Do Dark Pools Stabilize Markets and Reduce Market Impacts? ～ Investigations using Multi-Agent Simulations ～

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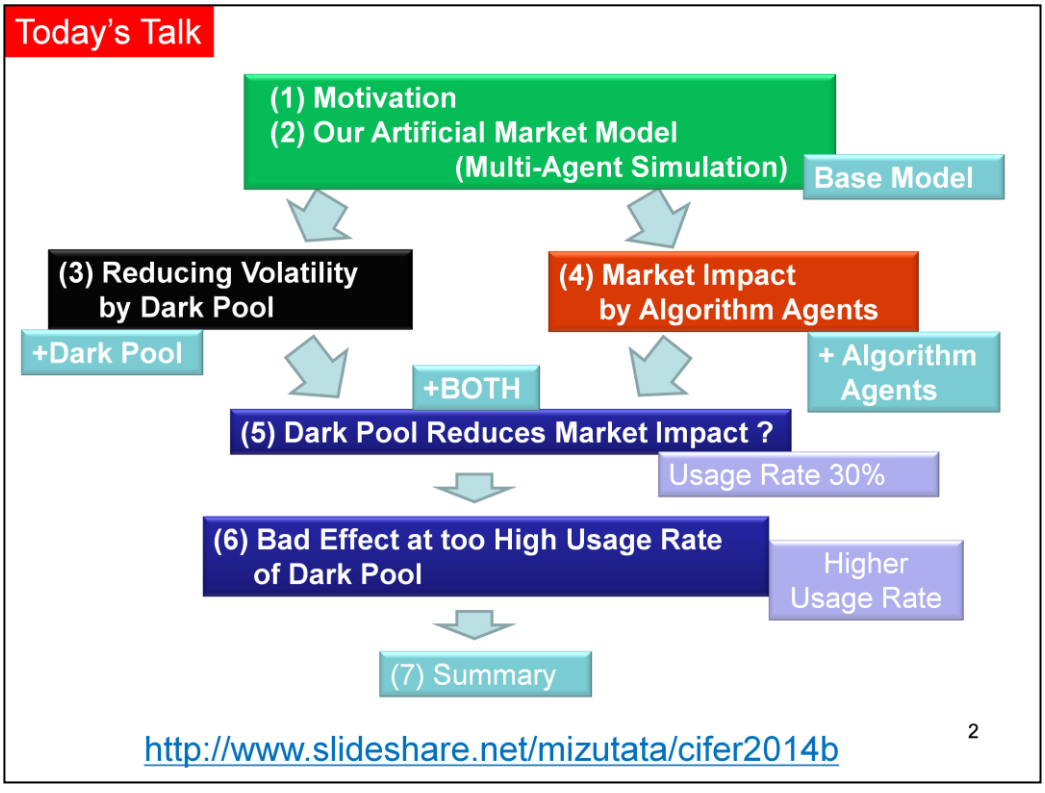
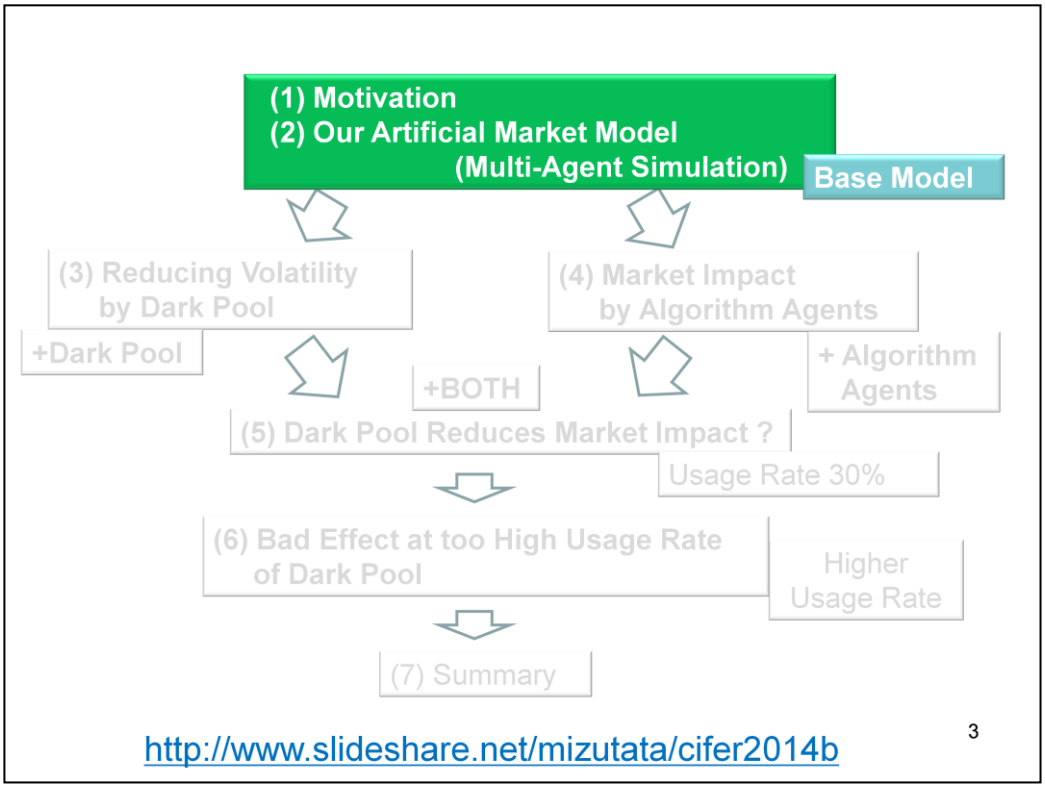
[Thank you very much. I'm] Takanobu MIZUTA from SPARX Asset Management.

[I'm also belonging to] The University of Tokyo.

[Today, I'm going to give a presentation under the title of This.]



[This is] Today's Talk, [table of contents is like this].



[First, I will describe] Motivation and our artificial market model, Base Model

・Dark Pool is a kind of Stock Market (matching venue)

・Dark Pool never provide any order books and quotes to traders

・[Dark Pools are] Becoming widely used, especially by institutional investors

Becoming More widely used Dark Pool leads,

[Some people says], Because very large market impacting orders are decreased, Market is more Stable.

[This opinion means Dark Pool is] good [for financial market].

[On the other hand], a conflicting opinion,

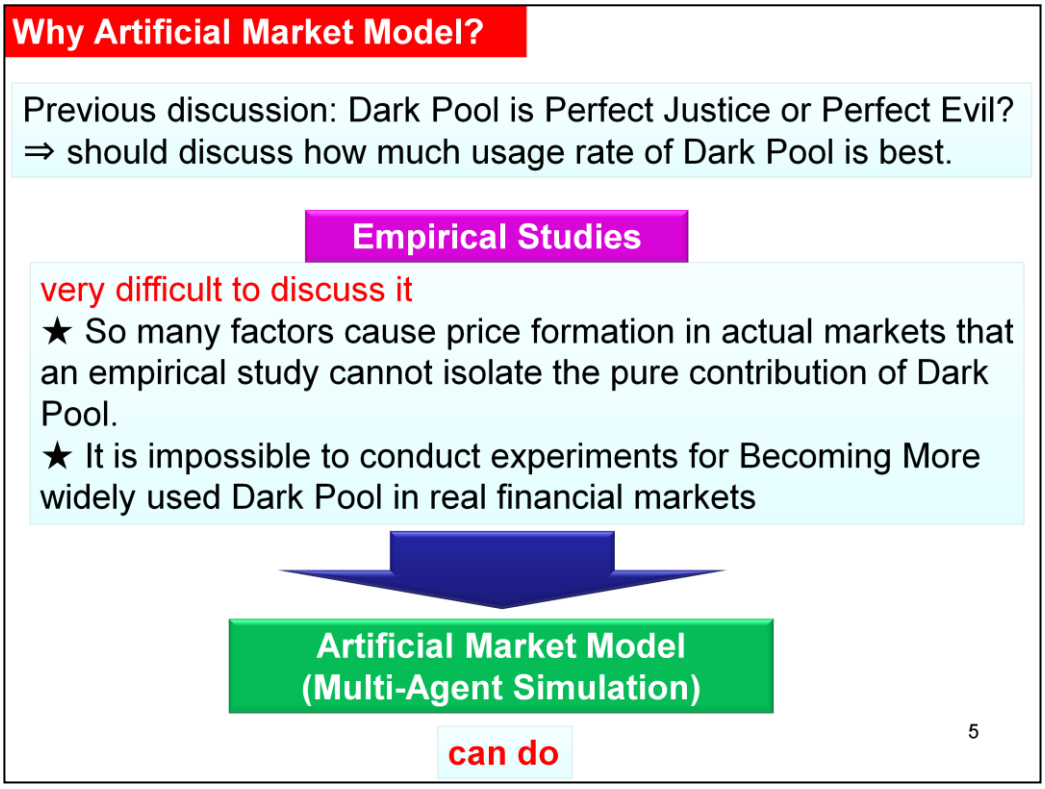
[Other some people says], Because Dark Pool has Never Price Discovery Function,

Price-discovery function of Whole Financial Market is decreasing.

