 to 2017 as samples, introduce the market maker system at the end of 2014 as exogenous variables to construct a quasi-natural experiment, combining propensity score matching and difference-in-difference method to verify. The empirical results show that the increase in stock liquidity is conducive to enhancing the innovation of small and medium-sized enterprises, and the improvement of liquidity of small and medium-sized enterprises with higher stock liquidity is more likely to bring innovation driving force. Therefore, this paper suggests that the government should establish a perfect market transaction system to improve the stock liquidity of small and medium-sized enterprises, so as to further release the innovation vitality of small and medium-sized enterprises.

## 1. Introduction

With the deepening of economic globalization, innovation plays a more and more critical role in promotingeconomic development and driving social progress. As one of the most important subjects in the economy, enterprises inevitably assume the important task of technological innovation. At the same time, we should note that although technological innovation can bring long-term and huge benefits, it also has the characteristics of complicated process, highly uncertain results, poor short-term performance and so on, which is bound to depress the confidence of enterprises to invest in research and development for technological innovation, hence bring obstacles to technological innovation. Therefore, many scholars have made various researches on how to improve enterprise innovation, and agree that a sound stock market is conducive to improving the financing constraints of enterprises and transferring risks, thus promoting the innovation and research and development investment of enterprises. In consideration of the situation in China, the original intention of the establishment of the A-share stock market is mainly to serve the state-owned enterprises and some enterprises with special status background. However, a large number of small and medium-sized enterprises that have made great contributions to China's economicgrowth have not received the support and assistance from the A-share stock market. Meantime, bank-led indirect financing tends to flow into large enterprises with more stable cash flows.Therefore, the Chinese government has launched the NEEQ market to ease the financing difficulties of small and medium-sized enterprises. Up to now, the number of companies listed on the NEEQ market has exceeded the sum of listed companies in Shanghai and Shenzhen A-share stock markets and as an important cornerstone of China's multi-level capital market, it has solved the huge demand for capital of millions of small and medium-sized enterprises. In this regard, a natural question is, how does the NEEQ market affect the innovation of small and medium-sized enterprises? This discussion is practical significant.

As an important component of the capital market, the stock market plays an indispensable role in influencing enterprise innovation. One of the important paths of influence is stock liquidity, but which will promote or inhibit enterprise innovation,this debate has not yet been finalized. Theoretically, some scholars believe that stock liquidity will impedetechnological innovation of

enterprises. For example, the improvementin stock liquidity will increase the probability of hostile takeover of companies. In order to prevent this condition and to protect the interests of shareholders, management may have to engage in projects with high short-term returns and give up long-term research and development investment[1]. At the same time, due to the increase in stock liquidity, the decrease of transaction cost will lead to more short-term profit-seeking speculators, aggravate the myopic behavior of management, and reduce the motivation of investment in enterprise technological innovation[2]. From an empirical point of view, Fang did a pioneering work by using of data from the US market to study the impact of stock liquidity on enterprise innovation, filling the gap in this aspect of empirical research. The research found that the increase in stock liquidity not only will not be good for enterprise innovation, but will have a restraining effect[3]. At the same time, China's Fenget al. used the split share structure reform as an exogenous variable to explore the correlation between stock liquidity of state-owned and private enterprises and enterprise innovation[4]. In consideration of that the NEEQ market has a higher investment threshold and is not active in trading, which is quite different from the relatively more mature overseas capital market and A-share market, whether these conclusions are suitable or not remains to be discussed. Therefore, this paper mainly discusses two issues: first, does the stock liquidityaffect technological innovation of small and medium-sized enterprises? Second, is the impact on the innovation ability of small and medium enterprises under different liquidity levels and stock liquidity consistent?

From the perspective of academic value, the innovation and significance of this paper are mainly reflected for the following aspects: First, from the perspective of the NEEQ market, this paper enriches the mechanism and economic consequences of the impact on the innovation of small and medium-sized enterprises. Second, the quasi-natural experiment that introduces the market maker system as an exogenous variable affecting stock liquidity, and the method of propensity score matching and difference-in-difference are used to better alleviate the influence of endogenous problem between stock liquidity and enterprise innovation. Third, according to the results of empirical analysis, relevant policy recommendations are provided.

Each part of the full text is arranged as follows: The second part is theoretical literature and empirical assumptions; The third part is research design,sample selection and data sources, variable selection, model setting and descriptive statistics. The fourth part is empirical analysis, including regression analysis, robustness check and treatment of endogenous problems. The last part is the conclusion.

