A Change of Order Balance Implies Intraday Price Trend in Japanese Stock Market

Hwion YOON

CMD Laboratory Inc.
1-3-2, Sendagaya, Shibuya-ku, Tokyo, Japan
yoon@cmdlab.co.jp

***Abstract*— This paper focuses on the relation between order book condition and price movement. The presented model is applicable to making trading strategies during the day and to estimating them in the Japanese stock market. Nevertheless, it is difficult to reveal the absolute mechanism of the financial market. We find that the information on order books are more meaningful in constructing a trading strategy rather than the information from traded prices and volume data. Particularly, a change of the balance on order book implies price trend not only in a moment, but also over a certain period, due to a memory effect. Additionally, it is indicated that thinning out data is still good enough to study intraday market movement, even if there are many HFT order flows. We can recognize that HFT requires algorithmic trade, but algorithmic trade does not require HFT.**

***Keywords*— Order Book, Ita, Stock Market, Market Impact, Algorithmic Trade, High Frequency Trade, Intraday movement.**

I. INTRODUCTION

The price in financial markets seems to be determined when the quantity of demand which buyers wish and the quantity of supply which sellers wish balance. Although the sense that market mechanism balances demand and supply is common in economics, the price is not necessarily determined from the result of demand and supply in real financial markets, particularly in intraday movement. In the Japanese equity market, the price is caused from balancing demand and supply directly at the market opening and closing, but the price is not determined by the excess demand or excess supply during the trading hours.

This paper shows that the methodology that approximates the demand or the supply with a power function during the trading hours in Japanese equity market is effective. Using the approximation model by a power function, we discuss the influence on a subsequent price change from the change of a demand-supply balance on an order book. A change of demand-supply balance on an order book may serve as an information source in an algorithmic trade or HFT. Finally, we refer why order book information is so important for regarding the relation between algorithmic trade and HFT.

II. ORDER BOOK AND INTRADAY PRICE MOVEMENTS IN JAPANESE STOCK MARKET

In the Japanese equity market, opening price and closing price are determined by the Ita-yose methodology. The Ita-yose methodology is a system in which the price and the trading volume are determined by the intersection of a demand curve and a supply curve just before a certain time, such as opening or closing. In Japanese, the order book table is called "Ita" and the matching is called "Yose", so we say Ita-yose for demand-supply matching. On the other hand, a market participant trades for Ita shown as Fig.1 during intraday-trading hours. We call this price and trading volume determinant system "Zaraba". The key issue for the difference between Ita-yose and Zaraba is that the Ita-yose system reflects demand-supply, but Zaraba does not. On the Zaraba system, one market participant watches Ita, then he or she decides to trade at bid or ask. Depending on the order book information, he or she may get aggressive or hesitate to trade. This means intraday movement is caused from the information of demand-supply situation, not from demand-supply condition directly.

Sell amount	Price	Buy amount
	M.O.	
47,230	OVER	
230	1013	
110	1012	
320	1011	
210	1010	
30	1009	
110	1008	
60	1007	
200	1006	
	1005	
100	1004	
70	1003	
	1002	
50	1001	
	1000	25(
	999	70
	998	130
	997	360
	UNDER	34,570

Fig. 1 Order book, "Ita" illustrated by Tokyo Stock Exchange

III. THE MODEL OF MARKET IMPACT

In order to recognize the information of demand-supply situation, a real Ita sample is shown in Fig.2. It is a snap shot

of the Sony order book at 9:00:01 on Feb 15th, 2012. Buy orders are positioned on the right hand side, and sell orders on the left hand side. The black bar indicates immediate executable price range where one order can make a price push up or down. The range is calculated from the current market price. In case of Fig.2, the current price is 1526, and the range corresponding to it is 80 yen, so one order may trigger to push the price up or down 5.24%.