[This opinion means Dark Pool is] Bad [for financial market].

[These 2 opinions are big battle.]

In EU, many discussion about Regulations of Dark Pool. MiFID II will restrict Dark trading to 8% of total EU liquidity.



Why Artificial Market Model?

[Many] Previous discussions [are such as] Dark Pool is Perfect Justice or Perfect Evil?

[However, we] should discuss how much usage rate of Dark Pool is best.

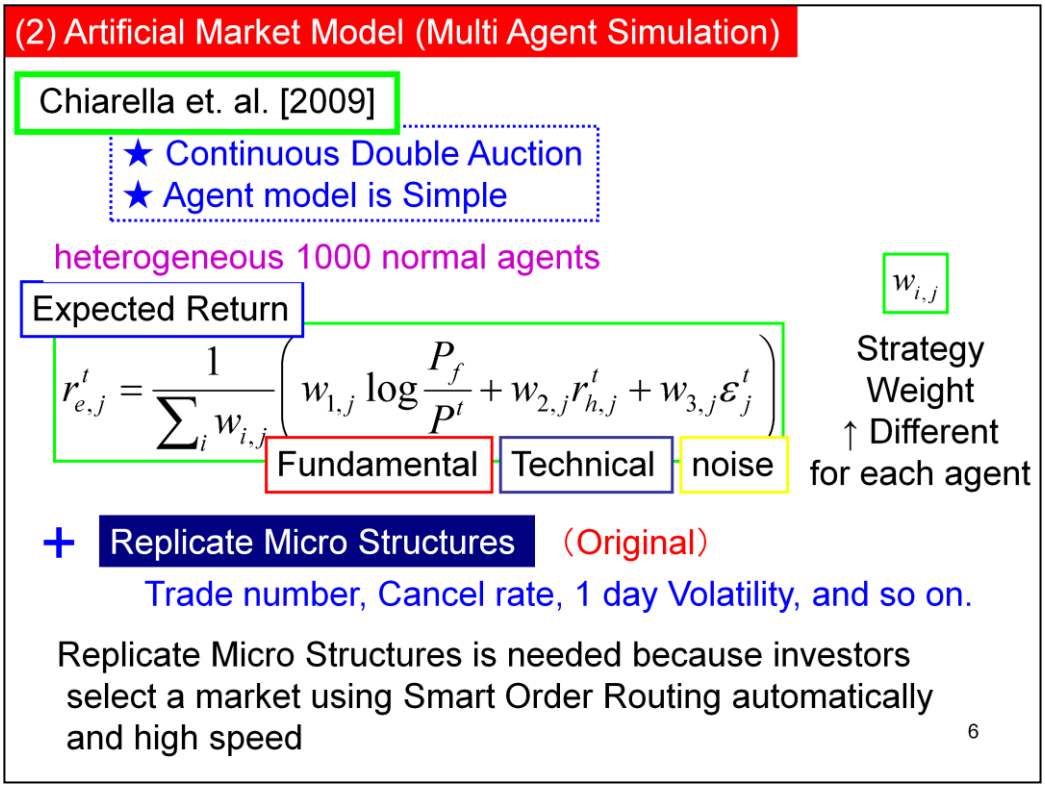
Empirical Studies are very difficult to discuss it [because],

So many factors cause price formation in actual markets that an empirical study cannot isolate the pure contribution of Dark Pool.

[and because],

It is impossible to conduct experiments for Becoming More widely used Dark Pool in real financial markets

[On the other hand], Artificial Market Model (Multi-Agent Simulation) can do [them].



We built an artificial market model on basis of Chiarella et. al. 2009.

[Pricing mechanism] is Continuous Double Auction. [We need to implement market selection model].

Agent Model is Simple. [This is to avoid arbitrary result].

[We think Artificial Market Models should explain Stylized Facts as Simply as possible].

[There are] heterogeneous 1000 agents. [All agents calculate] Expected Return [using this equation],

[And, the] strategy weights [are] different for each agent

・[First term is a] Fundamental [Strategy: When the market price is smaller than the fundamental price, an agent expects a positive return , and vice verse].

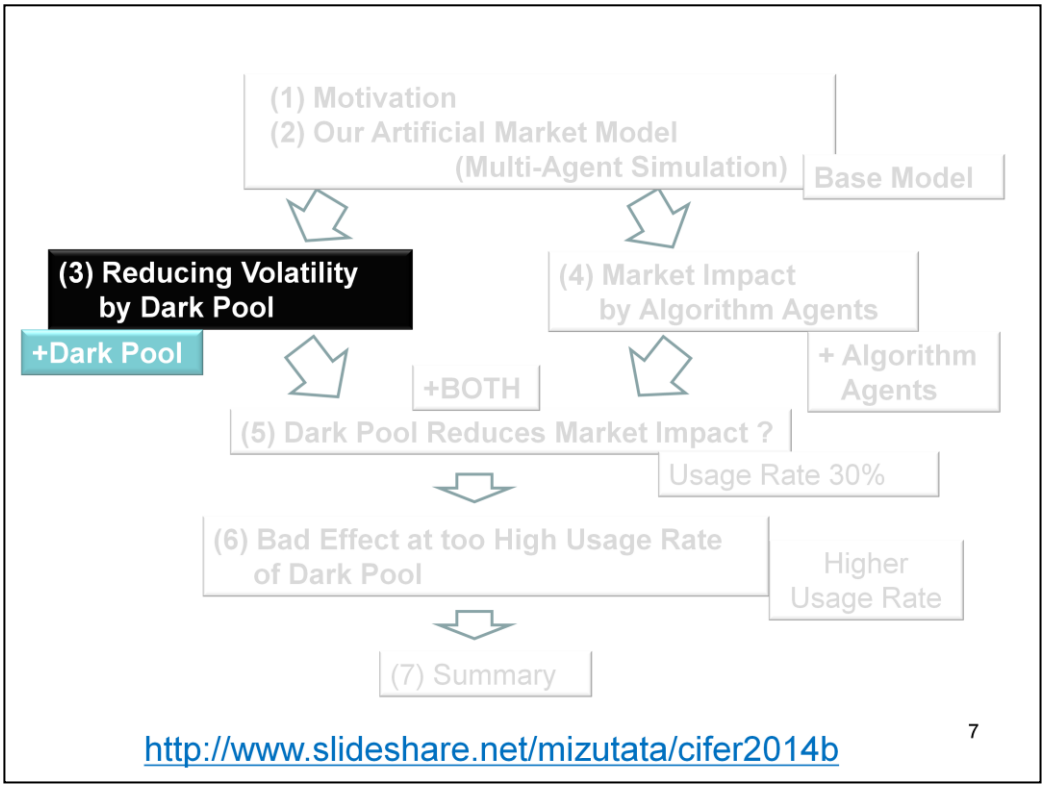
・[Second term is a] technical [strategy]: [When historical return is positive, an agent expects a positive return, and vice verse].

・[Third term is] noise.

[We also] replicate micro structures, [this is our] Original.

Trade number, cancel rate, 1 day return 1 day Volatility, and so on.

Replicate Micro Structures is needed because investors select a market using Smart Order Routing automatically and high speed



[Next, I talk about] Reducing Volatility by Dark Pool [using the model combined Base model plus Dark Pool mode]l.

(3) Reducing Volatility by Dark Pool

Model of Dark Pool

Lit Market
(Normal Market)

Ask (Sell)	Price	Bit (Buy)
84	101	
176	100	
	99	2
	98	77

Dark Pool

Ask (Sell)	Bit (Buy)
	175

No Traders See this No.

When sell(ask) is ordered, Trade Price (100+99)/2=99.5

Lit Market: Traders determine Sell or Buy, Price, No. of Shares.

Dark Pool: Traders determine Only Sell or buy, No. of Share.
⇒ Trade Price is determined Mid price between best ask and best bit in the Lit Market.

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[At First, I will describe] Model of Dark Pool.

[Left side is an Example of Order Book of Normal Market, providing all order book to Traders],

[we call "Lit Market" as a opposite term "Dark Pool"].