## 2. Theories and Assumptions

In the research literature on the impact of stock liquidity on enterprise innovation, there are two opposite views. Some scholars believe that stock liquidity will inhibit innovation. One of the main reasons is the short-term model theory of company managers put forward by Stein. The theory holds that the liquidity demand of investors, the potential possibility of being merged and the expected project yield will all affect the short-term decision-making of company management[5]. At the same time, faced with the pressure of hostile takeover from outside, management is likely to sacrifice long-term research and development investment due to asymmetric information inside and outside the enterprise, which may cause short-term performance pressure to ensure stable stock prices and not be underestimated[6]. In addition, Porter points out that if the stock liquidity is high, it may attract those short-term profit-seeking institutional investors. At this time, if the company has bad news, they are more likely to sell the stock. On the contrary, if the company liquidity is low, the transaction cost is relatively high, they will choose to continue to hold the stock, while paying less attention to short-term returns and paying more attention to long-term returns, which is conducive to the improvement of corporate governance[7]. Fang et al. conducted a groundbreaking empirical study on the above two inhibition viewpoints based on the data of the U.S. stock market. The study found that the higher the liquidity, the weaker the innovation ability of the enterprise, and the lower the number of patents and the number of patents cited by the company[3]. Other scholars hold the opposite attitude, believing that stock liquidity will promote innovation. Among them, there are two main points widely recognized: first, the intervention mechanism of large shareholders, the higher

stock liquidity will help improve the corporate governance environment, ease the opportunism of management, and enable management to make decisions from a longer-term perspective[8]; The second is the threat of shareholder withdrawal, large shareholders in a stock market with good liquidity are more convenient to conduct large-scale stock transactions, enlarge the possibility of withdrawal, and avoid the management from making decisions detrimental to large shareholders[9].

From the research literature in China, Hu et al. used the data of A-share listed companies to discuss from the perspective of management's short-term behavior, and found that when external shocks enhance stock liquidity, they will attract more institutional investors to hold shares. These short-term investors attach more importance to short-term securities investment performance, promote short-term behavior of companies, and thus reduce innovation expenditure[10]. Based on the data of A-share listed companies in China, Feng et al. found that the moderating effect of enterprise nature on the stock liquidity in China's capital market is different between the technological innovation of state-owned enterprises and private enterprises[4]. The improvement of stock liquidity reduces the technological innovation level of private enterprises, but has a positive effect on the innovation ability of state-owned enterprises.

However, the transmission route and conclusion of the above conclusions are mainly based on mature and developed capital markets in Europe and the United States and China's A-share high-liquidity market, which is difficult to apply in the NEEQ market. From the perspective of hostile takeover, Zhang et al. found that the choice target of Chinese hostile takeover is more to consider its ownership concentration than stock liquidity[11]. However, the listed companies in A-shares are generally large-scale enterprises with stable operation and good liquidity, which are different from the small and medium-sized enterprises in the NEEQ market. On the other hand, short-term institutional investors are mainly concentrated in the main board market in China, while liquidity is relatively scarce in the NEEQ market, so speculators who pay attention to short-term performance are difficult to exist in the NEEQ market, and this theory is not applicable to the actual situation of the NEEQ market, which denies the two channels of inhibiting and transmitting the impact of stock liquidity of small and medium-sized enterprises in the NEEQ market on enterprise innovation. Therefore, we should turn to another possibility, stock liquidity may play a promoting role in the technological innovation of China's NEEQ enterprises. Xiong provides evidence that when the stock has abundant liquidity, the amount of information transmitted in the stock price will increase, which is beneficial to reduce the information asymmetry, thus enabling external institutional investors to better play the function of supervising enterprises, restraining managers' short-term opportunism and mobilizing their willingness to invest in innovative research and development[12].

Due to its low listing threshold, the NEEQ market plays an important role in helping small and medium-sized enterprises to finance and solving the allocation of market resources. However, all along, the NEEQ market has adopted an agreement trading system, which has led to a serious lack of liquidity for a long time. Therefore, at the end of 2014, the government introduced a market-making transfer system to enhance the liquidity of the shares of the NEEQ company. Compared with the original agreement transfer method, the participants of securities that prefer to be transferred by market makers are more diversified and have obvious advantages in the continuity of transactions and the improvement of liquidity. Liu found that after the introduction of this system, the liquidity level of stocks traded by market makers is higher than that of stocks still traded by agreement[13]. At the same time, the improvement in liquidity brought about has attracted more and more attention from venture investors. These venture investors invest in the NEEQ enterprise mainly to find the next potential unicorn enterprise. Therefore, in order to maximize profits, they will also bring more resources to the enterprise to help it grow, and force the management to pay attention to the short-term and long-term performance of the enterprise, increase research and development investment and improve the innovation ability of the enterprise. Meng's research also found a positive relationship between the liquidity of the NEEQ enterprise's stock and venture capital, and this positive relationship will be further strengthened in highly liquid enterprises[14].