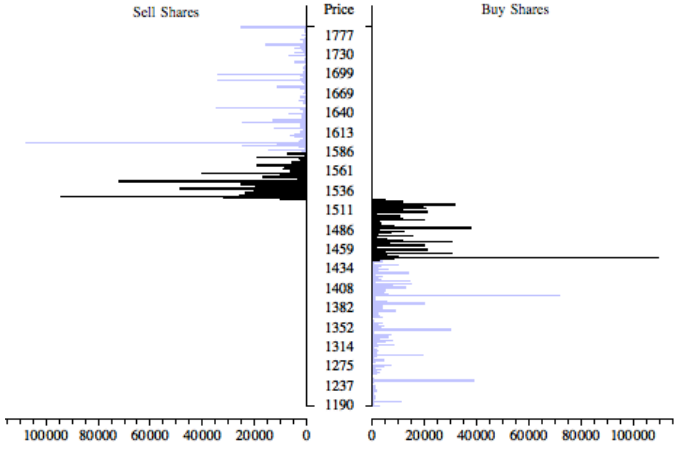

Fig. 2 A snap shot of Sony's Ita at 10:00:02 on Feb. 15th, 2012

Focusing on the range, we can draw a market impact curve that indicates the cost for the number of trading shares. Fig.3 shows two impact curves for the market, one for the buyer and one for the seller. The horizontal axis is the order quantity, and the vertical axis is the trading cost. For example, if you wish to buy 500,000 shares of Sony stock at 10:00:02 on Feb. 15th, 2012, your buying cost should be 1535.99 yen from the Ita condition. It should be noticed that impact curve indicates the cost not market price.

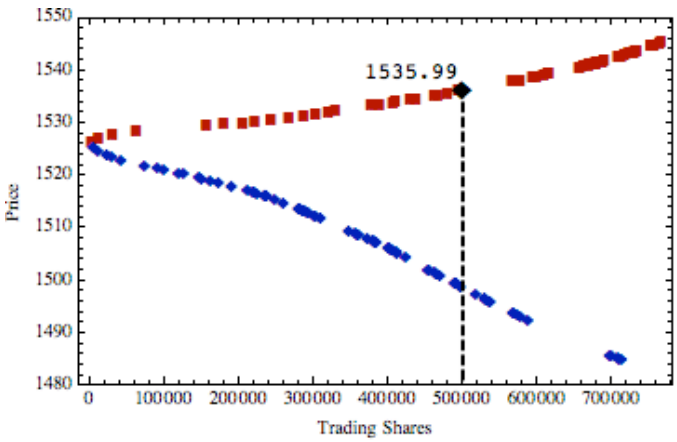

Fig. 3 A snap shot of Sony's Ita curves at 10:00:02 on Feb. 15th, 2012

Observing a snap shot data of Ita, we can approximate the curve, (1) as a liner function, (2) as an exponential function, and (3) as a power function.

$$impact = a \cdot S \quad (1)$$

$$impact = a \cdot \exp(b \cdot S) \quad (2)$$

$$impact = a \cdot S^{c} \quad (3)$$

In the function, S is trading shares, impact = Abs[executed price – current price], a is a scale coefficient, b is a exponential coefficient, c is a power low coefficient.

Corresponding to curves in Fig.3, these 3 approximated curves are shown in Fig.4. A intraday movement in financial market is so unstable that these coefficient numbers are variable, even triggered by one order.

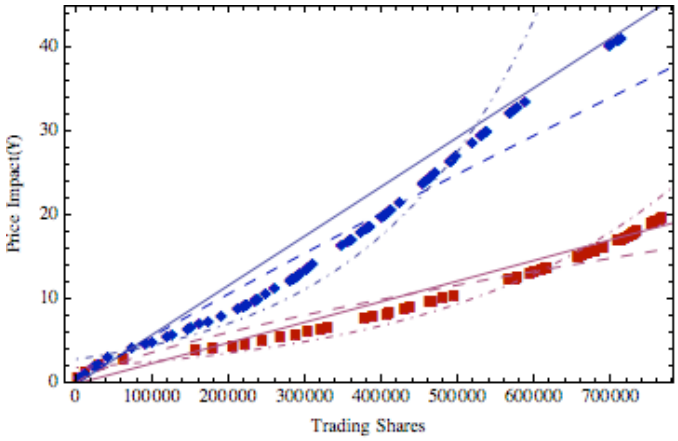

Fig. 4 Approximating function curves for snap shot of Sony's Ita

Here, approximating functions are follows;

