Financial Markets
Lecture Notes Week 3

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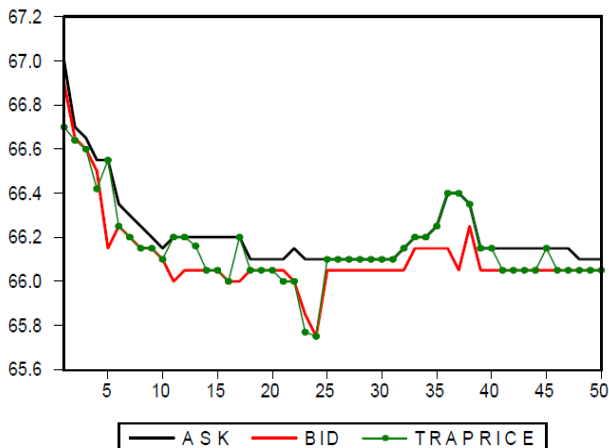# This Week: Order Flow and Price Dynamics

Why and how do orders move prices?

Why are markets not perfectly liquid?

What risks and costs do market makers face?

What is inventory risk and how does it affect prices?

Intraday Price Fluctuations and Order Flow

- price falls with sell orders and rises with buy orders
- considerable movement, despite absence of news
- returns (price changes) are negatively correlated (-0.45)

Why do orders move prices?

- Orders move prices because markets are not perfectly liquid

- But then why are markets not perfectly liquid?

- Why do liquidity providers (e.g., market makers) not ensure that markets are perfectly liquid?
  - What are costs/limits to liquidity provision?
  - What risks do market makers face?

Market Makers

- Market makers (aka dealers, liquidity providers):
    - trading firms that provide liquidity
    - quote prices at which they are willing to buy and sell
    - provide **immediacy:** investors can trade **immediately**

- Pure dealer markets (e.g., corporate bonds, FX):
    - mostly banks

- Exchanges / limit order markets:
    - banks
    - non-banks, e.g.:
        - Optiver: www.optiver.com
        - All Options: www.alloptions.nl
        - IMC: www.imc.nl
        - Flow Traders: www.flowtraders.com

What do MMs do? The Case of Flow Traders

"Flow Traders is a leading global technology-enabled liquidity provider specialised in Exchange Traded Products. We are an independent principal trading firm. Our trading desks in Europe, the US and Asia enable us to provide liquidity on all major exchanges, 24 hours a day.
. . . We are a principal trading firm and do not have clients or offer investment services. We trade for our own account only."

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www.flowtraders.com/about/video-what-we-do
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How do MMs earn money?

- ▶ MMs make money in various ways:
  - ▶ bid-ask spreads
  - ▶ proprietary trading profits
  - ▶ exchanges may pay them
    - ▶ flip side: MMs may have to **commit** to provide minimum levels of liquidity in terms of minimum volume and maximum spread
    - ▶ such MMs are referred to as "designated MMs" or "sponsors"

- ▶ Useful background references (no exam material!):
  - ▶ NYSE: click
  - ▶ Euronext: click
  - ▶ BIS 2014 survey: click

What risks/costs do MMs face?

- MMs face three major types of risks:
    1. **inventory risk** - risk due to price fluctuations
    2. **adverse selection risk** - risk of trading against better informed parties
    3. **picking-off risk** - risk of trading against "faster" parties
        - faster access to new information
        - quicker reaction to new information

- Other costs include
    - order processing costs
    - infrastructure, technology, employees

⇒ MMs must generate revenue to compensate for
    1. adverse selection costs & picking-off risk (next week)
    2. the costs of bearing inventory risk (this week)
    3. other costs, including order processing costs (this week)

Frictionless Benchmark

- To start with, consider the following benchmark setting:
    1. dealers are risk-neutral and perfectly competitive
    2. no adverse selection/picking-off concerns
    3. no order processing costs