To sum up, this paper puts forward the following assumptions: the improvement of stock

liquidity in NEEQ enterprises will promote enterprise innovation. For enterprises with high liquidity level, this "stock liquidity-enterprise technological innovation" will play a more significant role in promoting.

## 3. Research Design

### 3.1 Sample Selection and Data Source

In this paper, the NEEQ companies from 2013 to 2017 are selected as the research object. The data sources and sample selection process are as follows: First, based on a detailed analysis of the financial statements of all the NEEQ companies from 2013 to 2017, the innovative data of the NEEQ companies are obtained, including the number of patent applications and the R&D ratio of the companies, as well asthe companies with serious data missing values are excluded. Secondly, through certain steps, the enterprises that traded through the market maker system from 2015 to 2017 and the enterprises that traded through agreements from 2015 to 2017 are selected. Third, enterprise financial data are matched from Wind database. At last, this paper sorts out the above data according to stock code and year index, and finally forms the research sample of this paper.

### 3.2 Variable Selection

### 3.2.1 Innovation Index

This paper measures the innovation level of an enterprise for the following two aspects: First, the innovation output of an enterprise, expressed by the number of patents, is recorded as patent; Second, the enterprise's innovation efficiency, learn from Hirshleifer et al., measure the enterprise's innovation efficiency by the ratio of the patent and the natural logarithm of the amount of research and development investment, and record it as P/R[15]:

$$\frac{P}{R} = \frac{Patent}{\ln(R\&D)} \tag{1}$$

### 3.2.2 Liquidity Index

This paper uses Amihud & Mendelson'sresearch method for reference, and uses illiquidity, a non-liquidity index, to measure stock liquidity[16]:

$$\text{illiquidity} = \frac{1}{D}\sum_{d=1}^{D_{it}}\left(\frac{|r_{itd}|}{V_{itd}}\right)\times 100 \tag{2}$$

In the above formula,$r_{itd}$ and $V_{itd}$are the return rate and transaction amount of the specific stock i on the d day of the t year respectively; D is the total number of trading days in the current year; $|r_{itd}|$/ $V_{itd}$ is the stock price change caused by the turnover per million yuan, taking its annual average value and multiplying it by 100 as the illiquidity index. The larger illiquidity is, the greater the fluctuation of stock price caused by each unit exchange, which indicates that the depth of market transactions is shallow, the liquidity of stocks is poor, and vice versa. Therefore, illiquidity index is the reverse index of stock liquidity measurement.

### 3.2.3 Control Variables

This paper adds a series of variables that can affect the technological innovation of enterprises. Including: First, company size: this paper uses the natural logarithm of the total assets of the company at the end of the year to measure the size of the enterprise, which is respectively expressed as size; Second, Profitability: expressed as Roe;Third, Capital structure: expressed by asset-liability ratio, recorded as Lev;Fourthly, Debt paying ability: expressed in current ratio and recorded as LR; Fifthly, Operational capacity: expressed in total asset turnover rate, recorded as Turn; Sixthly, Growth ability: expressed in terms of sales revenue growth rate, recorded as GR; Seventhly, R&D intensity: expressed by the natural logarithm of the ratio of R&D expenditure divided by operating income, and recorded as R/S.

### 3.3 Model Setting

There are many methods to evaluate the implementation effect of a certain policy, among which panel data model and difference-in-difference method are more common. Although the former can solve the problem of missing variable deviation caused by sample heterogeneity and improve the estimation accuracy, it is sometimes difficult for the sample data to meet the assumption of independent and uniform distribution because the disturbance items of the same individual in different periods may have autocorrelation. At the same time, there may be a symbiotic problem between stock liquidity and enterprise innovation, there may be a mutual influence relationship between the two. In order to overcome this problem, this paper adopts the method of difference-in-difference to carry out empirical analysis. Through twice difference, the net effect of policy impact can be separated. This paper chooses exogenous variables by constructing a quasi-natural experiment method,the introduction of market maker system into the NEEQ enterprises, finds that this will have a direct impact on the stock liquidity of the NEEQ enterprises but will not have a substantial impact on enterprise innovation, and then further analyzes the relationship between stock liquidity and enterprise innovation by using propensity score matching and difference-in-difference method.

