University of Zurich[UZH]

Agent-based Financial Economics
Lesson 5: Stocks

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

- Richard Feynman

Today

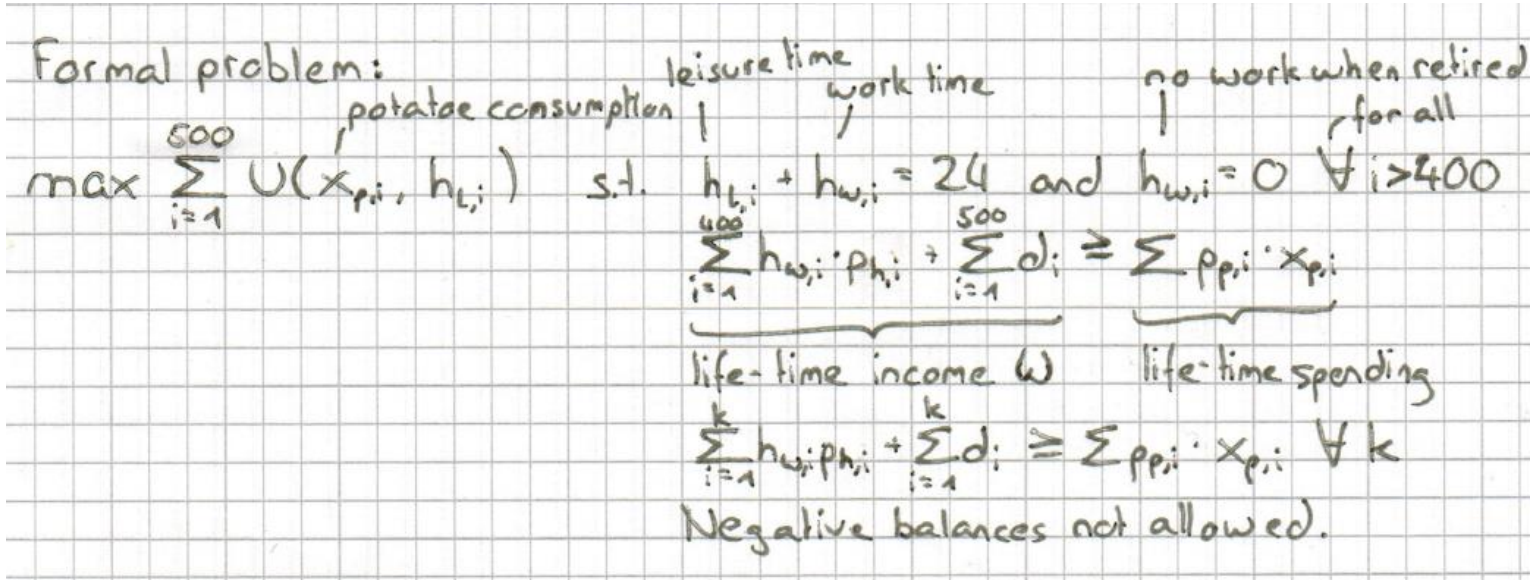
- Discussion of exercise 4
- Stocks
- Market making
- The Bancor protocol
- Exercise 5: stocks

Exercise 4 - Ranking

Rank	Consumer	Utility	Source	Version
1	team104-Farmer(Owner)	5.7792224944024495	source	David Maurenbrecher on 2018-10-18T12:21:00Z
2	team102-Farmer(Owner)	5.776329185055425	source	mhoegger on 2018-10-18T12:40:57Z
3	team100-Farmer(Owner)	5.631442952884267	source	Sommer1872 on 2018-10-17T12:35:22Z
4	team101-Farmer(Owner)	5.592635213220236	source	Richard Chan on 2018-10-18T18:27:12Z
5	team103-Farmer(Owner)	5.545087761854268	source	Albina Gilmijarova on 2018-10-18T19:05:23Z
6	team105-Farmer(Owner)	5.4772642069223965	source	Markus Göckeritz on 2018-10-18T20:15:50Z
7	team102-Farmer(Worker)	4.714281101400905	source	mhoegger on 2018-10-18T12:40:57Z
8	team104-Farmer(Worker)	4.591517888733191	source	David Maurenbrecher on 2018-10-18T12:21:00Z
9	team100-Farmer(Worker)	4.453539934226236	source	Sommer1872 on 2018-10-17T12:35:22Z
10	team105-Farmer(Worker)	4.452616909198087	source	Markus Göckeritz on 2018-10-18T20:15:50Z
11	team103-Farmer(Worker)	4.445925563585477	source	Albina Gilmijarova on 2018-10-18T19:05:23Z
12	team101-Farmer(Worker)	4.44395718151372	source	Richard Chan on 2018-10-18T18:27:12Z