- Let μ_t denote stock's fundamental value at time t

- How does a dealer set his bid and ask quotes?
    - profit from executing buy order (dealer sells):

    $$a_t - \mu_t = 0 \Rightarrow a_t = \mu_t$$

    - profit from executing sell order (dealer buys)

    $$\mu_t - b_t = 0 \Rightarrow b_t = \mu_t$$

- Conclusion: no spread, transaction prices = fundamentals

Order Processing Costs

- Order processing cost $c > 0$ per share traded:
  - profit buy order (dealer sells):

$$a_t - \mu_t - c = 0 \Rightarrow a_t = \mu_t + c$$

  - profit sell order (dealer buys):

$$\mu_t - b_t - c = 0 \Rightarrow b_t = \mu_t - c$$

- Conclusion:
  - positive (but constant) spread: $a_t - b_t = 2c > 0$
  - transaction prices $\neq$ fundamentals
  - deviations from fundamentals are **transient**: while the type of order (whether we have a buy or sell order) at time t matters for the price at time t, it does not matter for future prices
    - not realistic: orders often have lasting price impact!

Inventory Risk

- Next, suppose that dealers care about inventory risk because, e.g.:
  - limited capital/funding liquidity
  - financial distress costs
  - regulatory capital requirements (banks)
  - imperfect and/or costly hedging

- If dealers are risk-averse, they must be compensated for the corresponding inventory holding costs $\Rightarrow$ bid-ask spread

- Simple model to analyze inventory risk, based on Stoll (1978)

Inventory Risk: Simple Model

- Stock with uncertain value v, $E[v] = \mu$, $\text{Var}[v] = \sigma^2$

- Representative **risk-averse** dealer
  - inventory: z shares, M cash
  - dealer portfolio value when selling y shares:

$$w = M + py + (z - y)v$$

  - dealer preferences:

$$U = E[w] - \underbrace{\rho/2 \times \text{Var}[w]}_{\text{inventory cost}}$$

  where ρ: coefficient of risk aversion

- For simplicity: no order processing costs

Inverse Supply Function

- In a competitive market, what is the price at which the dealer is willing to supply y shares ($y < 0$: dealer buys)?

- Dealer's problem: choose y as to

$$\max_{y} \ U = \underbrace{M + py + (z - y)\mu}_{=E[w]} - \overbrace{\rho/2 \times \underbrace{(z - y)^2\sigma^2}_{=\mathrm{Var}[w]}}^{\text{inventory cost}}$$
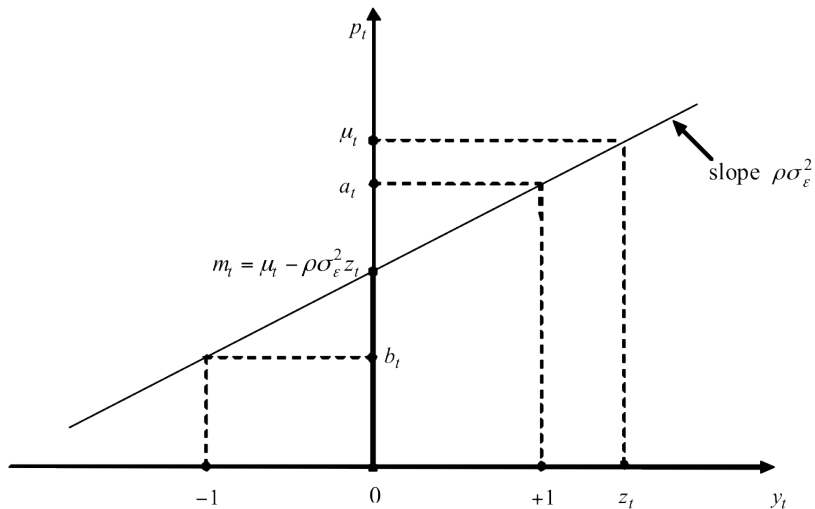
- First order condition w.r.t. y:

$$p - \mu + \rho(z - y)\sigma^2 = 0$$

Solving for p yields the **inverse supply function**:

$$p(y) = \underbrace{\mu - \rho\sigma^2 z}_{\text{intercept}} + \underbrace{\rho\sigma^2}_{\text{slope}} \cdot y$$

Inverse Supply Function

Ask, Bid and Spread

$$p(y) = \underbrace{\mu - \rho\sigma^2 z}_{\text{mid quote } m} + \rho\sigma^2 y$$