The basic idea of propensity score matching (PSM) is matching, obtaining samples of comparable companies through controlling other variables. Because the use of market maker system will have an exogenous impact on the liquidity of stocks, the liquidity of stocks has changed greatly before and after the adoption of market maker system by enterprises. Therefore, the adoption of market maker system by enterprises can form a control group with enterprises that still use agreement trading. Therefore, this paper hopes to control other characteristic variables of the company to obtain comparable company samples with different liquidity shocks. The experimental group of liquidity shock (Treated=1) constructed in this paper is to select NEEQ enterprises that use market maker system to trade from 2015 to 2017, while the control group (Treated=0) selects NEEQ enterprises that use agreement to trade from 2015 to 2017.

On the basis of sample matching and taking into account the differences in the nature of enterprises, this paper uses DID method to analyze the relationship between stock liquidity and the innovation level of enterprises.

$$Patent \ or \ \frac{P}{R} = \beta_0 + \beta_2 \text{Time*Treated} + \beta_3 \text{After}_1 + \beta_4 \text{After}_2 + \beta_5 X_C + \beta_{IY} + \varepsilon \qquad (3)$$

In the above model, Time*Treated indicates the variables that enterprises will use the market maker system for stock trading in 2015, and the virtual variables $\text{After}_1$ and $\text{After}_2$ respectively indicate that the market maker system will be used for trading in 2016 and 2017. In the above formula, if the coefficient of $\beta_2$ is positive, it indicates that the impact of increased liquidity has greatly increased the technological innovation level of the high liquidity group; $X_C$ represents all control variables, $\beta_5$ is its influence coefficient; $\beta_{IY}$ indicates that it controls the firm's fixed effect of individual and time. $\varepsilon$ is a stochasticdisturbance term.

### 3.4 Descriptive Statistical

Table 1 is descriptive statistics of the main variables in this paper. As can be seen from the table, the average number of Patent per company per year is 7.245, the median number is 7, the minimum value is 1, and the maximum value is 15, with the standard deviation reaching 4.635. From the perspective of P/R of R&D efficiency, the average is 0.460, the median is slightly lower than the average, and the standard deviation is 0.294. From the two variables measuring the innovation level of enterprises, it can be found that the technological innovation capabilities of the enterprises in the NEEQ market are quite different, but the median value is quite close to the average value, indicating that the distribution of the innovation capabilities of the sample enterprises is relatively normal, and most of the companies are at the level around the average value. The average illiquidity is 2.198, which is greater than the median value of 1.913, and the standard deviation is 6.297, which means that the liquidity of most sample enterprises is higher than the average.

Table 1 Summary Statistics

| Variables | Min | 25% | Median | Mean | 75% | Max | SD | N |
|---|---|---|---|---|---|---|---|---|
| Patent | 1.000 | 3.000 | 7.000 | 7.245 | 11.000 | 22.000 | 4.635 | 495 |
| P/R | 0.055 | 0.186 | 0.427 | 0.460 | 0.711 | 1.337 | 0.294 | 495 |
| Illiquidity | 0.347 | 0.749 | 1.913 | 2.198 | 6.104 | 15.373 | 6.297 | 495 |
| ROE | -1.267 | 0.020 | 0.097 | 0.057 | 0.168 | 0.419 | 0.231 | 495 |
| Lr | 0.573 | 1.740 | 2.649 | 5.642 | 4.552 | 81.595 | 11.110 | 495 |
| Lev | 0.011 | 0.182 | 0.302 | 0.322 | 0.455 | 1.001 | 0.191 | 495 |
| Size | 16.868 | 18.421 | 18.969 | 18.940 | 19.478 | 21.307 | 0.882 | 495 |
| Turn | 0.052 | 0.433 | 0.615 | 0.656 | 0.842 | 1.797 | 0.335 | 495 |
| R/S | 0.003 | 0.052 | 0.078 | 0.134 | 0.139 | 1.989 | 0.224 | 495 |
| Gr | -0.651 | -0.077 | 0.144 | 0.197 | 0.385 | 1.701 | 0.415 | 495 |

Note: All variables have shrinked 1% winsorize processing to overcome the influence of outliers. The same below.