Exercise 4 - Theory

Formal problem looks complicated, with lots of variables and unknowns…



That's why I suggested to assume constant prices and wages, reducing the problem to:

$max \sum_{i=1}^{500} u(x_{p,i})$ subject to the budget constraint $\sum_{i=1}^{500} p x_{p,i} = \sum_{i=1}^{400} w_i = 400w$ (without dividends for now)

→ You will find that it is optimal to smooth consumption, and to consume the same number of potatoes every day. But what if prices can change?

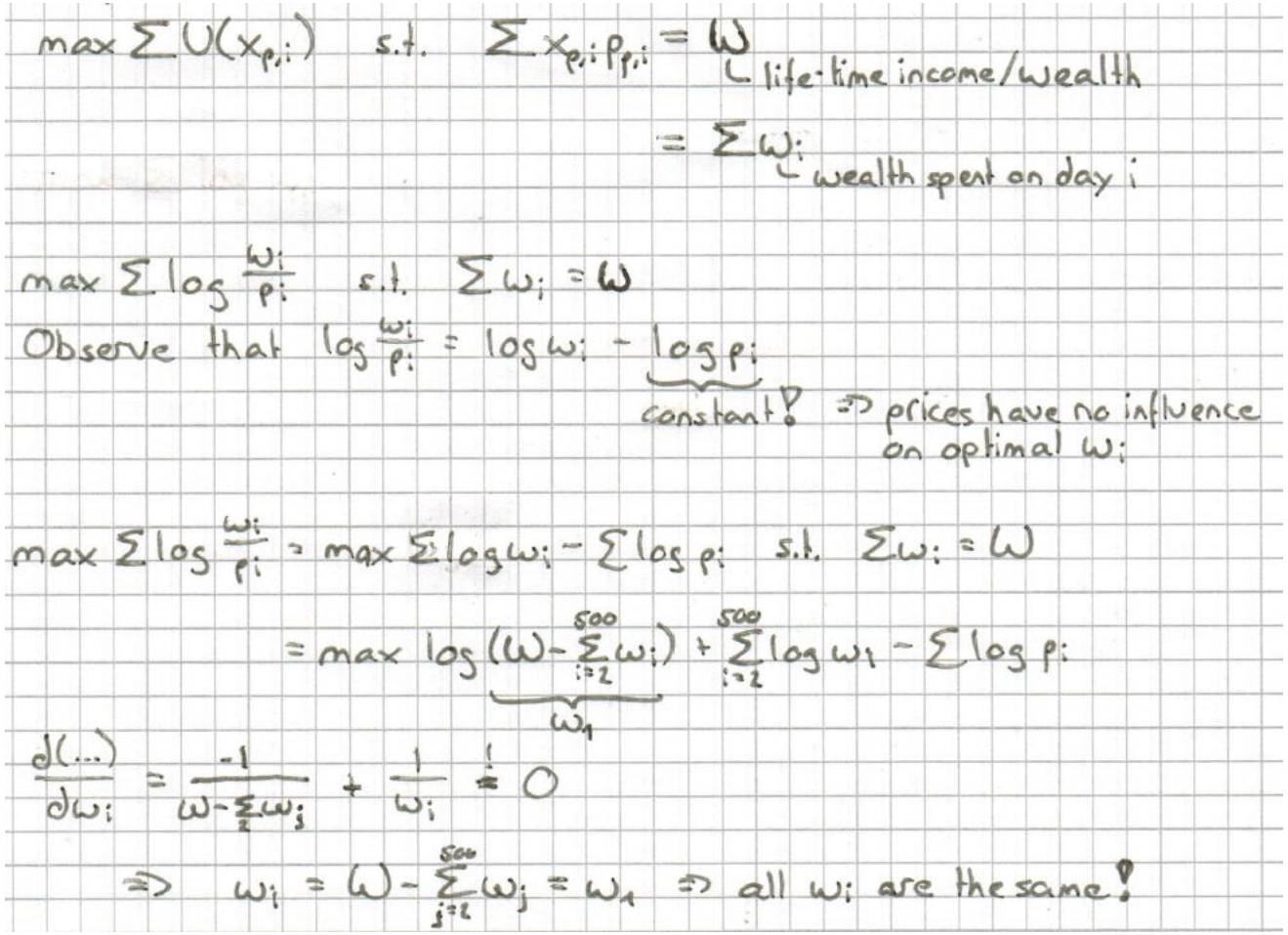
