JPX Working Paper【Summary】
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Impacts of Speedup of Market System on Price Formations using Artificial Market Simulations

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(1) Introduction

(2) Artificial Market Model

(3) Simulation Results

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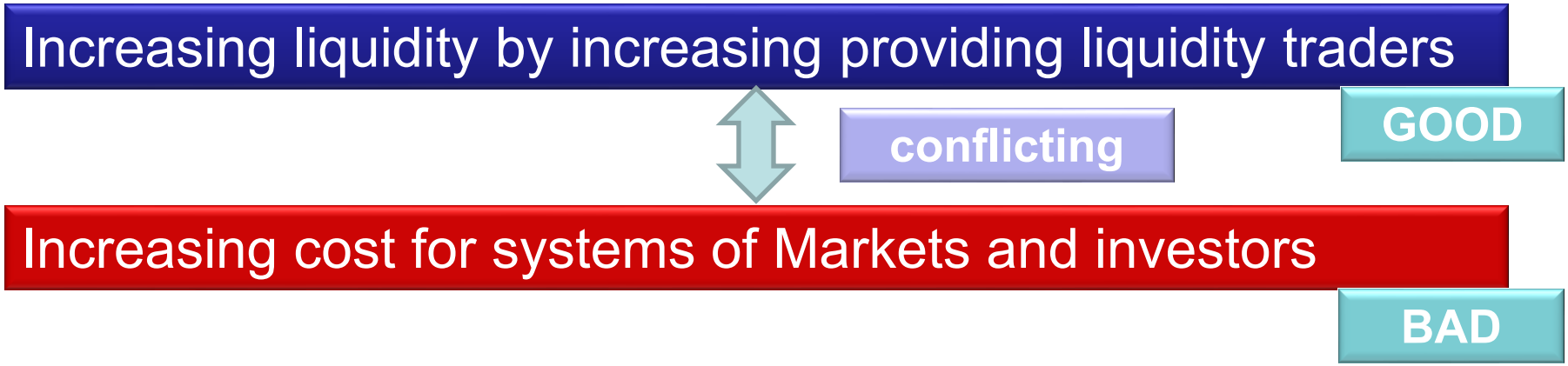
Speedup of Exchange System

Because of competition between Markets and big investors demands



How much speedup is best?

Need Discussions

Does Market speed purely effect market efficiency?

-> So many factors cause price formation :
An empirical study cannot isolate the pure contribution

What are Mechanisms?

-> Analysis Micro Process: Impossible by empirical study

How much enough speedup is Market system?

-> No Market experienced more Speedup:
Impossible by empirical study

Artificial Market Simulation
(Multi-Agent Simulation)

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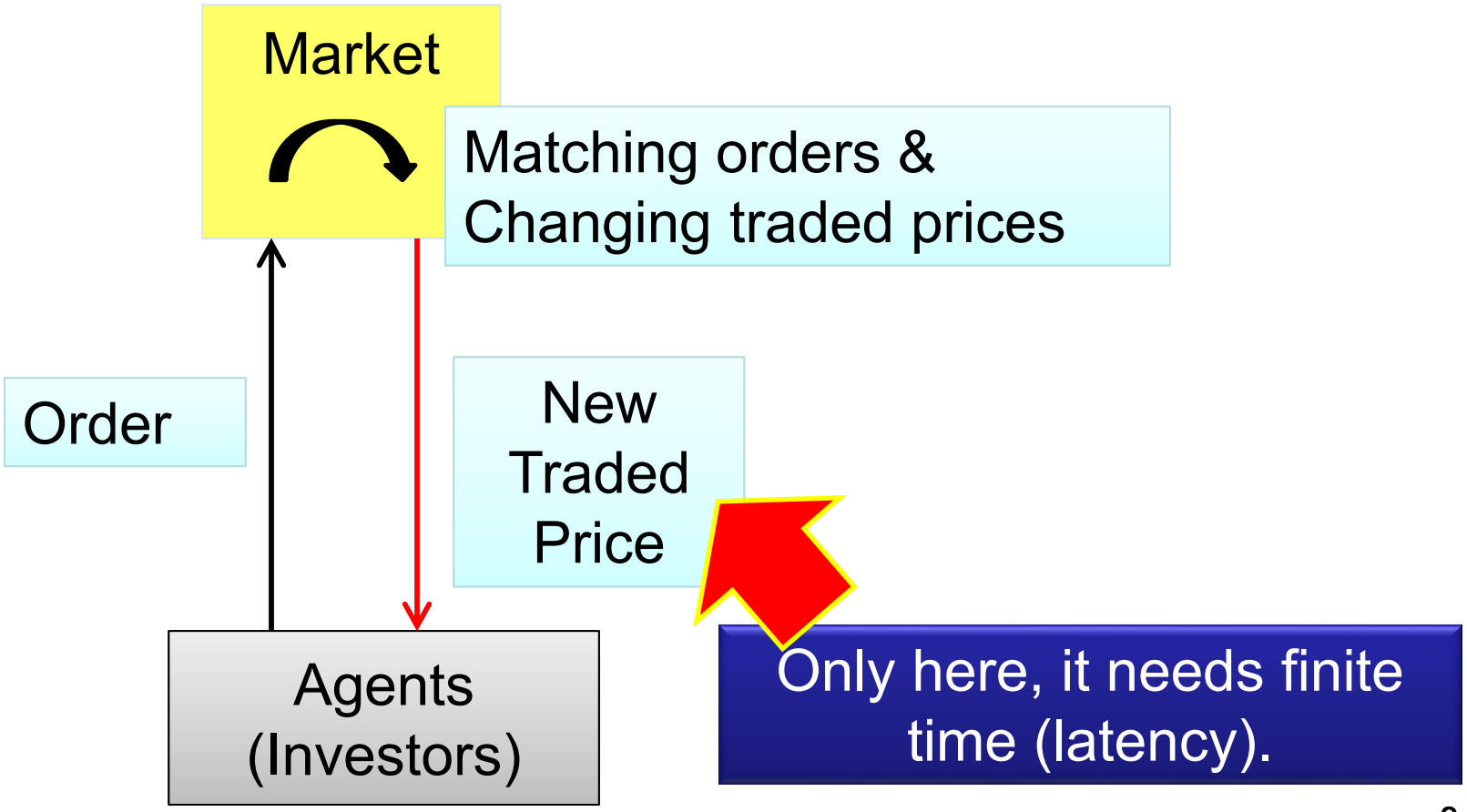
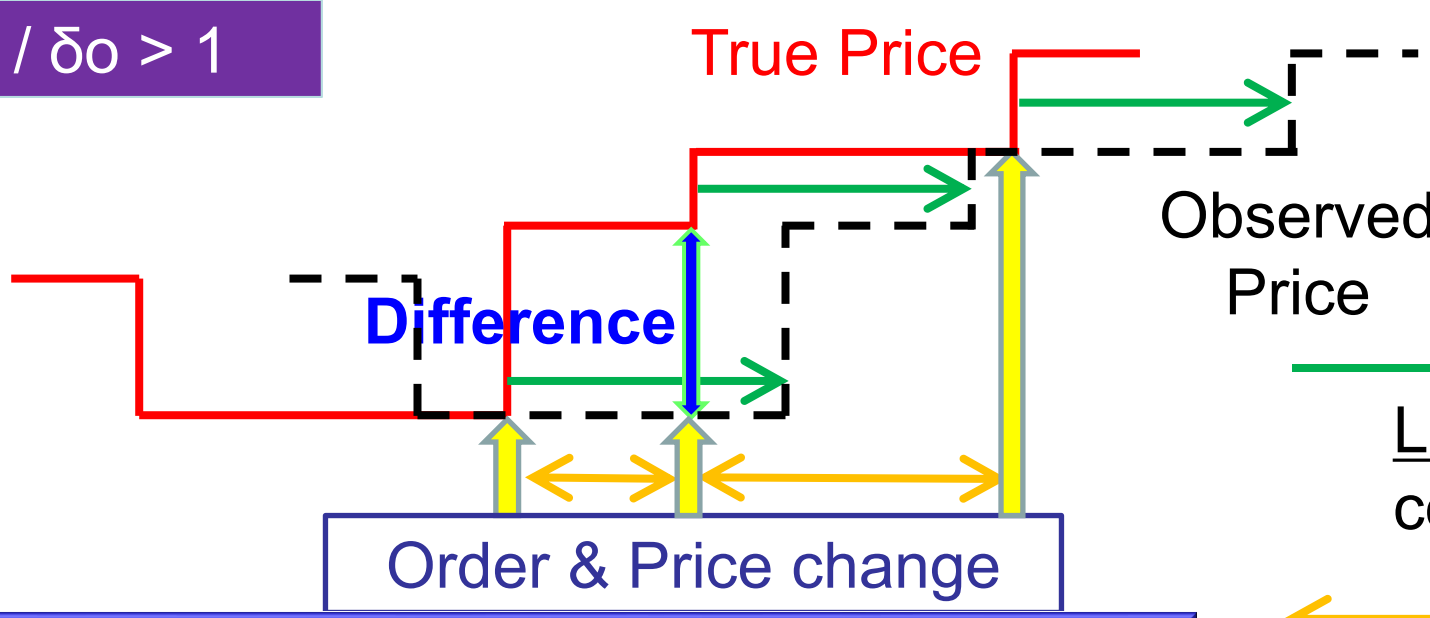
Model of Latency