## 4. Empirical Analysis

### 4.1 The Influence of Stock Liquidity on Enterprise Innovation

This paper uses the difference-in-difference method to regress the innovation level of NEEQ companies to the variables of market maker system. Since the number of patents used in this paper is non-negative integer data and is panel data, the panel Poisson counting model will have a better estimation effect. Meanwhile, this paper also uses the negative binomial regression technology to solve the problem that the mean and variance of individual non-observed disturbances are not equal.

Table 2 shows the empirical results of the relationship between the introduction of market maker system, stock liquidity and technological innovation under DID model. Possion regression results show that the introduction of market maker system has significantly increased the number of patents of listed enterprises, and verified that the improvement of stock liquidity is conducive to improving the innovation level of enterprises. At the same time, the innovation ability of enterprises adopting market maker system in the following year is also significantly better than that of enterprises adopting agreement trading system. The results of negative binomial regression model are similar to those of Possion model, but the significance has been significantly improved. We can see that the liquidity increase brought by the adoption of market maker system for stock trading has promoted the growth of the number of patents in both the year of impact and the next two years, although the impact is also gradually diminishing. Judging from the regression results on the innovation efficiency of enterprises, the improvement of liquidity have a positive impact on the R&D efficiency of enterprises. Based on the above analysis, we can find that the improvement in stock liquidity of NEEQ company caused by the introduction of market maker system will significantly improve the innovation level of listed companies.

Table 2 Introducing Market Maker System, Stock Liquidity and Innovation

| Variables | Patent | | P/R |
|---|---|---|---|
| | Poisson | Nbreg | FE |
| Treated*time | 0.4812** | 0.5483*** | 0.2187** |
| | (0.2176) | (0.2036) | (0.0901) |
| After1 | 0.4199** | 0.5061** | 0.1840* |
| | (0.2126) | (0.2036) | (0.0938) |
| After2 | 0.2546 | 0.3301* | 0.1294 |
| | (0.1924) | (0.1978) | (0.0921) |
| Control variables | Included | Included | Included |
| Firm fixed effect | Included | Included | Included |
| Year fixed effect | Included | Included | Included |
| Number of obs. | 495 | 495 | 495 |
| p-value(F-test) | 0.0000 | 0.0003 | 0.0056 |

Note: (1) In the table * * *, * *, * indicate that the statistics are significantly correlated at the levels of 1%, 5%, and 10%, respectively. (2) Robust standard error is shown in brackets, and panel

negative binomial regression model cannot use robust standard error. (3) Space and importance are limited, and other variables are not reported. The same below.

## 4.2 Treatment of Endogenous Problems

There are two problems that cannot be ignored when studying the impact of the introduction of market maker system to improve stock liquidity and thus technological innovation in NEEQ enterprises. First of all, there is a "counterfactual" problem in the process of causal inference in empirical research, the sample data can only reflect the situation of listed enterprises after choosing the market maker system to trade, but cannot reflect the situation that these enterprises still use the agreement to trade. For this problem, if the process of enterprises choosing to use the market maker system is random, then the difference-difference method can compare the two groups of enterprises to study whether the improved liquidity will affect their innovation. However, we need to consider whether there will be an endogenous problem between the process of introducing market maker system into listed enterprises and the innovation ability of enterprises, the level of innovation will directly affect whether enterprises choose to introduce market maker system for stock trading. If this process is non-random, then the impact cannot be directly estimated by difference-in-difference method.

In order to reduce the impact of endogenous problems, this paper adopts the method of propensity score matching to match each listed enterprise adopting market maker system with the corresponding listed enterprise adopting agreement trading system, approaching the process from non-random to randomization as much as possible, so as to reduce the impact of enterprise innovation level on the selection process, alleviate the possible endogenous problems, and further ensure the effectiveness and accuracy of the regression results.

The premise of propensity score matching is to determine the influencing factors of the process of introducing market maker system. This paper selects the number of enterprise patents and all control variables, and forecasts the possibility of enterprises choosing market maker system for stock trading based on Probit model. The model is set as follows:

$$Probit(Treated) = (\beta_0 + \beta_1 Patent + \beta_2 X_C + \varepsilon) \tag{4}$$

The Probit model regression results on the propensity score matching of listed enterprises to introduce market maker system are shown in Table 3 below. The results show that the process of selecting market maker system is not related to the innovation level of enterprises, but is significantly related to the liquidity ratio, asset-liability ratio, asset scale, asset turnover rate and R&D intensity of enterprises.

