University of Zurich[UZH]

# Agent-based Financial Economics
# Lesson 7: Market Making

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"What I cannot create, I do not understand."

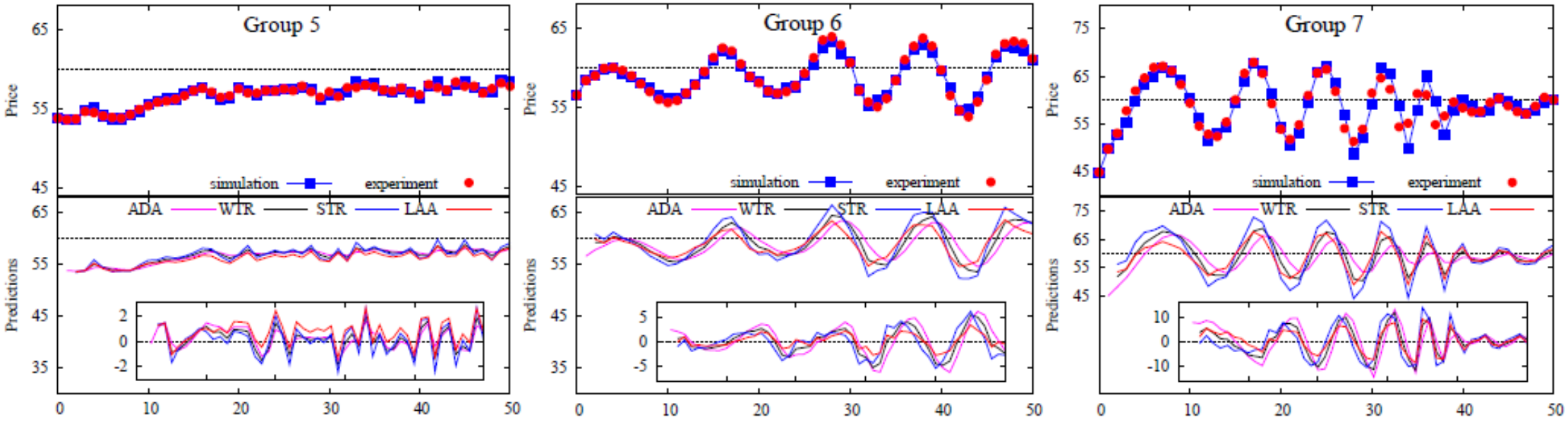
- Richard Feynman

# Today

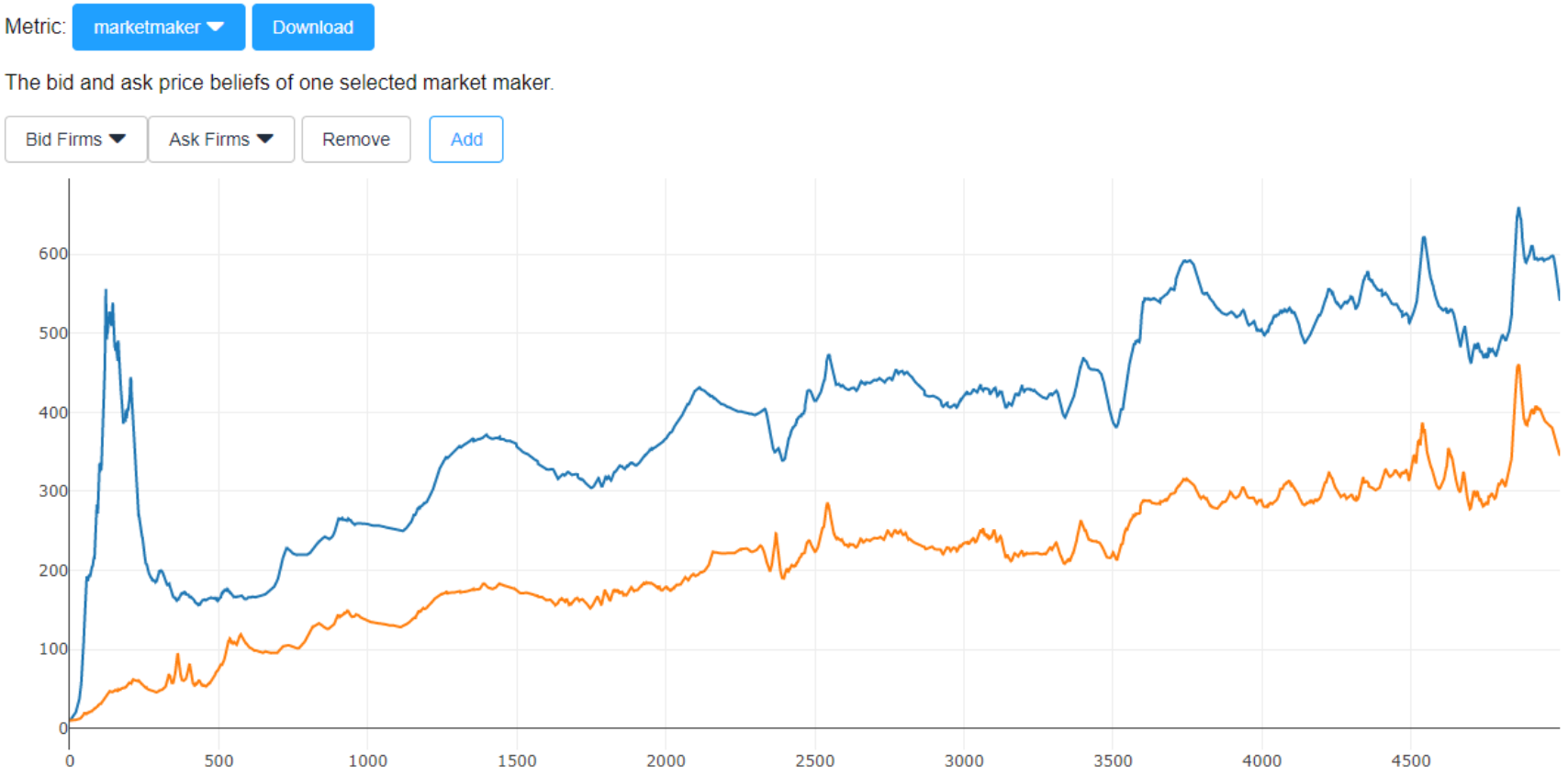
- Cars Hommes's Model
- The market maker's problem
- Exercise 5: Flow

# Cars Hommes's Experiments

- Professor at University of Amsterdam
- Runs agent-based models with real humans as agents
- Separate slide deck for details



# Market Maker




Early attempt from the past.
Not trivial to do well.

# Market Maker - Literature

Garman, M.B., 1976. Market microstructure. *Journal of financial Economics*, *3*(3), pp.257-275.

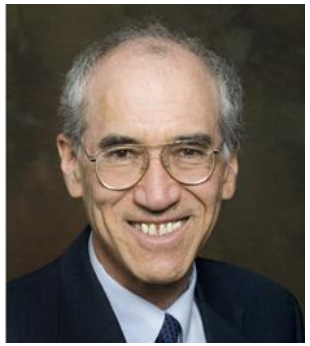
Assumptions:

- Arrivals of buy and sell orders to the market are Poisson distributed in time, with stationary rate functions.
- All exchanges are made through a single central ‘market-maker’, who possesses a monopoly on all trading. No direct exchanges between buyers and sellers are permitted.
- The market-maker is a price-setter, in the sense that he may control the price-probability functions for aggregate demand and supply (for example, by refusing all orders that do not meet his price). Specifically, we assume that he sets a price at which he will fill buy orders and correspondingly a price for sell orders, yielding the resultant order rates. The asset that is bought and sold shall hereafter be termed ‘stock’, the numiraire asset ‘cash’.
- At time 0, the central market-maker has cash and stock inventories of 1 and 0. Subsequent negative inventories imply the market-maker’s ‘failure’, i.e., inability to continue in his role.
- The market-maker seeks to maximize expected profit per unit time, subject to the avoidance of certain ultimate failure.
- There are no transactions costs for the market-maker.