Latency Most important factor of Market speed

Needed time for matching orders and/or data transfer



δl / δo > 1

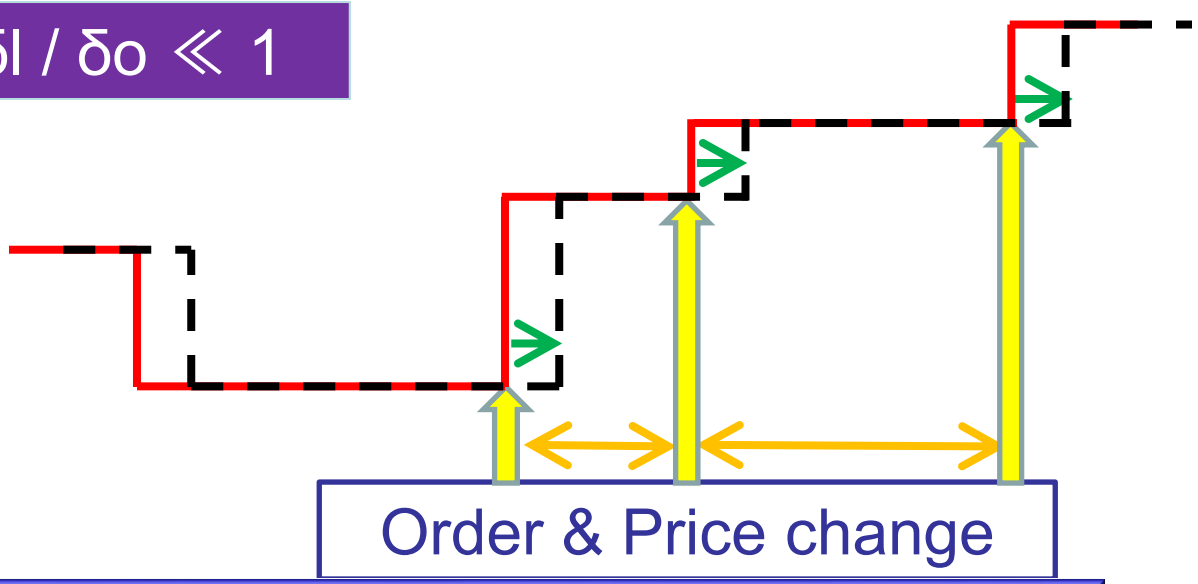


True and Observed prices are difference

Latency
constant = δl

Order interval
exponential random numbers
Avg. = δo

δl / δo ≪ 1



Most cases, agents know True Price

Agents (Investors) Model

Same Model as JPX Working Paper vol.2; Mizuta et. al. 2013

*** Continuous Double Auction: to implement realistic latency**
*** Simple Agent model: to avoid arbitrary result**

heterogeneous 1000 agents

Expected Return

$$r_{e,j}^{t} = \frac{1}{\sum_i w_{i,j}} \left(w_{1,j} \log \frac{P_f}{P^t} + w_{2,j} r_{h,j}^{t} + u_j \varepsilon_j^{t} \right)$$