[In Lit Market], Traders determine Sell or Buy, Price, No. of Shares.

[Right side is an Example of Order Book of Dark Pool providing no information to Traders],

No traders see this number.

[In dark Pool], Traders determine Only Sell or buy, No. of Share.

Trade Price is determined Mid price between best ask and best bit in the Lit Market.

[In this example], When sell is ordered, Trade Price (100+99)/2=99.5

Why is Market Volatility reduced?

Lit Market
(Normal Market)

Ask (Sell)	Price	Bit (Buy)
84	101	
176	100	
	99	2
	98	77

Dark Pool

Ask (Sell)	Bit (Buy)
	175

When sell(ask) is ordered,
Trade Price
(100+99)/2=99.5

When market 3 shares sell is ordered,
Case of Lit Market Only → Price is down to 98
Case of usage Dark Pool → Trade Price is 99.5
Dark Pool will absorb big market impact orders.
→ Market Volatility will be reduced.

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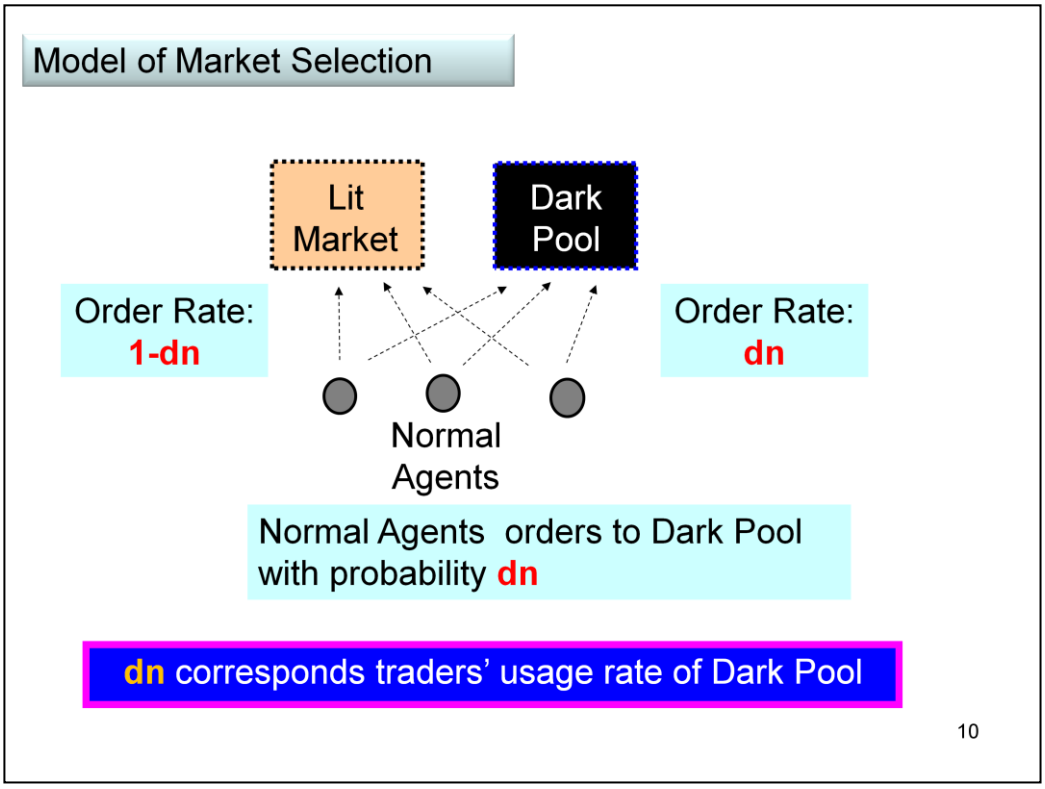
Why is Market Volatility reduced by Dark Pool?

[I show a example using these order books].

When market 3 shares sell is ordered,
[In the] Case of Lit Market Only → Price is down to 98
[In the] Case of usage Dark Pool → Trade Price is 99.5
Dark Pool will absorb big market impact orders.
→ Market Volatility will be reduced.

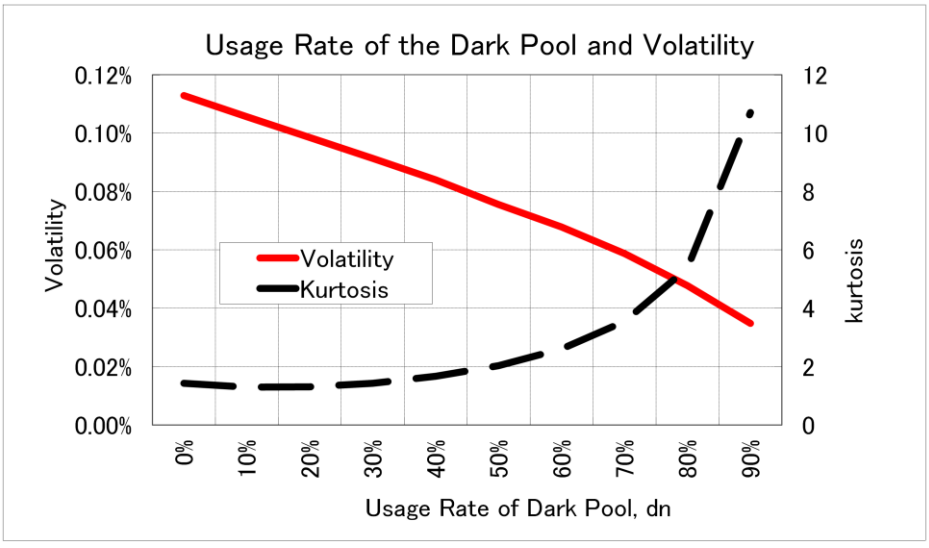


[Next, I describe] Model of Market Selection.

Normal Agents orders to Dark Pool with probability dn.
[And, to Lit Market at a rate of 1-dn].

dn corresponds traders' usage rate of Dark Pool

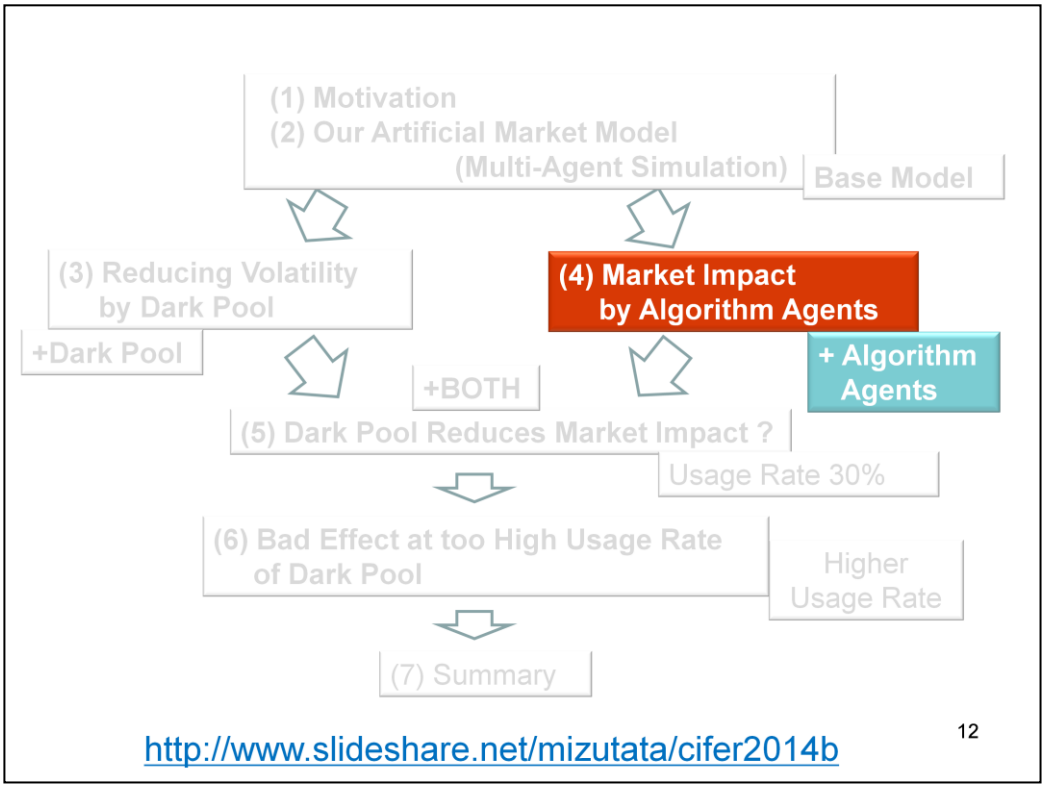
Relationship between Usage Rate of Dark Pool and Volatility



