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Expectations and Market Microstructure when Liquidity Is Lost

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Expectations and Market Microstructure when Liquidity Is Lost

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Abstract

In this paper, we focus on the halt of price discovery function in the financial markets and the evaporation of market liquidity. We explore the mechanism of these phenomena by using simulation techniques shown in Muranaga and Shimizu (1999). In order to generate evaporation of market liquidity, we exogenously reduce traders' expected values of asset. In one simulation, it is assumed that market participants do not amend their expectations on future price levels in response to large movements in market prices, but instead become more uncertain about whether the expectations would be realised. The simulation result shows that the loss of market liquidity can play a role of a built-in stabiliser in the market, and can prevent a precipitous drop in prices. As uncertainty increases, market participants become less willing to trade, the number of orders declined, and, consequently, market liquidity evaporates. When market liquidity is low, price discovery is not conducted as often, so an endogenous (secondary) crash in prices is less likely to develop. In another simulation, it is assumed that market participants amend their expectations on future prices in response to large price movements and uncertainty remains unchanged. In this case, the simulation result suggests that secondary crashes might develop. This is because order flows, which would not be interrupted, could become one-way, reflecting the sharply lower expected future prices and triggering secondary crashes.

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CONTENTS

1. Introduction

Market liquidity is a precondition for the smooth pursuit of all financial activities, including the pricing of financial products, the risk management of financial institutions, and the conduct of monetary policy. Looking back in detail at past financial crises, including Black Monday, the EMS shock, and the recent Asian and Russian financial crises, the cessation of the market's price discovery function caused by a rapid decline in market liquidity was in each case the critical issue.

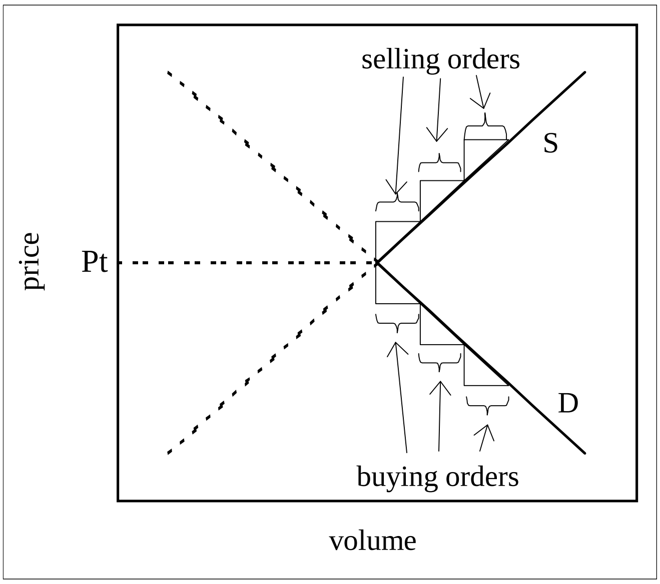
This paper explores the mechanism of market liquidity evaporation, which leads to the cessation of the market's price discovery function, using a simulation technique proposed by Muranaga and Shimizu (1999). In order to analyse dynamics of market liquidity, we incorporate feedback mechanisms through which traders modify their expectations of future asset price. Since we focus on the stressful situation of the market, we give an initial exogenous shock to our artificial market and analyse the generating process of market liquidity evaporation. The simulation results show the factors affecting the process resulting in market cessation, and the factors affecting the process of the market's autonomous resumption following the state of cessation.

The rest of this paper is organised as follows. Section 2 briefly reviews microscopic understanding of market liquidity evaporation. Section 3 presents the outline of the simulation, including the feedback mechanism through which traders revise their expectations of asset. Section 4 shows the simulation results. Our concluding remarks appear in Section 5.

2. Microscopic understanding of the phenomena

We interpret the cessation of the market's price discovery function caused by market liquidity evaporation as follows. When an equilibrium price is discovered at the market in normal times, supply of and demand for asset are in equilibrium at market price P_t as shown in Figure 1. The horizontal length of the triangles in the figure represents the volume of selling and buying limit orders which remain unexecuted, and the vertical length represents the tick size or minimal price unit. If some external shock causes the demand (or supply) curve to shift, and selling (or buying) order flows react with a minimum length of lag so as to follow this shift, only one-off jump in price is observed. However, it should be noted that the portion of the demand (supply) curve above (below) P_t is regarded as the "effective supply and demand" which is actually not realised at the point of *t*.[1] In other words, when an external shock causes a shift of the demand (or supply) curve, and leads to a shift of buying (or selling) order book, there may be cases which actual orders are not realised immediately following such shifts. If, on the one hand, effective supply and demand are realised as actual orders leading gradually toward the new equilibrium, we will observe a selling climax at which price changes gradually tend to one direction (Roll [1988]). If, on the other hand, it takes a substantial time for effective supply and demand to become realised as actual orders, we will face a situation in which trades are not executed because of the wide divergence of the best bid and the best ask or disappearance of buying (selling) limit orders.

Figure 1. Supply-demand in the market



As suggested in the analysis of Lanterbach and Ben-zion (1993), the above cases are based on the supposition that it is a supply-demand imbalance which leads to a cessation of the price discovery function because there is some friction which prevents the underlying effective supply and demand from being realised. When we look further into the details of such process, we can see that the way in which market participants' expected value of assets and future market liquidity alters, especially under the effects of external shocks, does play an important role. The price discovery process will be affected in various ways, according to the speed and magnitude of such expectation change. In some cases, the demand curve alone shifts rapidly to the left while becoming more steep, reflecting a decline of the price elasticity of demand, resulting in the delay

[1] See Muranaga and Shimizu (1999) for discussion about "effective supply and demand."

in the realisation of effective supply and demand (Figure 2-1). In other cases, the demand curve shifts to the left while the supply curve becomes more flat, reflecting a rapid increase in the price elasticity of supply, which results in the disappearance of (both selling and buying) orders (Figure 2-2). Changes in the price elasticity of supply and demand are observed through changes in the order-book profile.

