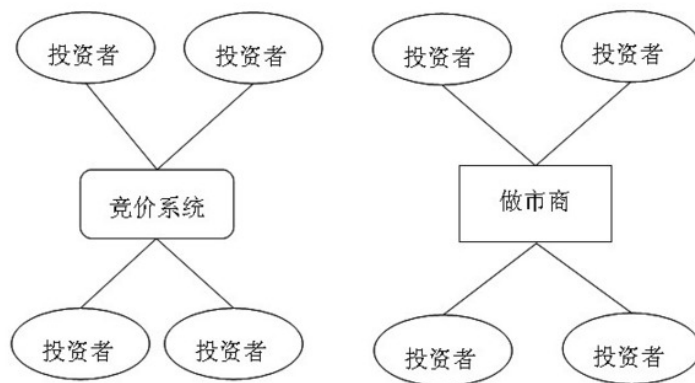# 连续竞价市场微观结构

主讲人 韦立坚 博士

要点

- 了解连续竞价市场微观结构
- 掌握市场质量的衡量指标
- 了解资产短期价格的形成机制
- 掌握连续竞价市场的建模思想
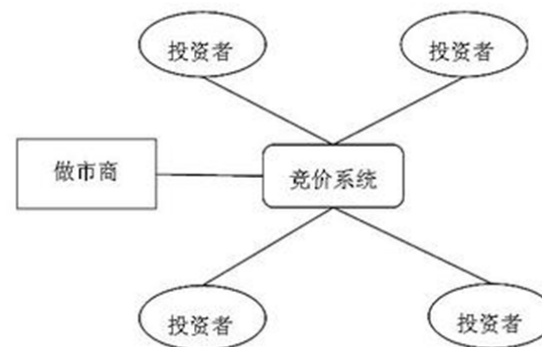
第一部分：基础知识
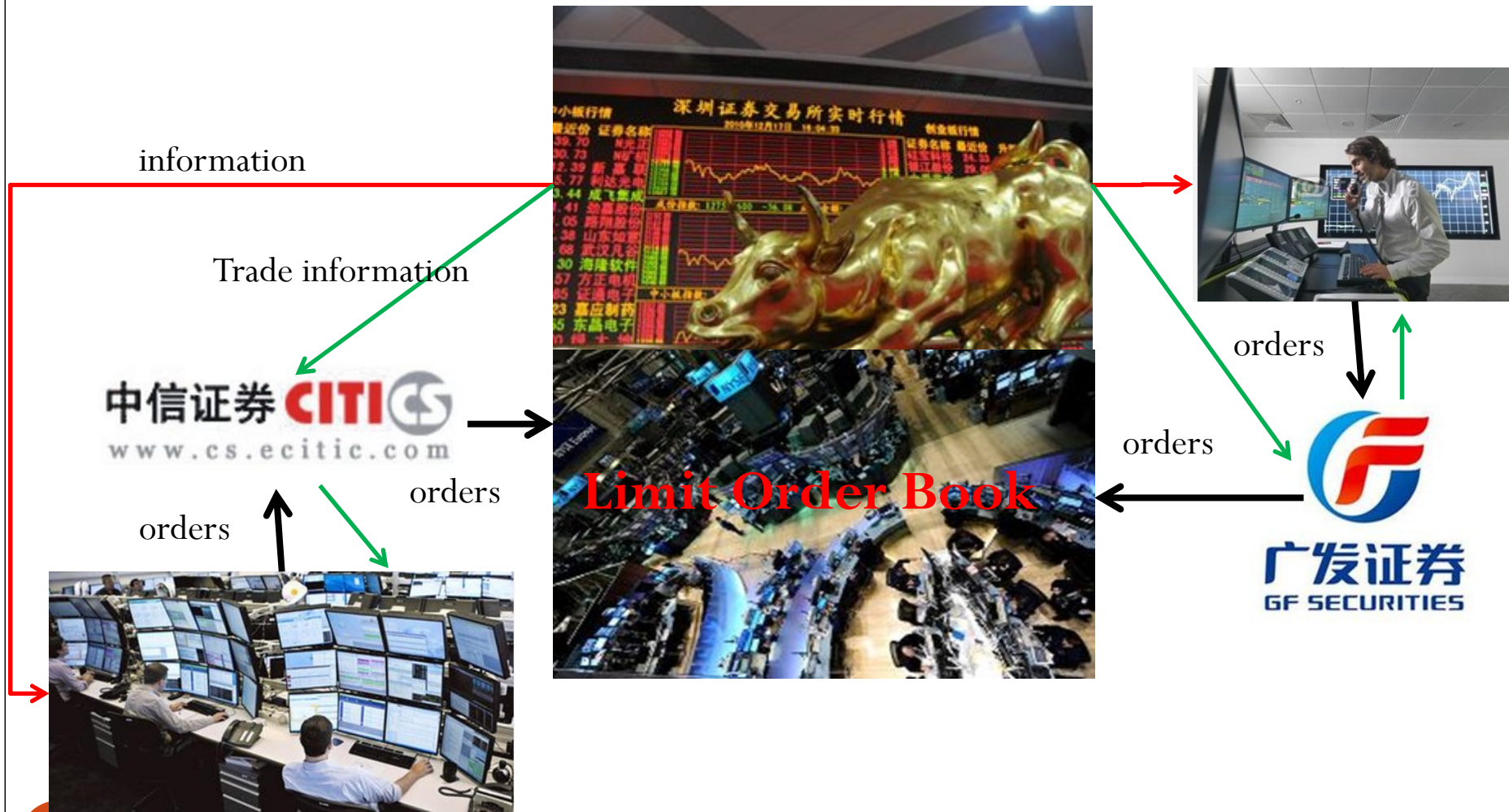
连续竞价市场