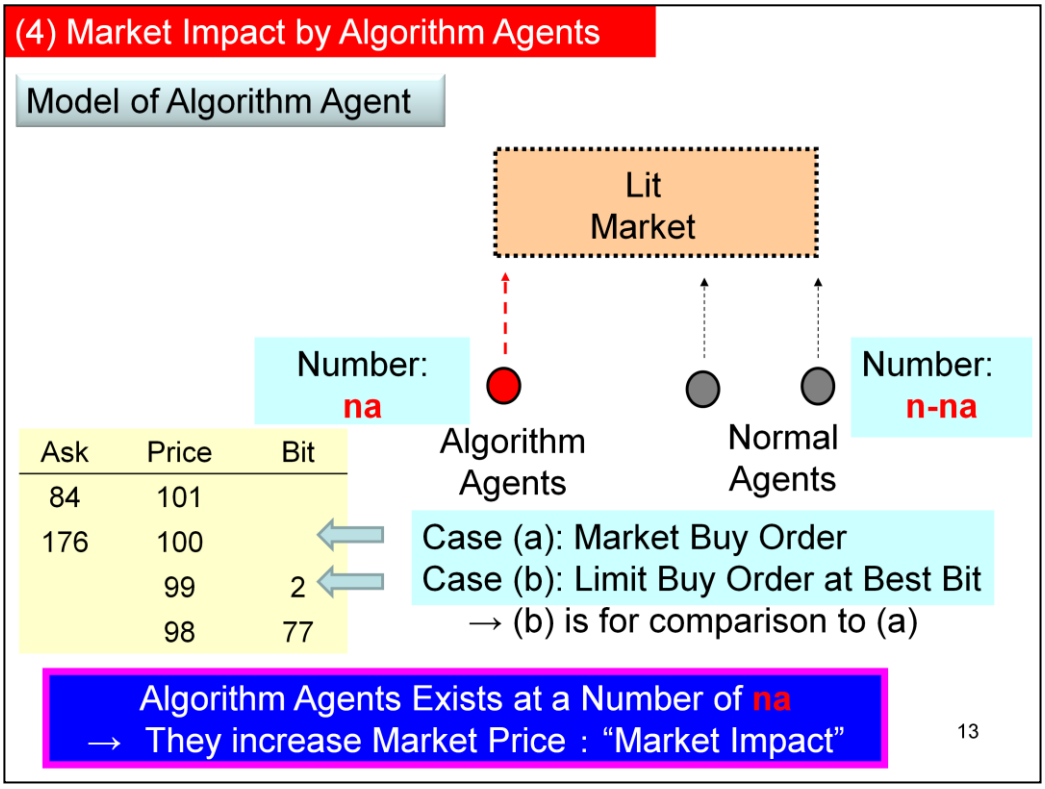
Increasing Usage Rate of Dark Pool, Decreasing Volatility.
However, Kurtosis Increasing → Fatter Tail

[This Figure shows] Relationship between Usage Rate of Dark Pool and Volatility

[Horizontal Axis is] Usage Rate of Dark Pool, dn



[Next, I talk about] Market Impact by Algorithm Agents [using the model combined Base model plus Algorithm Agents].



Model of Algorithm Agent

[Algorithm agents make only buy orders in a regular cycle].

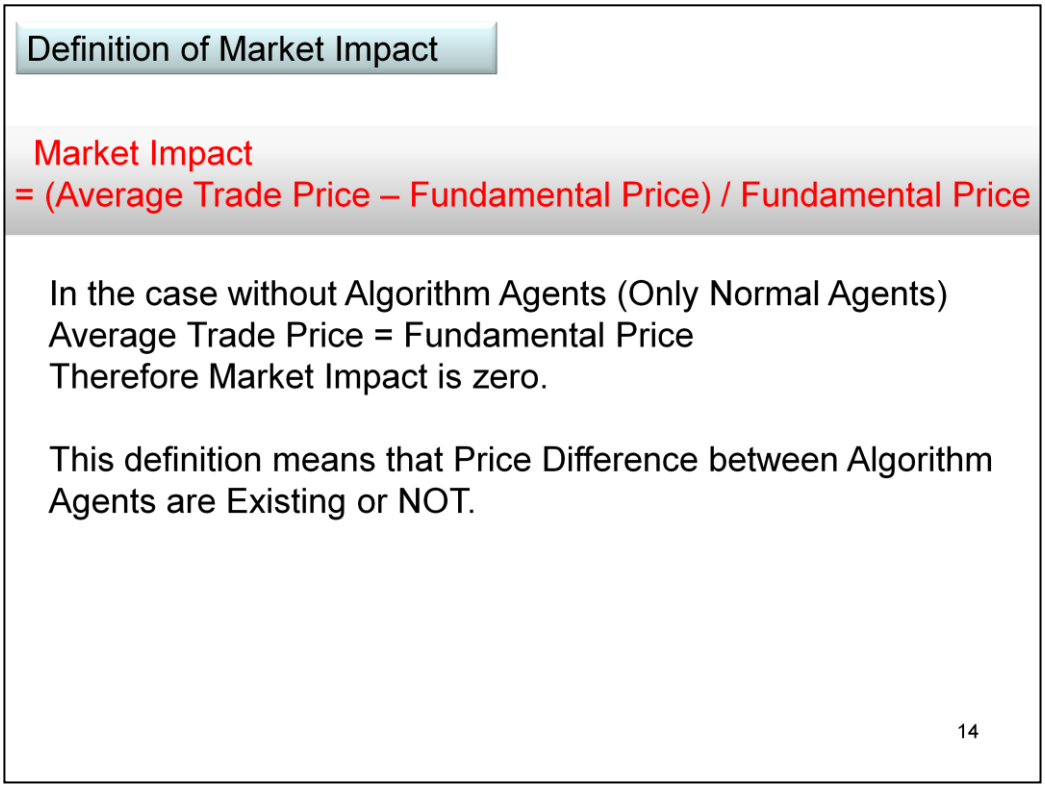
[We investigate two cases].

Case (a) [They make only] Market Buy Order

Case (b) [They make only] Limit Buy Order at Best Bit. Case (b) is for comparison to (a) .

Algorithm Agents Exists at a Number of na

They increase Market Price. [This incrementation is corresponding to] Market Impact



Definition of Market Impact

We define Market Impact = (Average Trade Price – Fundamental Price) / Fundamental Price

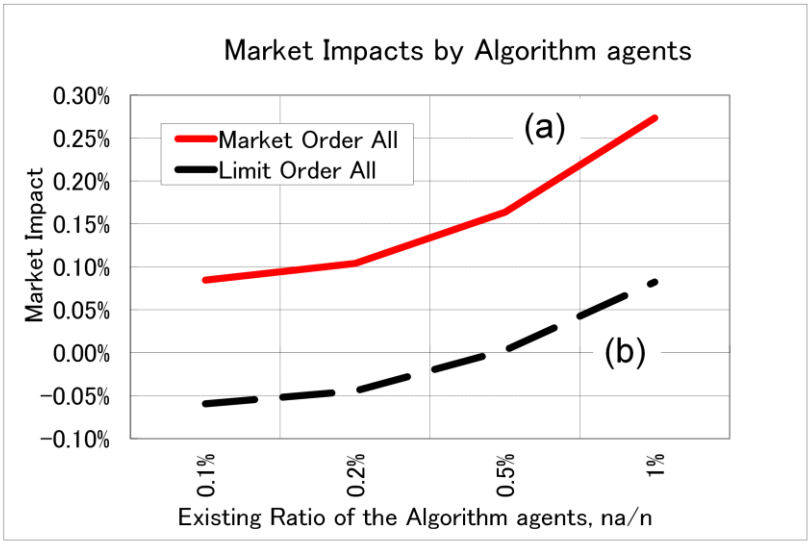
In the case without Algorithm Agents (Only Normal Agents)

Average Trade Price = Fundamental Price

Therefore Market Impact is zero.