Table 3 Probit Model Regression Results

|  | (1) | (2) |
|---|---|---|
| Patent | 0.0138 |  |
|  | (0.0157) |  |
| Pr |  | 0.2050 |
|  |  | (0.2461) |
| Roe | 0.3481 | 0.3434 |
|  | (0.3874) | (0.3890) |
| Lr | 0.0611* | 0.0612* |
|  | (0.0313) | (0.0313) |
| Lev | -1.1465** | -1.1449** |
|  | (0.5832) | (0.5841) |
| Size | 0.3765*** | 0.3818** |
|  | (0.0841) | (0.0842) |
| Turn | 1.0315*** | 1.0378*** |
|  | (0.2925) | (0.2934) |
| R/s | -0.7867** | -0.7672** |
|  | (0.3468) | (0.3413) |
| Gr | -0.0916 | -0.0902 |
|  | (0.1721) | (0.1659) |
| Number of obs. | 496 | 496 |

| p-value(F-test) | 0.0000 | 0.0000 |
|---|---|---|

Note: In the table * * *, * *, * indicate that the statistics are significantly correlated at the levels of 1%, 5%, and 10%, respectively.

After the propensity score matching, each listed company that trades with market maker system shall be matched one-to-one with the listed company that trades with agreement according to the nearest matching rule. The matching deviation is shown in Table 4. From this table, it can be seen that there are significant differences in Roe, Lr, Lev, R/S and other indexes between the control group and the experimental group before matching, and the absolute value of deviation between the two groups after matching becomes insignificant from statistical significance. After matching, the difference of Gr is reduced to a certain extent. Although the match between Size and Turn was significant before and after, the gap between the two groups also narrowed. On the whole, after matching, the gap between groups of most variables is no longer statistically significant, and the effect of score matching is ideal.

Table 4 Deviation Change Of Control Group and Treatment Group after Nearest Neighbor Matching

| Variable | Unmatched | Mean | | %reduct | | t-test | |
|---|---|---|---|---|---|---|---|
| | Matched | Treated | Control | %bias | \|bias\| | t | p>\|t\| |
| Roe | U | 0.091 | -0.030 | 48.7 | 84.5 | 4.890 | 0.000 |
| | M | 0.097 | 0.116 | -7.5 | | -1.260 | 0.207 |
| Lr | U | 6.760 | 2.806 | 42.4 | 91.4 | 3.230 | 0.001 |
| | M | 3.720 | 3.380 | 3.6 | | 1.220 | 0.223 |
| Lev | U | 0.296 | 0.387 | -47.4 | 85.3 | -4.360 | 0.000 |
| | M | 0.320 | 0.333 | -7.0 | | -0.880 | 0.381 |
| Size | U | 19.018 | 18.742 | 31.4 | 30.3 | 2.820 | 0.005 |
| | M | 19.005 | 18.813 | 21.9 | | 2.640 | 0.009 |
| Turn | U | 0.691 | 0.567 | 38.5 | 10.3 | 3.350 | 0.001 |
| | M | 0.697 | 0.808 | -34.5 | | -4.090 | 0.000 |
| R/s | U | 0.113 | 0.186 | -26.5 | 83.0 | -2.940 | 0.003 |
| | M | 0.098 | 0.111 | -4.5 | | -1.560 | 0.119 |
| Gr | U | 0.215 | 0.152 | 14.5 | 35.6 | 1.370 | 0.173 |
| | M | 0.211 | 0.252 | -9.4 | | -1.280 | 0.200 |

After completing the matching between the control group and the experimental group, the matching samples are further used to carry out the innovation level of the NEEQ enterprises through the difference-in-difference method, and the variables of the market maker system introduced by the enterprises are regressed, and the results are shown in Table 5. After matching, the significance of Treated*time variable coefficient has decreased, but it is still significant. The lag variable $After_1$ is significant at the level of 5% in negative binomial regression, which shows that after controlling the factors that affect the choice of market maker system, the improvement of enterprise liquidity can still improve the innovation technology level of enterprises.

Table 5 Introducing Market Maker System, Stock Liquidity and Innovation (Psm)

| Variables | Patent | | P/R |
|---|---|---|---|
| | Poisson | Nbreg | OLS |
| Treated*time | 0.4436** | 0.4597** | 0.1991* |
| | (0.2242) | (0.2033) | (0.1049) |
| After1 | 0.3731 | 0.4471** | 0.1631 |
| | (0.2289) | (0.2122) | (0.1022) |
| After2 | 0.2339 | 0.2978 | 0.1216 |
| | (0.2063) | (0.2094) | (0.0981) |
| Control variables | Included | Included | Included |
| Firm fixed effect | Included | Included | Included |
| Year fixed effect | Included | Included | Included |
| Number of obs. | 359 | 359 | 363 |
| p-value(F-test) | 0.0020 | 0.0030 | 0.0037 |

Note: (1) In the table * * *, * *, * indicate that the statistics are significantly correlated at the

levels of 1%, 5%, and 10%, respectively. (2) Robust standard error is shown in brackets, and panel negative binomial regression model cannot use robust standard error.