Figure 2-1. Shift of supply-demand

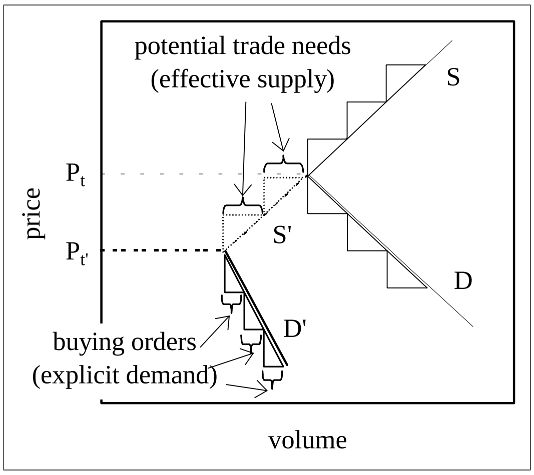
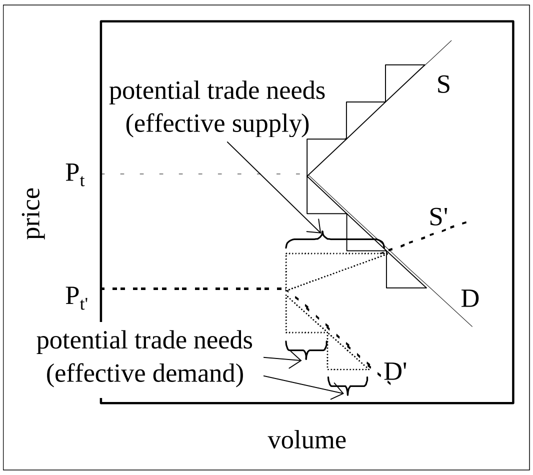


Figure 2-2. Shift of supply-demand



During such phenomena, each market participant decides his/her ability to exit market based on their expectation of future price and market liquidity, and as a result, his/her behaviour such as expediting or delaying orders will be observed. According to Gerety and Mulherin (1992) and Subrahmanyam (1994), such a behavioural mechanism is observed in daily transactions through the increased trade volume toward closing, and can be rationally derived when considering trading behaviour in multiple periods. What becomes crucial here are: how expectations about price and market liquidity are formed; how risk is recognised based on such expectations; and how a market participant decides the type of order by comparing the recognised risk with his/her own risk tolerance. By analysing such realising mechanism of trade needs, we can clarify the halt and resumption of the price discovery function.

3. Outline of the model and simulation

This paper employs an extended version of the trader model and the trade execution model used in Muranaga and Shimizu (1999). There are two types of traders in the market: “momentum traders” who make market orders following short-term market trends, and “value traders” who place limit orders based on their certain expectations such as expected values of asset and confidence in their own forecasts. As for the trade execution model, we employ a continuous auction system following that of the Tokyo Stock Exchange (TSE).

Muranaga and Shimizu (1999) assume that each trader's variables such as expected value, confidence in forecast, and risk preferences are constant. This approach interpreted to observe the effects of changes in the above variables caused by different market microstructures. In the actual market, however, traders are believed to revise those variables by monitoring market information. In order to analyse dynamics of the mechanism through which traders' potential trade needs realise corresponding to changes in market environment, we incorporate feedback mechanisms through which traders modify their expectations of asset. Since our analysis deals with the decline in market liquidity and the cessation of price discovery function, we give an initial exogenous shock by changing all traders' expected values at once,[2] and observe the process in which this shock leads to a stressful situation of the market.

As for feedback effects, we will consider two of the most simple mechanisms: (1) feedback to trader's expected value, and (2) feedback to trader's confidence in expectation. As shown in Figure 3-1, feedback mechanism to expected value is that a trader revises his/her own expected value based on market information he/she receives. Specifically, when trader *i*, who holds initial expected value $\tilde{P}_{i,0}$, observes that the market price just before his/her order is below a certain confidence level[3] of his/her expected distribution of $\tilde{P}$ (γ), he/she forecast an market equilibrium price based on the market trend and revise $\tilde{P}_{i,t}$ accordingly.

As shown in Figure 3-2, feedback to confidence is that a trader revises his/her confidence in expectation, that is, variance of traders' expected values, based on market information he/she receives. Specifically, when trader *i*, who holds initial expected variance of $\gamma_{i,0}$, observes that the market price just before his/her order is below the "trigger," he/she revises γ of time *t* to $\gamma_{i,t}$, so that observed market price will fall within the range above the 'trigger.'

[2] We assume that there was a public announcement which gives downward shock for prices, reduce all value traders' expected values by 5%.

[3] Hereafter, we call the certain confidence level which causes such revision as "trigger."