This definition means that Price Difference between Algorithm Agents are Existing or NOT

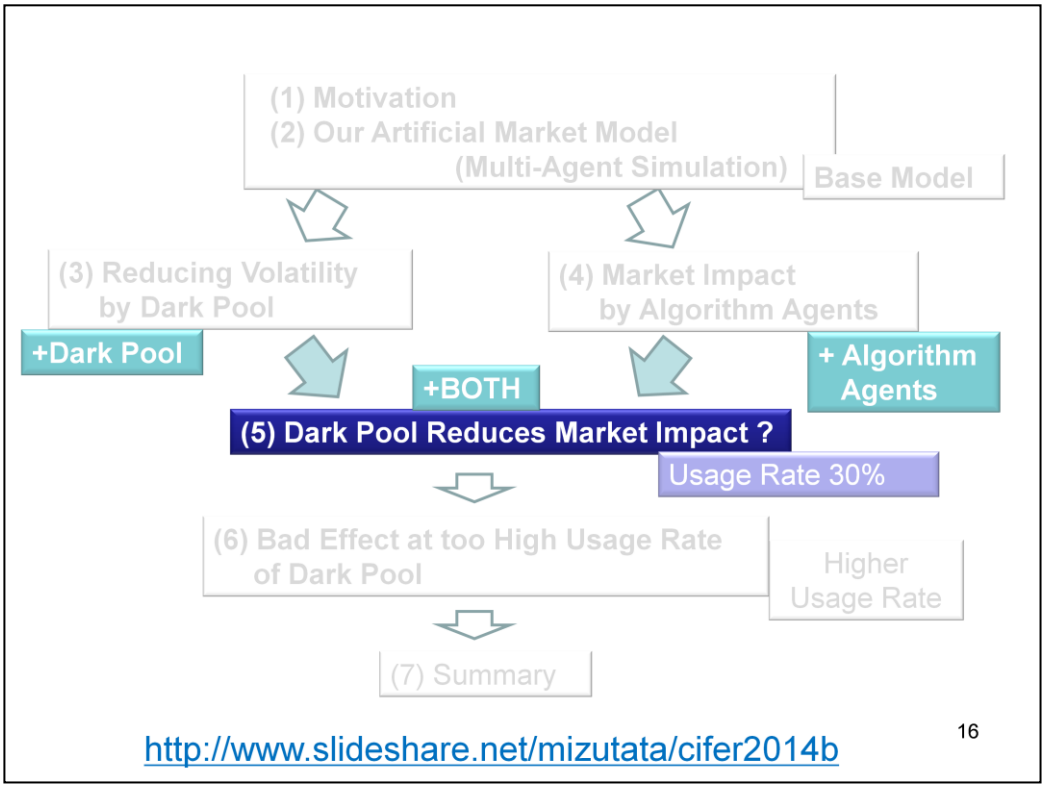
Market Impacts and Existing Ratio of Algorithm Agents



Increasing Algorithm Agents, Increasing Market Impact.
Eave though in Case (b), They “indirectly” impact market price.
Afterward, We fix na/n = 1%

[This figure shows relationship between] Market Impacts and Existing Ratio of Algorithm Agents

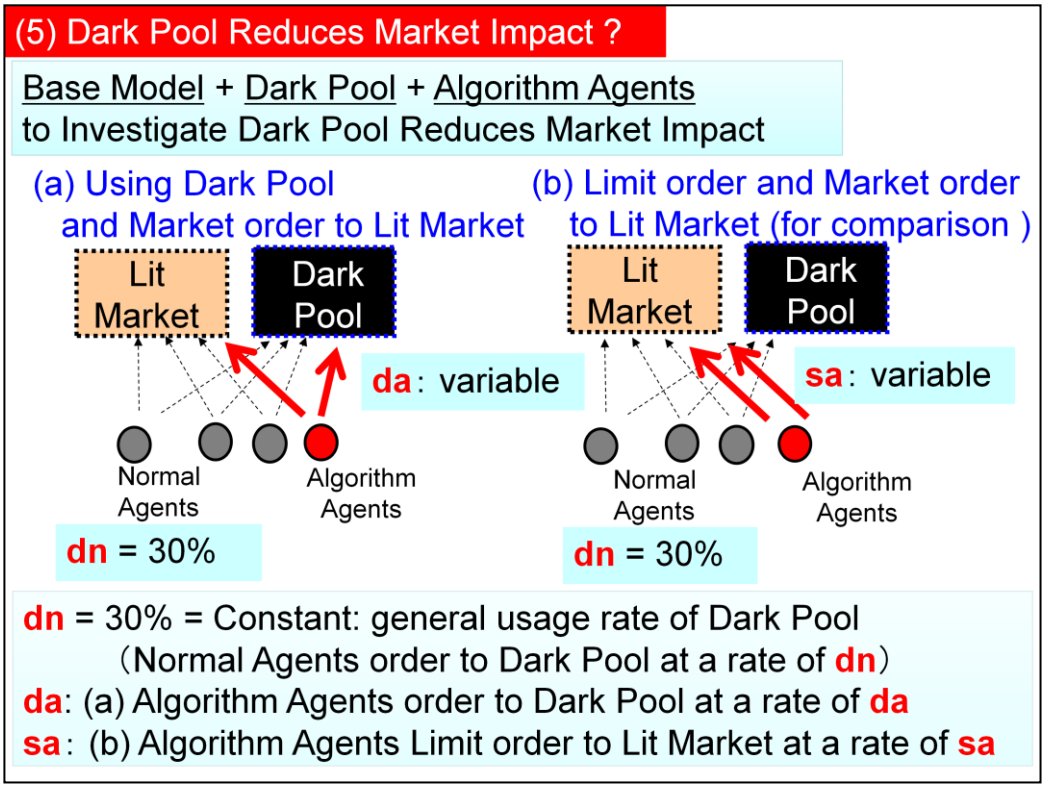
limit orders do not change market prices directly]



[Next, I investigate], Dark Pool Reduces Market Impact ?

U[sing the model combined] Base model [plus] Dark Pool [and plus] Algorithm Agents

[Fixsing Dark pool] Usage Rate 30%



[We investigated two cases].

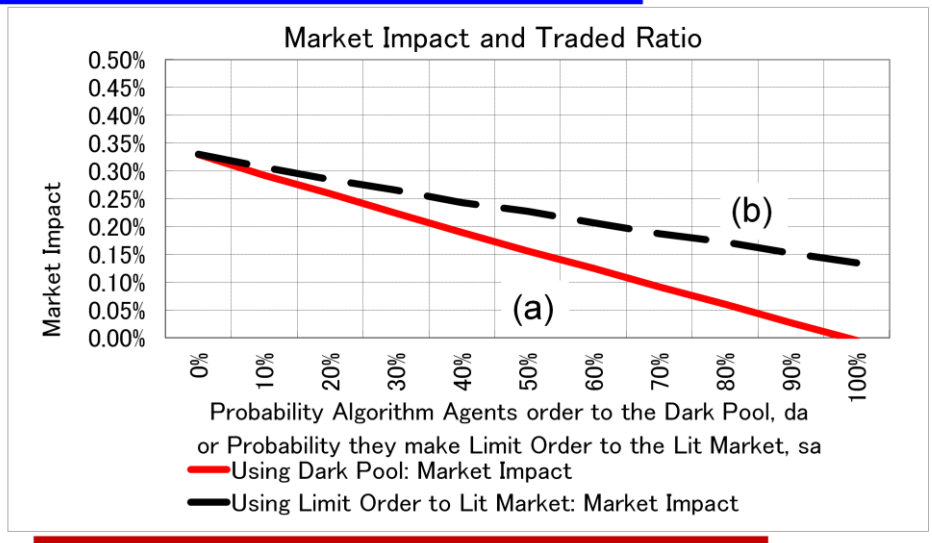
[Case] (a), Algorithm Agents order to Dark Pool at a rate of da, da is variable.

Normal Agents order to Dark Pool at a rate of dn, dn = 30% = constant, general usage rate of Dark Pool

[Case] (b), [for comparison to case (a)]

Algorithm Agents Limit order to Lit Market at a rate of sa, sa is variable.

Dark Pool Reduces Market Impact ?



Yes, Dark Pool Reduces Market Impact !!

Increasing Algorithm Agents use Dark Pool, Market Impacts are reduced, more than case (b), limit order to Lit Market. 100% Dark Pool, Market Impact is ZERO.

