University of Zurich[UZH]

Agent-based Financial Economics
Lesson 8: Testing

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

- Richard Feynman

Today

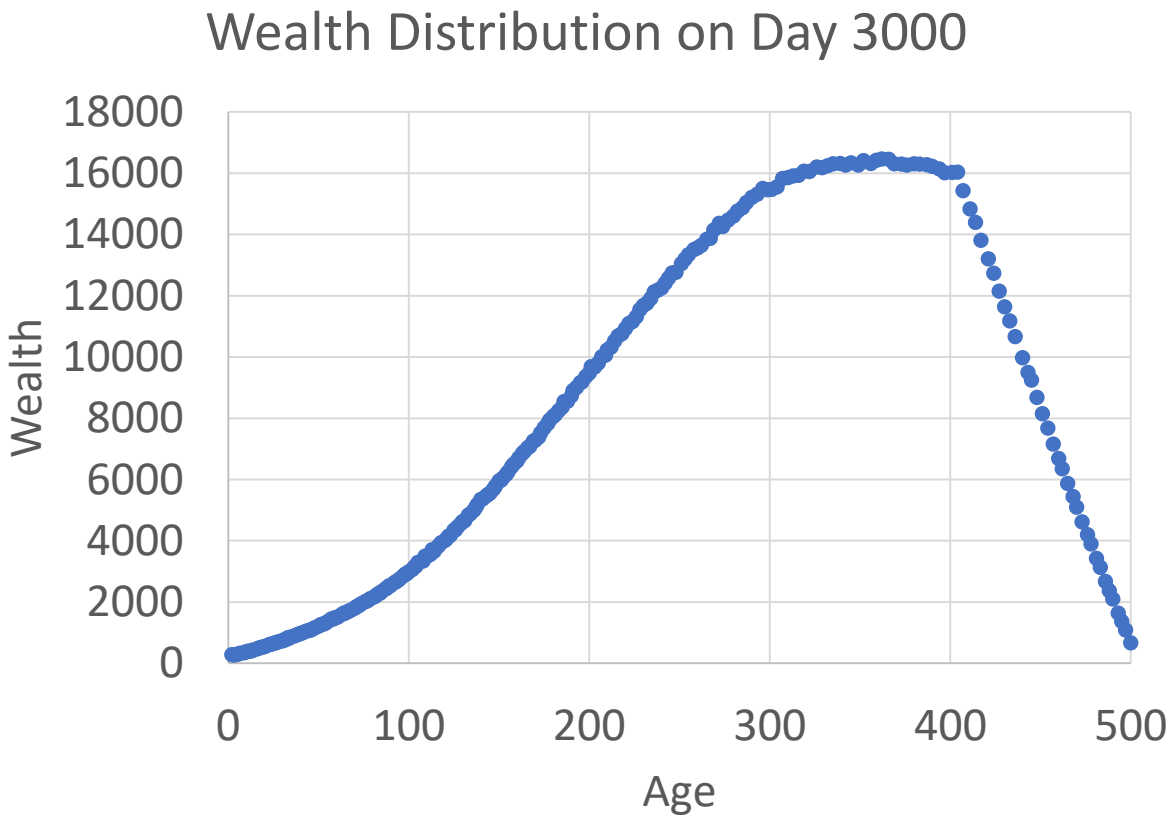
- Discussion of exercise 7
- Cars Hommes's Model
- Course outlook
- The market maker's problem
- Exercise 8: System Dynamics of the Market Maker class

Exercise 7 – Equality

Gini does not behave like an average: adding new distinct groups with distinct wealth level increases Gini.

→Global Gini can decline even when Gini in every country in the world raises.

→Looking “more closely” at homogeneous groups leads to lower inequality for each individual group than for the whole.