连续竞价市场与做市商市场

混合市场
纽交所、纳斯达克

Trading in security markets

information

Trade information

orders

Limit Order Book

orders

orders

orders

Think. Change. Do
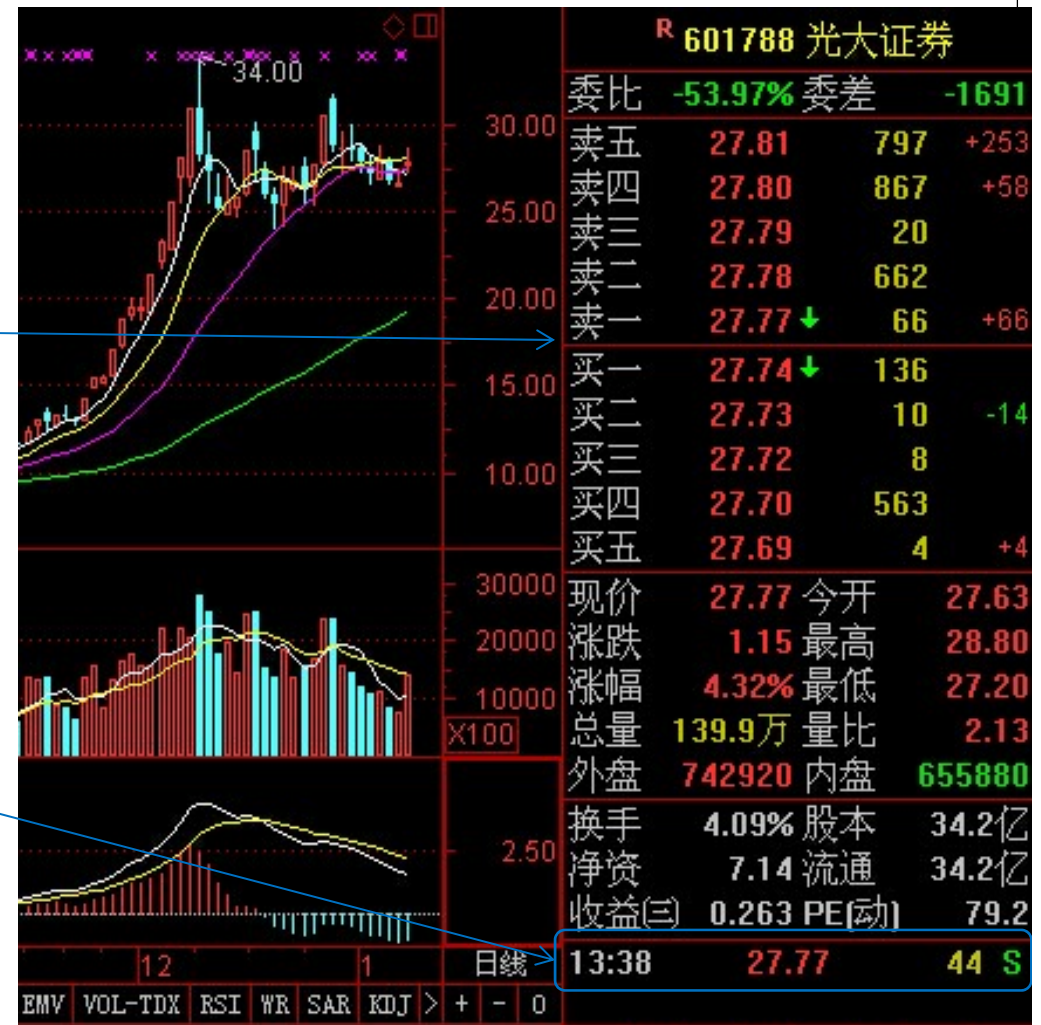
An example of limit order book

The limit order book reports the best 5 asks and the best 5 bids

The bottom reports the transaction happened at 13:38 pm. The trade price is 27.77, the transaction was initiated by a market sell order, the trading volume is 44 .

Think. Change. Do

Limit buy order

Buy price

Order size

A limit order gains *price-improvement* but does **NOT** result in an immediate matching upon submission, it faces *unexecuted risk* and has *waiting cost*.

Market buy order

Order size

A market order that results in an *immediate matching* upon submission
but has *more transaction cost* than a limit order.

Limit sell order

Sell price

Order size

买入	卖出	撤单	成交	持仓	刷新	卖出

股东代码：	沪A E006602614 ▼	
证券代码：	601788	光大证券
卖出价格：	27.80	元
最大可卖：	0	全部 股
○ 1/2 ○ 1/3 ○ 1/4 ○ 1/5		
卖出数量：	800	股
	卖出下单	

卖五	27.84	82
卖四	27.83	398
卖三	27.82	107
卖二	27.81	81
卖一	27.80	131
买一	27.78	68
买二	27.77	53
买三	27.76	10
买四	27.75	174
买五	27.73	33
现价 27.78	涨停 29.28	
昨收 26.62	跌停 23.96	

Think. Change. Do

Market sell order

Order size

Think. Change. Do

Schematic of limit order book

ALO: aggressive limit order

LOA: limit order at the quote

ULO: unaggressive limit order

MO: market order
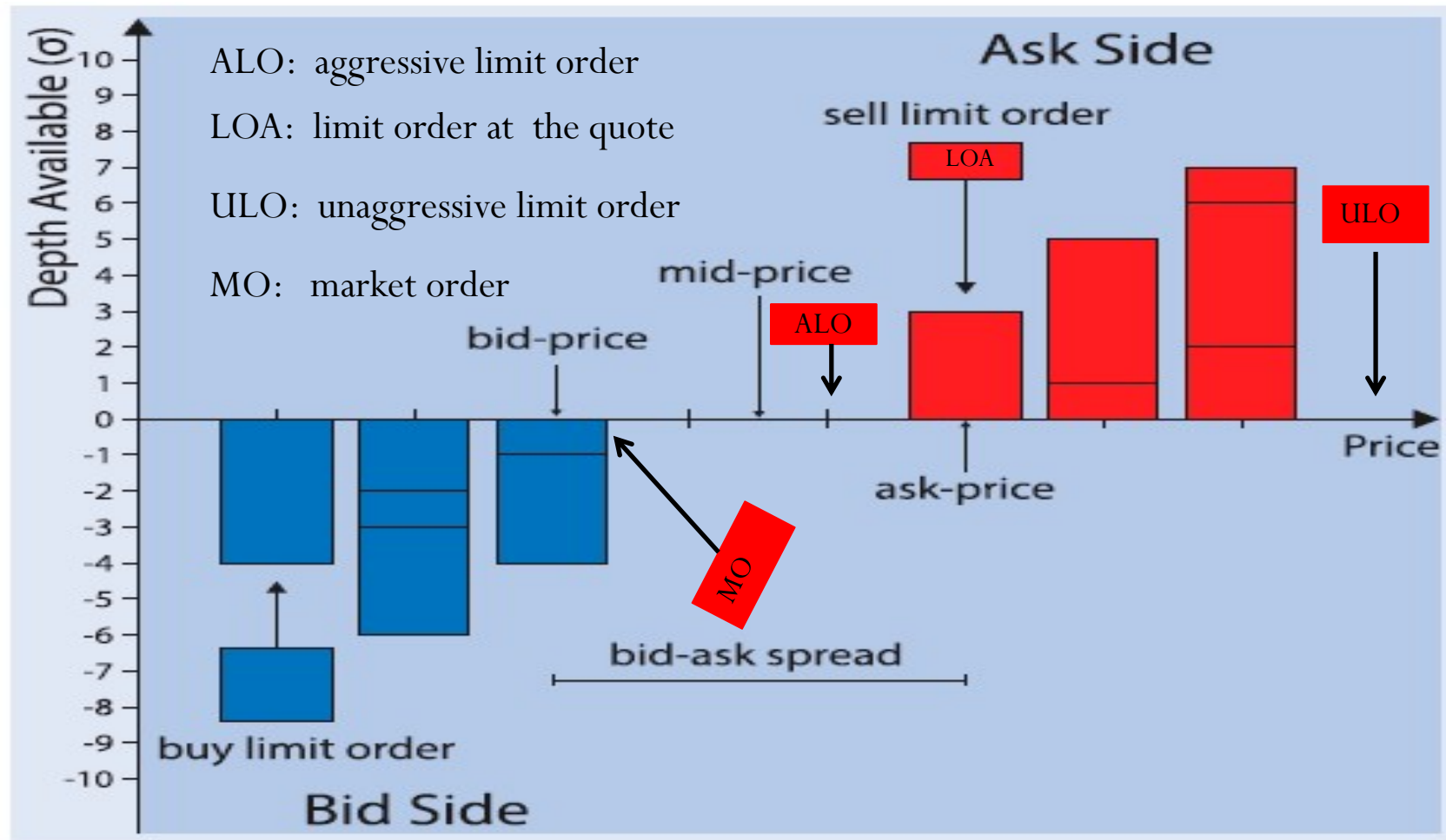
Indicators of limit order book