Findings:

- The exact solution of eqs. (6) and (7) for the ultimate failure probabilities is quite complicated, due to the fact that (a) there are two interrelated state variable equations, and (b) eq. (6) alone requires the solution of a polynomial of order pB+ps [cf. Feller (1968, p. 363ff.)]. As an alternative, we may approximate the ultimate failure probabilities as a function of the market-maker’s price strategy as follows.
- By being willing to take profits in the form of stock inventory increases, the market-maker can artificially inflate prices by maintaining the inequality pe > ps > p*; in no case, however, will the market-maker be able to set both prices below p* without ultimate stock failure.
- it clear that the specialists must pursue a policy of relating their prices to their inventories in order to avoid failure.

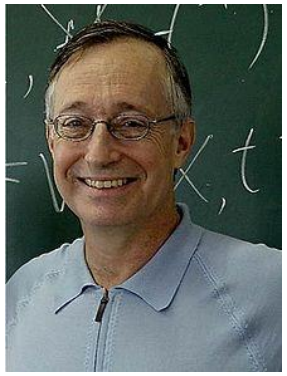
# Market Maker - Literature



Amihud, Y. and Mendelson, H., 1980. Dealership market: Market-making with inventory. *Journal of Financial Economics*, *8*(1), pp.31-53.

“It is proved that the prices are monotone decreasing functions of the stock at hand, and that the resulting spread is always positive.”

# Market Maker - Literature



Paul Milgrom

Lawrence Glosten

Glosten, L.R. and Milgrom, P.R., 1985. Bid, ask and transaction prices in a specialist market with heterogeneously informed traders. *Journal of financial economics*, *14*(1), pp.71-100.

"The presence of traders with superior information leads to a positive bid-ask spread even when the specialist is risk-neutral and makes zero expected profits."

"this paper is based on the idea that a bid-ask spread can be a purely informational phenomenon, occurring even when all the specialist's fixed and variable transactions costs (including his time, inventory costs, etc.) are zero and when competition forces the specialist's profit to zero. "

"In this paper, we use a formal model to show how the spread arises from **adverse selection**".

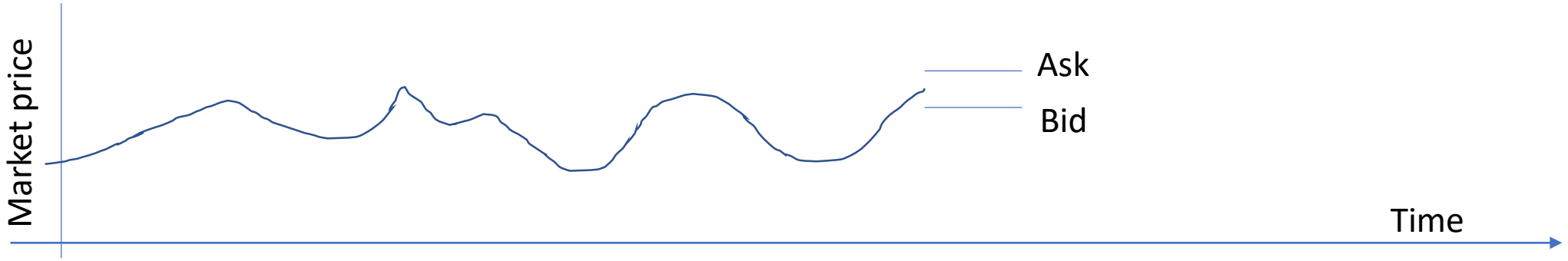
"The welfare loss we have described is at least partly due to the requirement that the specialist must break even on each trade." (Bancor trader does not have that requirement.)

Adverse selection: market maker can never know whether an incoming trade comes from a liquidity trader (who buys or sells to reallocate his assets) or from an information trader with new insights about the true value of the stock. Whenever the market maker trades with an information trader who knows the true value of the stock, the market maker makes a small loss.

→ The spread is needed to recover the money lost to information traders.
→ If there are too many information traders, spreads go through the roof and the market breaks down.