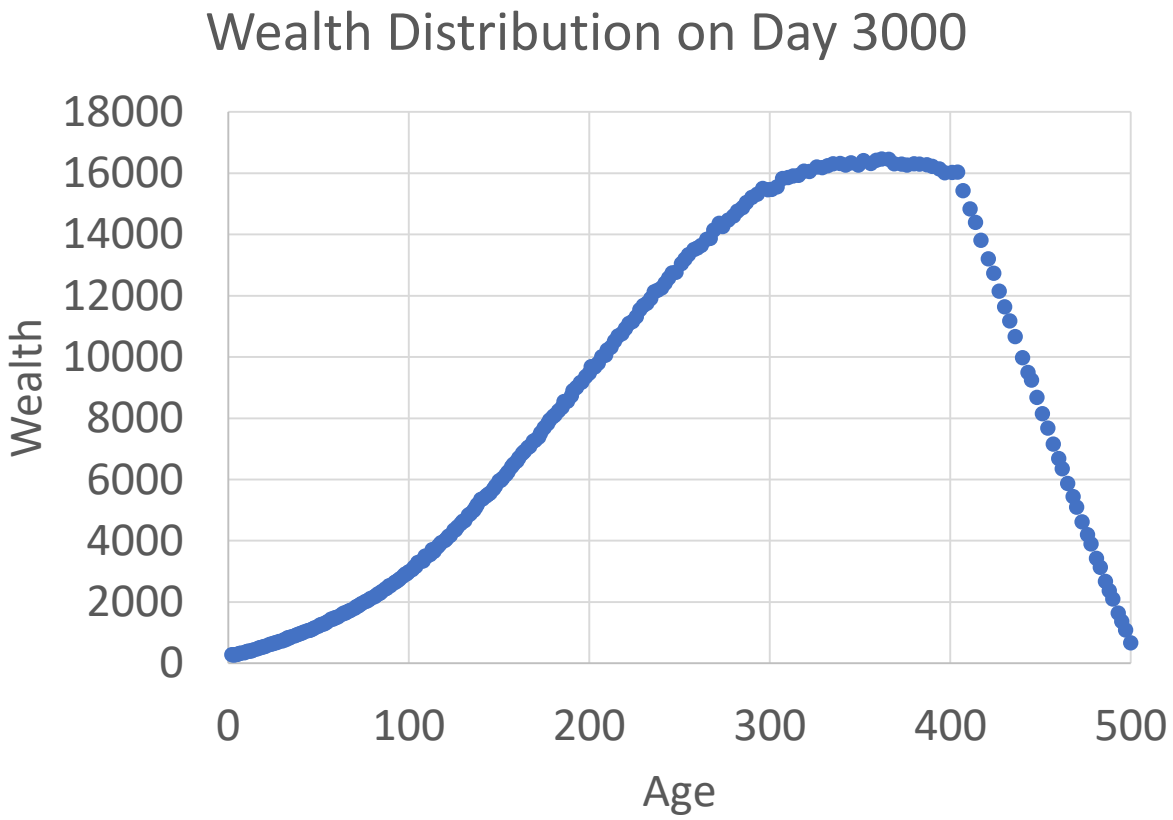


Exercise 7 – Equality – Day 3000

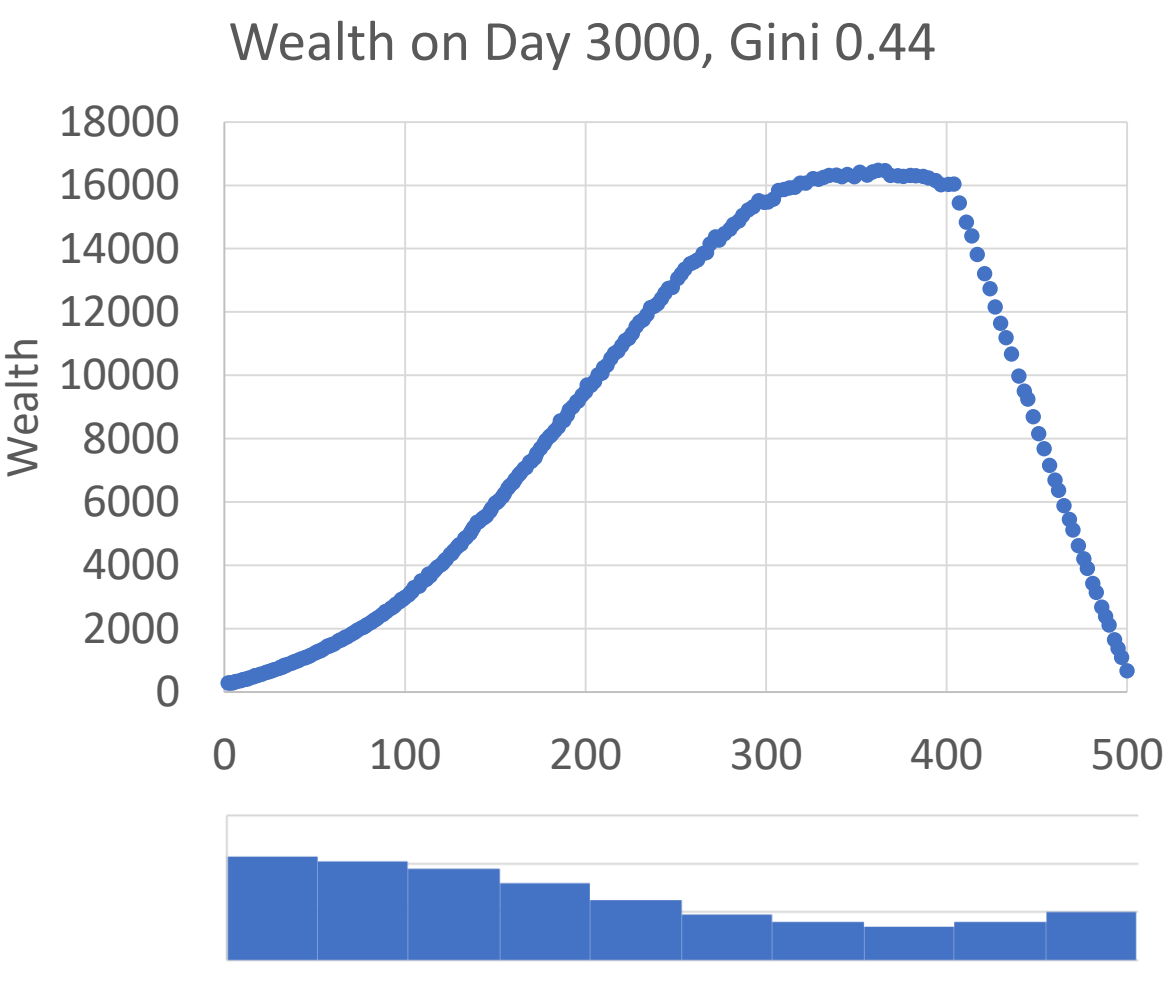
As discussed in the lecture: a linear distribution of wealth that starts at zero leads to a Gini of 0.33, regardless of how steep or long the “line” is.

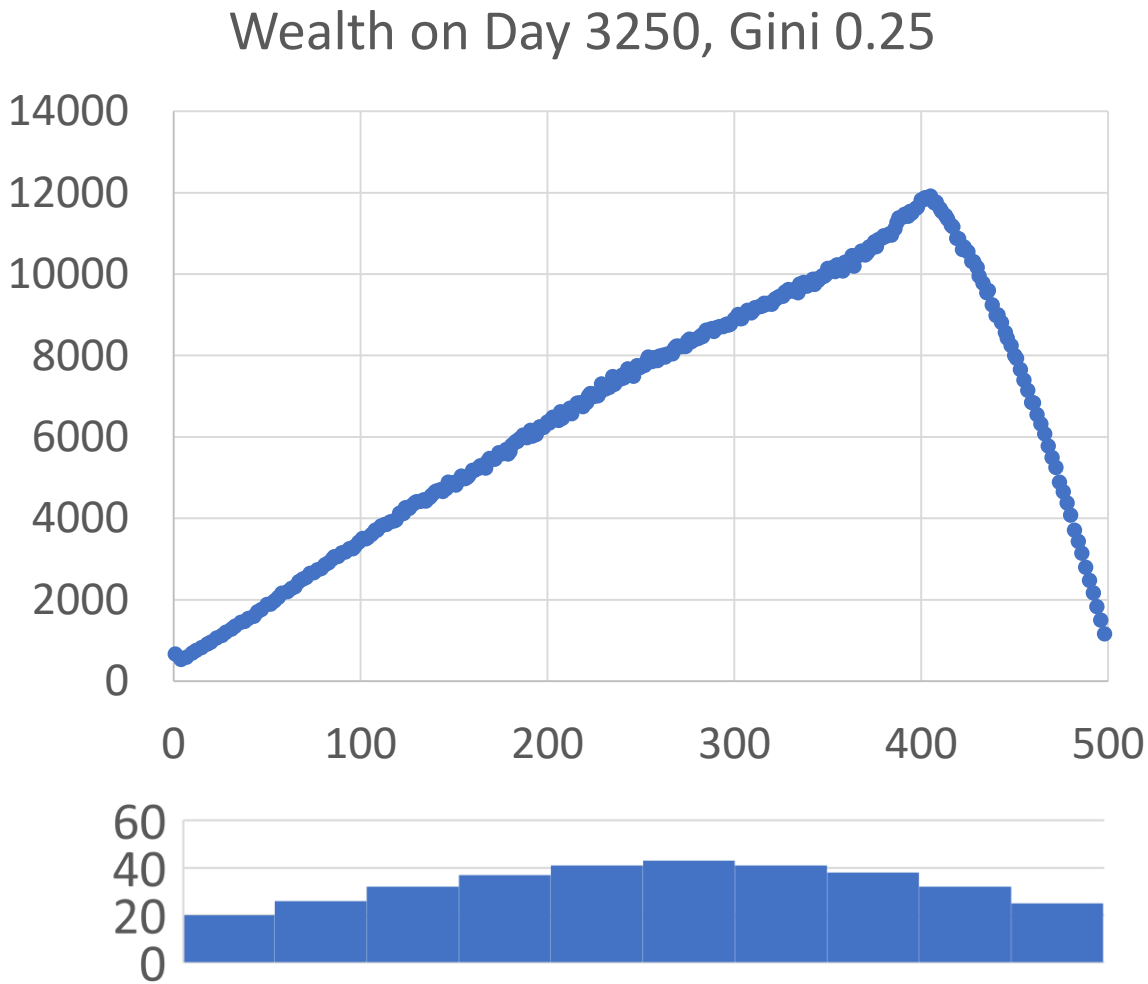
→The youngest and the oldest cohort follow an approximate line starting at zero. Thus, their Gini is about 0.33. This can go lower when the line is “heavier” in one end.