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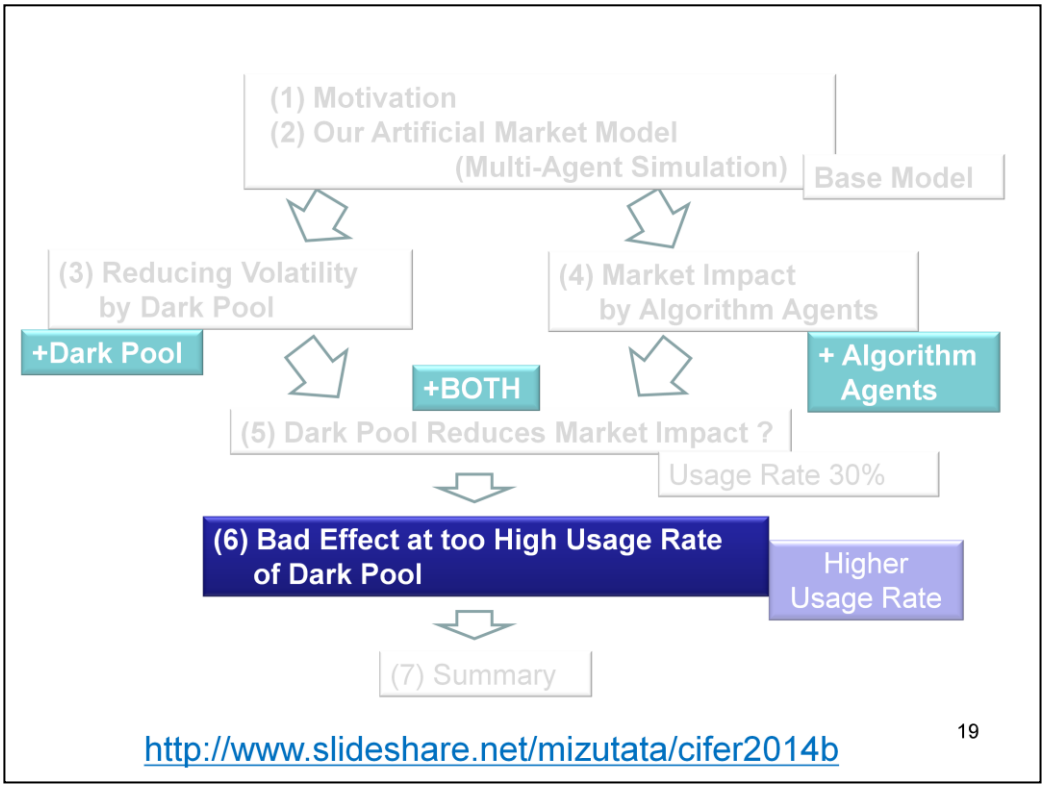
[This figure shows Market Impact for various da and sa].

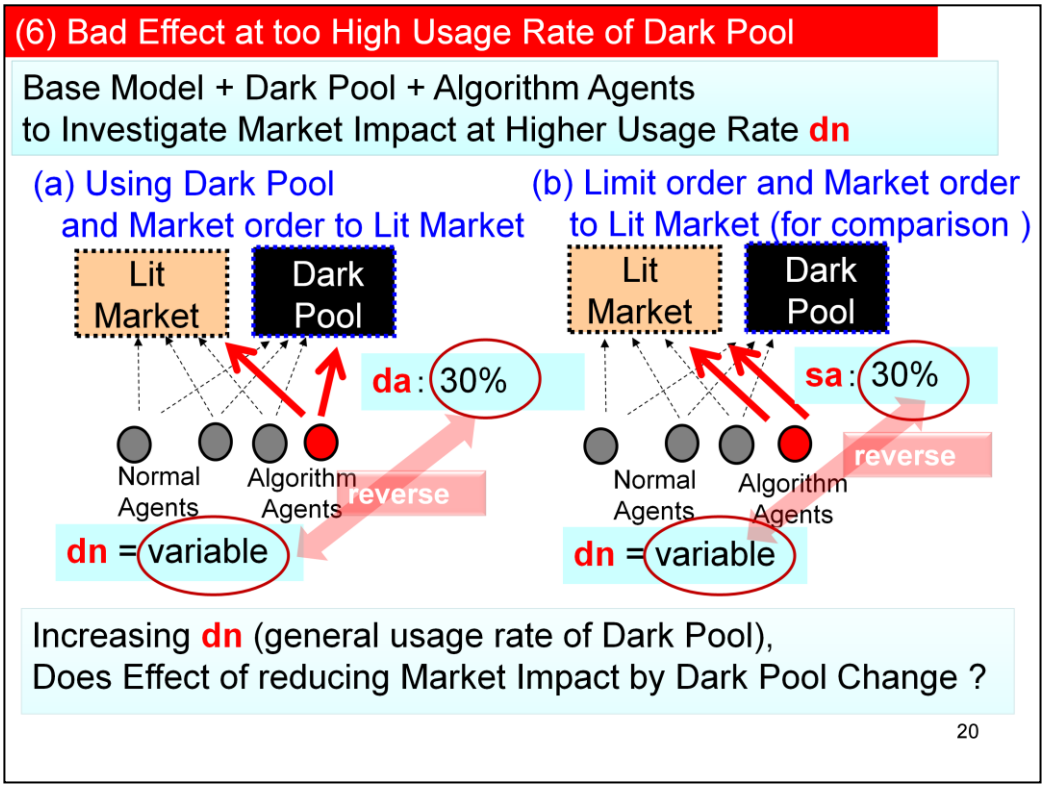
[Horizontal Axis is da or sa]

Dark Pool Reduces Market Impact ?

Yes, Dark Pool Reduces Market Impact !!



[Lastly, I investigate], Bad Effect at too High Usage Rate of Dark Pool
Higher [Dark pool] Usage Rate



[Analysis Setting is similar to previous analysis].

[but in reverse to previous analysis],

da and sa are fixed, 30%

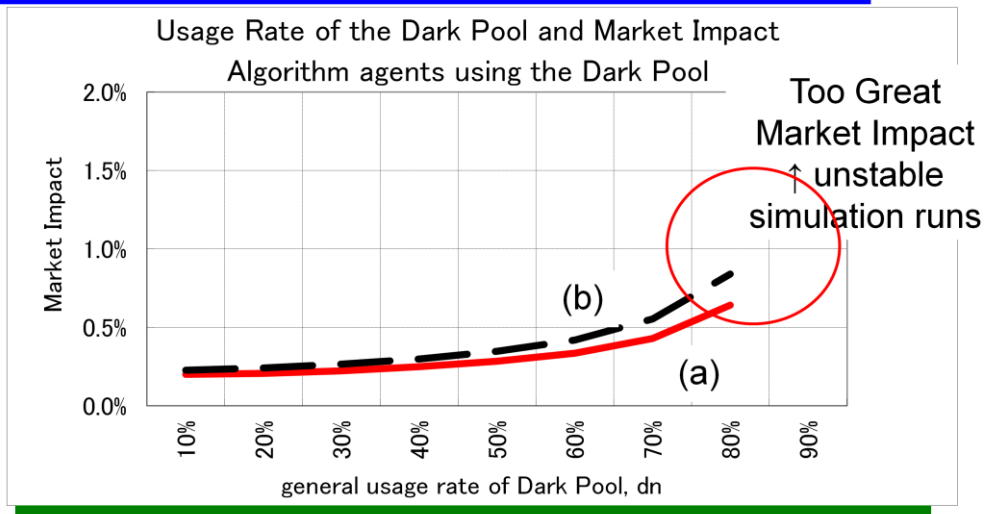
Dn is variouble.

[We investigated that]

Increasing dn (general usage rate of Dark Pool),

Does Effect of reducing Market Impact by Dark Pool Change ?

Using Dark Pool and Market order to Lit Market



At very High Usage rate of Dark Pool, Dark Pool can not reduce Market Impact. Traders must use Dark Pool more than many others to decrease Market Impact.

Traders will less use Lit Market, and decreasing price-discovery function.