A. Approximating Impact Functions in Buying(Red lines)

1) The liner Approximation (the red line)

$impact = 0.0000245 \times S$, R^2=0.97

2) The Exponential Approximation(the red dashed lines)

$impact = 1.93 \times \exp(0.0000032 \times S)$, R^2=0.91

3) The Power Approximation (the red dot-dashed lines)

$impact = 0.00105 \times S^{0.711}$, R^2=0.93

B. Approximating Impact Functions in Selling(Blue lines)

4) The liner Approximation (the blue line)

$impact = 0.0000589 \times S$, R^2=0.98

5) The Exponential Approximation(the blue dashed lines)

$impact = 2.93 \times \exp(0.0000045 \times S)$, R^2=0.87

6) *The Power Approximation (the blue dot-dashed lines)*
$impact = 0.000137 \times S^{0.923}$, R^2=0.97

Considering the variable market conditions and mathematical reason that the function should pass through point zero, the exponential function or the power function is better than the liner function. Analyzing for empirical data, the power function seems to be suitable for the approximating function for market impacts. Finally we propose the market impact model as follows;

$$impact_i(S,t) = a_i(t) \cdot S(t)^{C_i(t)} \qquad (4)$$

Here, i is a dummy index for recognizing stock, S is trading shares, t is a time parameter.

IV. The Empirical Study for Japanese Equity Market

A. Data

Tokyo Stock Exchange, Inc. calculates market impact parameters, a_i in buying impact, C_i in buying impact, a_i in selling impact, C_i in selling impact, and publishes them every 5 seconds on the web site "TSE Market Impact View."

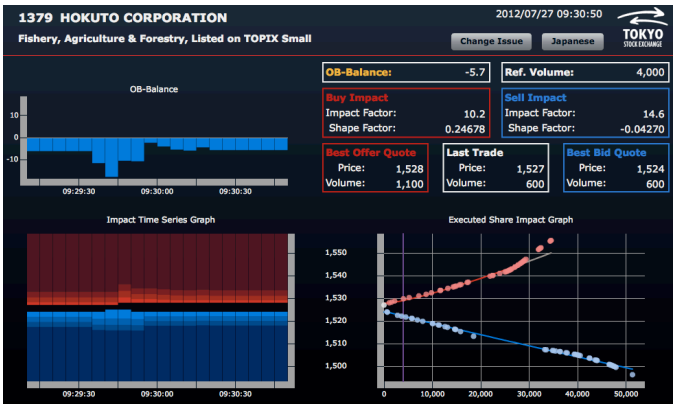

Fig. 5 TSE Market Impact View

TSE also calculates Ita balance data by the following definition.

$$\Delta_B = I_B^{\text{buy}} - I_B^{\text{sell}} = \log\left(S_B^{\text{buy}} S_B^{\text{sell}} / (P^{mid})^2\right) \qquad (5)$$

Here, I_B^{buy} is buyer's impact at basic trading shares, I_B^{sell} is seller's impact at basic trading shares, S_B^{buy} is basic trading shares on buyer's, S_B^{sell} is basic trading shares on seller's, P^{mid} is mid price, and basic trading shares are 10% of total shares within the immediate executable range on yesterday's Ita. We show Sony's intraday price movement and Ita balance movement on Feb. 15th, 2012 in Fig.6 as one example. The horizontal axis is time, the left vertical axis is stock price, and the right vertical axis is the degree of Ita balance in which plus values indicate more buyer' s order shares and minus values do more seller's order shares on Ita. The mid dot line separates the morning session and the afternoon session at 11:30 am (the morning session close) or 12:30 pm (the afternoon session open).