→The other cohorts have a lower Gini as their wealth does not start at zero for the poorest agents.

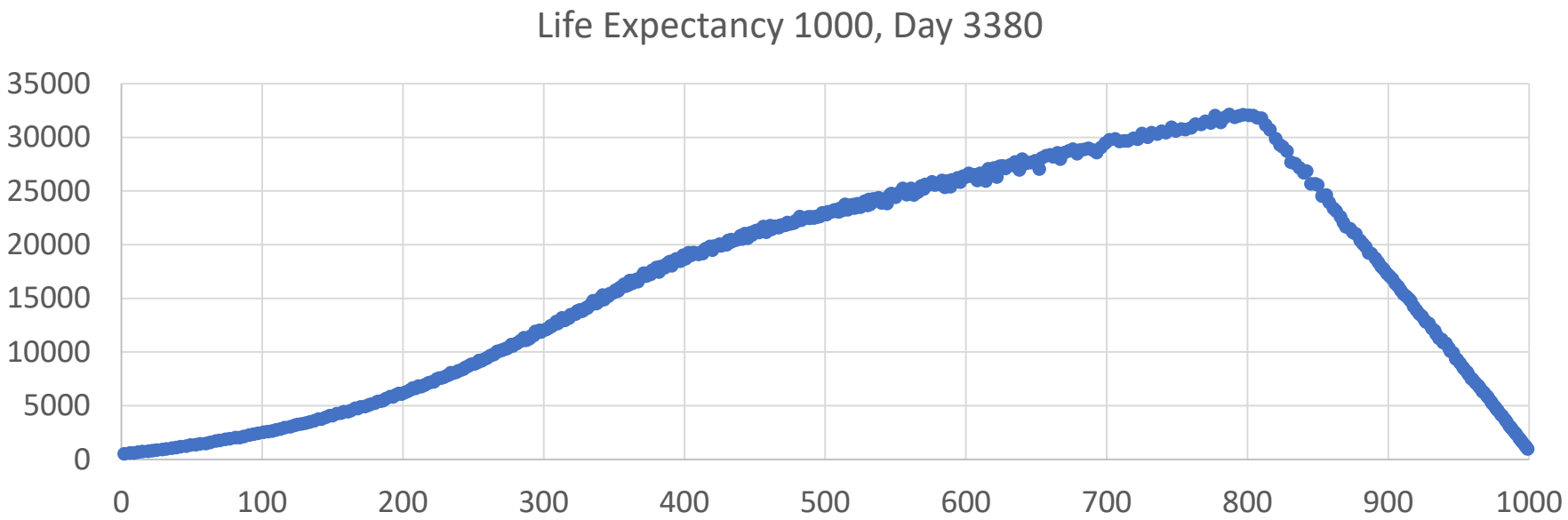


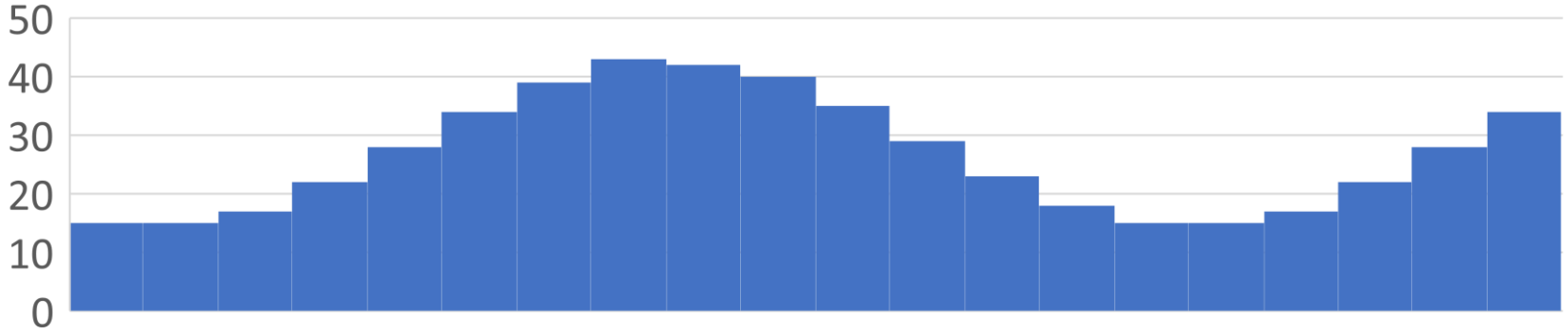
Exercise 7 – Equality – Comparison





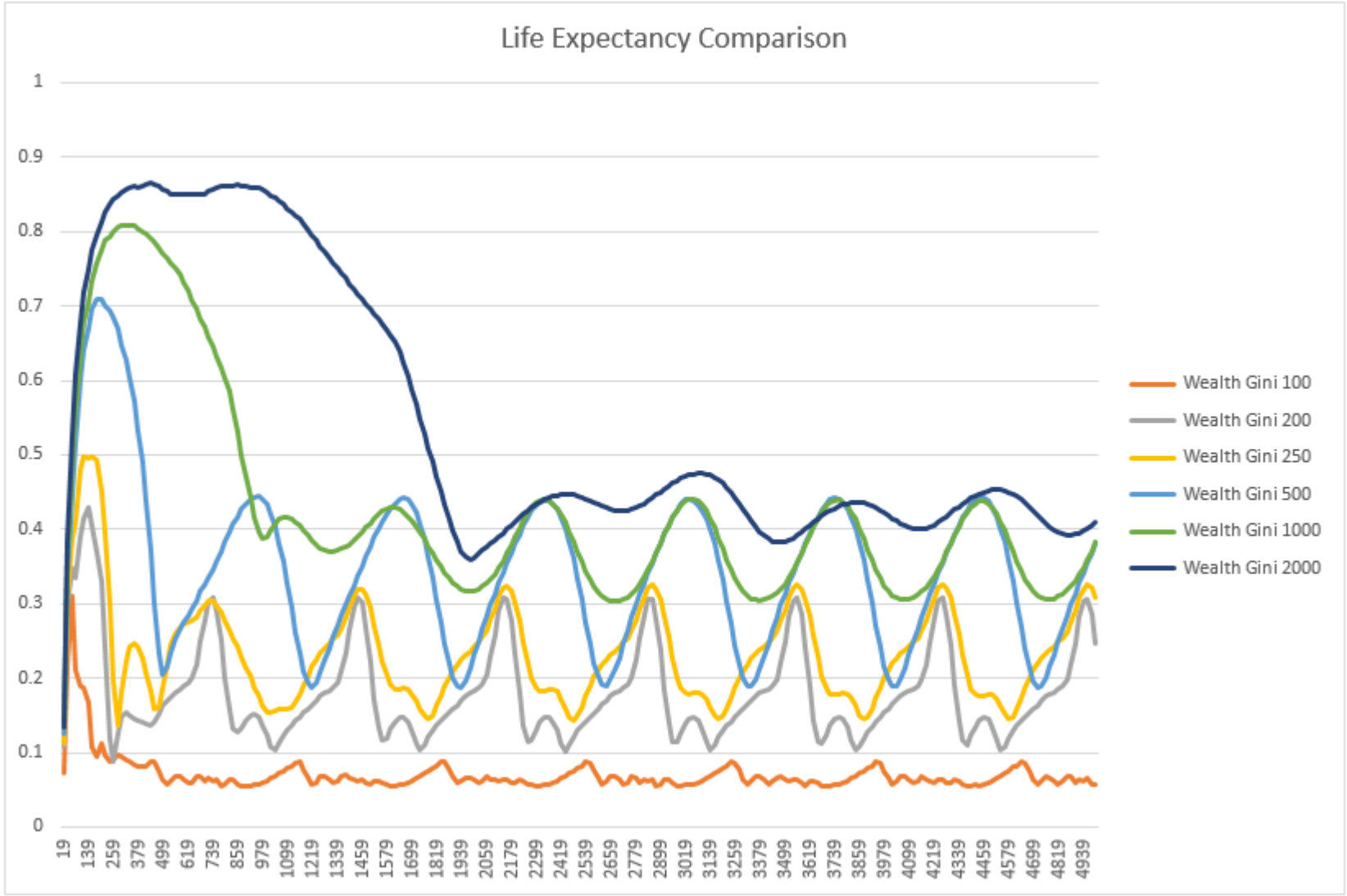
Exercise 7 – Equality – Longer Lifes