Exercise 4 - Theory

Still assuming a given total life-time income W, how do we optimally allocate our budget when prices change?

→ Distribute budget evenly, spend the same amount every day.

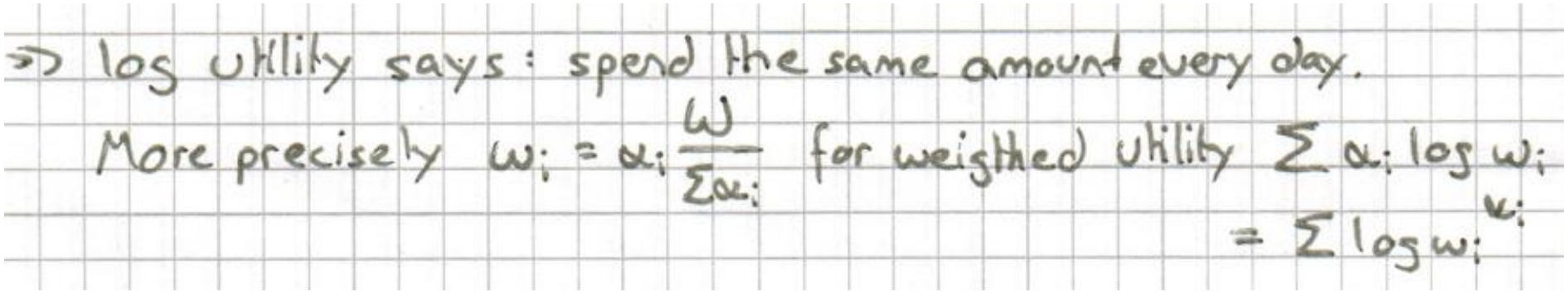
Income effect: when potatoes are cheap, I should buy more of them.
Substitution effect: when potatoes are cheap, I save money by spending less on them.

With log-utility, these two effects cancel out and the spending stays the same, regardless of the price.