- The best bid

$$b_t^1 = 1.50$$

- The best ask

$$a_t^1 = 1.53$$
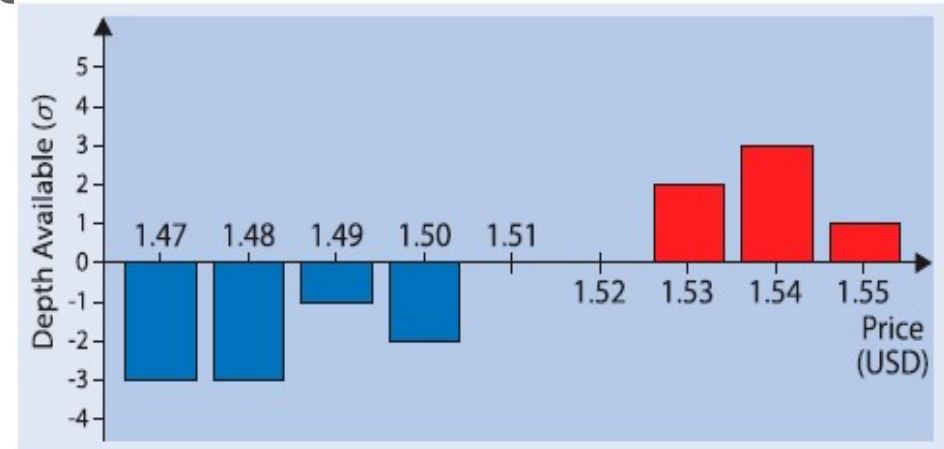
- The minimize tick size

- The mid-price

$$\kappa = 0.01$$

- The bid-ask spread $p_t^M = (a_t^1 + b_t^1)/2 = (1.53 + 1.50)/2 = 1.515$

- The relative bid-ask spread $s_t = (a_t^1 - b_t^1) = 1.53 - 1.50 = 0.03 = 3ticks$

$$s_t^R = (a_t^1 + b_t^1)/p_t^M = (1.53 - 1.50)/1.515 = 0.0198 = 198bps$$

Think. Change. Do

Indicators of order book

- Depth of buy side:

$$d_t^B = \sum_{i=1}^{n} \sigma_{b_t^i}$$

where $\sigma_{b_t^i}$ is the order size of limit buy at price

$$b_t^i, i = 1, 2, 3 \ldots n$$

- Depth of sell side:

$$d_t^B = 2 + 1 + 3 + 3 = 9 \qquad d_t^S = \sum_{i=1}^{n} \sigma_{a_t^i}$$

$$d_t^S = 2 + 3 + 1 = 6$$

Think. Change. Do

Price-time priority

Most markets use price-time priority, such as Shanghai and Shenzhen stock markets.
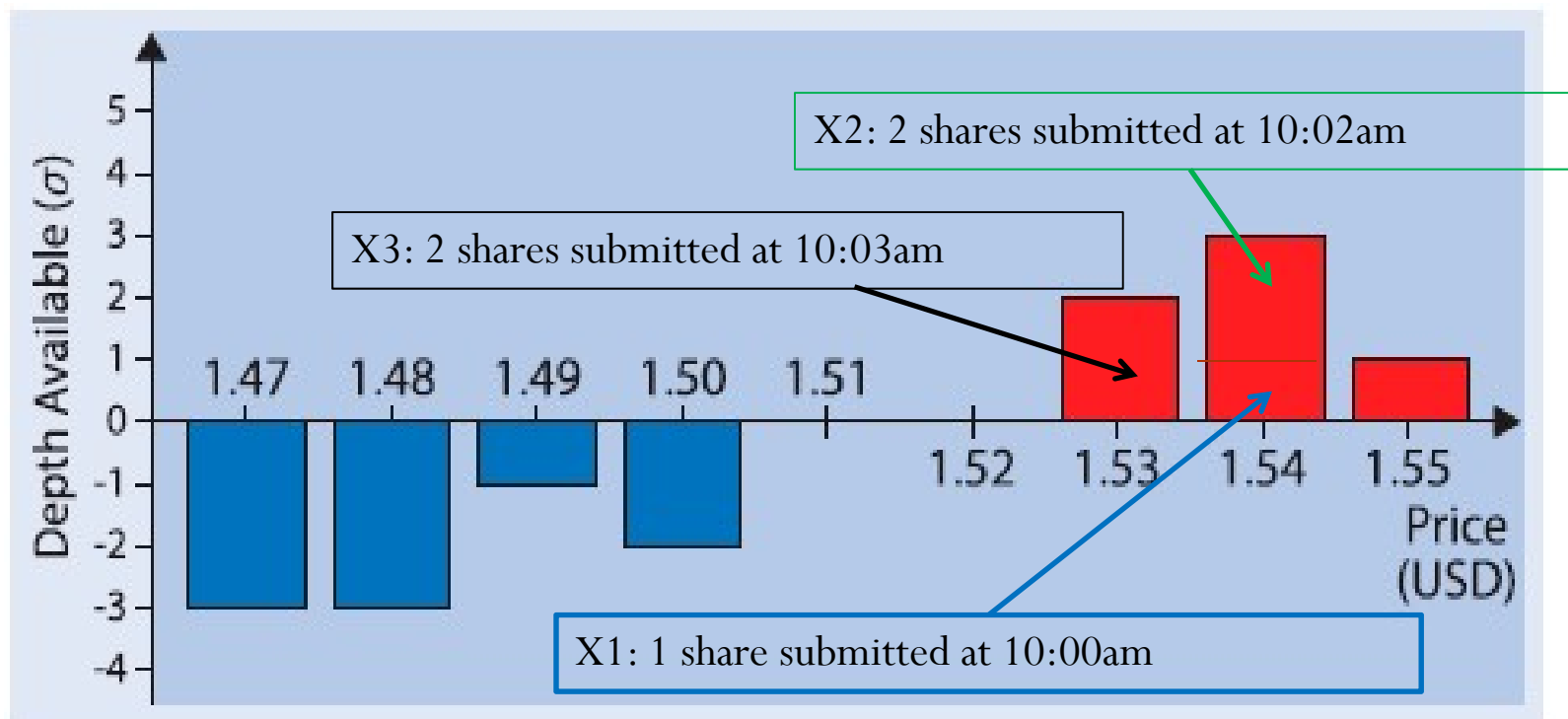
Transaction initiated by a market order