# Market Maker Problem

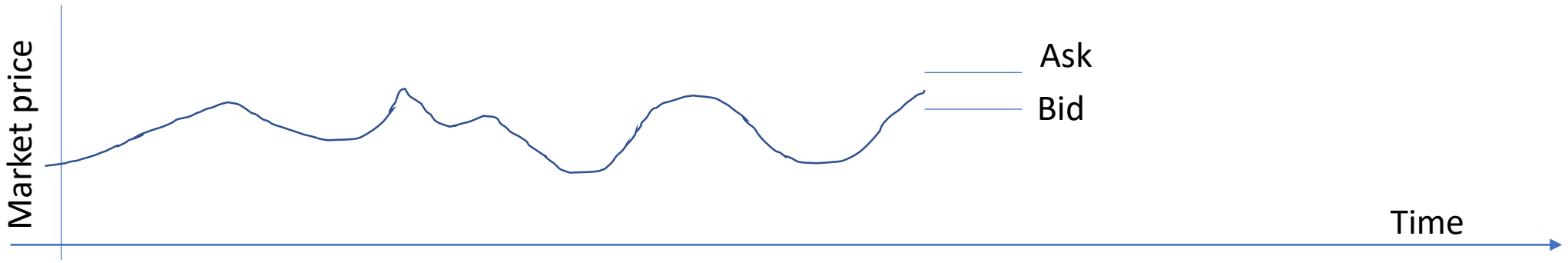
- The market makers are the only agents that are allowed to place limit orders
- Everyone else can only do market orders, and must therefore always trade with a market maker
- Market makers are risk-neutral
- Market makers maximize profits and compete with each other (Bertrand competition)
- Market makers should avoid running out of money or out of inventory. If they run out of both, they are bankrupt.
- There is an exogenous, stochastic inflow of money, i.e. 1000 USD on a particular day
- There is an exogenous, stochastic outflow of shares, i.e. 10 shares on a particular day
- The market maker has no access to external information about the true value of the stock