Fundamental | Technical | noise

$w_{i,j}$

Strategy Weight ↑ Different for each agent

Replicate traditional Stylized Facts and Replicate Micro Structures

Latency has Micro Structure Time Scale, MilliSeconds

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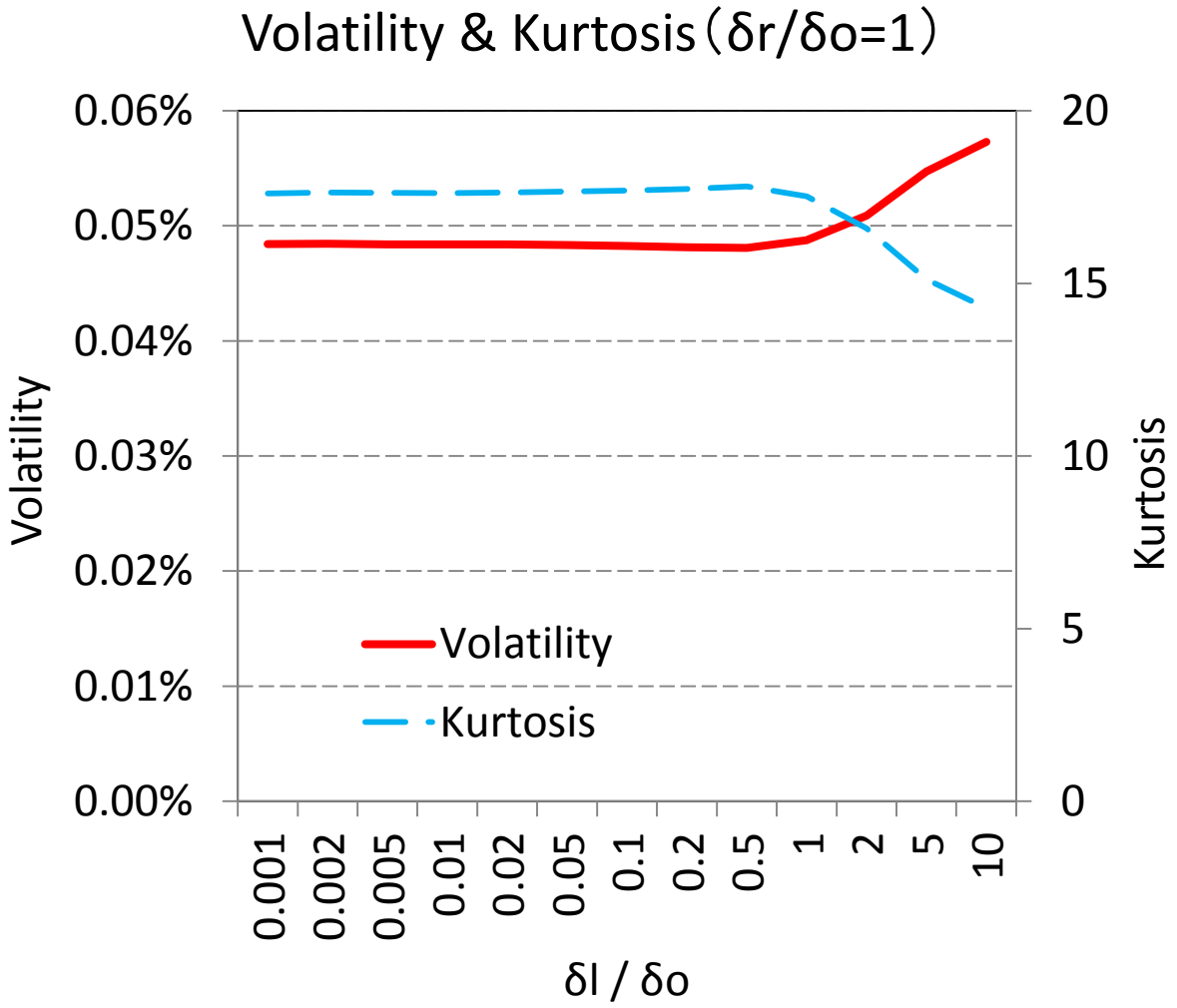
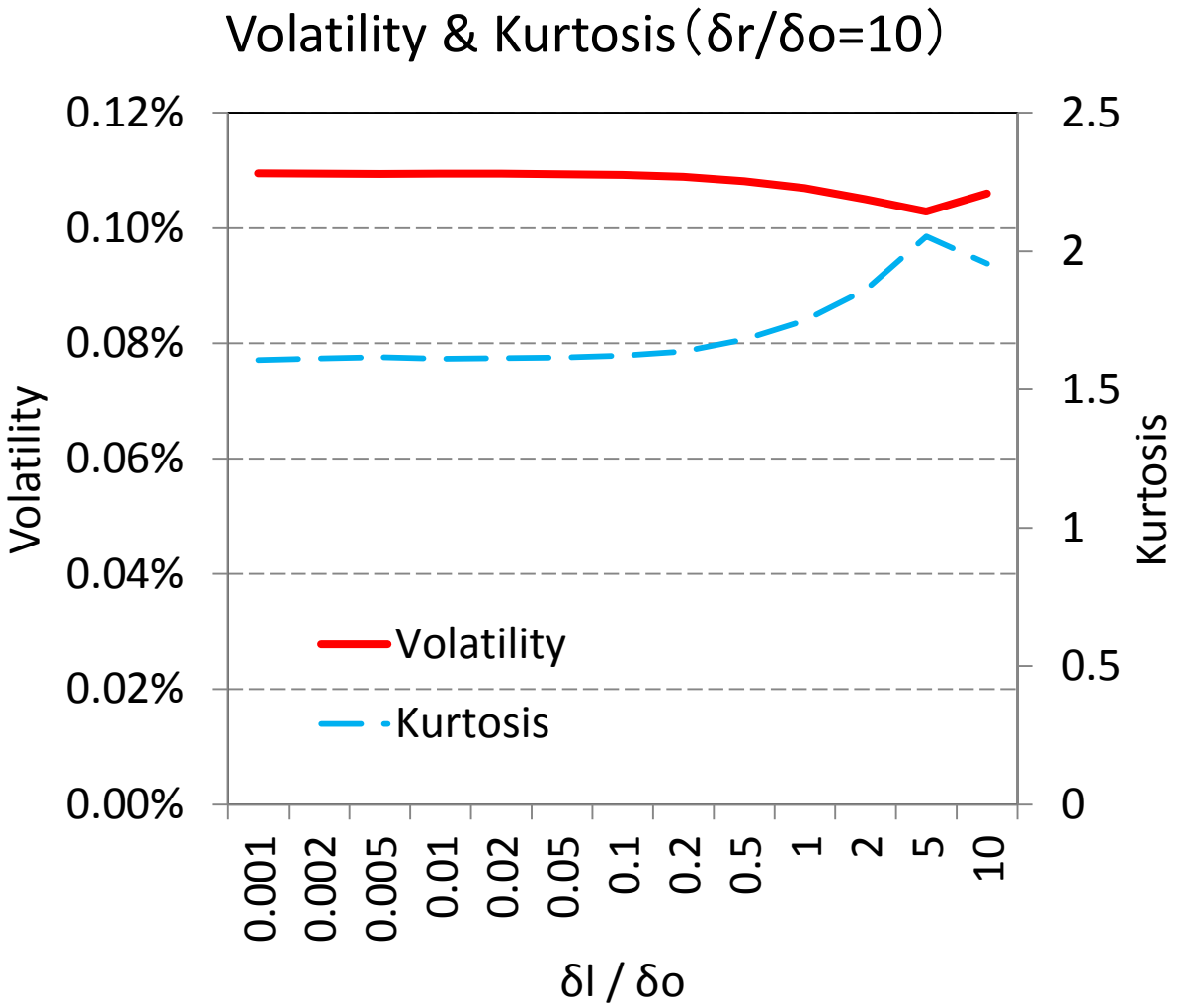