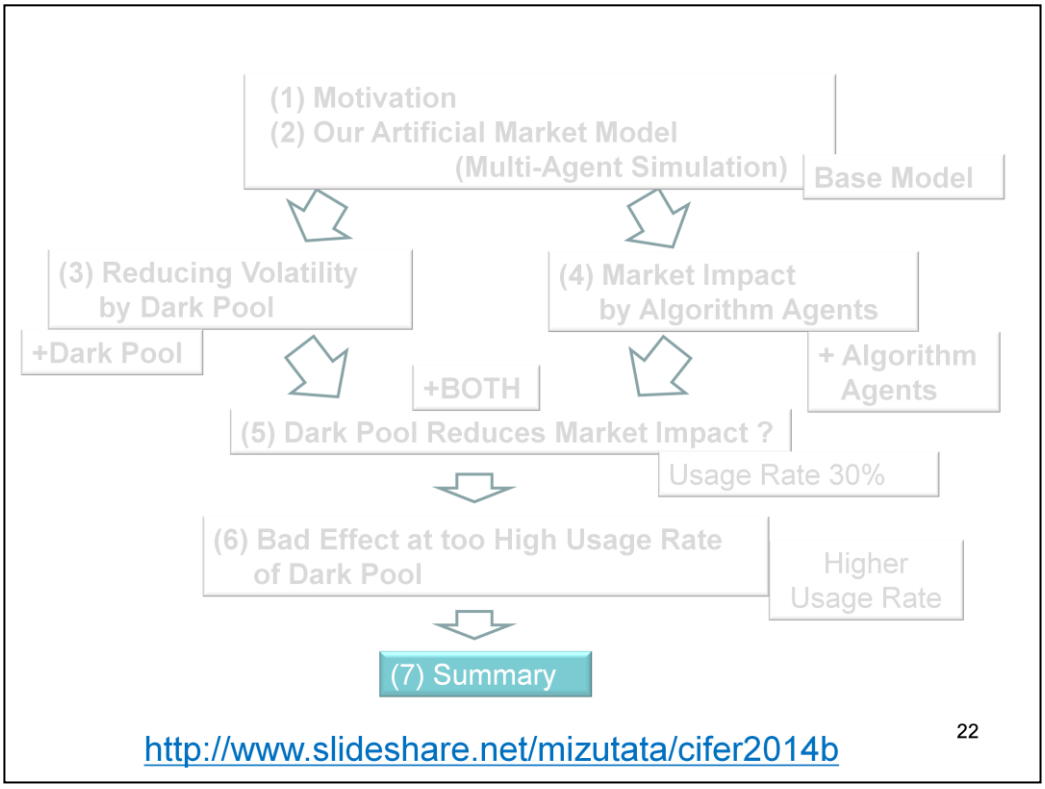
[This figure shows market Impact, Horizontal Axis is] general usage rate of Dark Pool, dn.

[Very high usage area, we can not plot data],

[because] Too Great Market Impact [and] unstable simulation runs

At very High Usage rate of Dark Pool, Dark Pool can not reduce Market Impact.

Traders must use Dark Pool more than many others to decrease Market Impact.



[Lastly, I will mention] Summary.

(7) Summary

- We built an artificial market model to investigate how is Dark Pool effects Market Price formations.
- Dark Pool is increasingly used, markets become more stable.
- Using Dark Pool more reduces the market impacts.
- However, when Usage Rate become Upper “some Threshold”, Dark Pool can not reduce Market Impact. Traders must use Dark Pool more than many others to decrease Market Impact. Traders will less use Lit Market, and decreasing price-discovery function.

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・We built an artificial market model to investigate how is Dark Pool effects Market Price formations.
・Dark Pool is increasingly used, markets become more stable.
・Using Dark Pool more reduces the market impacts.
・However, when Usage Rate become Upper “some Threshold”, Dark Pool can not reduce Market Impact. Traders must use
Dark Pool more than many others to decrease Market Impact. Traders will less use Lit Market, and decreasing price-discovery function.

[These opinions are I mentioned at Motivation.]

[This study showed that], BOTH Opinions is Right under/upper the Threshold.

Becoming More widely used Dark Pool leads,,,

Because very large market impacting orders are decreased, Market is more Stable?

Yes, under the Threshold

Because Dark Pool has Never Price Discovery Function, Price-discovery function of Whole Financial Market is decreasing?

Yes, upper the Threshold

[Therefore],

Dark Pool is GOOD, the Usage Rate Under Threshold,

Dark Pool is BAD, the Usage Rate Upper Threshold

Future Works

In EU, many discussion about Regulations of Dark Pool.
MiFID II will restrict Dark trading to 8% of total EU liquidity.
[Urrutia 13, Bowley 14]

Our results suggest the threshold might be about 50%,
which is much lager than about 8%.
However, need more investigations about the threshold.

Investigation the most suitable the threshold.
How the threshold depend on the design of the artificial agents.

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Future Works
[About This EU Regulation],
Our results suggest the threshold might be about 50%,
which is much lager than about 8%.
However, need more investigations about the threshold.

Investigation the most suitable the threshold.
How the threshold depend on the design of the artificial agents.

Could you say that again? (もう一度、おっしゃっていただけますか？)

I don't quite understand your question. (ご質問の趣旨が良く分からないのですが)

Could you please rephrase your question? (ご質問を分かりやすく言い換えていただけますか)

So, you are asking me about.... (つまり、お尋ねの内容は...ですね)

I totally agree with you. (私も全くあなたと同意見です)

That's a very challenging question for me to answer. (それは私にとって非常に答えがいのある質問です)

That's a question I'm not sure I can answer right now. (そのご質問にすぐお答えできるかどうか分かりません)

It would require further research. (さらなる研究結果を待ちたい)

You are right on that point. (その点に関してはあなたが正しい)

Our method will not solve the problem. (我々の方法ではその問題は解決できない)

Reference (about Artificial Market Model)

* Mizuta, T., Hayakawa, S., Izumi, K., Yoshimura, S. (2013)
Simulation Study on Effects of Tick Size Difference in Stock Markets Competition,
The 8th International Workshop on Agent-based Approach in Economic and Social Complex Systems (AESCS 2013), 2013

* Chiarella C., G. Iori and J. Perello (2009)
The impact of heterogeneous trading rules on the limit order book and order?, Journal of Economic Dynamics and Control, 33, 3, 525-537

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Reference (about Dark Pool)

[SEC 10] Securities and Exchange Commission: Concept release on equity market structure, Federal Register, Vol. 75, No. 13, pp.3594-3614 (2010)

[Johnson 10] Johnson, B.: *Algorithmic Trading & DMA: An introduction to direct access trading strategies*, 4Myeloma Press (2010)

[EC 10] European Commission : Public Consultation Review of the Markets in Financial Instruments Directive (MiFID), *Consultation Report*, Vol. 8, (2010)

[Ye 12] Ye, M.: Price manipulation, price discovery and transaction costs in the crossing network, *Price Discovery and Transaction Costs in the Crossing Network (March 14, 2012)* (2012)

[Urrutia 13] Urrutia, J. P.: Progress in the MiFiD review: Stock-taking at the End of the Irish Presidency of the European Council, http://www.itg.com/marketing/ITG_Blotter_JP_Urrutia_MiFID_Review_20130607.pdf (2013)

[Bowley 14] Bowley, A.: Agreement of MiFID II Reforms, http://instinet.com/docs/msr/2014/Agreement_of_MiFID_II_Reforms-Quick_Analysis.pdf (2014)

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Appendix

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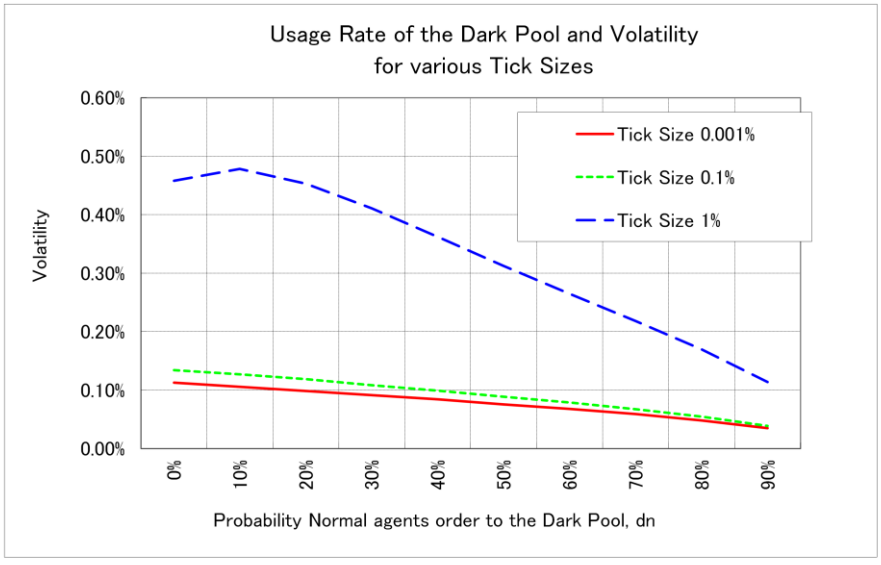
Fig. 6



Increasing Tick Size, Dark Pool reduces Volatility more.