As the agents life longer relative to the length of the birth waves, the birth fluctuations are smoothened out more and lead to less distinct differences between the extremes in inequality.

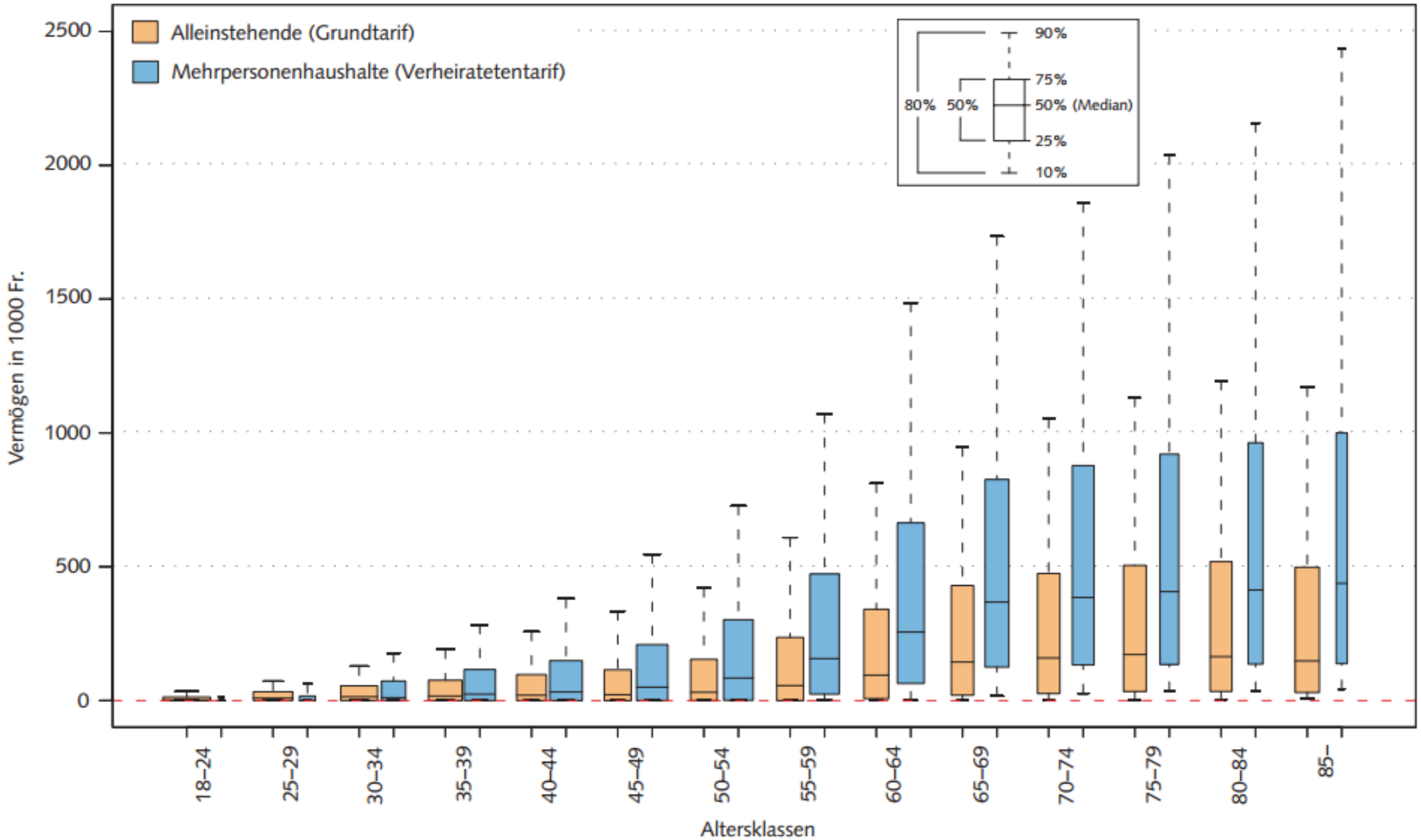
Exercise 7 – Changing Life Expectancy



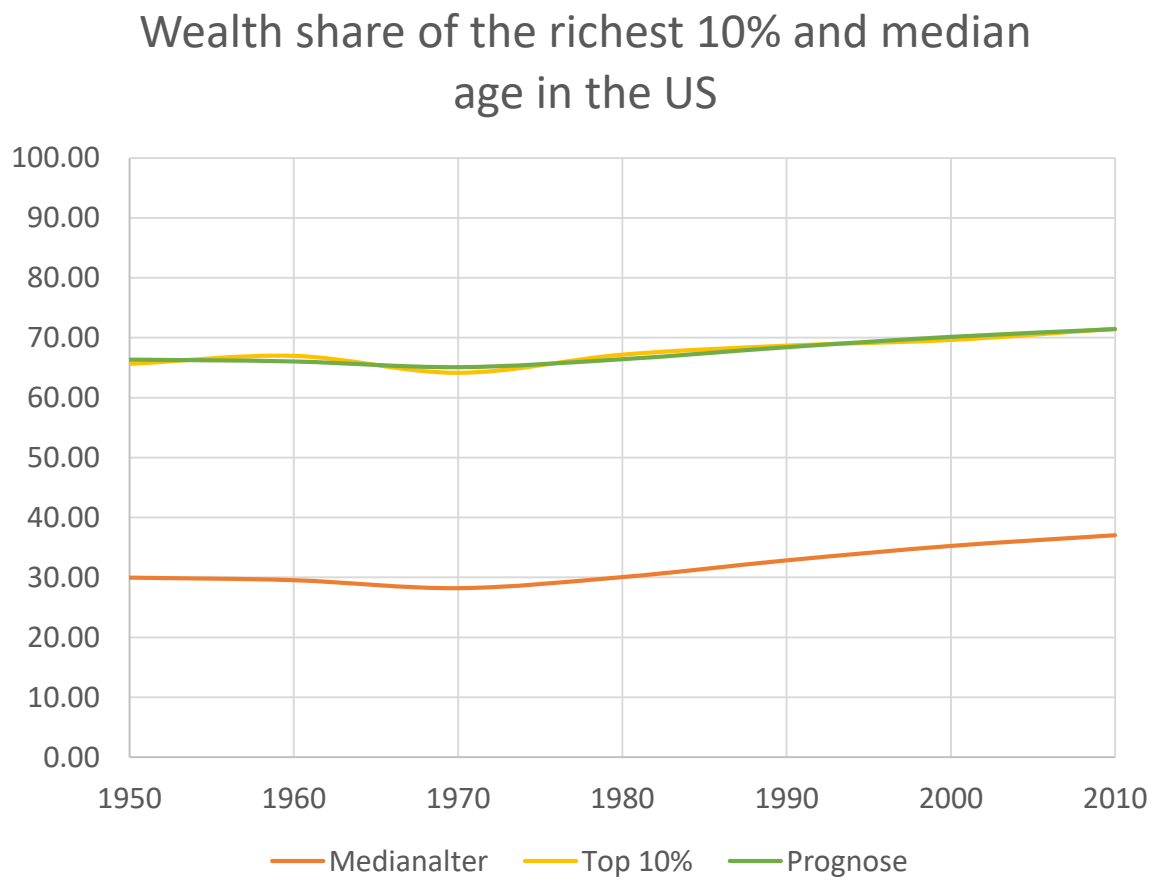
Nice chart by team 5.