- Market orders

Think. Change. Do
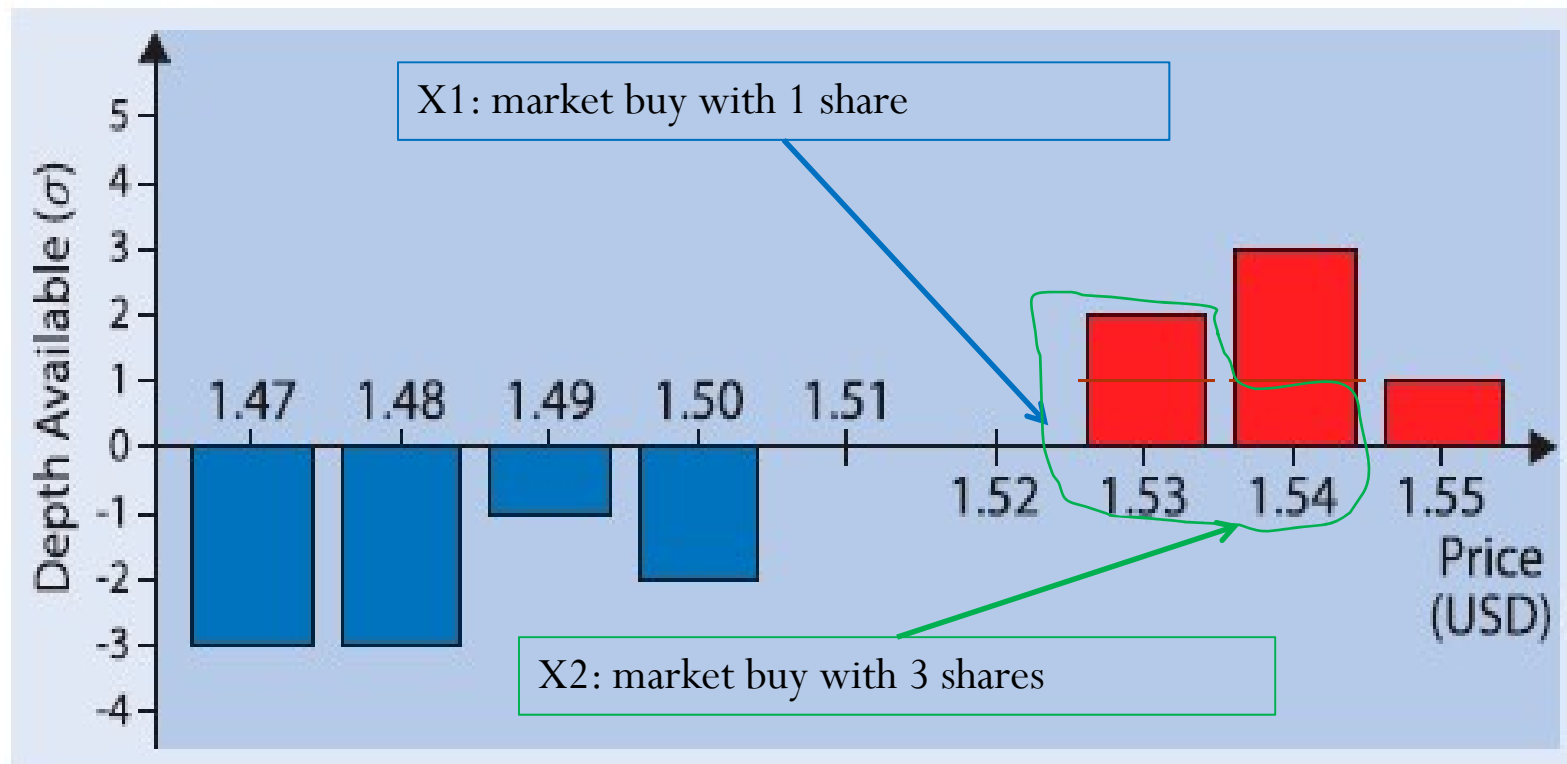
沪深300股指期货IF1509合约的交易

- bid-ask spread=4.4 CNY=22 ticks!

- Relative bid-ask spread=4.4/3273.4=13.4bps.

- Depth of buy side=4

- Depth of sell side=1

卖	5	—	—
	4	—	—
	3	—	—
盘	2	—	—
	1	3275.6	1
	1	3271.2	4 +1
买	2	—	—
	3	—	—
盘	4	—	—
	5	—	—

Think. Change. Do

The risk of market orders

- "2.28" Fishing Order Incident

On Feb. 28, 2007, Haier Warrant

At 9:15:01 am, a buyer submitted a large limit buy with 1 million shares with price 0.001 (Fishing order).

At 9:30:01 am, a seller submitted a large market sell executed with the Fishing Order for 820 thousands shares!

The fishing order earned about 700-times profit!

Think. Change. Do

Large market sell

Ask side

depth

0

0.645 0.646 0.647 0.648   0.650   0.651   0.652   0.653

price

Clean out

Bid side

Fishing order
price 0.001
unobservable on the book
order size: 1 million

Opening price: 0.650
Closing price: 0.669
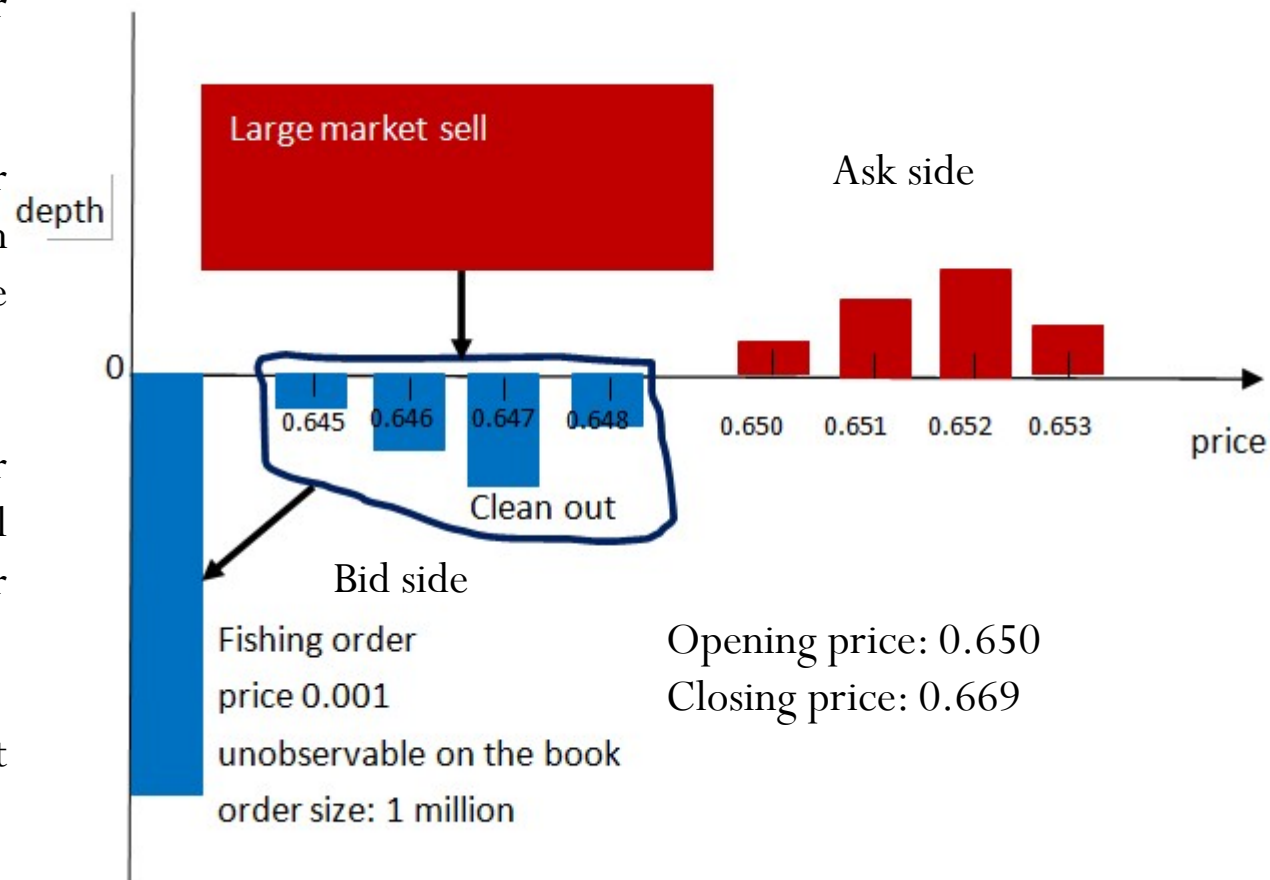
Transactions initiated by a marketable limit order