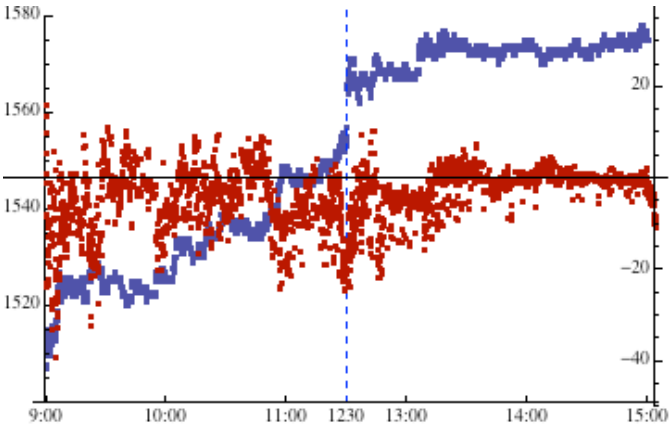

Fig. 6 Intraday price movement and Ita balance movement of Sony on Feb. 15th, 2012

B. Observing the relation between Ita balance value and price movement

First, simply we observe the relation between Ita balance value and price movement of the next 5 seconds.

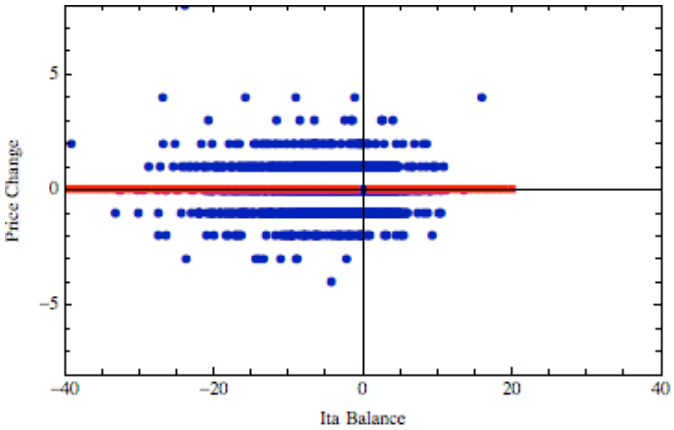

Fig. 7 The relation between Ita balance value and price change of Sony on Feb. 15th, 2012

Fig.7 shows the case of Sony on Feb. 15th, 2012. The red line is the linear regression as follow;

$PriceChange = 0.000320 \times S + 0.0197$, R^2=0.0000072

Fig. 8 shows a case of Fuji Film on Oct. 12th, 2012, and Fig.9 shows intraday movement for Fuji Film on the day, which are picked just as an example. The linear regression is;

$$PriceChange = 0.000188 \times S + 0.0018, \quad R^2=0.0000140$$

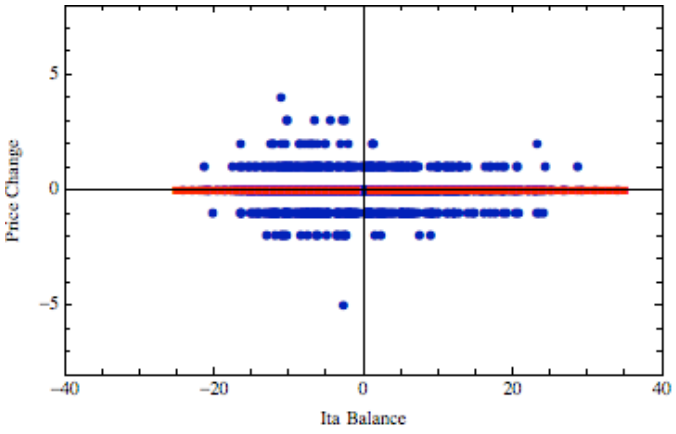

Fig. 8 The relation between Ita balance value and price change of Fuji Film on Oct. 12th, 2012

There seems to be no correlation between them according to Fig.7 and Fig.8. However, the most of market participants strongly believe that some relation exists and that market movement is not random walk. On the next section, we discuss the issue whether the relation between order conditions and price movements exist.