Figure 3-1. Feedback to expected value

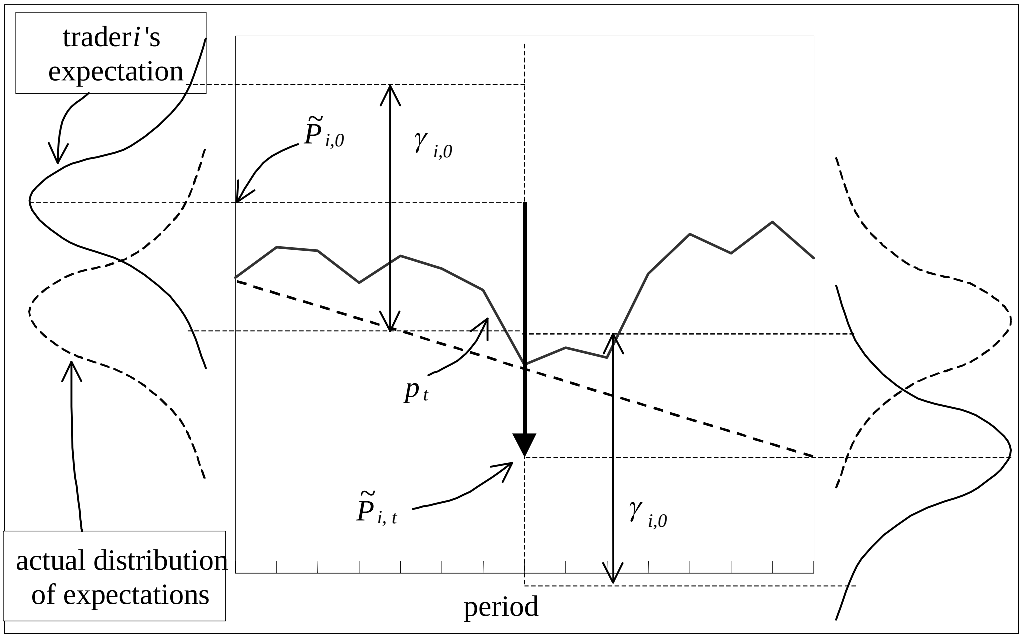


Figure 3-2. Feedback to confidence

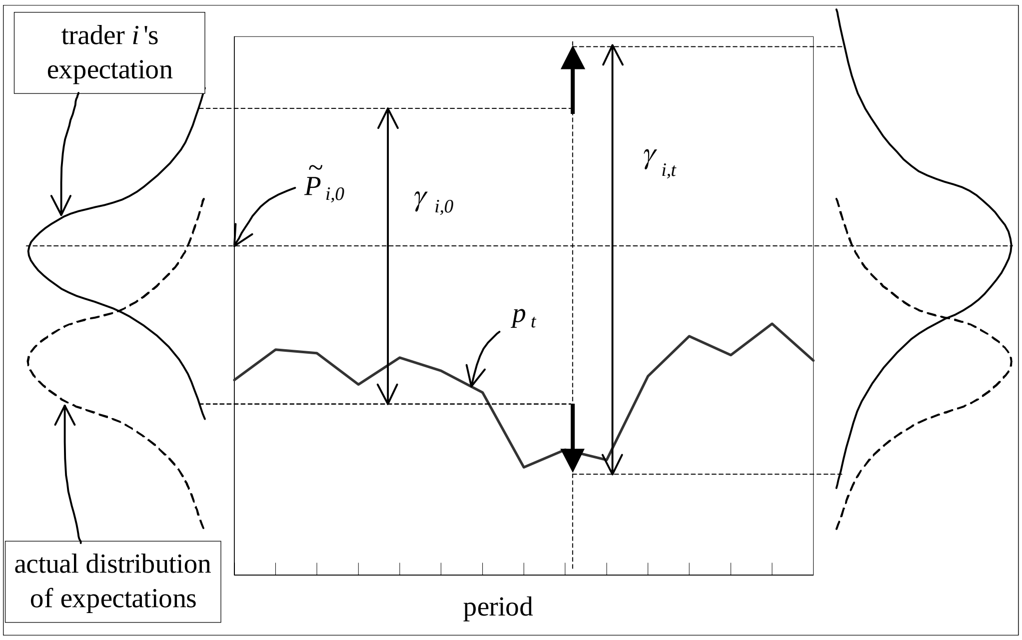


Figure 4 shows a set of paths of execution price drawn by the simulation. Traders consist of 50 value traders, who revise their expected values at trigger level of 20 percentile, and 10 momentum traders. As an initial shock, we reduced value traders' expected values by 5% after the end of period 75. Movements of execution price before the shock have been within 20 yen range around 1,000 yen, which is the average of traders' expected values, while the price movements became widely dispersed after the shock. Figure 5 shows a histogram of the final execution price after the whole simulation. The average of final execution price was 947 yen, a level which was about 5% lower than 1,000 yen and consistent with the magnitude of the initial shock, while price dispersion became quite large compared with the pre-shock range (above/below 20 yen). These results imply that the existence of feedback seems to have substantial effects on the instability of the market's price discovery function, that is, on market efficiency and stability when exogenous shock has been added to the market.

Figure 4. Paths of trade prices drawn by the simulation

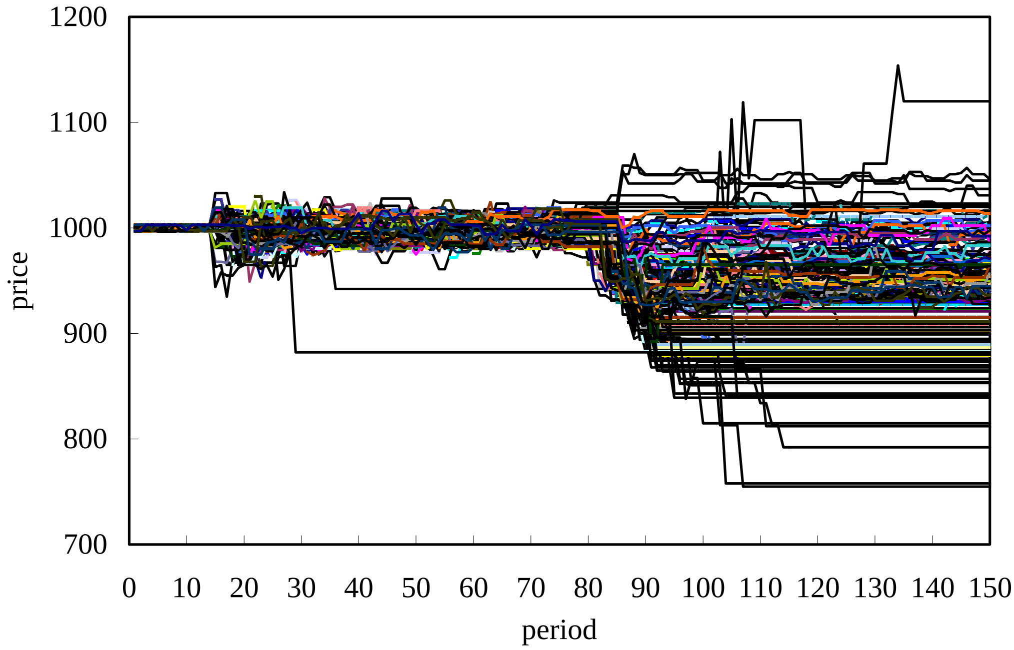
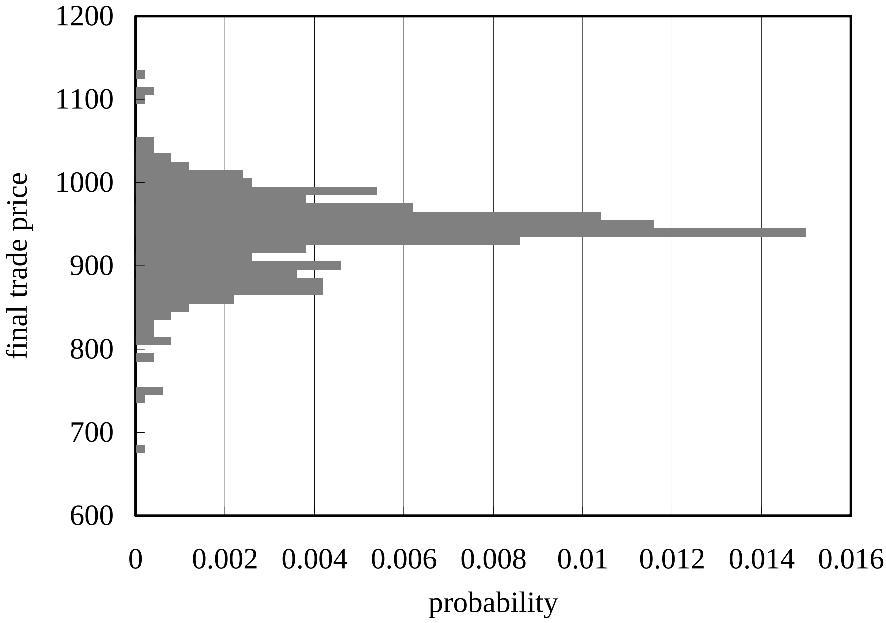