▶ To obtain the bid-ask spread, consider unit-size transactions:

$$
\begin{aligned}
a &= p(1) = m + \rho\sigma^2 \\
b &= p(-1) = m - \rho\sigma^2 \\
S &= a - b = p(1) - p(-1) = 2\rho\sigma^2
\end{aligned}
$$

▶ Weighted-average bid-ask spread (y: order size):

$$S(y) = p(y) - p(-y) = 2\rho\sigma^2 \times y$$

Price Dynamics

- Suppose that in trading round *t* the dealer executes a sell order, i.e., he buys y_t shares. Thus, inventory increases to

$$z_{t+1} = z_t + y_t > z_t.$$

- Ask and bid prices in the next trading round:

$$
\begin{aligned}
a_{t+1} &= \underbrace{\mu - \rho\sigma^2 z_{t+1}}_{\text{mid quote } m_{t+1} \, < \, m_t} + \rho\sigma^2 < a_t \\
b_{t+1} &= \underbrace{\mu - \rho\sigma^2 z_{t+1}}_{\text{mid quote } m_{t+1} \, < \, m_t} - \rho\sigma^2 < b_t
\end{aligned}
$$

Thus, following a sell order (dealer inventory $\uparrow$), the dealer revises both ask and bid prices **downwards**:

- ask $\downarrow$ (less compensation required for executing buy orders)
- bid $\downarrow$ (more compensation required for executing sell orders)

Price Dynamics

- How would we expect the dealer's price revisions to affect subsequent trades, assuming fundamentals stay the same?
  - ask ↓ should encourage buy orders
  - bid ↓ should discourage sell orders

- Thus, the next order is more likely to be a buy order
  - following the buy order, dealer's inventory declines
  - this induces the dealer to revise prices **upwards**

- Summing up:
  - **short-term** price impact of a sell order is negative
    - sell order executed at bid (or lower)
    - also, dealer revises prices downwards
  - in the **medium-term**, we expect this effect to partially reverse: prices ↓ → encourages buy orders → prices ↑
  - in the **long-term**, price impact eventually dissipates

Price Dynamics

- Similarly, the short-term price impact of a buy order is **positive:** prices move in the direction of the trade

- In the medium-term, this effect **partially reverses**:
    - prices $\uparrow \rightarrow$ sell orders/volume $\uparrow$
    - dealer inventory $\uparrow \rightarrow$ prices $\downarrow$

- In the long-term, price impact eventually **dissipates**

Price Dynamics (buy order at time *t*)
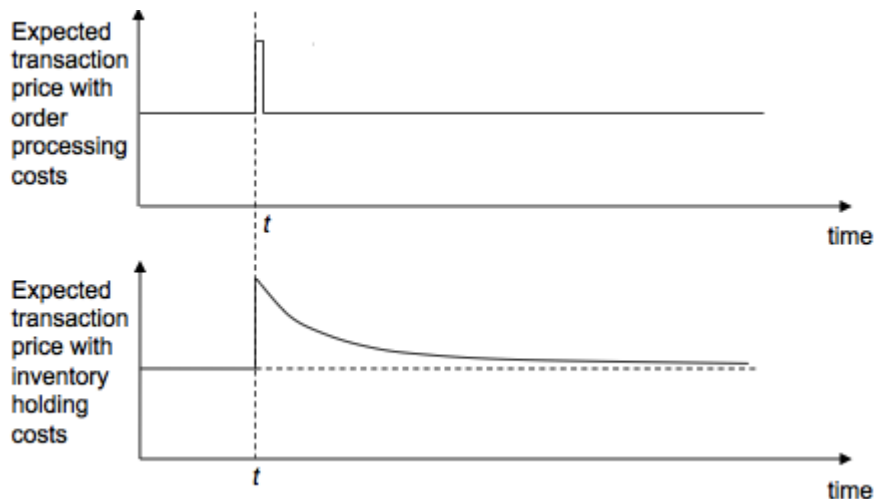
Key Concepts

- Market makers: business model, risks & costs

- Price dynamics in "perfect" markets
  - orders have no impact on prices

- Price dynamics with order processing costs
  - orders affect prices only in the short-term

- Price dynamics with inventory costs
  - orders affect prices in the short- and medium-term