The Influence of Short-selling on Market Efficiency—from a View of Pair Trading

DONGYUN DU and SIYU JIANG

ABSTRACT

Theoretically, the equity market would become more complete and stock price be more sensitive to new information with Margin Trading. This paper focuses on the influence of margin trading on pricing efficiency and bases its study on pair trading. Ornstein-Uhlenbeck process is called to simulate the spread of the prices of pair stocks and MLE is used to estimate its mean reversion rate, which represents the pricing efficiency. It is found that margin trading improves the pricing efficiency but its influence varies with different industry and market value of the stock.

INTRODUCTION

China has long banned the practice of short-selling. However, since 2006/6/30, China has launched many regulations related to Marginal Trading and Short-selling. The initialization and development of Marginal Trading and Short-selling exert a positive influence on the market.

Theoretically, stock price can contain more information when Marginal Trading and Short-selling are permitted. Otherwise, two types of investors cannot enter the market, pessimistic investors without securities and optimistic ones without capital. With the two operations, the first group can exercise their view by short-selling and the second group can practice by marginal trading, buying more stocks with limited amount of money. In this sense, Marginal Trading and Short-selling can improve the market liquidity, pricing efficiency, and reduce abnormal volatility.

The first literature about the Short-sales is Miller [12]. This paper shows that short-sale constrained stocks should be overpriced because the prices reflect the beliefs of only optimistic investors. Diamond and Verrecchis [4] show that short-sale constraints should reduce the speed of adjustment to negative information. Chang et al. [3] reports the prices of the stocks with covered short sale constraints are seriously overvalued on the Hong Kong stock Exchange. Li Ke et al. [9] exploits the natural experiment to the stock of the list companies in Chinese wine industry and finds the stocks with short-sale constrains are seriously overvalued and the fundamental value of stock doesn’t contribute to explain the overprice. Li Zhisheng et al. ([10],[11]) finds that the introduction of margin trading promotes the price stability and improves stock price efficiency by comparing the volatility characteristics for stocks eligible for margin trading and those ineligible.

Pair trading is a popular relative-value strategy. In the strategy it is assumed that the relative prices of two stocks, which depart from their equilibrium value, will converge to its equilibrium value soon. Distance model ([1], [2] and [6]), co-integration and mean reversion model [14], GGR method [8] and stochastic model [7] are used in pair trading. Most papers show that pair trading is profitable even if some papers ([8],[5]) show the downward trend in the profitable of pair trading in US equity market.

Dongyun Du, Department of Financial Engineering, School of Banking and Finance, University of International Business and economics
Siyu Jiang, School of Engineering and Applied Science, Columbia University
This paper estimates the influence of Marginal Trading and Short-selling on pricing efficiency, which we define to be the velocity of returning to fair value, when the price is experiencing abnormal jumps. Since absolute fair value of a securities is hard to define, so this paper uses its relative fair value. It is assumed that the prices of related stocks also have a quantitative relationship, which is taken as the relative fair value of a stock. When a security is overestimated or underestimated than its relative fair value, the investors in the markets will make the price of the security converge to the relative fair value. In order to test this mechanism, this paper found stock pairs in the market, and group them according to whether it is a target for marginal trading and short-selling or not. Then, its return velocity is analyzed when price deviates from its fair value.

The structure of this paper is as follows: section II introduces the models, section III introduces the data and empirical results, section V concludes.

MODELS

Matching stocks

In this paper, two steps are taken to find the matching stocks within industries. In the first step, we applied Cointegration Theory, brought up by Engle and Granger, to find the stock pairs that cointegrate. In the second step, we added more criterions regarding its characteristics. We go into details of these two steps as following.

Step 1 Cointegration

Classic regression model is based on the assumption that the time series is a stationary process, which means the statistic properties of the time series remain the same as time goes by. Using of classic regression, when the assumption of stationary process is broken, will lead to spurious regression problem. Cointegration is one way to solve it.

Step 2 Match stock characteristic

The velocity of matching stocks is not only exposed to investors’ behaviors, but also its own inner features. In order to show the influence of marginal trading and short selling on pricing efficiency, we choose stocks with high similarity in stock characteristics.

In the paper, we referred to the Distance Method in [13], but we selected different character indexes.