- Marketable limit orders

X1: limit buy, price 1.54, 8 shares

2

3

3

new limit buy: price 1.54, 3 shares
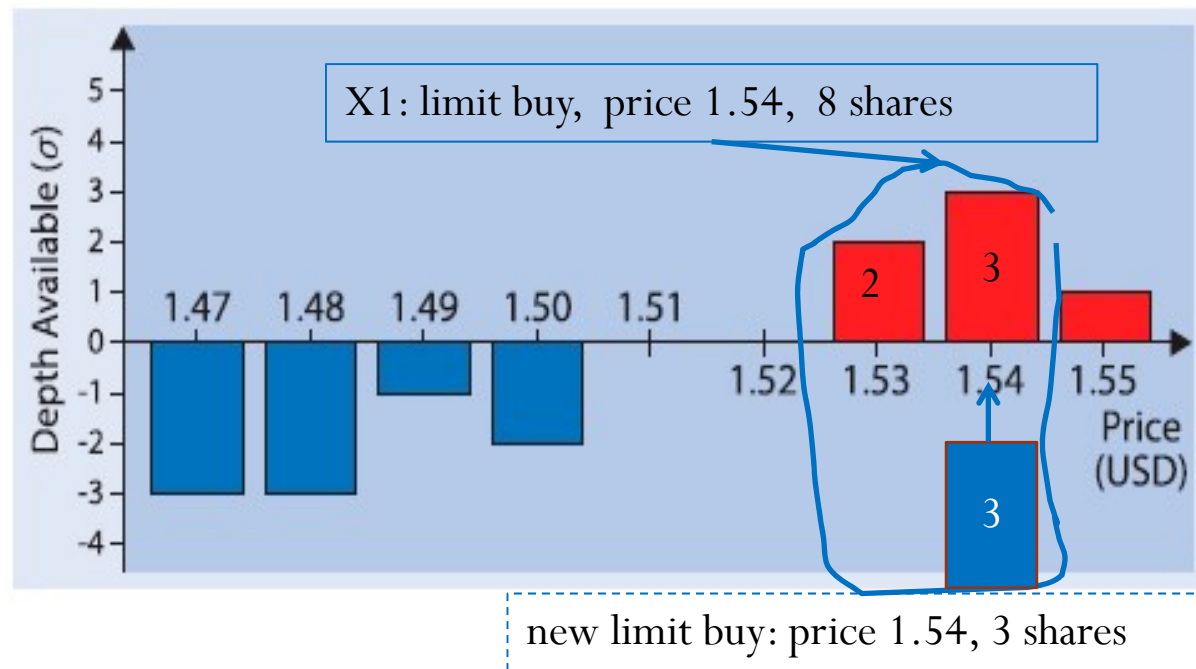
Most traders prefer to use marketable limit orders in Chinese security markets.

Think. Change. Do

Price-size pro-rata priority

- In some futures markets: such as Chicago Mercantile Exchange , EurExchange money market futures.

A market buy with **3** shares

$f1=X1/(X1+X2)=1/3$

$f2=X2/(X1+X2)=2/3$

2 shares submitted at 10: 02 am

4 shares submitted at 10: 00 am

Think. Change. Do

Transaction cost of market order

- Limit orders supply liquidity.
- Market orders consume liquidity, they pay the bid-ask spread to obtain the trade immediacy.
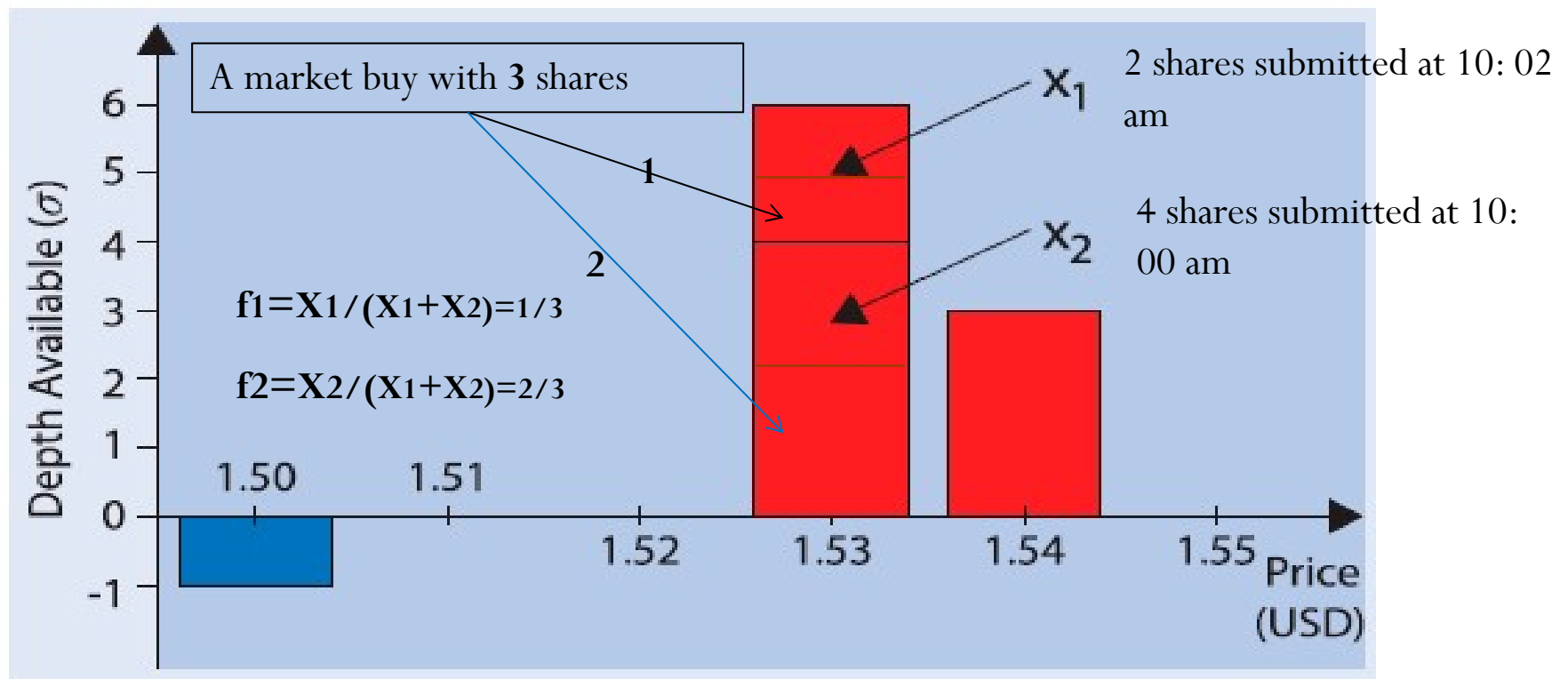- Effective bid-ask spread: two times of the distance of the trade price p_t to the mid-price p_t^M :