Vermögensverteilung nach Alter und Haushaltstyp

2003, Kanton Zürich



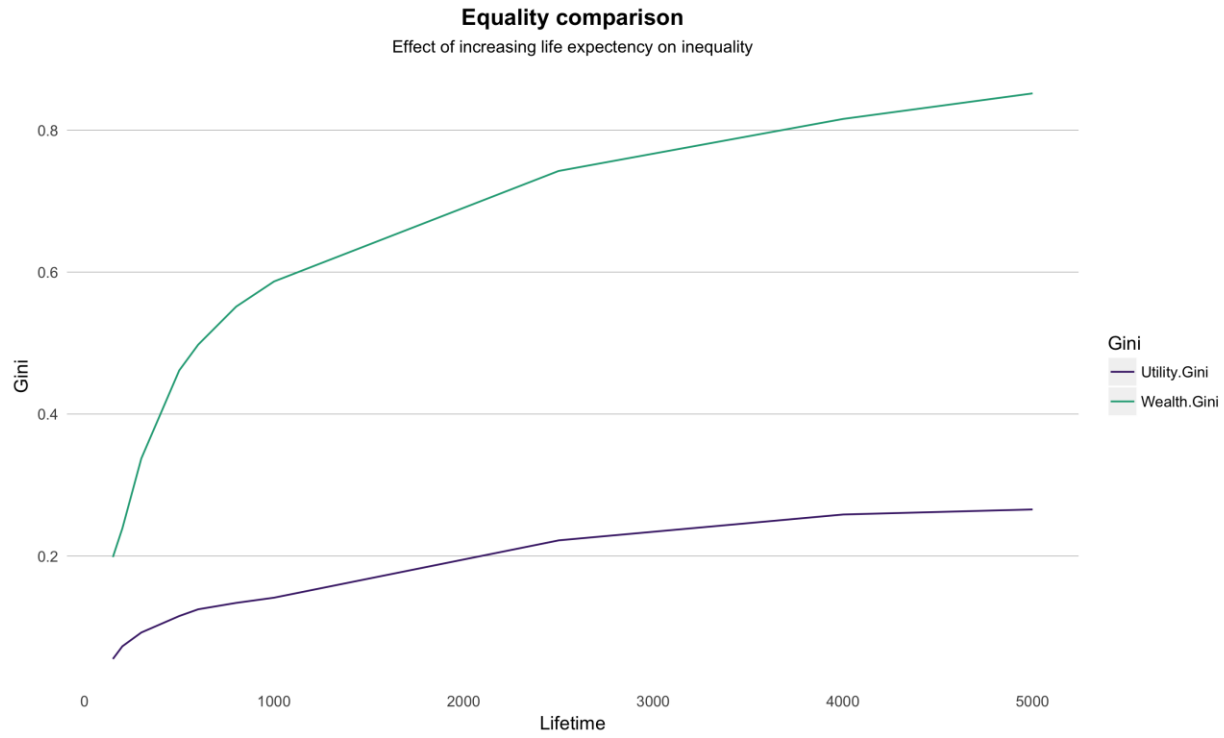
Regression: Age and Wealth Inequality



- Intercept: 44.86
- Slope: 0.717
- t-value: 7.26
- p-value: 0.0008
- Adj. R^2: 0.896

-> Statistically significant correlation at least in the US

Exercise 7 - Equality



(This nice chart has been made by team 3.)

Some of you concluded here: “money does not seem to buy happiness”

This conclusion depends on the shape of the utility function, or diminishing additional utility when consuming more. I.e. the assumption that spending twice as much on something does not make you twice as happy.

WORLD | BY COUNTRY | DATA | METHODOLOGY | ABOUT US | NEWS

WORLD WEALTH & INCOME DATABASE

http://wid.world

COUNTRY & REGION

KEY INDICATORS

AVERAGE INCOME
- Per adult national income
- Per adult GDP

AVERAGE WEALTH
- Per adult national wealth
- Wealth-income ratio

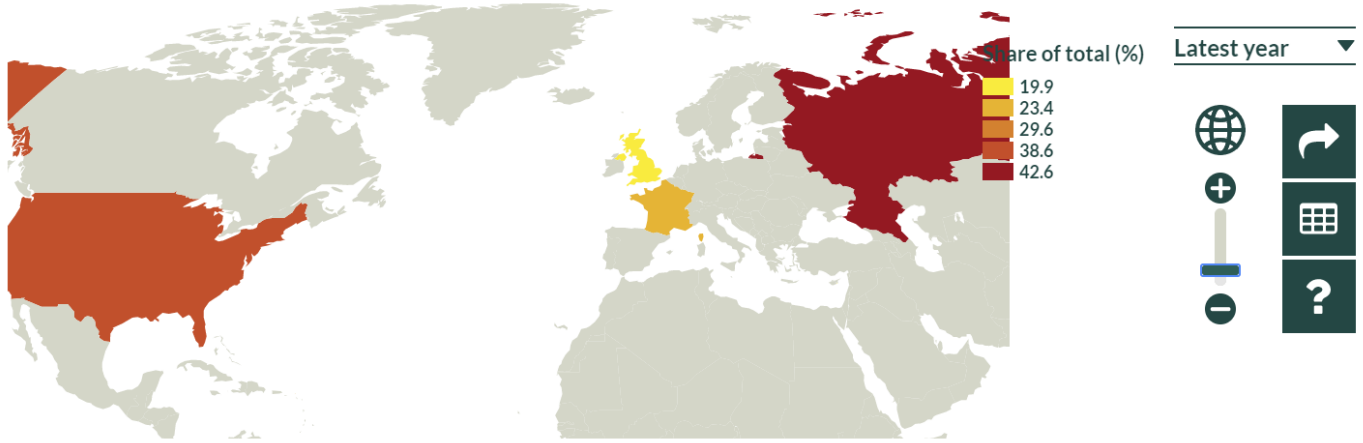
INCOME INEQUALITY
- Top 10% share
- Middle 40% share
- Bottom 50% share
- Top 1% share