First, we mapped stocks within the industry. Second, we calculated the average market value, the volatility of daily return, and daily turnover of the stock during sampling time intervals. Matching stocks are expected to minimize the following:

$$\text{Distance} = \sum_{i} \left( \frac{\text{factor}_{i}^{\text{strd}} - \text{factor}_{i}^{\text{matched}}}{\sqrt{\left( \frac{\text{factor}_{i}^{\text{strd}} + \text{factor}_{i}^{\text{matched}}}{2} \right)}} \right)$$

Where factors refer to market value, daily volatility, and turnover respectively. Factors with superscript “strd” denotes the factor value of target stock, and those with “matched” denotes the stocks pool.

After matching stocks are chosen, we applied Ornstein–Uhlenbeck process to simulate the time series of their spread and estimate the parameters.
Estimate the Mean-Reverting Velocity

Ornstein–Uhlenbeck process

When we observed the spread series of matching stocks, we found significant mean-reversion effect. The spread series is chosen as an Ornstein-Uhlenbeck process:

\[ \frac{d\epsilon}{\sigma} = \frac{\kappa}{\sigma} (\mu - \epsilon) dt + \sigma dW_t \]

where \( \kappa, \mu, \sigma \) denotes mean-reverting velocity, mean, and volatility, \( W_t \) is a Wiener process. According to Ito Lemma, the closed form of the process is,

\[ \epsilon(t) = \epsilon(0) e^{-\kappa t} + \mu - \frac{\sigma^2}{2\kappa} + \sigma \sqrt{\frac{2}{2\kappa}} N(0,1) \]

And the transition probability function is,

\[ P(\epsilon(t+\Delta t)|\epsilon(t); \kappa, \sigma, \Delta t) = \frac{1}{\sqrt{2\pi \Delta t}} \exp \left\{ -\frac{[\epsilon(t+\Delta t) - \epsilon(t) - \kappa \Delta t + \sigma \sqrt{2\kappa \Delta t} N(0,1)]^2}{2\sigma^2} \right\} \]

Where \( \Delta t \) is the time interval. By solving the equations \( \frac{\partial L}{\partial \alpha} = 0; \frac{\partial L}{\partial \kappa} = 0; \frac{\partial L}{\partial \sigma^2} = 0 \), we have:

\[ \begin{align*}
\alpha &= \frac{S_y S_{xx} - S_x S_{xy}}{n S_{xx} - S_x^2 - a S_y + na^2} \\
\kappa &= -\frac{1}{\Delta t} \left( \frac{S_{xx} - a S_x - a S_y + na^2}{\sigma^2} \right) \\
\sigma^2 &= \frac{1}{n} \left[ \frac{S_{xy}^2 - 2S_{xy}S_{xx} - S_{xx}^2}{\sigma^2} + n \alpha^2 \left( 1 - e^{-\kappa \Delta t} \right)^2 \right] \\
S_x &= \sum_{i=1}^{n-1} X_i, S_y = \sum_{i=2}^{n} X_i, S_{xx} = \sum_{i=1}^{n-1} X_i^2, S_{xy} = \sum_{i=1}^{n-1} X_i X_{i+1}, S_{yy} = \sum_{i=2}^{n} X_i^2
\end{align*} \]

\( \kappa \) is the mean-reverting velocity. When the prices of the two matched stocks deviate from the long-term mean, the velocity it heads to the mean is \( \kappa \).

EMPIRICAL STUDY

Data

The data in the paper all comes from Wind, the time interval is 2011/01/01 – 2012/12/31 and 2014/01/01 – 2015/03/20. For computation convenience, we used daily data to choose the match stocks; for better capture the stock volatility, we used 1-minute close price to calculate the mean-reverting velocity. Assume the price series of two stocks are \( p_1^t, p_2^t \) respectively, procedures before estimation are as following.

Step 1, get spread series with cointegration regression:
Step 2, centralize the series by subtracting the mean from the original series, and we get the error term:
\[ \epsilon_t = \text{spread}_t - \text{mean} \text{spread} \]

**Matched Stocks**

By observing the result, we found that the velocity varies from pairs to pairs, which means the influence of stock characteristics is very significant. In order to minimize the impact, we compared the velocity of each pair in different years. Also, market in different years might show different trends, we compared different pairs in the same time period to get rid of the market effect. To make the pairing stock more alike, we only select stocks within the same industry, we applied the Shenwan industry classification criterion. For each marginal trading target stock, we paired two stocks for it, one also coming from target stocks, one coming from non-target group as control group. We think the most convincing group is the target stock which has two paired stock (one from target and one from non-target). If only one paired stock can be found, we put them to the control group.