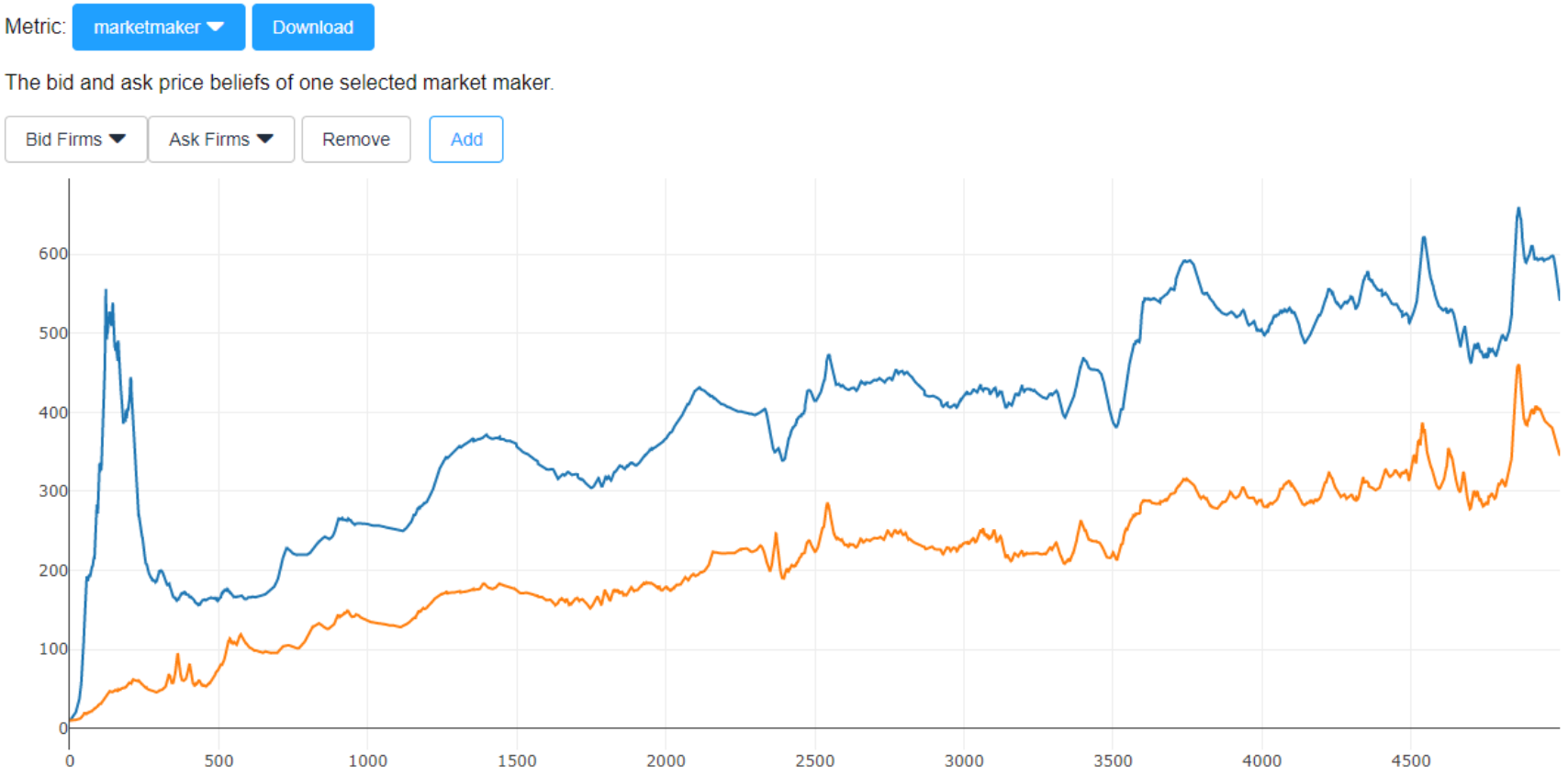
# Market Maker Problem

Order of events:

1. Market makers place their limit orders in random order
2. Market maker orders are matched against each other
3. Other market participants place their market orders



# Market Maker

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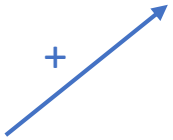
# Market Making – System Dynamics

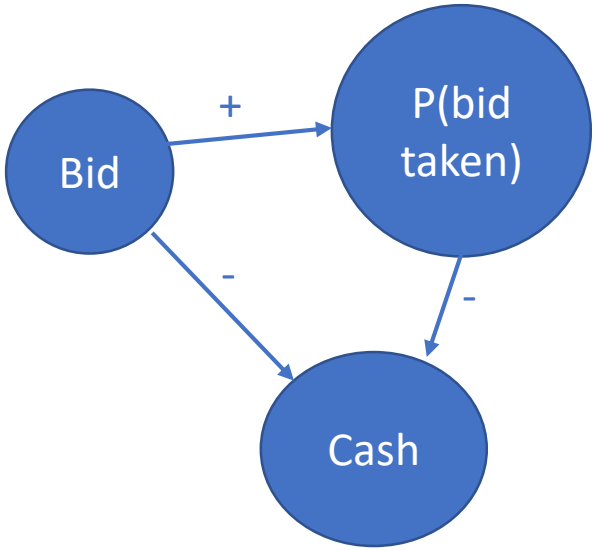
Circles are variables




Arrows indicate a positive (+) or negative (-) relationship.

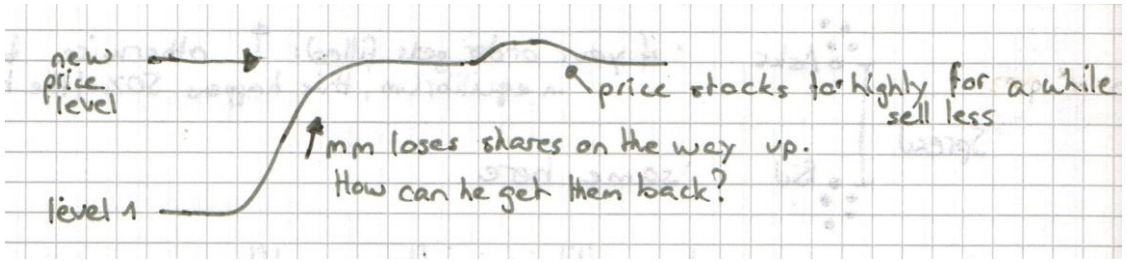
Ideas for variables:

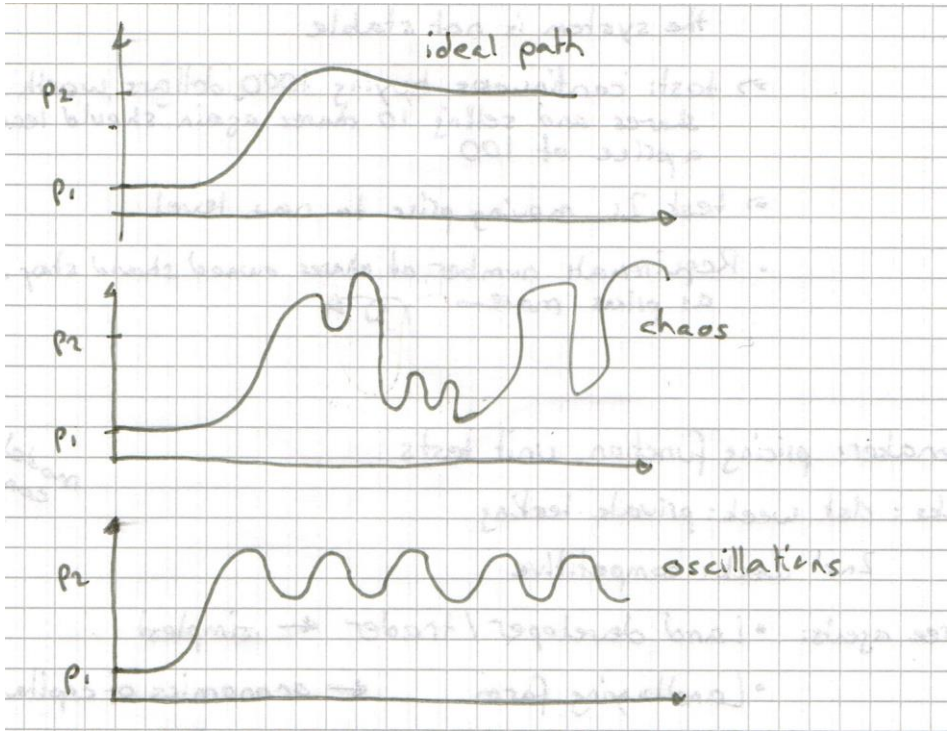
- Bid price
- Ask price
- Spread
- Equilibrium price
- Inventory: stocks
- Inventory: cash
- Inflow
- Outflow
- Profit
- …

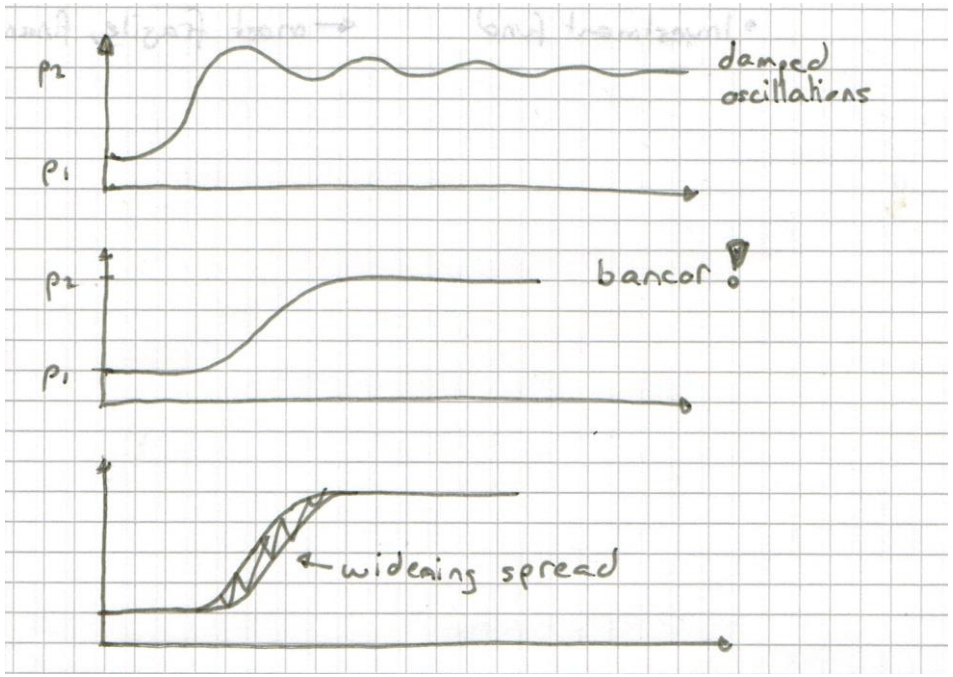



Example relation: a higher bid leaves the market maker with less cash. Also, it increases the probability of the bid being taken by a market participant, thereby further reducing cash.