WEALTH INEQUALITY
- Top 10% share
- Middle 40% share
- Bottom 50% share
- Top 1% share

MORE INDICATORS

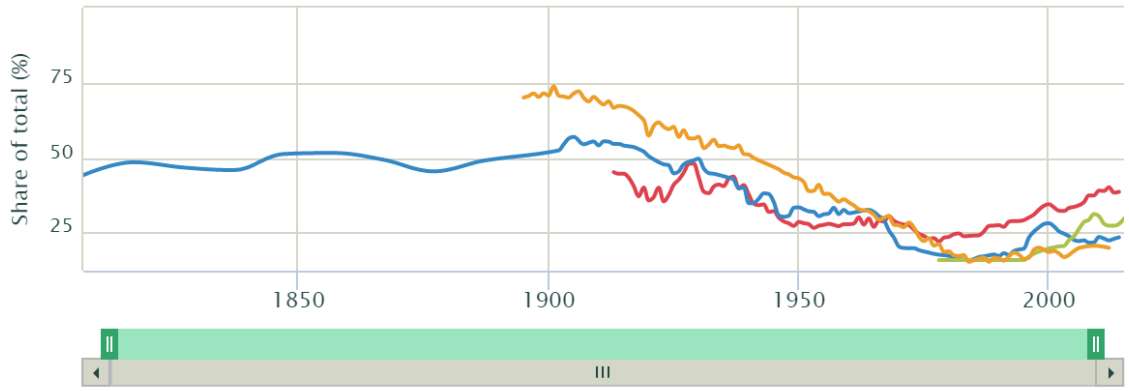
Search a concept...

Top 1% net personal wealth share



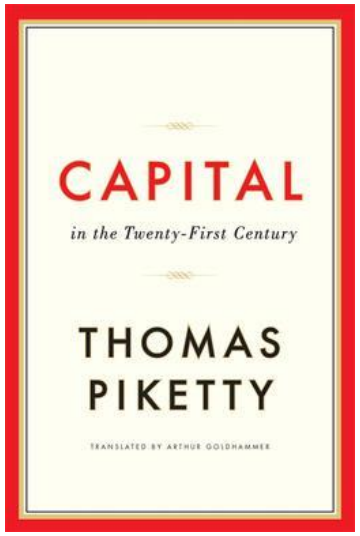
Latest year

Share (%) | Share (%) | More options



USA | France | China | United Kingdom

Picketty



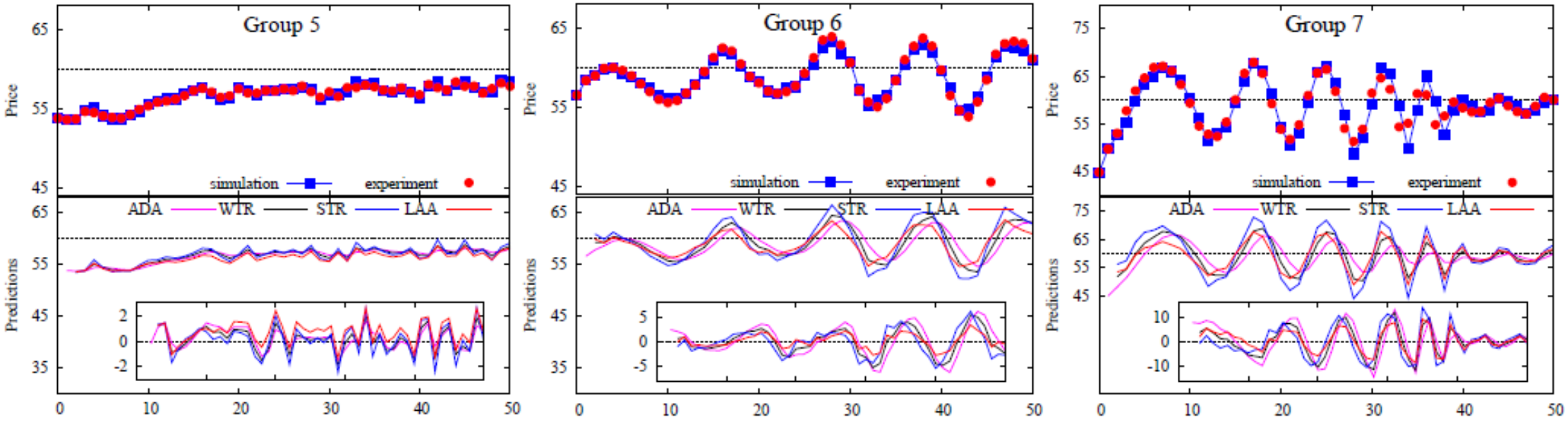
- Huge collection of historical data on wealth and income in the Western world
- Main finding: inequality has been increasing in the past decades in many western countries
- Model: return on capital is higher than economic growth, so the rich get richer.
- Proposed measure: introduce a global wealth tax.

Criticism:

- Used a questionable method to fill gaps in the data. (http://marginalrevolution.com/marginalrevolution/2017/10/pikettys-data-reliable.html) But this does not change much.
- Only looks at countries individually. It is possible for equality to decreasing in every country but still increase globally.
- Implicitly assumes that “the size of the pie is fixed”
- Disregards other causes of inequality, like ageing of the society (as we have seen in the simulation), people having fewer children, more divorces, etc.
- My conclusion: started an important discussion about a real risk. In the digital world, the winner takes it all. But maybe everyone can find a niche to win in?
- Zuckerberg, Gates and others are worried and are loudly thinking about a basic income.