δl/δo：latency / order interval
δr/δo：return calculation period / order interval

δl/δo>1: increasing Volatility, decreasing Kurtosis (flatter fat tail)
⇒ be inefficient?



δl/δo>1：Volatility is flat, Increasing Kurtosis (fatter fat tail)
⇒ be inefficient?

We should use the way independent of return calculation period

Market Inefficiency

$$\text{Market Inefficiency} = \frac{\text{Average of } |\text{Market Price} - \text{Fundamental Price}|}{\text{Fundamental Price}}$$

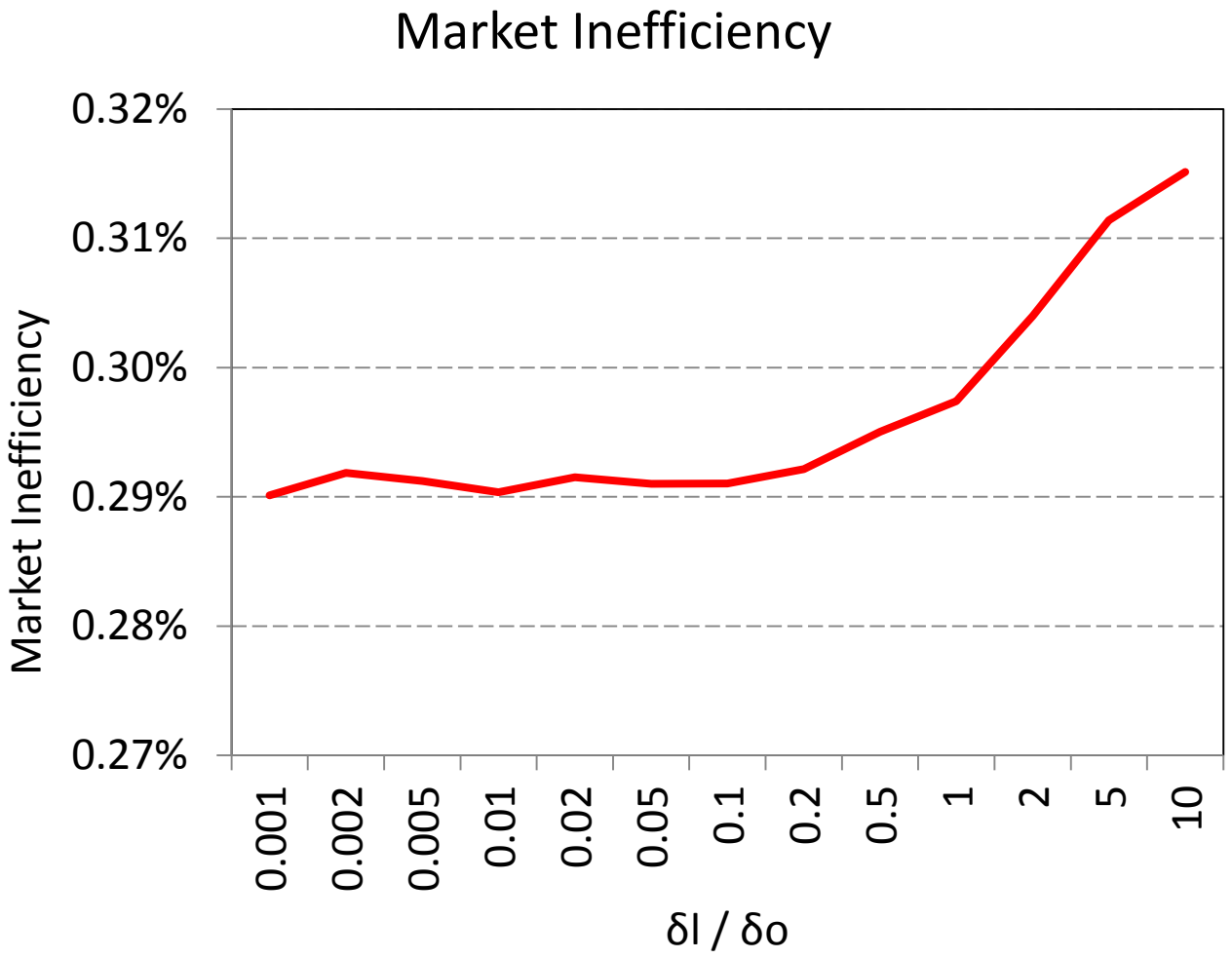
If Market was perfect efficient, Market prices were exactly same as the fundamental price.

This Market Inefficiency is defined actual difference between market and fundamental prices.

−> We can not use this definition for an empirical study.
Experimental study for human sometimes uses this definition.