$$s_t^E = 2 \mid p_t - p_t^M \mid$$

- Relatively effective bid-ask spread:

$$s_t^{RE} = 2 \mid p_t - p_t^M \mid / p_t^M$$

- The effective bid-ask spread measures the transaction cost of market orders. A larger effective bid-ask spread indicates a larger transaction cost.

Order choice is a key issue in limit order markets

- Order types: market order, aggressive limit order, limit order at the quote, unaggressive limit order.

- Market order gets the trade immediacy but pays more transaction cost; limit order gains price improvement but faces unexecuted risk and has waiting cost.

- A key issue is that how traders determine their *order choice* according to the conditions of limit order book.
  - If you have private information, how do you maximize your trading profit?
  - If you need to trade (buy or sell) large amount shares, how do you minimize your transaction cost?

Think. Change. Do

连续竞价市场流动性

- 流动性（Liquidity)指标
  - 流动性就是市场的一切（O'Hara, 1995)
  - 价格冲击指数：即买卖一定金额股票所产生的反向价格变化的平均成本
  - 流动性指数：指使价格上涨 1%所需要的买入金额和使价格下跌1%所需要的卖出金额的均值
  - 买卖价差
  - 订单簿深度 (order book depth)

市场价格冲击指数

3. 价格冲击指数。 价格冲击指数衡量一定金额（或股票数量）的交易对市场价格的冲击程度，价格冲击指数越高，交易成本越高。设 $A_1, A_2, A_3 \cdots A_k$ 分别表示股票 i 在 t 时刻限价订单薄中的多个卖出价格，且 $A_1 < A_2 < A_3 < \cdots < A_k$，$S_1, S_2, S_3 \cdots S_k$ 分别表示 $A_1, A_2, A_3 \cdots A_k$ 所对应的数量；$B_1, B_2, B_3 \cdots B_{k'}$ 分别表示股票 i 在 t 时刻限价订单薄中的多个买入价格，其中 $B_1 > B_2 > B_3 > \cdots > B_{k'}$，$D_1, D_2, D_3 \cdots D_{k'}$ 分别表示 $B_1, B_2, B_3 \cdots B_{k'}$ 所对应的数量，则在 t 时刻购买 Q 金额股票 i 的价格冲击指数为：

$$\frac{Q / [\sum_{j=1}^{k-1} S_j + (Q - \sum_{j=1}^{k-1} S_j \cdot A_j) \Big/ A_k] - (A_1 + B_1)/2}{(A_1 + B_1)/2},$$

其中 $\sum_{j=1}^{k} S_j A_j > Q \geq \sum_{j=1}^{k-1} S_j A_j$ (若 K 不存在,则用空值表示)

价格冲击指数

- 卖出价格冲击指数

$$\frac{\left| Q \,/\,[\sum_{j=1}^{k-1}D_j + (Q - \sum_{j=1}^{k-1}D_j \cdot B_j)\Big/ B_k] - (A_1 + B_1)/2 \right|}{(A_1 + B_1)/2},$$

其中 $\sum_{j=1}^{k}D_jB_j > Q \geq \sum_{j=1}^{k-1}D_jB_j$ (若 K 不存在,则用空值表示)

- 即为所有样本日指数每十个卖出价指数的均值。

上海证券交易所的价格冲击指数

- 购买10万金额

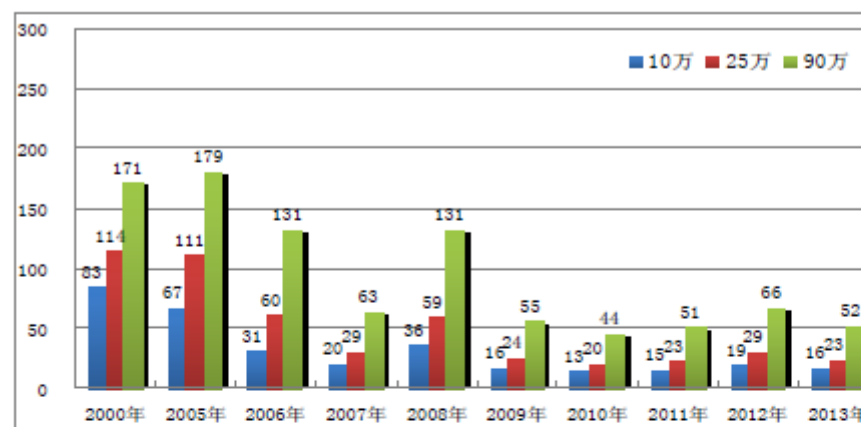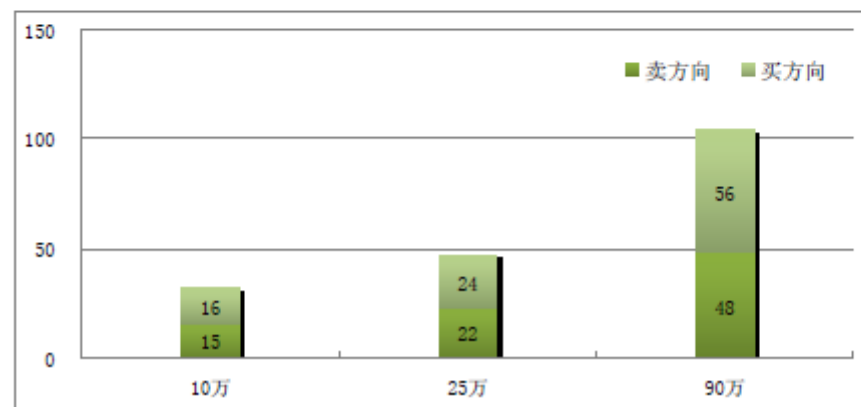图 1 相关年份所有股票价格冲击指数（2013）　　单位：基点