Cars Hommes's Experiments

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



Course Outlook

November 9th: Last weekly exercise: market maker dynamics

November 16th: Final task setup, open topic 1

November 23th: open topic 2

December 1st: open topic 3

December 8th: three presentations

December 15th: three presentations

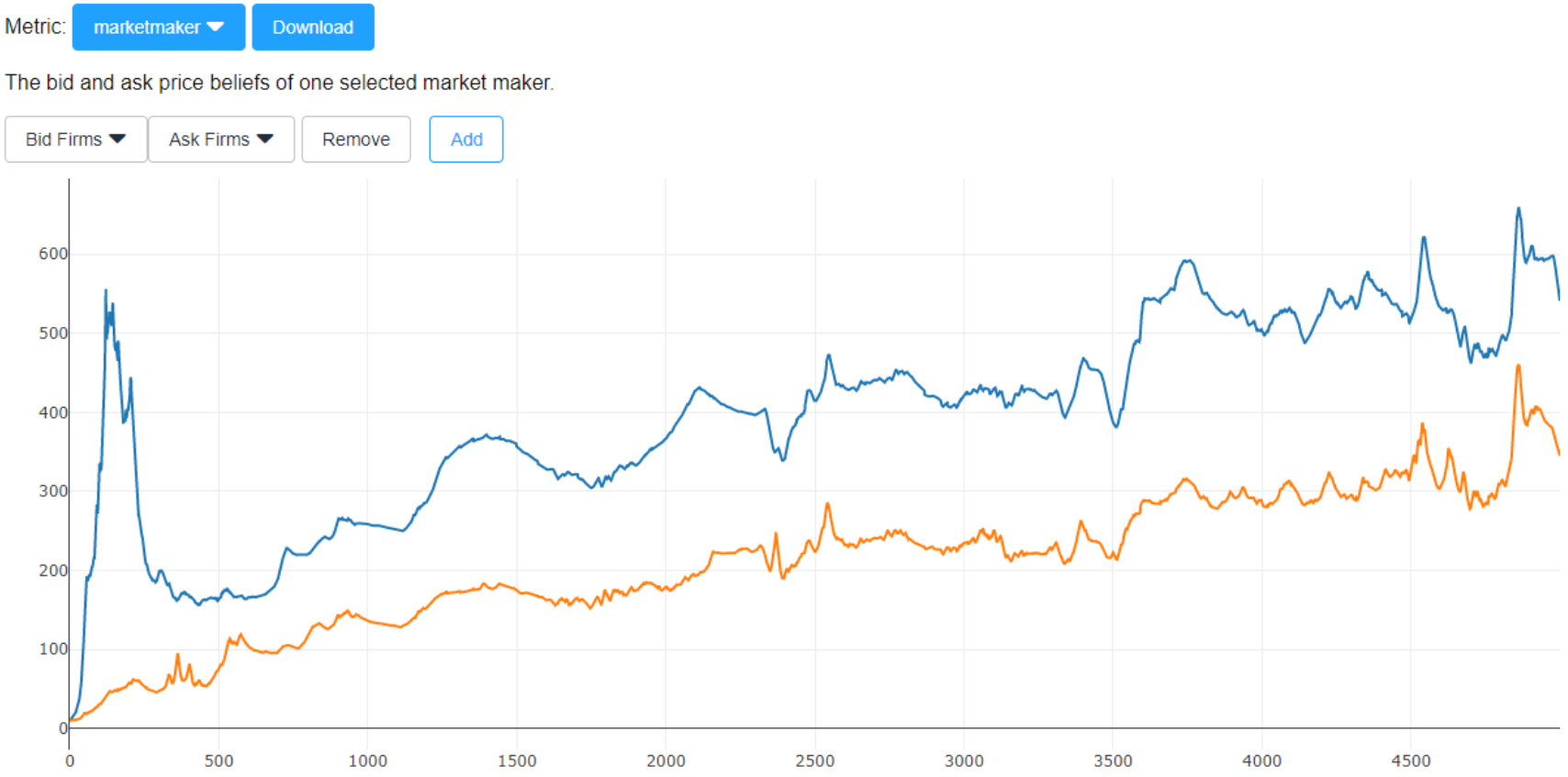
December 22nd:: open topic 4

Grading: 65% exercises, 35% presentation

Course Outlook

- Heterogeneous inputs (i.e. different types of man-hours)
- Heterogeneous outputs (i.e. different types of consumption goods)
- Heterogeneous preferences (i.e. agents need more medicine when old)
- Intermediate goods (i.e. grass that can be fed to cows)
- Capital accumulation (land development and trading)
- Technology
- Learning and control theory
- Credit and leverage
- Try out Bancor market making
- Trade between multiple countries with distinct currencies
- Other ideas?

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.

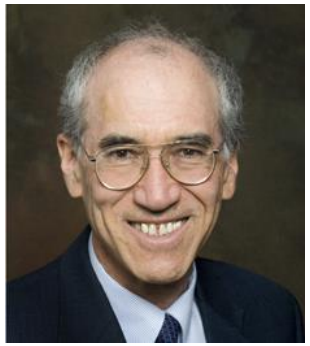
Assumptions:

- 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.

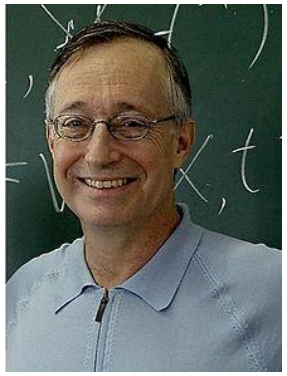
Market Maker - Literature



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**".

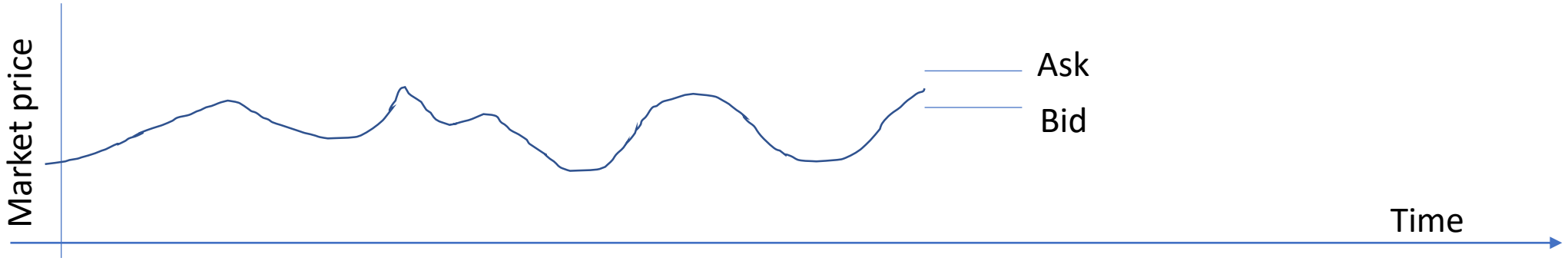
"The welfare loss we have described is at least partly due to the requirement that the specialist must break even on each trade." (Bancor trader does not have that requirement.)

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

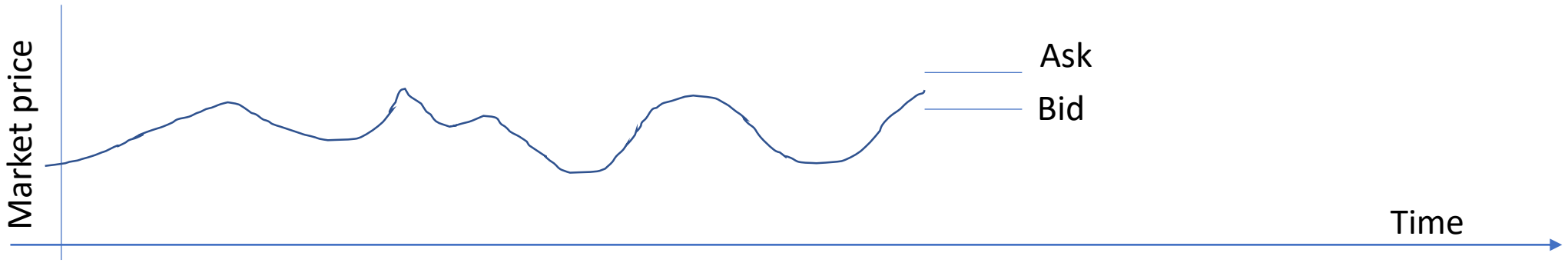
- The market makers are the only agents that are allowed to place limit orders
- Everyone else can only do market orders, and must therefore always trade with a market maker
- Market makers are risk-neutral
- Market makers maximize profits and compete with each other (Bertrand competition)
- Market makers 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