Figure 5. Histogram of the final trade prices at the end of the simulation



4. Simulation results

4.1 Effects of trigger level

By conducting simulations for the feedback to expected value and feedback to confidence, we have observed (1) a convergence of traders' expected values, and (2) an increase of risk which traders recognise. The effects of trigger level in the simulations applying the feedback to expected value and the feedback to confidence are shown in Figures 6 and 7, respectively. Here, higher trigger level means more frequent feedback. Figure 6 shows that, as trigger level increases, the distribution of traders' expected values converges, in shorter period, around the average. This suggests that, feedback more frequently reaches traders whose expected values are further from the average of all traders' expectations, thereby revising the traders expectations close to the average of the actual distribution in a shorter period of time. From Figure 7, we can see that as the trigger level increases, the average of the extent of traders' risk aversion reaches a higher level, and the time needed to reach a certain level becomes shorter. As was the case for the feedback to expected values, when the trigger level increases, the feedback more frequently reaches traders whose expected values are further from the average of the true distribution of traders' expectations, thereby risk or uncertainty the traders increases more rapidly.

Figure 8 shows the features of market data when the trigger of feedback to expected value is changed. The indicators we observe are the same as those Muranaga and Shimizu (1999) observe. From Figures 8-1 to 8-6, we can see that as the trigger level increases, probability of quote existence, trade frequency, volatility of trade price, volatility of mean price, average spread, and gross order book volume all decrease. When we look at Figures 8-7 and 8-8, volatility of the gross order book volume and standard deviation of the net order volume are not affected a great deal.

Figure 9 shows the features of market data when the trigger of feedback to confidence is changed. As the trigger level raises, trade frequency declines (Figure 9-2). Other indicators do not show clear tendency against the changes in trigger level.

Figure 6. Convergence of traders' expected values

(Feedback to the expected value)