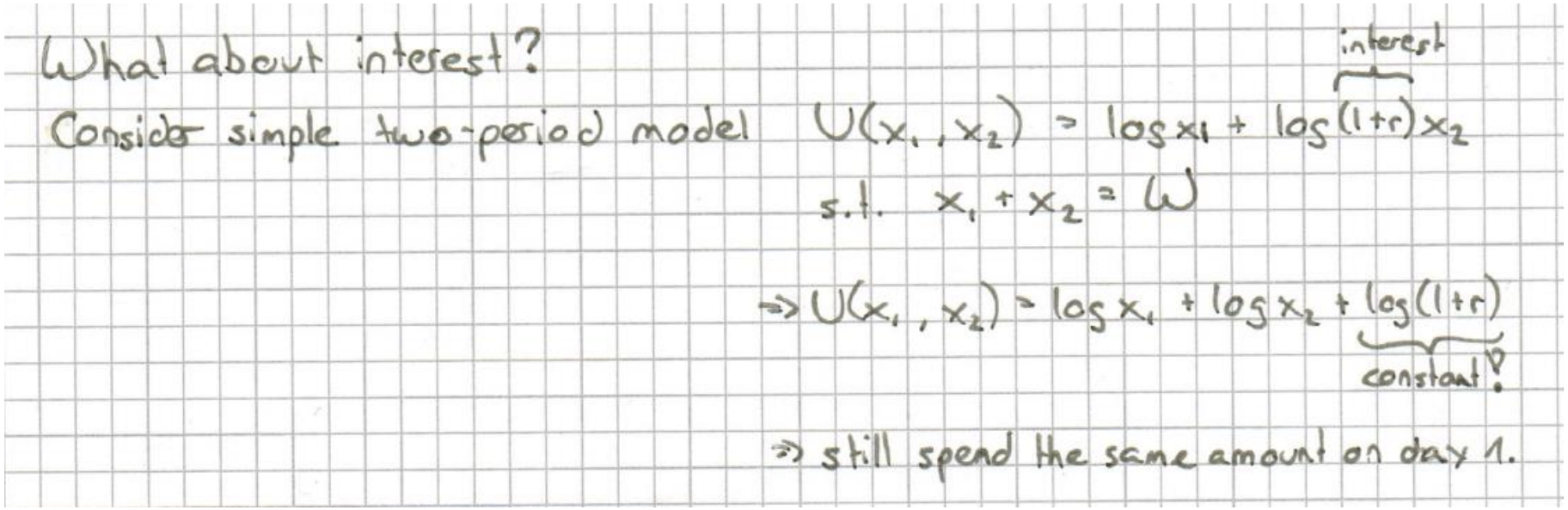
Exercise 4 – Theory (side remark)

More precisely: with log utility, optimality implies spending according to the weights given in the utility function. In ours, all the weights are 1, so it does not matter. But more generally, it looks like this:



Exercise 4 – Theory: But what about interest?

Adding interest rates does not change anything either.
The income effect tells me: “Save money today, so you can spend even more on potatoes tomorrow.”
The substitution effect tells me: “You can spend more today, thanks to interest your money will grow back.”
→ Both effects cancel out, and I still decide to spend the same amount today.
(More precisely, if I previously spent 100 on day one and 100 on day two, introducing an interest rate of 10% does not affect my spending on day one, but I will spend 110 on day two.)



Exercise 4 – Retiree decision heuristic

These considerations lead us to a very simple, but also very effective decision heuristic for retirees:

Simply spend 1/d of your wealth today if you have d days left to live.

This heuristic is robust against:

- Nominal and real price changes
- Inflation / deflation
- Changes in nominal and real interest rate
- Dividends (work like interests), when stocks can be sold

Caveats:

- It only works so nicely thanks to assuming log-utility.
- It is not entirely correct when stocks cannot be sold.
- It is only efficient if the stocks have the right price on the stock market (discounted value of all future dividends).

Exercise 4 – Retiree decision heuristic

Thus, the implementation for the retiree could look as follows:

```
public void managePortfolio(IStockMarket stocks) {
    boolean retired = isRetired();
    if (retired) {
        int daysLeft = getMaxAge() - getAge() + 1;
        double consumptionToday = this.savings / daysLeft;
        this.savings -= consumptionToday;
    } else {
```

In exercise 5, when we can buy and sell shares instead of just saving money, it will look as follows:

```
@Override
public void managePortfolio(IStockMarket stocks) {
    boolean retired = isRetired();
    if (retired) {
        int daysLeft = getMaxAge() - getAge() + 1;
        double proceeds = getPortfolio().sell(stocks, this, 1.0d / daysLeft);
        listeners.notifyDivested(this, proceeds); // notify listeners for statistics
    } else {
```

Exercise 4 – Worker decision heuristic

In order to spend the same amount every day, about 1/5 of the daily work income needs to be saved, and 4/5 can be spent on potatoes. In other words: if daily spendings are 100, an amount of 25 should go into savings.

```
public void managePortfolio(IStockMarket stocks) {
    boolean retired = isRetired();
    if (retired) {
        int daysLeft = getMaxAge() - getAge() + 1;
        double consumptionToday = this.savings / daysLeft;
        this.savings -= consumptionToday;
    } else {
        double dividends = getPortfolio().getLatestDividendIncome(); // how much dividends did we get today?
        double workFraction = 1.0d / getMaxAge() * getRetirementAge(); // 80%
        double retirementFraction = 1 - workFraction; // 20%
        this.savings += (getDailySpendings() - dividends) / workFraction * retirementFraction;
    }
}
```