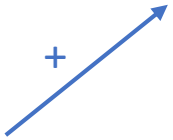
Order of events:

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 Making – System Dynamics

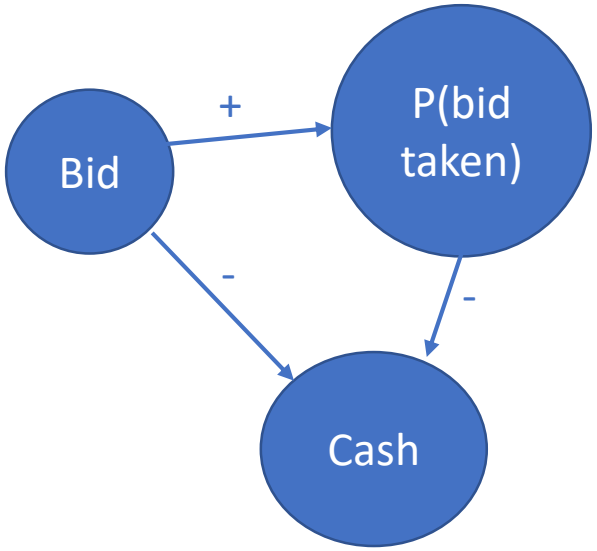
Circles are variables



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

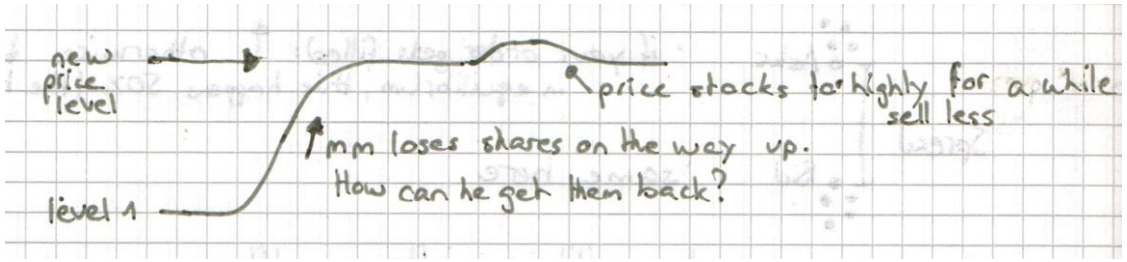
Ideas for variables:

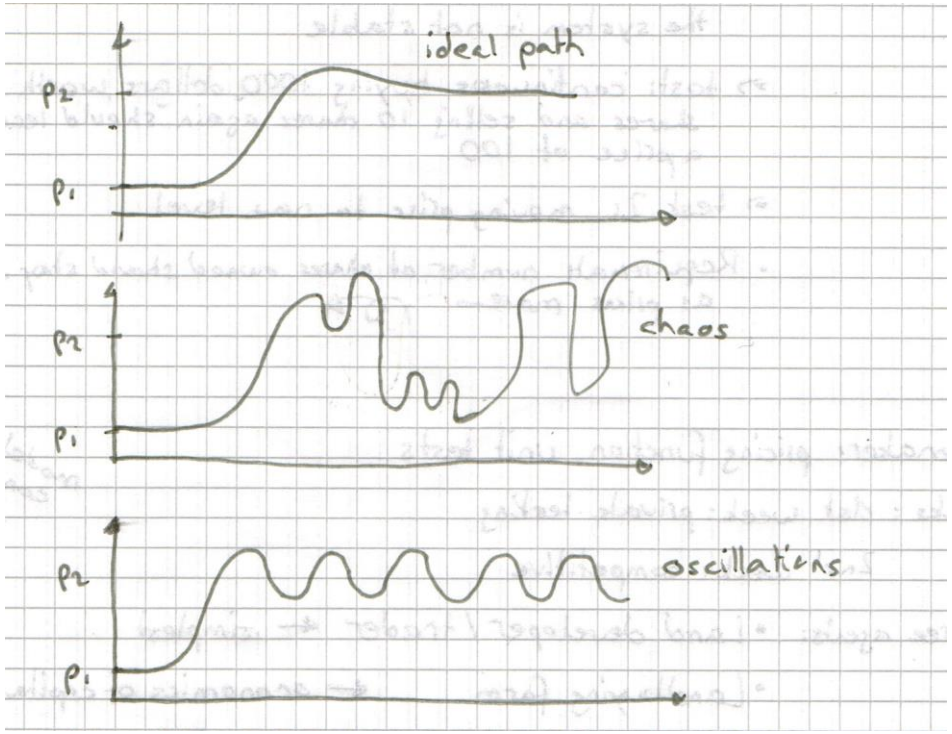
- Bid price
- Ask price
- Spread
- Equilibrium price
- Inventory: stocks
- Inventory: cash
- Inflow
- Outflow
- Profit
- …

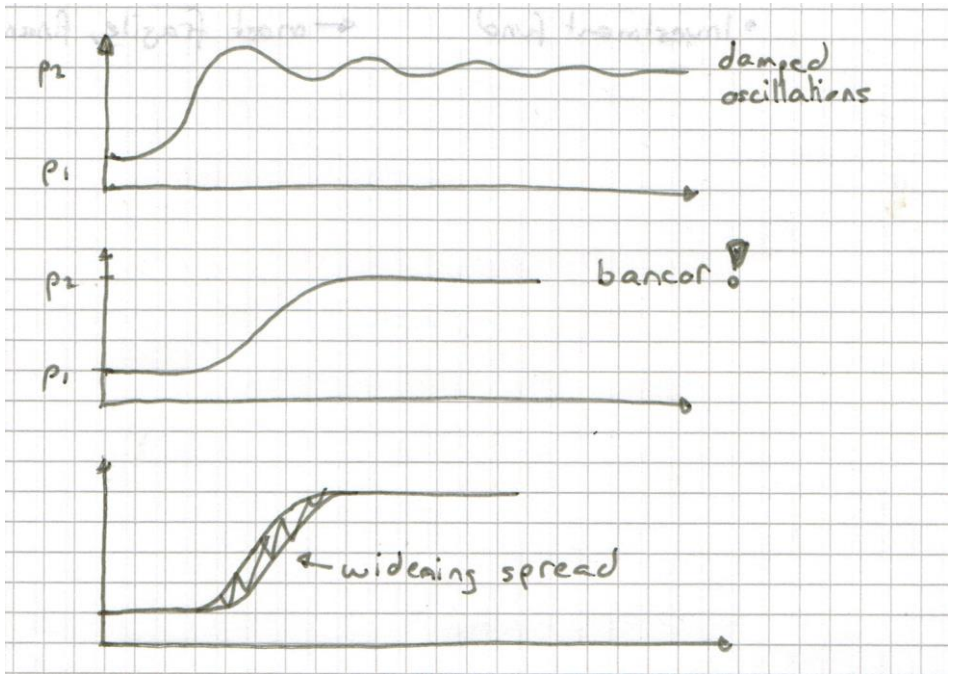


Example relation: a higher bid leaves the market maker with less cash. Also, it increases the probability of the bid being taken by a market participant, thereby further reducing cash.

Market Making







Exercise 8 – Market Maker

See exercise 8 on github.