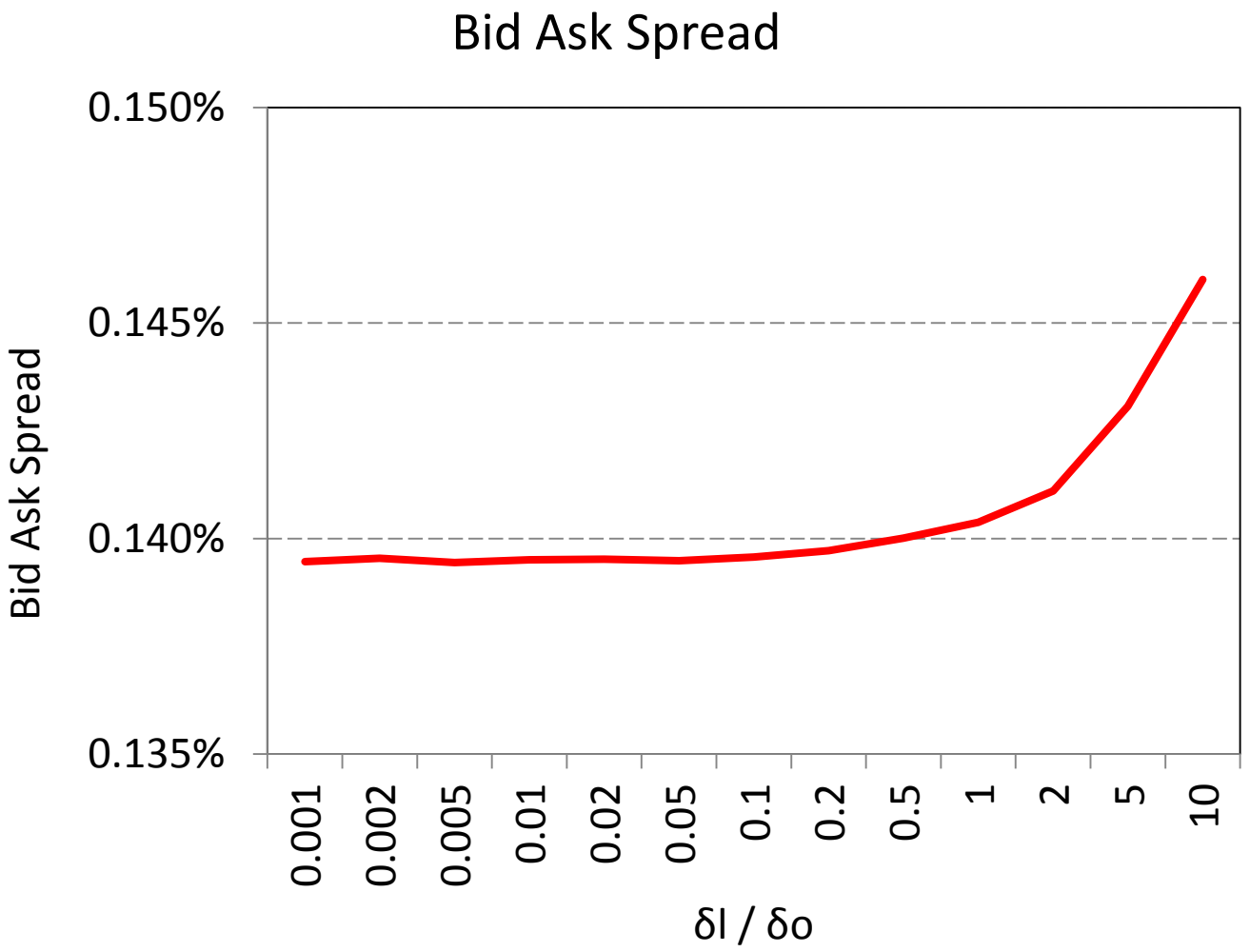
We can measure Market Inefficiency Directly,
not estimation in simulation studies.