## 4.3 Time Trend Chart of Enterprise Innovation and Stock Liquidity

An important premise for the implementation of the difference-in-difference method is the parallel trend assumption, so we calculated the average patent value and average liquidity value of the sample enterprises of the experimental group and the control group each year and tested them by constructing a time trend chart. in order to make the chart more intuitive, we took illiquidity as the inverse to obtain the positive liquidity index, as shown in figure 1. The experimental group and the control group basically meet the common trend assumption. Before the listed enterprises introduced the market maker system, the liquidity level of the two groups of enterprises was almost the same. After the system was implemented, the average liquidity of the stocks of the enterprises in the experimental group was significantly improved, with obvious differences between the liquidity of the enterprises in the control group. Judging from the number of patents in the innovation index of the enterprise, the average number of patents in the experimental group in the first two years is lower than that in the control group, but after the introduction of market maker system, the number of patents in the enterprise has obviously increased, and continues to be higher than that in the control group in the second and three years, which also verifies our previous assumption that for the NEEQ enterprise, the improvement of stock liquidity is conducive to improving the innovation level of the enterprise.

Fig.1 Time Trend Chart of Enterprise Innovation and Stock Liquidity

## 4.4 Further Analysis of Stock Liquidity and Enterprises Innovation

It can be seen from the findings in the previous article that there is a difference between the research by Fang et al. that the improvement of stock liquidity will hinder the technological innovation of enterprises[3] and the conclusion by Feng et.al of China that stock liquidity has a negative impact on the innovation level of private enterprises[4]. The reason may be that theirresearchesare mainly based on the stock market which is relatively mature and adopts call auction to trade. In this kind of market, stock liquidity is relatively high, trading is active, and investors are prone to short-sightedness, which affects long-term research and development investment decisions of enterprises. However, for the NEEQ market, trading activity is extremely low, stock liquidity is seriously insufficient, and even there is no trading for a whole year. Therefore, this low liquidity has prevented market investors from entering, and it is difficult to attract institutions to increase their holdings to improve the enterprise management mode. At the same time, the lack of market attention also makes the management not encourage long-term research and development innovation, which is undoubtedly not conducive to technological innovation of enterprises. Therefore, this paper further tests the difference of stock liquidity in groups. By calculating the average value of liquidity of each sample enterprise from 2013 to 2017, it divides the groups with higher than the average value of liquidity and lower than the average value of liquidity, and makes regression analysis on the stock liquidity and enterprise innovation indexes of the two groups respectively. As shown in Table 6, the research shows that in the lower stock liquidity group, the coefficient T value cannot pass the significance test at the level of 10%. In the high liquidity group, the coefficients all passed the significance test of at least 5%, which means that the improvement of stock liquidity has a significant positive effect on the R&D innovation of enterprises (illiquidity is the reverse index of liquidity). This further shows that enterprises want to improve the level of innovation, which requires higher stock liquidity as the premise. Under the condition of low stock liquidity, a small improvement in liquidity is difficult to bring about the improvement of enterprise innovation technology.

Table 6 Group Test Of Enterprise Innovation in Different Levels of Stock Liquidity

| Variables | High stock liquidity(above average) | | | low stock liquidity(below average) | | |
| --- | --- | --- | --- | --- | --- | --- |
| | Patent | | P/R | Patent | | P/R |
| | Poisson | Nbreg | FE | Poisson | Nbreg | FE |

| | | | | | | |
|---|---|---|---|---|---|---|
| illiquidity | -0.0369*** | -0.0405** | -0.0161** | -0.0268 | -0.0297 | -0.0143 |
| | (0.0148) | (0.0185) | (0.0077) | (0.0206) | (0.0192) | (0.0102) |
| Control variables | Included | Included | Included | Included | Included | Included |
| Firm fixed effect | Included | Included | Included | Included | Included | Included |
| Year fixed effect | Included | Included | Included | Included | Included | Included |
| Number of obs. | 220 | 220 | 220 | 275 | 275 | 275 |
| p-value(F-test)[2] | 0.0000 | 0.1671 | 0.0000 | 0.1851 | 0.0504 | 0.2235 |

Note: (1) In the table * * *, * *, * indicate that the statistics are significantly correlated at the levels of 1%, 5%, and 10%, respectively. (2) Robust standard error is shown in brackets, and panel negative binomial regression model cannot use robust standard error.