Figure 6-1. Trigger level 5 %

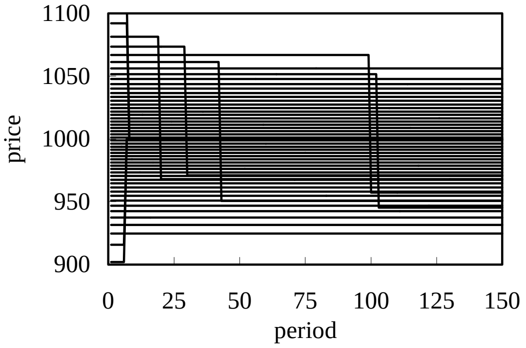


Figure 6-2. Trigger level 10 %

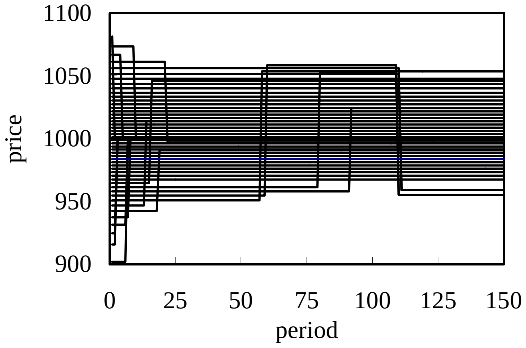


Figure 6-3. Trigger level 15 %

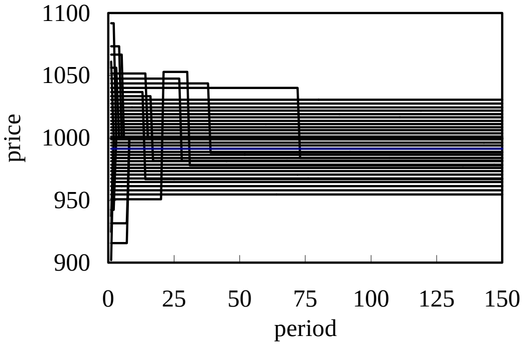


Figure 6-4. Trigger level 20 %

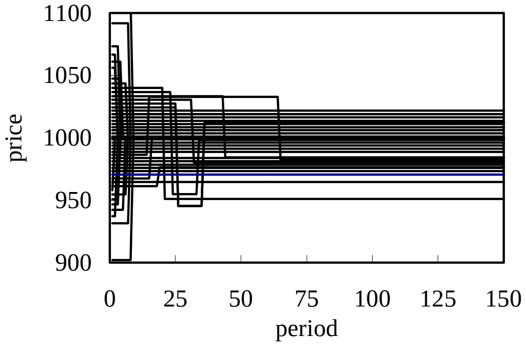


Figure 6-5. Trigger level 25 %

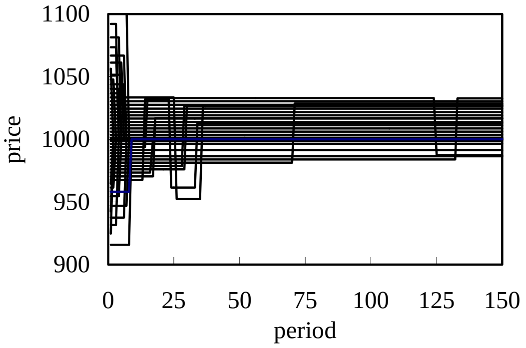


Figure 7. Increase in traders' estimated risks

(Feedback to confidence)

Figure 7-1. Trigger level 5 %

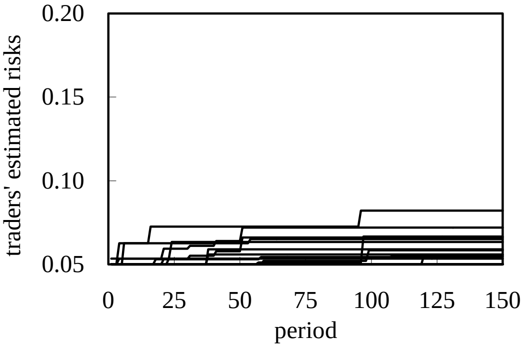


Figure 7-2. Trigger level 10 %

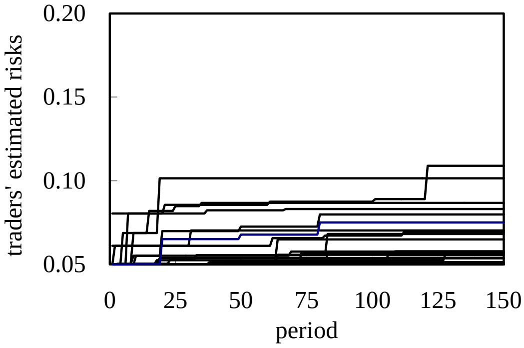


Figure 7-3. Trigger level 15 %

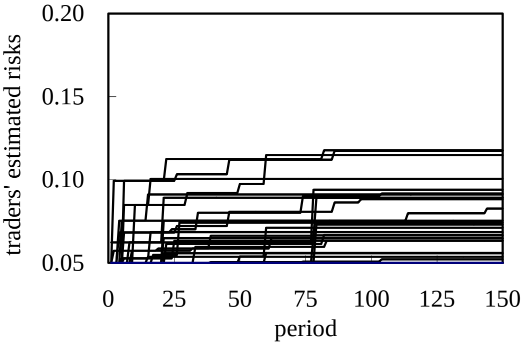


Figure 7-4. Trigger level 20 %

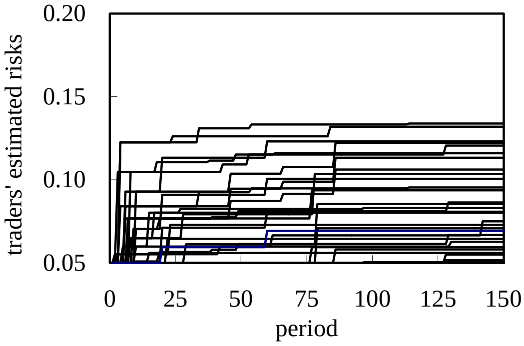


Figure 7-5. Trigger level 25 %

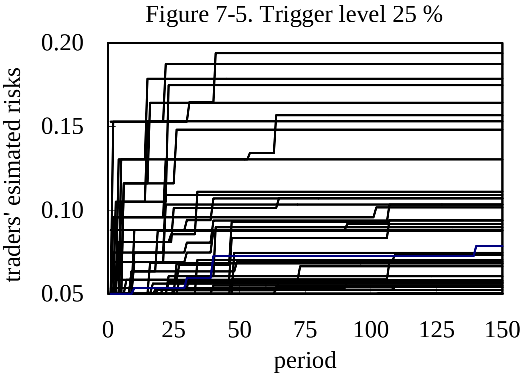


Figure 8. Effects of trigger level (Feedback to the expected value)