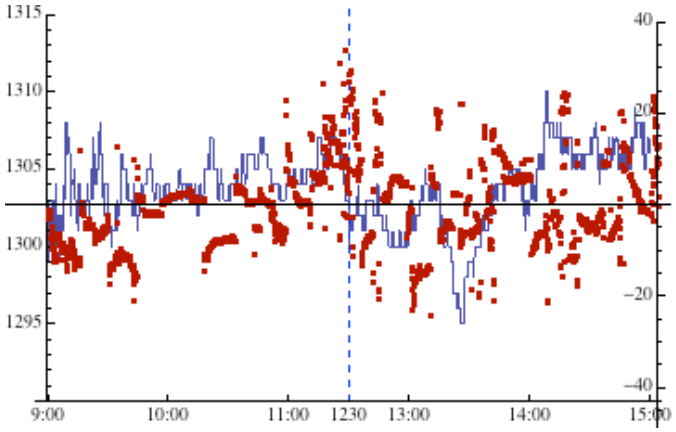

Fig. 9 Intraday price movement and Ita balance movement of Fuji Film on Oct. 12th, 2012

C. *Discussion for Ita balance*

If we accept the above previous pictures, the quantity of demand and supply seems to make no effect on the market. The key point in how we discuss their situations is that we should stand on a market participant's point of view. In case of the situation that there are many big selling orders on Ita, a buyer tends to wait and see the market situation. However in case of the situation that selling orders are decreasing, the buyer changes his or her attitude to pay more tension towards Ita and he ore she may buy immediately. It means the Ita balance value itself is not so important, but the change of the Ita balance value should be more focused on.

Considering the above reaction, we observe the relation between the change of Ita balance value and price movement in Fig. 10 and Fig. 11.

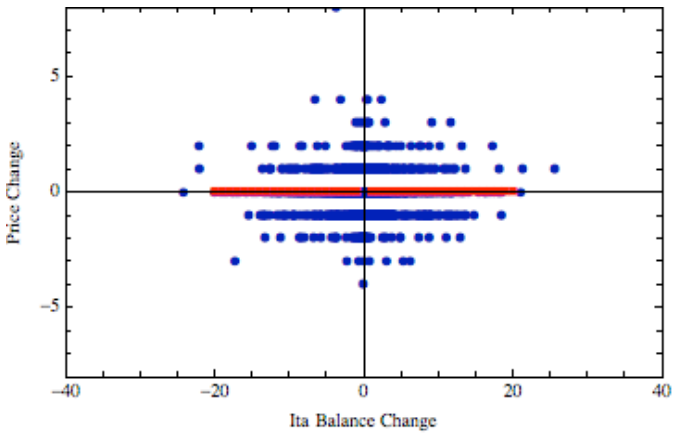

Fig. 10 The relation between the change of Ita balance value and price change of Sony on Feb. 15th, 2012

Here, the red line is the linear regression as follow;

$$PriceChange = -0.000557 \times S + 0.0189, \quad R^2=0.0000077$$

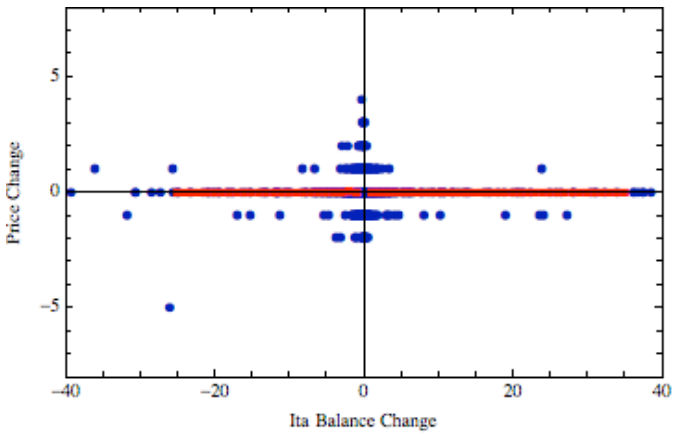

Fig. 11 The relation between the change of Ita balance value and price change of Fuji Film on Oct. 12th, 2012

Here, the red line is the linear regression as follow;

$$PriceChange = 0.000809 \times S + 0.0014, \quad R^2=0.0000509$$

Comparing Fig. 7 with Fig.10 and Fig.8 with Fig.11, it is difficult to recognize the obvious correlation between them.

Based on the above results, we try to apply a statistical test on them in order to find out whether the correlation between Ita balance and price movement exists or not.