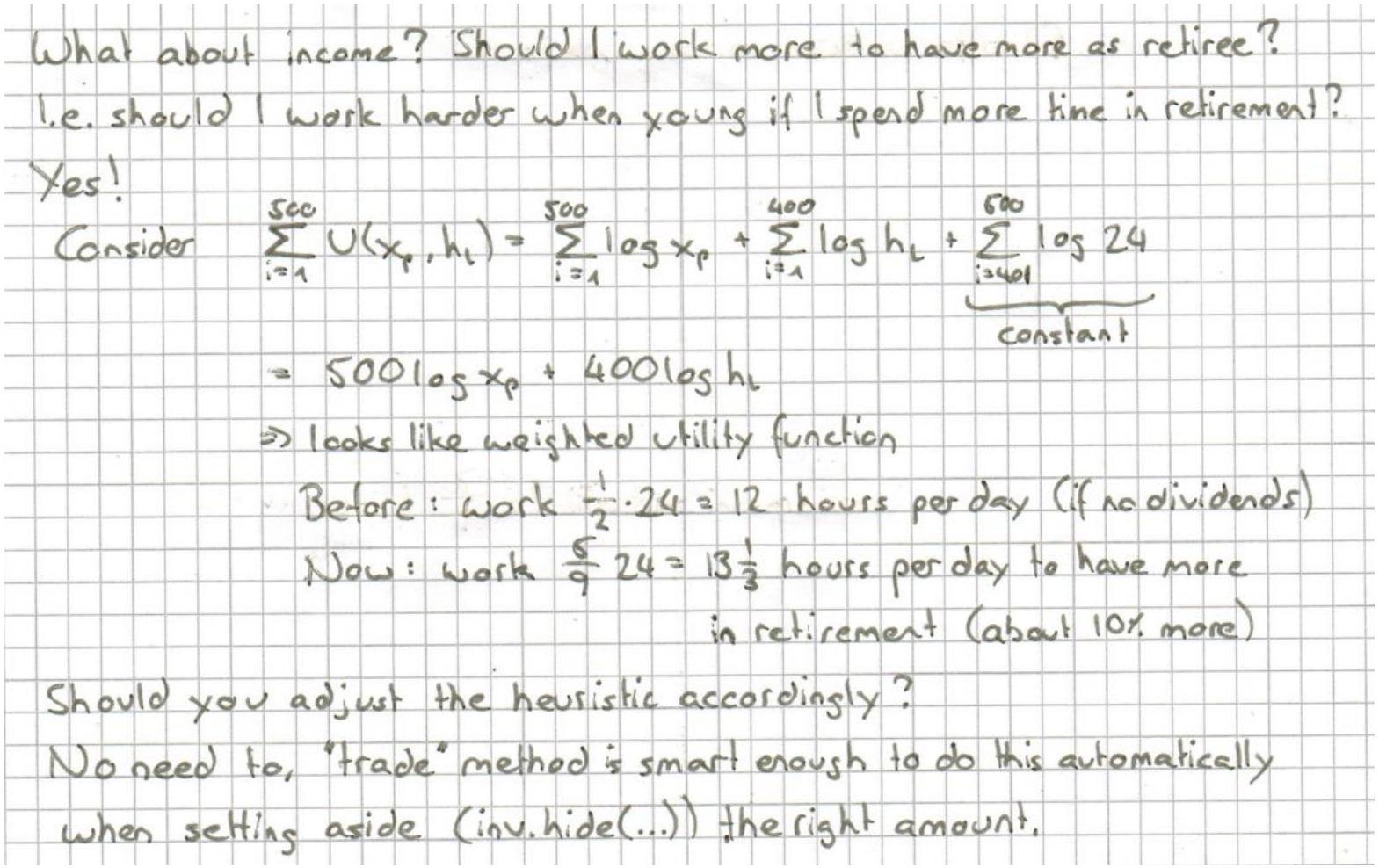
Exercise 4 – Theory: worker

But should workers work harder to save for retirement?