图 2 买方向与卖方向价格冲击指数（2013）　单位：基点
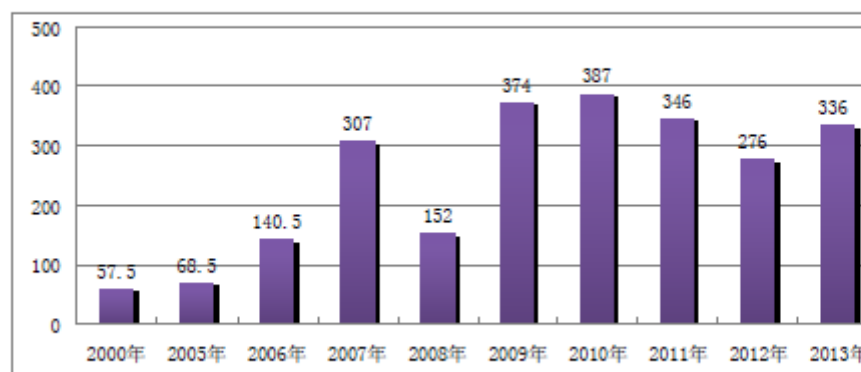
上交所的流动性指数

- 价格变动1%所需要的金额

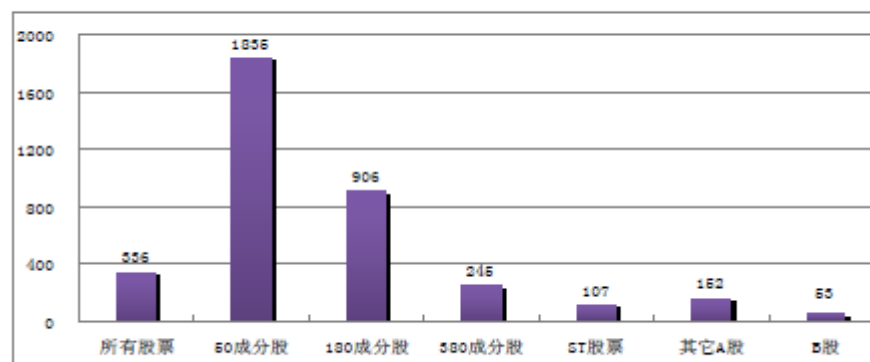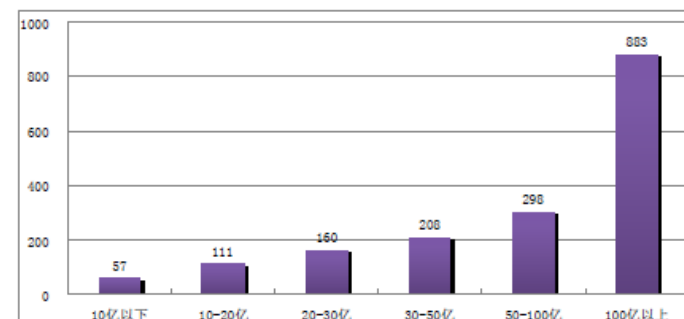图 8 相关年份流动性指数（2013）　　　单位：万元

图 10 按板块分组的流动性指数（2013）　　　单位：万元

图 11 按流通市值分组的流动性指数（2013）　　　单位：万元

流动性指数

4. 流动性指数。 流动性指数，也可称为价格影响成本指数，是指使价格发生一定程度变化所需要的交易金额，越大，市场流动性越好。设 $A_1, A_2, A_3 \cdots A_k$ 分别表示股票 i 在 t 时刻限价订单簿中的多个卖出价格，且 $A_1 < A_2 < A_3 < \cdots < A_k$， $S_1, S_2, S_3 \cdots S_k$ 分别表示 $A_1, A_2, A_3 \cdots A_k$ 所对应的数量；$B_1, B_2, B_3 \cdots B_{k'}$ 分别表示股票 i 在 t 时刻限价订单簿中的多个买入价格，其中 $B_1 > B_2 > B_3 > \cdots > B_{k'}$， $D_1, D_2, D_3 \cdots D_{k'}$ 分别表示 $B_1, B_2, B_3 \cdots B_{k'}$ 所对应的数量，

则在 t 时刻使价格上升△的流动性指数为：

$$\sum_{j=1}^{k-1} S_j A_j + A_k, \quad \text{其中} \quad k = \{\min(m) \mid \frac{|A_m - A_1|}{A_1} \geq \Delta\}$$

使价格下降△的流动性指数为：

$$\sum_{j=1}^{k-1} D_j B_j + B_k, \quad \text{其中} \quad k = \{\min(m) \mid \frac{|B_m - B_1|}{B_1} \geq \Delta\}$$

- 市场流动性指数是上升和下降指数的平均值

市场波动性

- 波动性指标
  - 方差/标准差（一般采用5分钟收益率的标准差）
  - 日内波动率

$$\frac{1}{n}\sum_{i=1}^{n}\frac{(H_i - L_i)}{H_i}$$

7. 超额波动率。 超额波动是衡量由噪音交易、交易机制等因素导致的临时波动性的近似指标。超额波动率等于日间波动率和日内波动率的差额。计算方法是：

设 H_{it} 为股票 i 在 t 日的最高价，L_{it} 为股票 i 在 t 日的最低价，P_{it} 为股票 i 在 t 日的收盘价，P_{it-1} 为股票 i 在 t-1 日的收盘价，则股票 i 在 t 日的超额波动率为：$|(H_{it}-L_{it})/P_{it-1} - |(P_{it}-P_{it-1})/P_{it-1}||$。
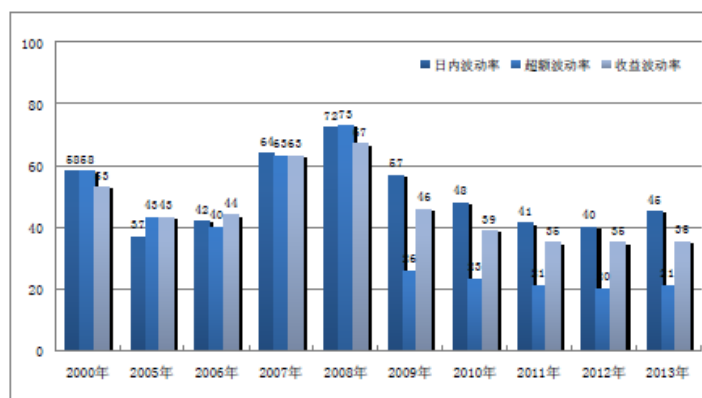
超额波动率越大，说明临时波动性越大。