Figure 8-1. Probability of quote existence

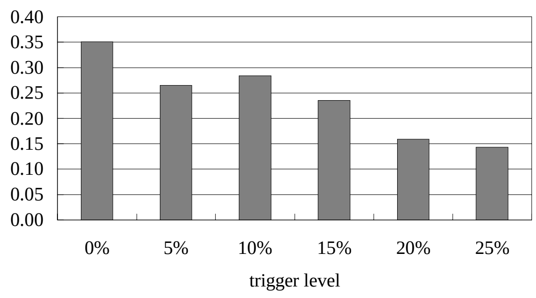


Figure 8-2. Trade frequency

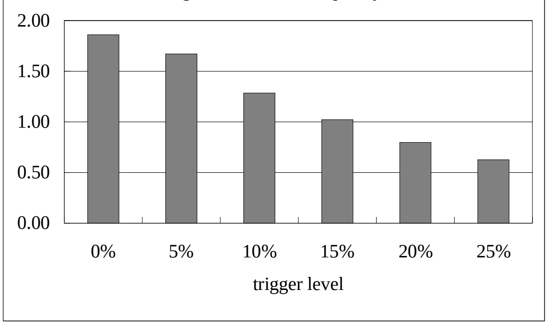


Figure 8-3. Volatility of trade price

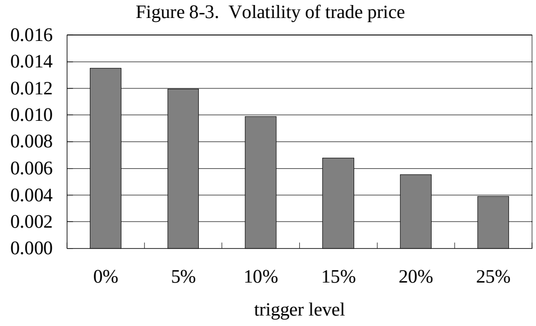


Figure 8-4 Volatility of mean quote

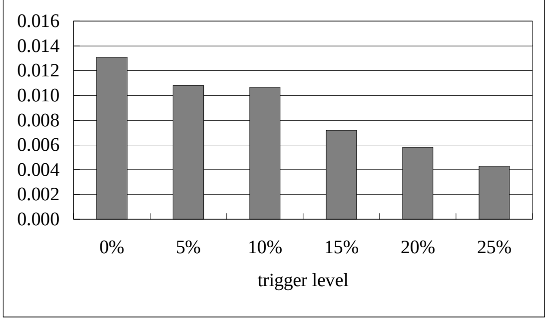


Figure 8-5. Average spread

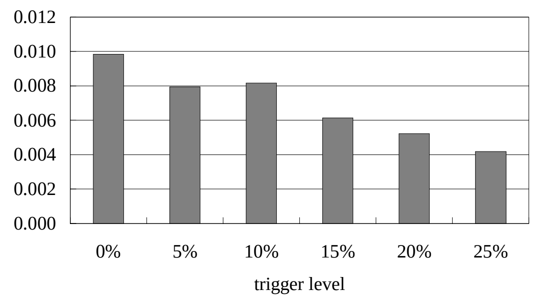


Figure 8-6. Average of gross orders

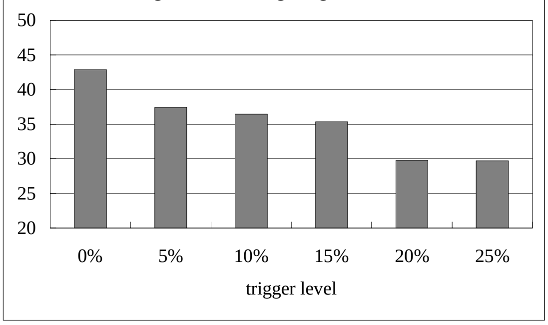


Figure 8-7 Volatility of gross order book volume

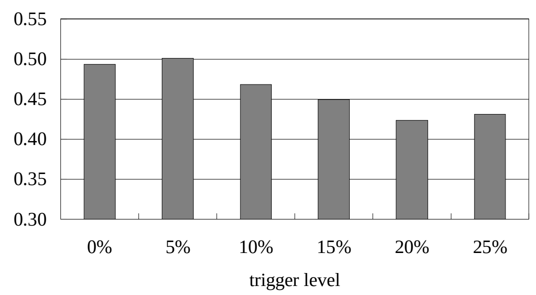


Figure 8-8 Standard deviation of net order book volume

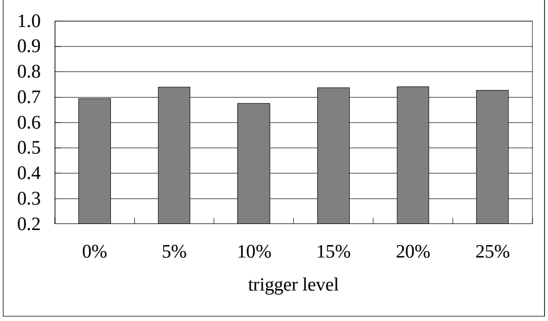
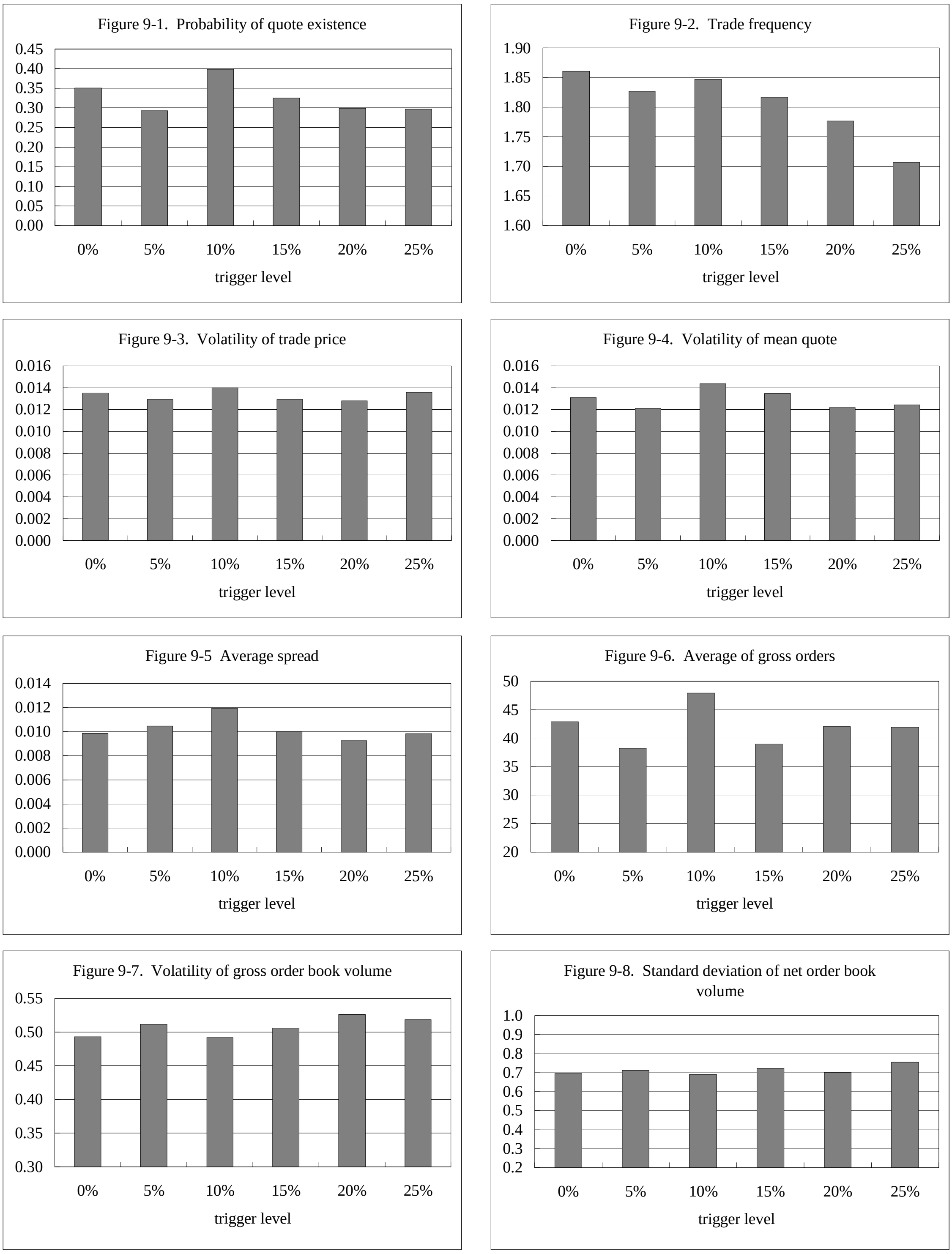