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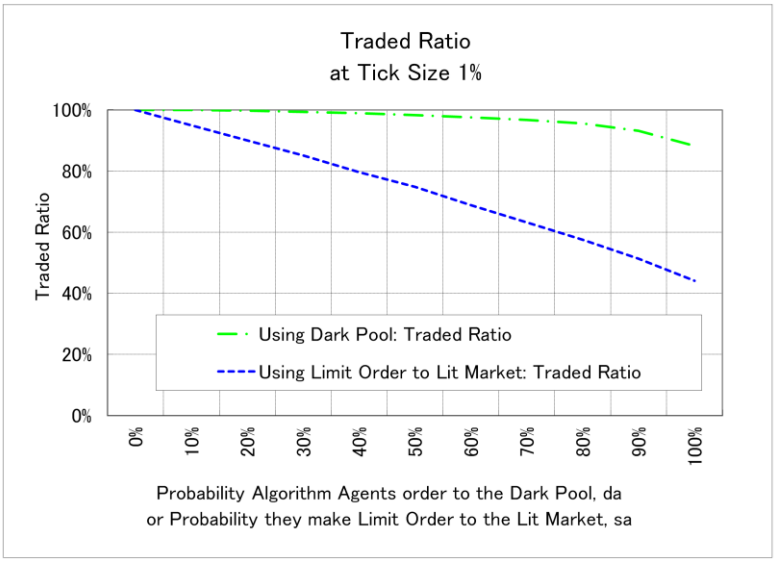
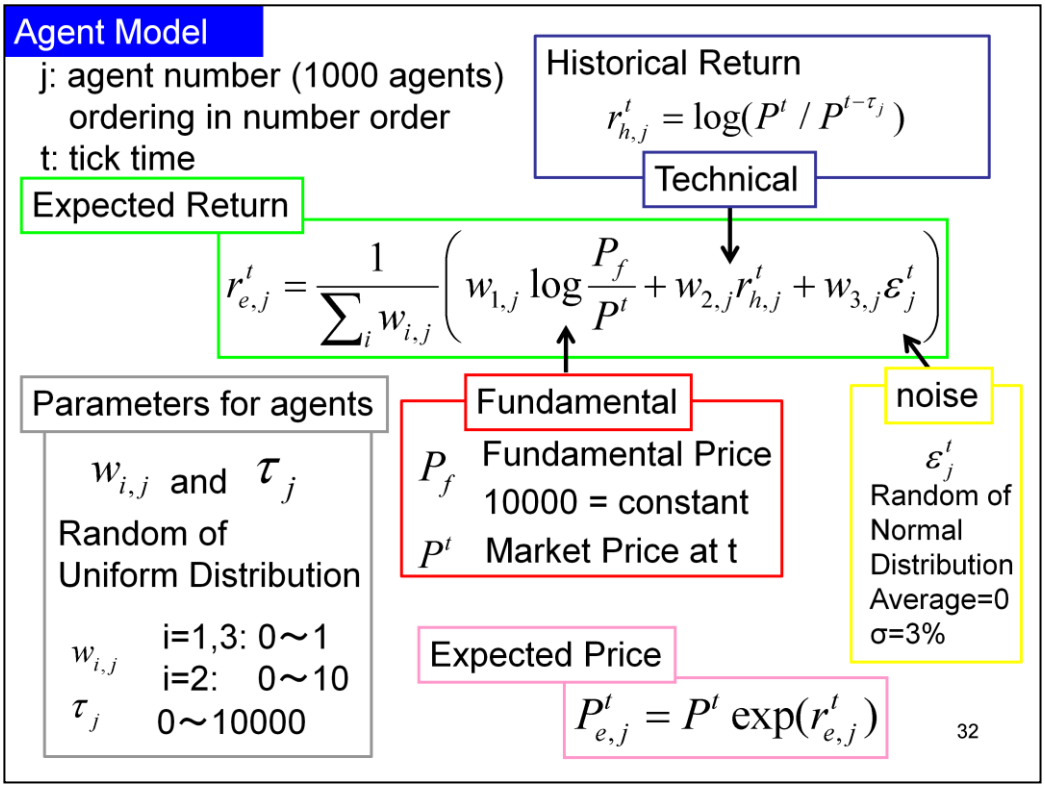
Fig. 7



When Tick Size is large,
It is need long time that Limit Orders reduce Market Impact.



Next, I will describe agent model.

All agents calculate Expected Return using this equation.

First term is a Fundamental Strategy:

When the market price is smaller than the fundamental price, an agent expects a positive return , and vice verse.

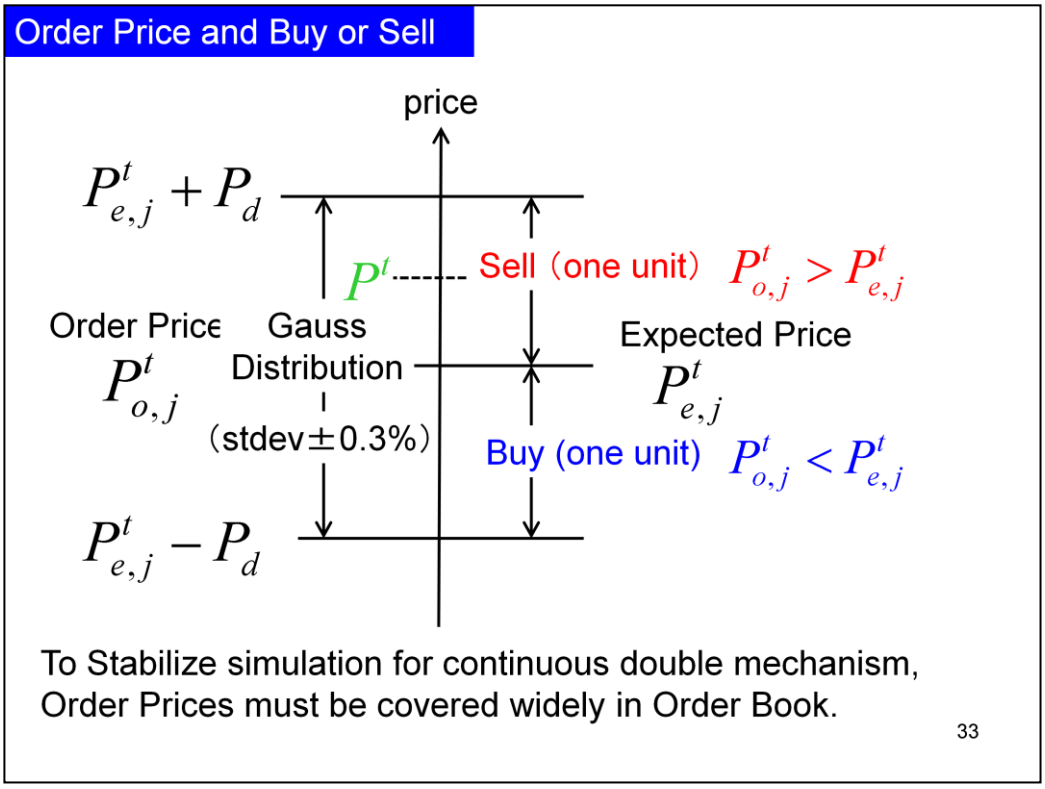
Second term is a technical strategy:

When historical return is positive, an agent expects a positive return, and vice verse.

Third term is noise,

After the expected return has been determined, an expected price is determined like this.

And, agents order base on this Expected Price.



Next, agents determine order price and, buy or sell.

To Stabilize simulation runs for the continuous double mechanism,

Order Prices must be covered widely in Order Book.

We modeled an Order Price, Po, by Random variables of Uniformly distributed in the interval from Expected Price, Pe, minus constant, Pd, to Pe plus Pd.

And then,

When Po lager than Pe, the agent orders to sell one unit.

When Po smaller than Pe, the agent orders to buy one unit.

Stylized Facts

about trading	trade rate	23.5%
	cancel rate	26.2%
	number of trades / 1 day	6,358
standard deviations of returns	for 1 tick	0.05%
	for 1 day (20000 ticks)	0.56%
kurtosis of returns		1.48
autocorrelation coefficient for square return	lag	
	1	0.228
	2	0.141
	3	0.108
	4	0.091
	5	0.078

Replicate Fat-Tail and Volatility-Clustering

\+ Replicate Micro Structures （Original）

Trade rate, Cancel rate, 1 tick and 1 day volatility

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This table list traditional Stylized Facts and statistics of Micro Structures for various Tick Size, in the case that there is One Market.

In all cases, both kurtosis and autocorrelation for square returns for all lag are positive.

This means that all cases replicate Traditional stylized facts: fat-tail and volatility-clustering.
Trade rate, Cancel rate, 1 tick and 1 day volatility are very similar to those of real stock markets.
Therefore the model replicate micro structures.
We found that Tick Time 20,000(twenty thousand) in simulation correspond to 1 day in real world.
Therefore we can convert simulation time and real time.
We emphasis that 1 tick volatility at Tick Size is enough small, 0.05% is very important number.
Whether Tick Size is bigger or smaller than 1 tick volatility, effects aspect of moving share of trading volume.
I define as Sigma t Var.