Independent of return calculation period

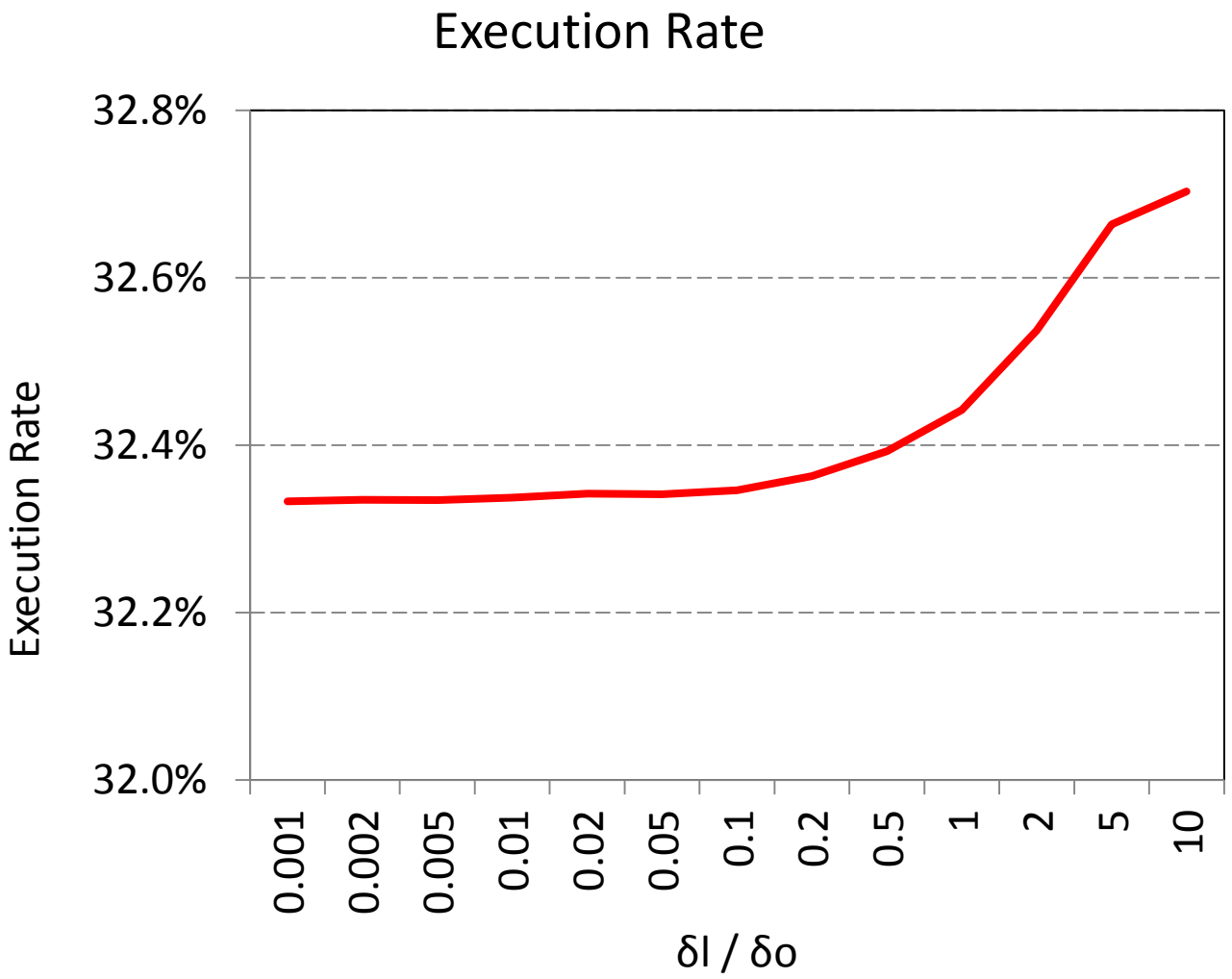


δI / δo > 1 : be Inefficient

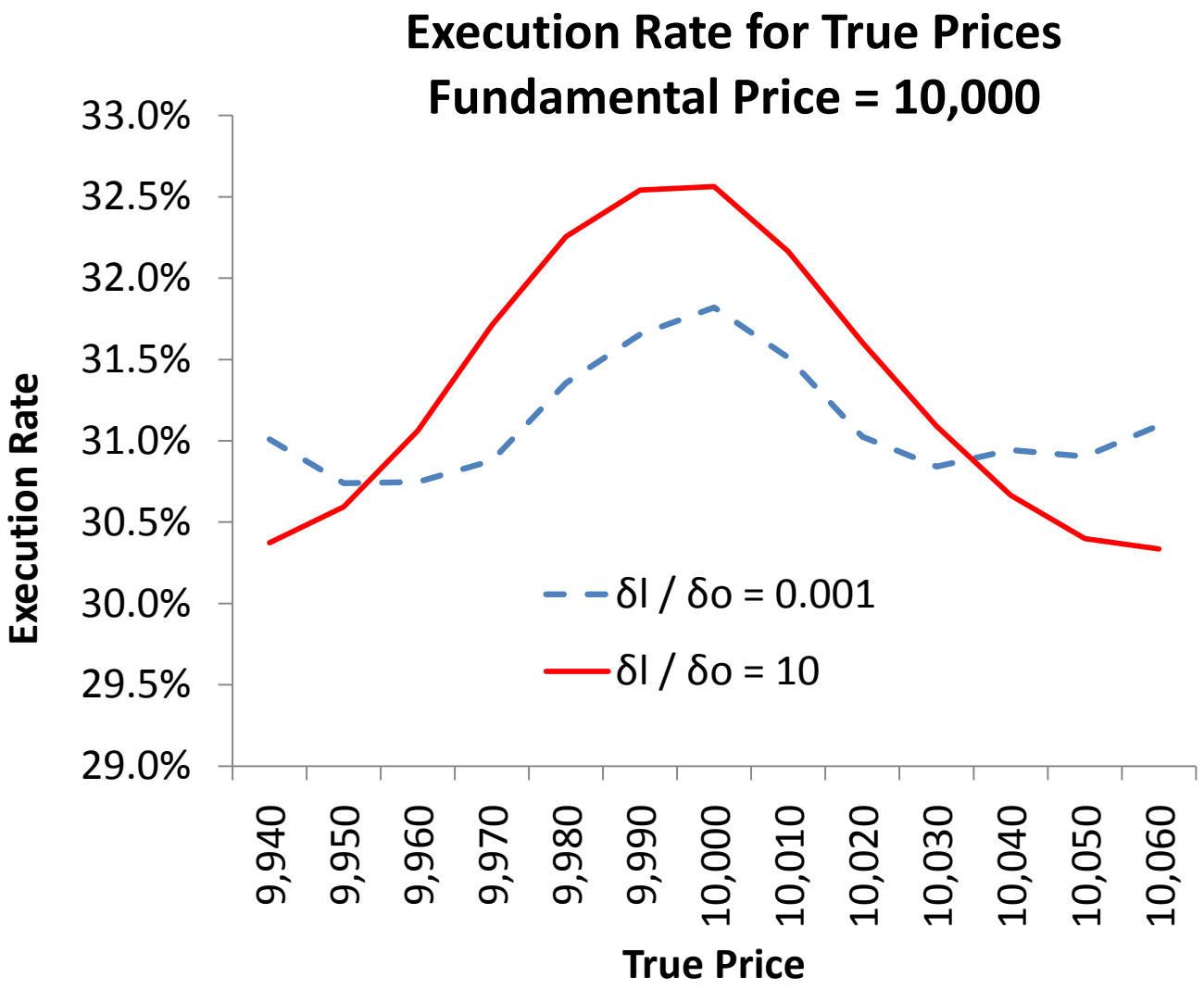
Right side δI / δo = 0.5, Market becomes Inefficient