I.e. should a worker that has maxAge=400 work less than one with maxAge=500?

→ Yes. The longer you spend in retirement, the harder you should work to accumulate retirement savings.

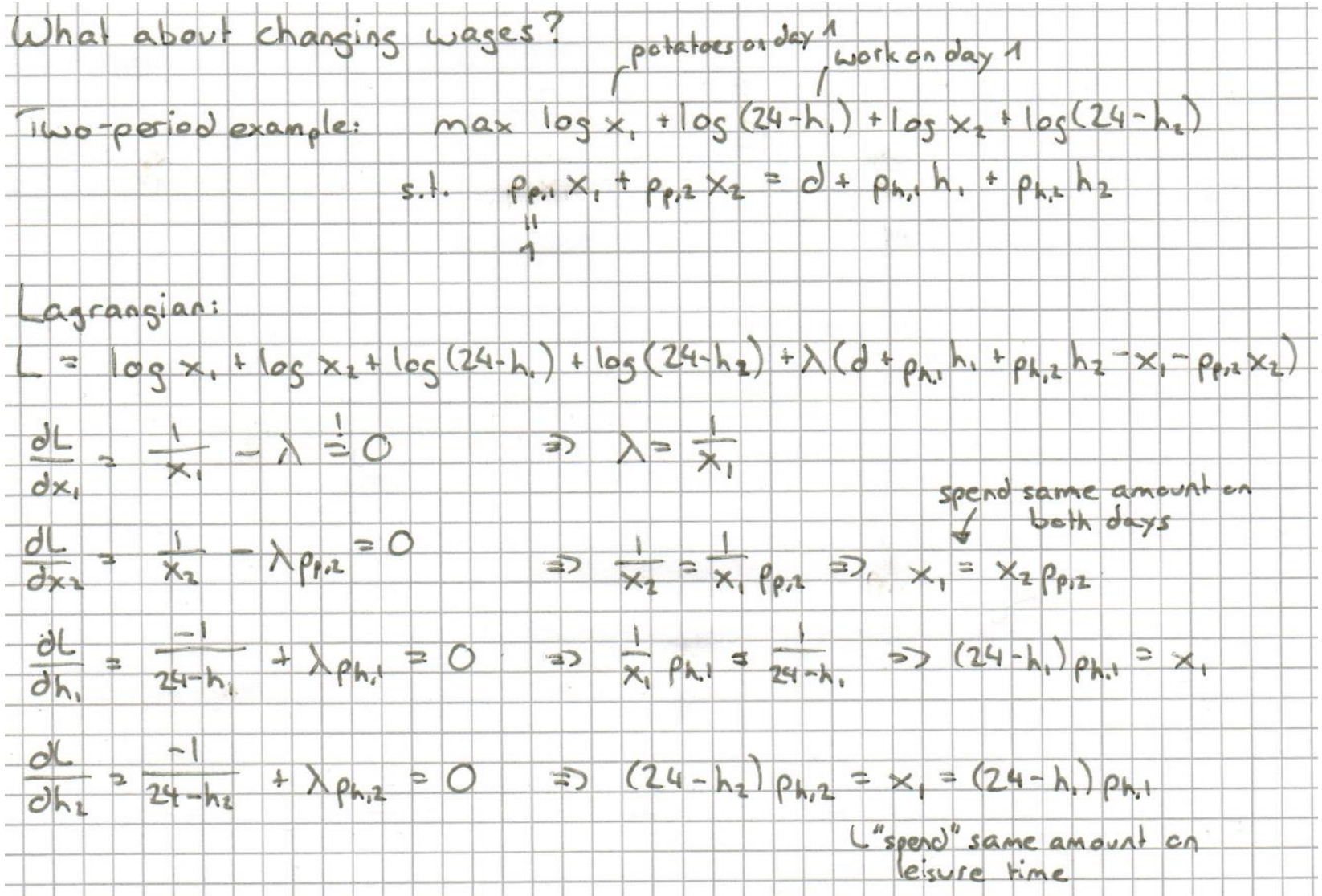
Nicely, this happens automatically in the trade function when hiding the right amount.