Figure 9.　Effects of trigger level (Feedback to confidence)



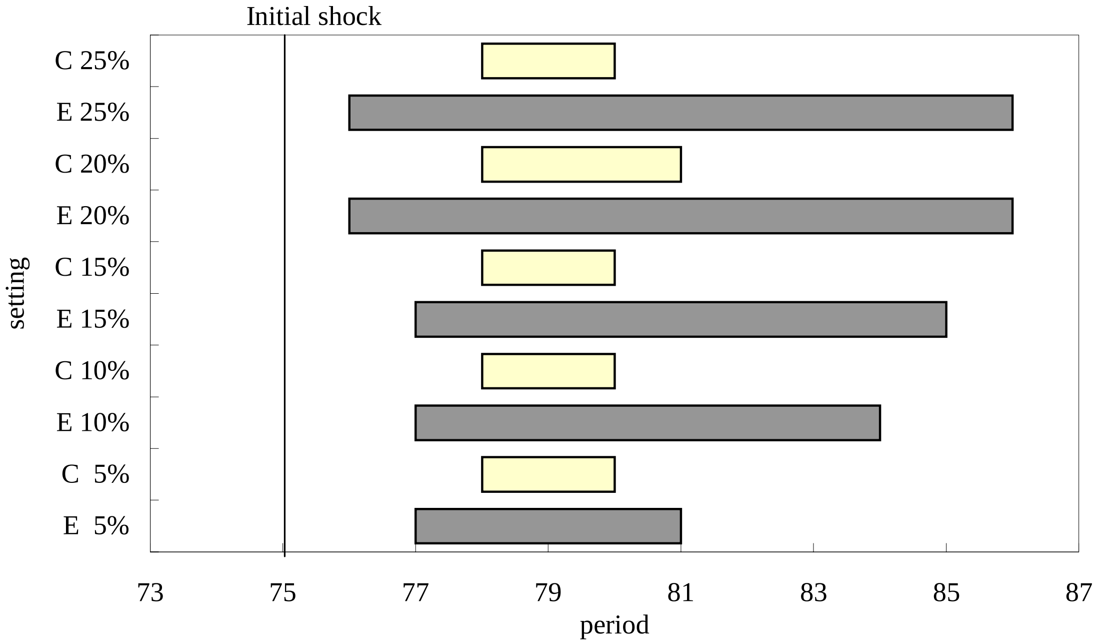
4.2 Analysis of stress

By observing endogenous stress phenomenon triggered by exogenous initial shock concerning price information, we have shown the possibility that different feedback mechanism generates different stress. Specifically, by comparing a case in which there is a feedback to value traders' expected values (value-feedback-type stress) with a case in which there is a feedback to traders' confidence (confidence-feedback-type stress), we observe difference in (1) the cessation period of price discovery function after the shock, and (2) the realisation process of potential transaction demand. In other words, depending on the type of stress, there seems to be difference in the state of market liquidity and the possibility of endogenous crash to be generated.

Figure 10 shows how trade cessation period[4] after the initial shock differs for the above mentioned two types of stress when trigger level has been changed. We can see that, regardless of the trigger level, cessation period is longer in the case of value-feedback-type stress. In addition, cessation period tends to become longer as trigger level increases from 5 to 20%. On the one hand, in the case of value-feedback-type stress, initial shock seems to affect traders' future price expectation, thereby shifts the demand curve (as we summarised in Section 2), and thus making it difficult to discover new equilibrium price. This interpretation is consistent with the tendency that the cessation period of price discovery function becomes longer as the pace of demand-curve shift accelerates. On the other hand, in the case of confidence-feedback-type stress, not the shift of demand curve but the decline in confidence hampers the realisation of potential transaction demand, and thus the cessation of price discovery function is less likely to happen compared with the case of value-feedback-type stress.

[4] Cessation period refers to a period in which trade has been executed less than once on average after the initial shock, that is, after the 75th period.