δl / δo > 1 : Wider Bid Ask Spread



δI / δo > 1 : Increasing Execution Rate



Increasing Execution Rate especially near the fundamental price

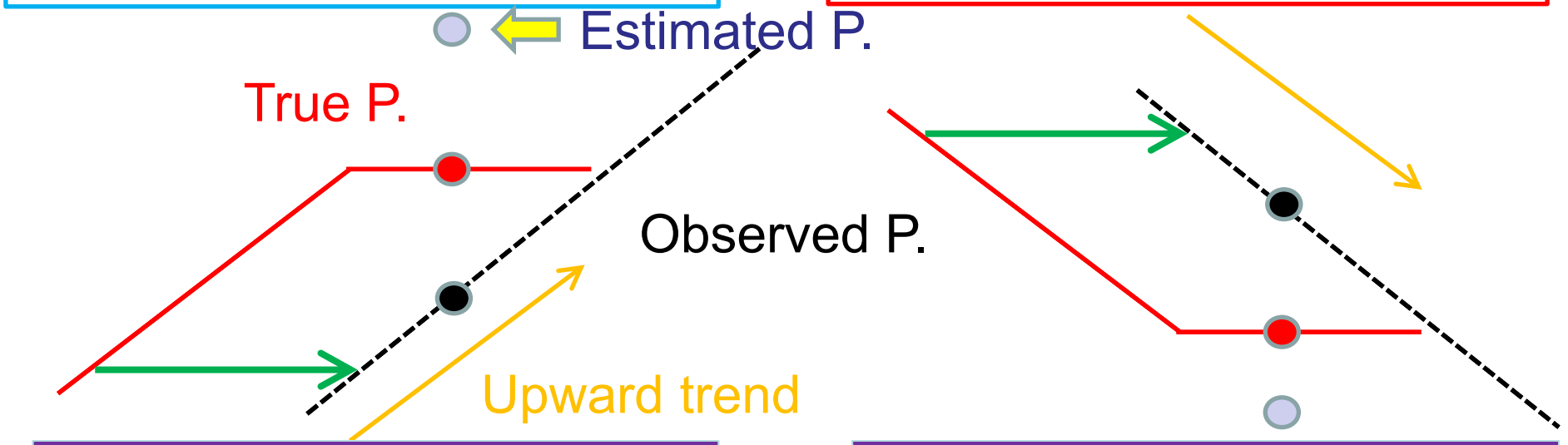
$\delta I / \delta o$		Execution Rate Sum	Buy Market Sell Limit Orders	Sell Market Buy Limit Orders	Avg. Estimated Return of agents
10	Observed P. < True P.	32.5%	28.9%	3.5%	0.28%
	Observed P. > True P.	32.5%	3.6%	28.9%	−0.27%
0.001	---	31.2%	15.6%	15.6%	0.00%

Observed Price < True Price: More Buy Market Orders: Positive estimated returns
Observed Price > True Price: More Sell Market Orders: Negative estimated returns

（near Fundamental Price）

Observed Price < True Price

Observed Price > True Price



Too High Estimated P.
⇒ Market Buy order
↑ If agents knew True P. they did not order.

Too Low Estimated P.
⇒ Market Sell order
↑ If agents knew True P. they did not order.

Stop market trend

But, agents cannot change Estimate price, quickly

Unnecessary market following trades

Mechanism of Large Latency（δI/δo>1）making Market Inefficient

Stop market trend

↓

But, agents cannot change Estimate price, quickly ← Large Latency

↓

Unnecessary market following trades ← Especially near Fundamental Price

↓

Increasing Execution Rate

↓

Decreasing Limit orders near Market Price, relatively

↓

Expanding Bid Ask Spread

↓

Market becomes Inefficient

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No.	Analysis Period	arrowhead	Order No. Avg. for day Avg. names	Calculation Period (min)	Avg. δo (ms) = Period (ms) / Order No.	Latency δI (ms)	δI / δo
1	December 2009 (one month)	Before	2,833	270	5,718	3,000	0.525
2	2 August 2010 – 18 November 2011	After	14,621	355	1,457	4.5	0.003
3	21 November 2011 – 26 November 2014		28,974	385	797	4.5	0.006
4	27 October 2014 – 26 November 2014		66,044	385	350	4.5	0.013
5	31 October 2014 (one day)		87,109	385	265	4.5	0.017
6	4 November 2014 (one day)		114,027	385	203	4.5	0.022