## 4.5 Robustness Check

In order to further test the robustness of the conclusion, this paper refers to Fang et al. and makes some changes, as well as constructs a new experimental group and a control group of liquidity shock by the following methods[4]:

Illiquidity of the sample enterprises adopting the market maker system for stock trading in the two periods before and after are calculated respectively, and the values before and after the introduction are subtracted and recorded as Delta_illiquidity, and then the liquidity difference is divided into quartile layers. Delta_illiquidity in the top 25% is recorded as the group with high liquidity improvement, and it is Treated=1 for the experimental group, while the enterprises in the bottom 25% are all the groups with low liquidity improvement, and it is Treated=0 for the control group.

The results of robustness test are shown in Table 7. From the perspective of the number of enterprise patents, although the coefficients of Possion and negative binomial regression models in 2015 are not significant and only significant at the level of 10% respectively, the increase in liquidity level has significantly improved the innovation level of enterprises in 2016 and 2017. This promotion effect is still continuously strengthening, and the enterprise innovation efficiency index shows the same results, which also proves the robustness of the hypothesis from another perspective.

Table 7 Robustness Check

| Variables | Patent | | P/R |
|---|---|---|---|
| | Poisson | Nbreg | FE |
| Treated*time | 0.5520 | 0.5506* | 0.2520* |
| | (0.3871) | (0.3164) | (0.1477) |
| After1 | 0.6276* | 0.7452** | 0.3390** |
| | (0.3413) | (0.3601) | (0.1537) |
| After2 | 0.6935** | 0.7951** | 0.4051*** |
| | (0.3391) | (0.3591) | (0.1518) |
| Control variables | Included | Included | Included |
| Firm fixed effect | Included | Included | Included |
| Year fixed effect | Included | Included | Included |
| Number of obs. | 185 | 185 | 185 |
| p-value(F-test) | 0.0000 | 0.0006 | 0.0000 |

Note: (1) In the table * * *, * *, * indicate that the statistics are significantly correlated at the levels of 1%, 5%, and 10%, respectively. (2) Robust standard error is shown in brackets, and panel negative binomial regression model cannot use robust standard error.

## 5. Conclusion

For a long time, the capital market has attracted more and more attention from the government and entrepreneurs in optimizing the corporate governance structure, improving the efficiency of capital allocation, and thus stimulating the vitality of enterprises. In the current economic transformation of China, the innovation of small and medium-sized enterprises is also playing an indispensable role on the way from a large manufacturing country to an innovative country.

Therefore, it is of great practical significance to explore the impact of a sound and highly liquid stock market on the innovation behavior of small and medium-sized enterprises.

Based on the analysis of the relationship between "stock liquidity and technological innovation" in the NEEQ market, and based on the data of listed companies in the NEEQ market from 2013 to 2017, this paper uses PSM-DID method to study the impact of stock liquidity on the innovation capability of small and medium-sized enterprises in China. Specifically, the following research conclusions are drawn: First, for the NEEQ enterprises, the liquidity of many small and medium-sized enterprises is at a relatively low level, and the inactive trading restricts the development of enterprises. Therefore, the improvement of stock liquidity can provide a better entry opportunity for long-term strategic investors, thus improving the attention of enterprises to long-term performance and playing an extremely significant positive role in enhancing the technology innovation level of enterprises. Second, compared with the low-liquidity enterprises, the NEEQ enterprises with high liquidity will further enhance their innovation ability with the improvement of stock liquidity, which shows that only with high trading activity can small and medium-sized enterprises further attract institutions to increase their shareholding, optimize the corporate governance structure, reduce information asymmetry, thus continuously forming a positive feedback function and providing a strong guarantee for enterprises to improve their innovation level.

The purpose of launching the NEEQ market is mainly to create a NASDAQ of China and provide better financing services for small and medium-sized enterprises and innovative technology enterprises at different levels.   Therefore, the government and the securities regulatory authorities should vigorously develop the NEEQ market, perfect the stock trading system and rules of the NEEQ market, further reduce the transaction cost and transaction threshold of securities, enhance the market transaction activity and improve the stock liquidity. This measure is not only favorable to improving the operation efficiency of the NEEQ market, but also conducive to promoting the innovation vitality of enterprises, thus promoting the national innovation to drive the pace of economic development.

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