Figure 10. Effects of trigger level on periods of trading halts

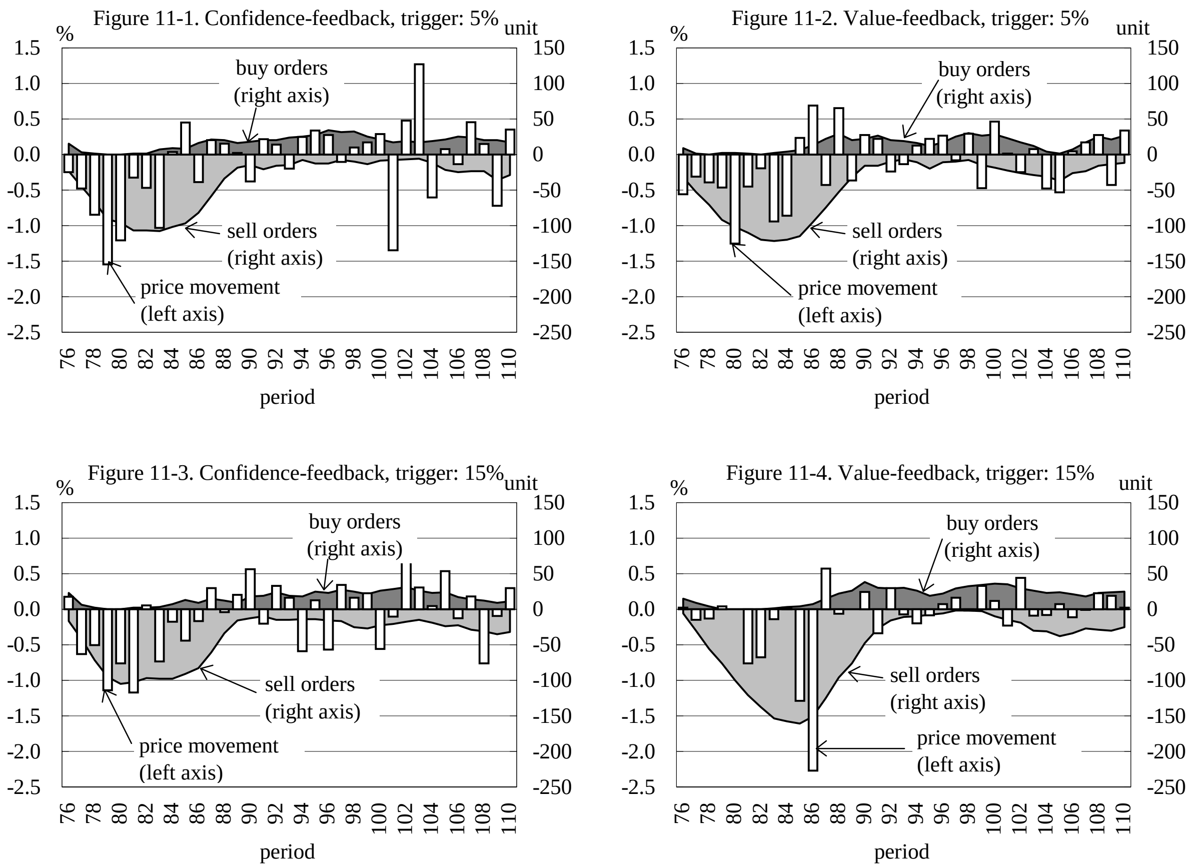


Note: "E" in the settings means feedback to expected value, while "C" means feedback to confidence. Figures in each setting denote the trigger level of traders' expectations revision.

Figure 11 shows in more detail about the features of generating mechanism for value-feedback-type stress and confidence-feedback-type stress. For each type of stress, and with the trigger level at 5% and 15%, the Figures illustrate the realisation of the limit order book (solid line. positive side for the volume of buying order book and negative side for the volume of selling order book) and price movements (bar graph) after the initial shock. We can see that, when trigger level is at 5% (Figures 11-1 and 11-2), buying order book disappears in about 2 periods after the shock and selling order book rapidly increases over 7 to 8 periods for both types of stress. Price movements peaks out over 7 to 8 periods and, along with the realisation of buying order book, stop declining over 8 to 10 periods.

When trigger level is at 15%, confidence-feedback-type stress (Figure 11-3) shows little difference in post-shock book disappearance/realisation processes compared with the case of trigger level at 5% (Figure 11-1). In the case of value-feedback-type stress, however, selling book rapidly increases (Figure 11-4), and its volume reaches, by 10 periods, to the level which is 40% more than that at the 5% trigger level (Figure 11-2). With respect to price movements, confidence-feedback-type stress shows little difference between 5% and 15% trigger levels, while value-feedback-type stress, reflecting the increasing pressure of selling order book realisation, induced secondary crash (rapid fall in price) at the 15% trigger level over 10 to 11 periods.

Figure 11. Developments in price movement and order flows



Above simulation results suggest that there is not one but several stress generating mechanisms depending on the type of feedback mechanism lying behind. In particular, the pressure to realise selling orders after the price shock may induce further crash in the market. Taking into account that the two types of stresses have different effects on the cessation of price discovery function, decline in market liquidity (delay in selling order realisation) may serve as a mechanism to avoid further drop in prices and avoid the long cessation of market discovery function in the case of confidence-feedback-type stress, in which market participants' price expectation does not shift significantly but their confidence decline after the shock. These findings awaits future verification for their robustness by using actual market data, although they are deemed useful in deepening our understanding about the stress generating mechanism in the market and about the role played by market liquidity.

5. Conclusions and further issues

In this paper, we constructed a hypothetical model consisting of hypothetical traders, who are characterised by various endogenous variables such as expected value and the confidence on it, and a hypothetical execution system which matches the orders from the traders, and conducted analyses based on a Monte Carlo simulation. Specifically, in order to analyse market behaviour at the occurrence of stress, we have incorporated traders' expected values and feedback effects to confidence.

The simulation results suggest that (1) stress generation pattern differs depending on the feedback mechanism, value feedback or confidence feedback, (2) post-shock cessation period of price discovery function is longer when the stress is value-feedback type, and (3) when feedback affects trader's confidence, further crash in price is unlikely to occur because of the liquidity constraints.

Our future tasks include: (1) verify the validity of the model by comparing the results with those obtained from empirical analyses, and (2) continue our consideration about the feedback effects on parameters other than expected price and confidence, or about the setting of the trigger. In addition, (3) based on our findings about the stress generating mechanism, autonomous restoration mechanism after the market crash and the effectiveness of artificial stress preventing mechanism, such as circuit breaker system, should be examined.

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