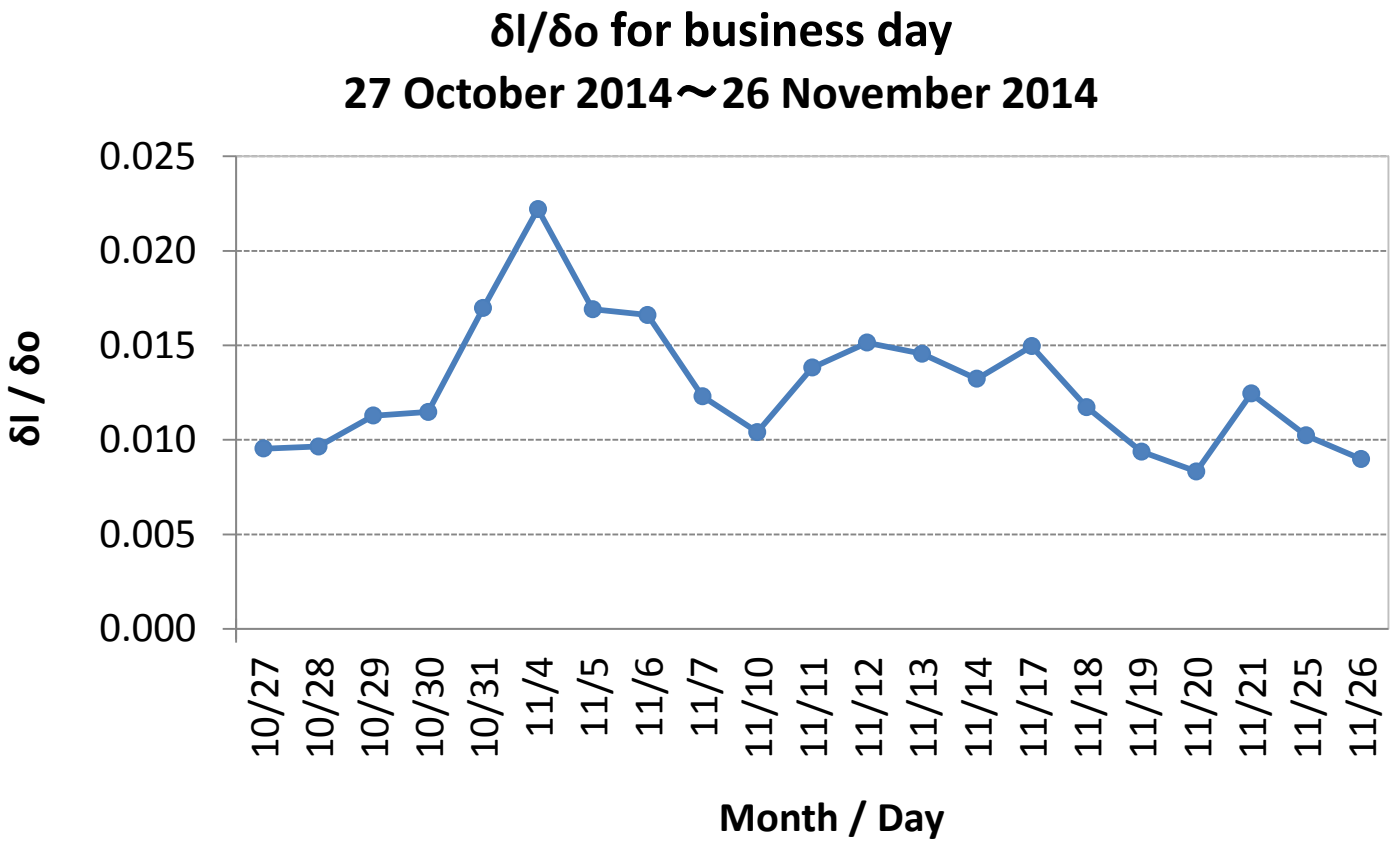
1：Uno, 2012
2～6:In this study

Before arrowhead

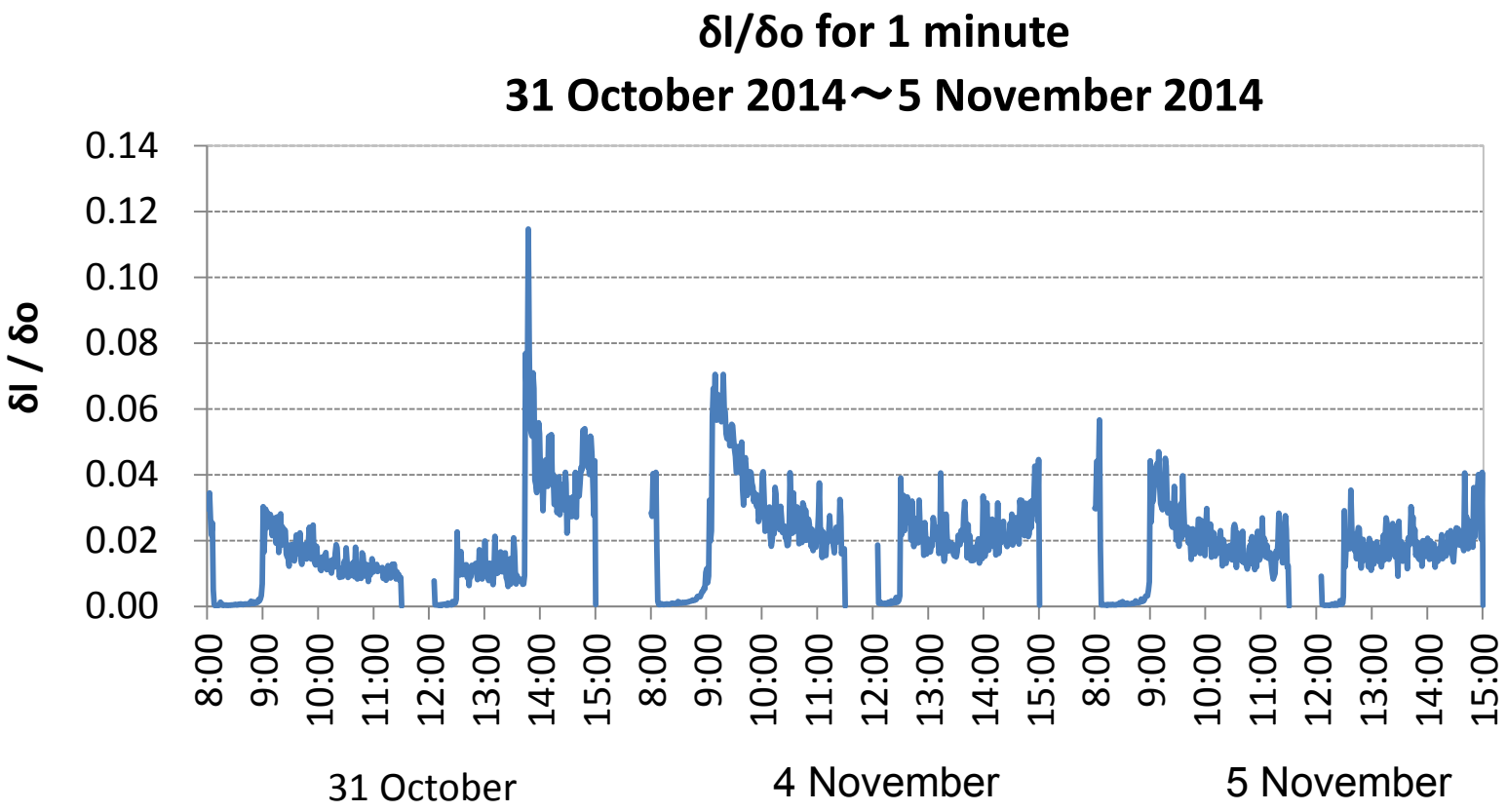
It is Possible that Market is Chronically Inefficient

After arrowhead

Market is NOT Chronically Inefficient by the Mechanism we showed



Even though near 31 October 2014, Bank of Japan announced "Expansion of the Quantitative and Qualitative Monetary Easing", Market is NOT Chronically Inefficient by the Mechanism we showed



Market is NOT Inefficient even for one minute

31 October 2014 at 13:44 Japan time, Bank of Japan announced it.
For a few minutes after the announcement, orders are crowded.

We cannot deny market inefficiency for less than one minute.

Future Works

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Summary

* The ratio（δl/δo）is key parameter,
  Latency（δl）per Order Interval（δo）

* Enough fast market system is required δl << δo.

* Stop market trend -> Large Latency
  -> agents cannot change Estimate price, quickly
  -> Unnecessary market following trades
  -> Increasing Execution Rate -> Expanding Bid Ask Spread
  -> Market becomes Inefficient

* Before arrowhead:
  It is Possible that Market is Chronically Inefficient

* After arrowhead:
  Market is NOT Inefficient even for one minute

Future Works

* We should discuss the case of very crowded orders for less than one minute, for example, at announced great market impacting information.
  -> needed simulation and empirical studies
    <- Certainly, such very short time scale event does not effect to general investors much.
    <-> It may effect to High Frequency Trading very much.

* We should discuss it in more kinds of agents.
  （For example: High Frequency Trading such as Market Maker strategy, Arbitrage Strategy, and so on.）

Appendix

Definition of Market/Limit order

In this study

A little difference from actual market

All agents decide an order price

sell

order book

buy

sell	price	buy
84	101	
176	100	
	99	2
	98	77

limit

market

Exist matching order
Order executed immediately

market

limit

No matching order
Order not executed immediately

Agents decide an order price,
if exist matching order, market order else limit order