图 43 相关年份波动率（2013）　　　　　　单位：基点
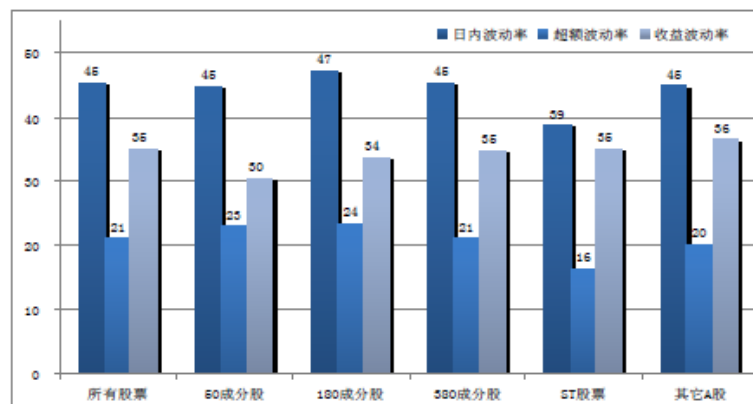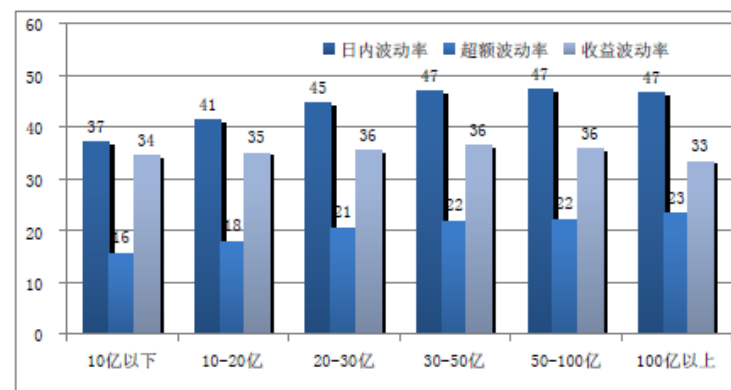

图 44 按板块分组的波动率（2013）　　　　单位：基点

图 45 按流通市值分组的波动率（2013）　　　单位：基点

第二部分：理论分析基础与实践

请自行学习有关文献和上交所、深交所的市场质量报告

资产价格短期形成机制

私有信息　市场信息　私有价值

风险偏好　市场约束（买空卖空、持仓限额等）　资金和头寸约束

反馈

订单簿状态

市场价格

信念 → 目标函数最大化 → 决定 → 买卖方向

订单

影响

生成订单

市价订单 → 订单数额

限价订单 → 订单价格

决定下单积极性

订单类型
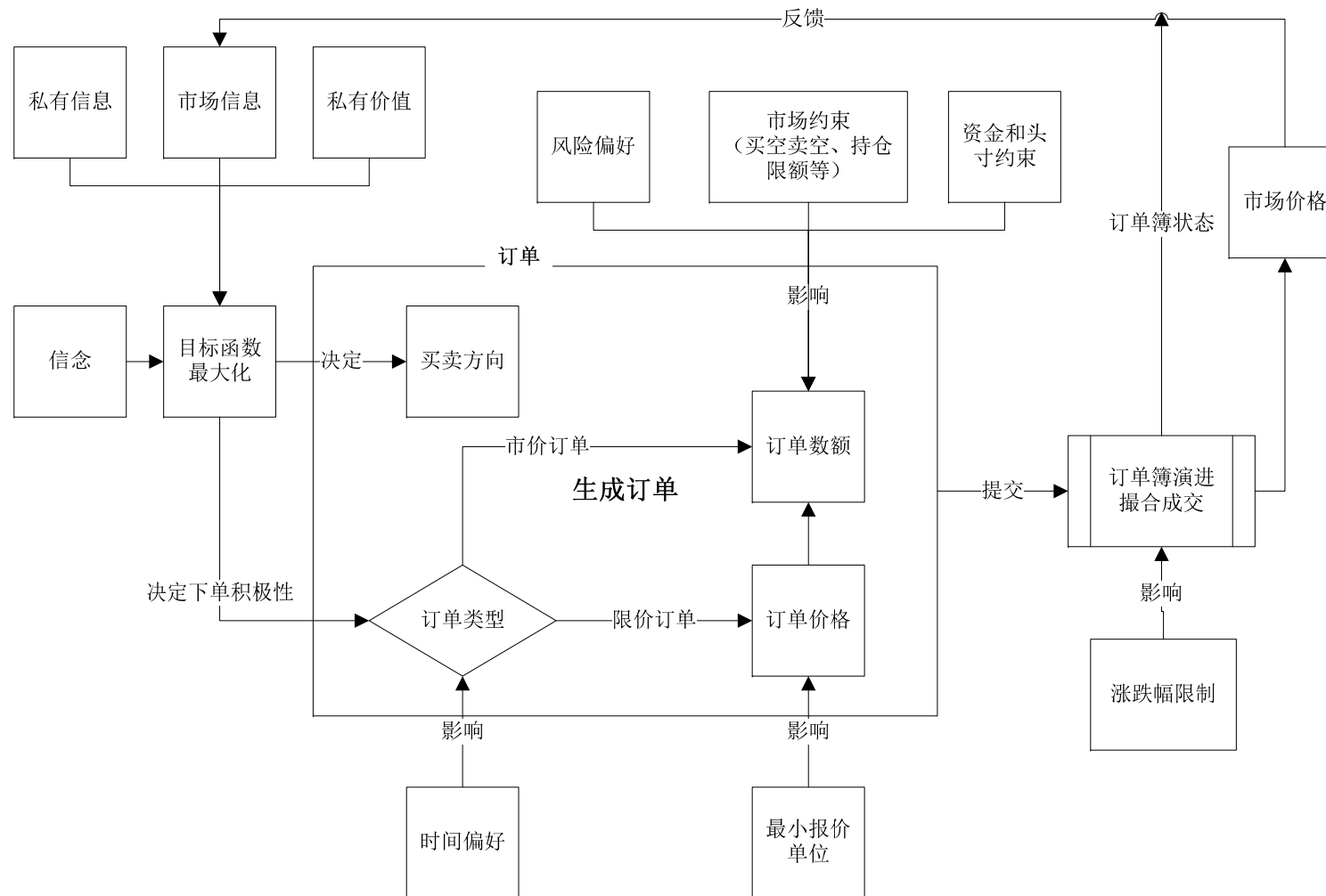
提交 → 订单簿演进撮合成交

影响

影响　影响

时间偏好　最小报价单位

涨跌幅限制

图1-1　资产短期价格形成逻辑过程

Information, Trading & Learning in Limit Order Markets

- **Goettler R. L. ,Parlour, C. A.andRajan U. Informed traders and limit order markets. *Journal of Financial Economics*. 2009.93 (1). 67–87.**

- **Chiarella C., He, X. and Wei, L. Learning, information processing and order submission in limit order Markets，*Journal of Economic Dynamics and Control*. 2015. 61，245-268**

- Gould, M., Porter, M., Williams, S., Fenn, D. and Howison, S. D. Limit order books. *Quantitative Finance.* 2013.13(11), 1709-1742.

- Rosu, I. Order Choice and Information in Limit Order Markets. in*Market Microstructure: Confronting Many Viewpoints*, Eds. Abergel, F. and Bouchaud, J. and Foucault, T. and Lehalle, C.A. and Rosenbaum, M., Wiley. 2012. 41–60.

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