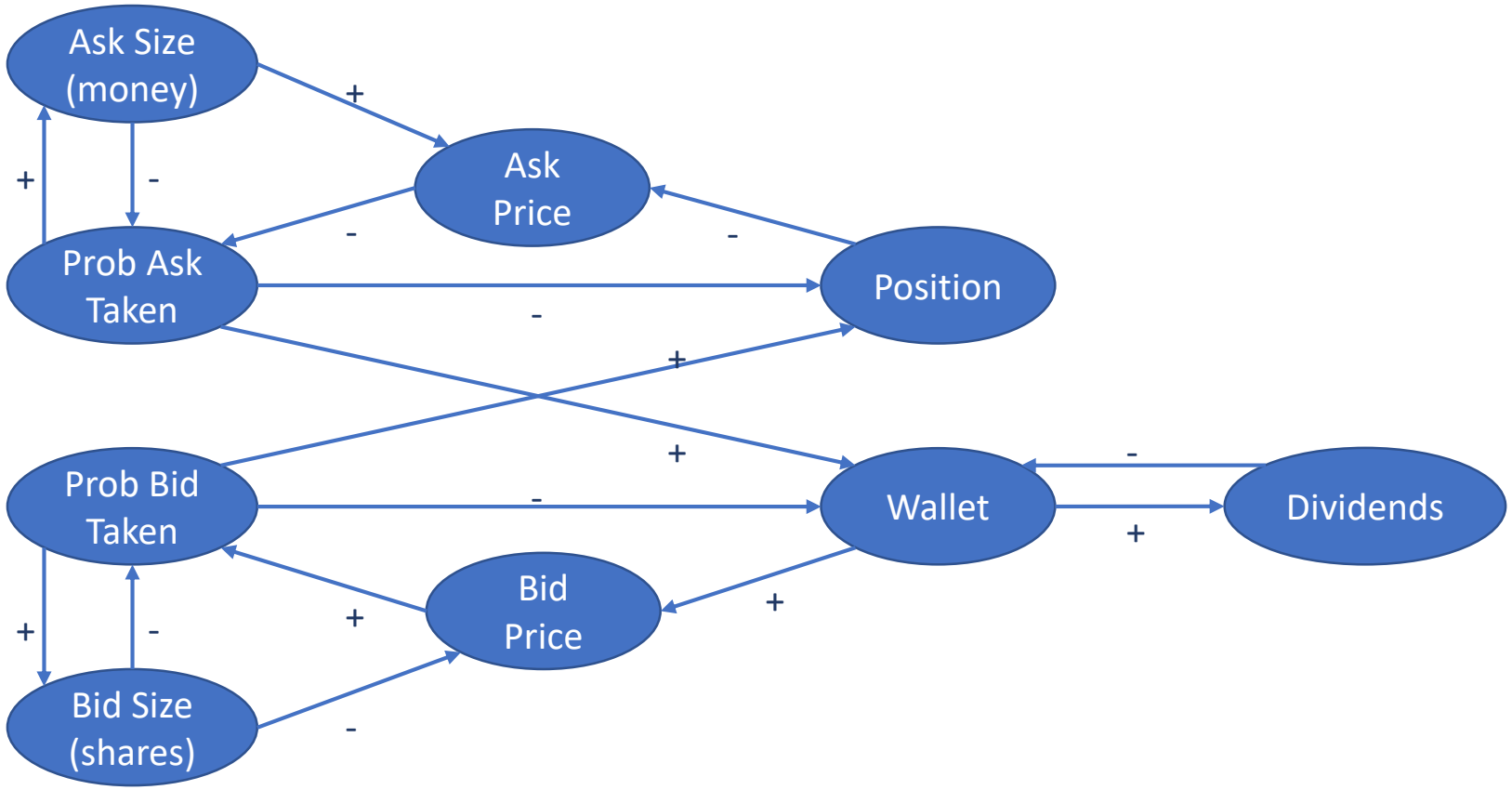
# Market Making



# Market Maker Dynamics



# Exercise 5 - Flow

See task…