D. The Kendall rank correlation test

Regarding intraday movement in financial market, price movement is not a random walk, so we should not premise normal distribution for price change. In this case, we should make a non parametric statistical test, then choose the Kendall rank correlation test in order to find out whether there is a correlation between Ita balance and price movement. The test process is as follows;

1) Null Hypothesis H_0 : population correlation coefficient is Zero.

2) Alternatives H_1 : population correlation coefficient is not Zero.

3) Test Statistics : $T = \dfrac{|r_k|}{\sqrt{\dfrac{4n+10}{9n(n-1)}}}$

n = sample size (= 3600), r_k is Kendall's rank correlation coefficient.

4) Critical region : $\alpha = 0.05, Z(\alpha/2) = 1.96$

5) Calculate : We calculate 2 pair of Test Statistics T of 10 stocks' intraday data. One is the pair of Ita balance - price change on next 5 seconds, and the other one is the pair of Ita balance change and price change on next 5 seconds just after Ita balance change, for each day from Jan. 4th, 2012 to Dec. 28th, 2012.

V. THE RESULTS OF STATISTICAL TEST

The calculated results are shown as Table.1. There are 248 trading days in 2012, but stock trading may have suspended time due to huge amount of in-balanced order, so available data shown in the mid column is not the same among them.

The results indicate 3 points as follows;

1. The correlation between Ita balance and price movement may be observed only less than 30%, but it seems to exist.
2. The correlation between the change of Ita balance and price movement may be more observable than Ita balance itself on each stock.
3. The change of Ita balance seems to be more useful information to predict intraday price movement, compared to Ita balance value.

TABLE I
THE RESULTS OF STATISTIC TEST

			Ita balance and Price movement	**Ita balance Change and Price movement**
Code	**Stock Name**	**number of data**	**number of Reject H_0**	**number of Reject H_0**
1379	Hokuto	247	41	72
1925	Daiwa House	243	44	89
2801	Kikkoma	246	73	84
3401	Teijin	210	1	50
4901	FujiFilm	230	35	50
6301	Komatsu	210	21	41
6758	Sony	212	13	45
7201	Nissan	217	5	65
8802	Mitsubishi Est.	233	69	49
9432	NTT	203	2	36

VI. DISCISSONS AND CONCLUSIONS

Although market demand and supply seem to influence market price movement, it is difficult to find out the obvious correlation between shares on order book and price movement.

The main reason why it is hard to see the correlation is un-stability on intraday trading circumstances. It is very common to trigger jumps or collapses by one order in the financial market, so the correlation as a linearity measure often disappears.

The other reason is the features of time dependency. Normally a market, just after opening, is more volatile compared to the other time periods. It means market condition is not a homogeneity, particularly during the intraday trading periods. As we calculate the correlation using whole intraday data, statistical figures sometimes eliminate the important property.

Today, information flow in the financial market is numerous and micro second movement occurs. It causes the idea that high-speed responses are necessary to trade. However, it is more important to recognize the current condition in market. Without recognition of the market condition, high-speed is meaningless. The essential matter should be to analyze the market features, and to reflect for trading strategy. A trading strategy is often realized by algorithmic trade, because it is necessary to manage huge information flows. After constructing management framework to trade, HFT technology gives us value-added methodology, not before. HFT is an addition to the last.

This paper concludes that focusing on the change of Ita balance seems to be better than Ita balance value itself. Even the degree of the correlation between Ita information and price information is limited, but the relation exists, and it has a possibility to develop dynamic algorithm trading strategies.

Lastly, we mention Ita information is suitable for HFT. Since Ita information is the current condition data, high-speed response needs the information which imply market

conditions. Lastly, executed price and traded volume are data in of the past. HFT should require the current information rather than the past information.

REFERENCES

[1] N. Bershova, and D. Rakhlin, The Non-Linear Market Impact of Large Trades: Evidence from Buy-Side Order Flow, Journal of Investment Strategies, Vol. 2, No. 2, Spring, 2013, p. 25-69

[2] N. Taleb, "The Black Swan," Random House, 2007.

[3] K. Gopal, "100 STATISTICAL TESTS," SAGE Publications, 2006.