Now, we have two pools of stocks, all of them are cointegrated with the specific stock we are going to match for, one pool is the target stocks and one is non-target stocks. According distance method, we choose the paired stock and then we examined the cointegration in minute-level data, if the cointegration fails, we try the stock with second-minimum distance.

(1) 2011-2012 Cross-data analysis

We searched for match stocks in the 2662 stocks in the market (28 industries in total). And we got the following result:

<table>
<thead>
<tr>
<th>Industry</th>
<th>Target Stock</th>
<th>Pairing Target Stock</th>
<th>Returning velocity</th>
<th>Target Stock</th>
<th>Pairing nonTarget Stock</th>
<th>Returning velocity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electronics</td>
<td>600089.SH</td>
<td>600550.SH</td>
<td>72.07</td>
<td>600089.SH</td>
<td>600869.SH</td>
<td>32.67</td>
</tr>
<tr>
<td>Real Estate</td>
<td>000002.SZ</td>
<td>603833.SH</td>
<td>184.17</td>
<td>000002.SZ</td>
<td>600791.SH</td>
<td>138.58</td>
</tr>
<tr>
<td>Steel</td>
<td>600085.SZ</td>
<td>600005.SH</td>
<td>222.61</td>
<td>600005.SH</td>
<td>600103.SH</td>
<td>136.59</td>
</tr>
<tr>
<td>Transport</td>
<td>600018.SH</td>
<td>601111.SH</td>
<td>65.41</td>
<td>600018.SH</td>
<td>601880.SH</td>
<td>243.64</td>
</tr>
<tr>
<td>Car</td>
<td>600033.SH</td>
<td>600104.SH</td>
<td>31.00</td>
<td>600033.SH</td>
<td>600741.SH</td>
<td>42.15</td>
</tr>
<tr>
<td>Non-banking finance</td>
<td>601318.SH</td>
<td>601601.SH</td>
<td>310.31</td>
<td>601318.SH</td>
<td>600109.SH</td>
<td>105.32</td>
</tr>
<tr>
<td>Bank</td>
<td>601398.SH</td>
<td>601939.SH</td>
<td>1008.08</td>
<td>601398.SH</td>
<td>601288.SH</td>
<td>1195.56</td>
</tr>
</tbody>
</table>

Note: target stock (A) means the stock which is eligible for short selling and marginal trading; pairing-target/non-target means the two stocks chosen to match with the Target Stock A, one is also eligible for short-selling and marginal trading, one is not.

If we denote the target/target stock pairs as group A, and target/non-target pairs as group B. From the table above, we know in most industries, such as electronics, real estate, nonbanking finance, and steel, the returning velocity of group A is higher than that of group B. Especially, in the mental industry, the difference between the two is very large. For electronics, the returning velocity of the group A is nearly twice as much as that of the group B. For real-estate and banking industry, the returning velocity of group A is higher than that of the group
B, showing that marginal trading and short-selling exert more effect on pricing efficiency. However, for steel, transport, and cars stocks, the velocity of the two groups is close, indicating that the effect of marginal trading is not significant.

(2) 2014-2015 Cross-data analysis

During year 2014-2015, there are 700 target stocks for short-selling and marginal trading.

<table>
<thead>
<tr>
<th>Industry</th>
<th>Target Stock</th>
<th>Pairing NonTarget</th>
<th>Returning velocity</th>
<th>Target Stock</th>
<th>Pairing NonTarget</th>
<th>Returning velocity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electronic device</td>
<td>600089.SH</td>
<td>600550.SH</td>
<td>14.04</td>
<td>600089.SH</td>
<td>600869.SH</td>
<td>10.52</td>
</tr>
<tr>
<td>Real Estate</td>
<td>000002.SZ</td>
<td>600383.SH</td>
<td>32.73</td>
<td>000002.SZ</td>
<td>600791.SH</td>
<td>8.07</td>
</tr>
<tr>
<td>Steel</td>
<td>600018.SH</td>
<td>601111.SH</td>
<td>91.92</td>
<td>600018.SH</td>
<td>601880.SH</td>
<td>73.91</td>
</tr>
<tr>
<td>Transport</td>
<td>601006.SH</td>
<td>601111.SH</td>
<td>52.80</td>
<td>601006.SH</td>
<td>601880.SH</td>
<td>32.14</td>
</tr>
<tr>
<td>Car</td>
<td>600104.SH</td>
<td>000338.SZ</td>
<td>58.45</td>
<td>600104.SH</td>
<td>601777.SH</td>
<td>43.56</td>
</tr>
</tbody>
</table>

Note: "\" means there is no cointegration relationship in minute-level data.

Except for Steel industry, we can observe that the returning velocity of group A is higher than that of group B by a large scale, especially the Real Estate and Transport industry. The result is consistent with our assumption. Meanwhile, we found that the returning velocity in 2014-2015 overall is lower than that in 2011-2012, we took it as the result of different market style in different years. So the returning velocities in different years cannot be compared.

(1) Explanatory Statistics

<table>
<thead>
<tr>
<th></th>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>186.32</td>
<td>189.35</td>
</tr>
<tr>
<td>Sd</td>
<td>249.71</td>
<td>293.84</td>
</tr>
<tr>
<td>Median</td>
<td>68.74</td>
<td>86.28</td>
</tr>
</tbody>
</table>

During year 2011-2012, the returning velocities of two groups are very close, with that of group B being higher. Also there exists high standard deviation, which means the velocities of different pairs varies greatly. However, during year 2014-2015, the mean and median of group A is higher than that of group B. And for group A the velocities of different pairs are closer (the standard deviation is lower). However, in 2014-2015, marginal trading and short-selling took up higher market, so their influence became more significant.

Further Analysis—the Influence of Industry and the market value

We computed the average returning velocity of all the stocks in one industry to indicate the overall condition of the specific industry. We found that the influence of marginal trading and short-selling is relevant with the industry. Therefore, we further compared the marginal-trading scale and industry scale. Because large amount of data before 2014 is missing, so we only consider the marginal trading scale and industry scale data up to 2014/12/21.

The average of the ratio of the industry marginal trading volume in market value is 2.2%. We found the ratios for banking, mental, electronic device, non-banking, real estate are 2.4%, 4.2%, 3.1%, 2.3% relatively. However, for cars,
transport, steel, the ratios are 1.6%, 1.5%, 2.0%. We found for those industry in which marginal trading has more influence, the ratio is higher (above average); however, for those in which marginal trading has less influence, the ratio is much lower (below average). So, we concluded that for some industry, the high ratio of the marginal trading volume of market value means that investors are more inclined to use marginal trading, so its influence on pricing efficiency is more significant.

The turnover of Transport Industry is much smaller than its market value. However, the value of the two indicators for real estate is large for real estate. So we can tell that the returning velocity of a pair of stocks has close relationship with its own market value. For banking stocks, they are of large market value. For example, the pair we took as insignificant, 601398.SH, 601939.SH, and 601398.SH, 601288.SH, their market value is more than 100 billion. For such pairs, the returning velocity for the targeted match group and target/non-target group is high and close to each other. For stocks with large market value, its trading volume is high, and its liquidity comes from different sources, so the influence of marginal trading may not be significant. However, small-cap stocks are vulnerable to abnormal events.

**Conclusion**

In the paper, cointegration and distance method are applied to select the matched stocks. OU process is called to simulate the time series of spread, and MLE to estimate the returning velocity. Finally, by comparing the velocity of different pairs, the influence of marginal trading and short-selling on pricing efficiency are analyzed.

Based on the analysis, we found the marginal trading and short selling have profound influence on the stock market. Generally, if the pairing stocks are both targeted stocks for marginal trading, the returning velocity is higher than the pairing stocks with one being targeted and one not. It means that, when mispriced, it is faster to return to the normal lever, which shows the pricing efficacy is higher. Further analysis shows that, the velocity is also influenced by industry and stock characteristics. For a specific industry, when the ration of marginal trading volume and market value is higher, the marginal trading’s influence on the pricing efficiency in the industry in more significant. Also, stock market value is an influential factor. For large stock, the returning velocity for both pairs are close and high. However, small-cap stocks are vulnerable to abnormal events. So for stocks with market value between $10^9 – 10^11$, the influence is most significant.

**REFERENCES**