Exercise 4 – Price changes

When solving the exercise, we assumed constant prices and wages.

What if this does not hold?



Exercise 4 – Price changes

$\Rightarrow 24 p_{h,2} - h_2 p_{h,2} = 24 p_{h,1} - h_1 p_{h,1}$

$\Rightarrow h_1 p_{h,1} = 24 p_{h,1} - 24 p_{h,2} + h_2 p_{h,2}$

$\Rightarrow h_1 = (24 p_{h,1} - 24 p_{h,2} + h_2 p_{h,2}) / p_{h,1} = 24 - (24 - h_2) \frac{p_{h,2}}{p_{h,1}}$

$\Rightarrow$ Work more on the day with the higher wage.

Or: invest less in leisure time when it is more expensive.

In a static world with constant productivity and no growth, it is optimal to work the same amount every day.

$\Rightarrow p_{h,2} = p_{h,1}$. If central bank manages price poorly, people work too much or not enough on the wrong days.

→ Unlike the potatoe price, which did not affect savings at all, the wage can make a difference.

→ A rational consumer works harder when he gets a higher salary.

→ Using our heuristic, the efficient outcome is only reached if the central bank prints the right amount of money.

Exercise 4 – Open questions

There are a number of interesting questions that we will skip in this course. However, I still want you to know that they exist:

- Correct estimation and discounting of future income. Affects savings schedule.
- Calculation of the efficient equilibrium. This can get hairy when it is unclear how to aggregate the agents.
- How should the central bank set its interest rate to attain the efficient equilibrium? What is the right interest rate?
- If there are overlapping generations: how should their utilities be weighted relative to each other? If we can make 100 young better off by making 50 old worse off, should we do so?
- What's the effect of a pay-as-you-go (AHV-like) pension system financed by taxing salaries?

→ Lots of interesting question. We move on to the stock market.

Stocks

- So far: no stock market, farms passed on to successor after death
- Similar to feudalism
- New: allow trading of stocks
- Savings should now be invested into stocks instead of money
- And stocks should all be sold over the course of retirement

--> Completely different dynamics.

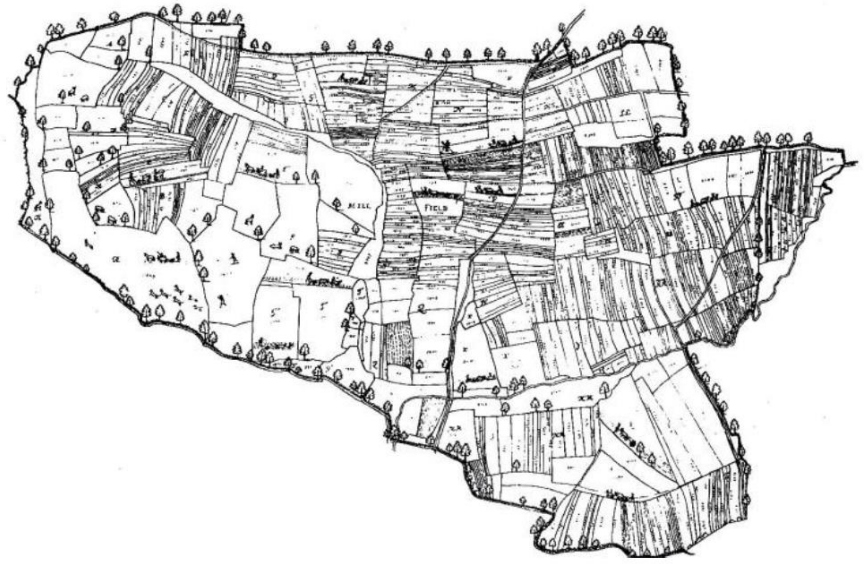


Figure 1.2: **Fragmentation of farmland in Laxton.** Allocation made in order to give a fraction of each type of land to each family. Reprinted from *The Open Fields*, by C. S. and C. S. Orwin, 1954, Oxford Clarendon Press.

Terms 1/3

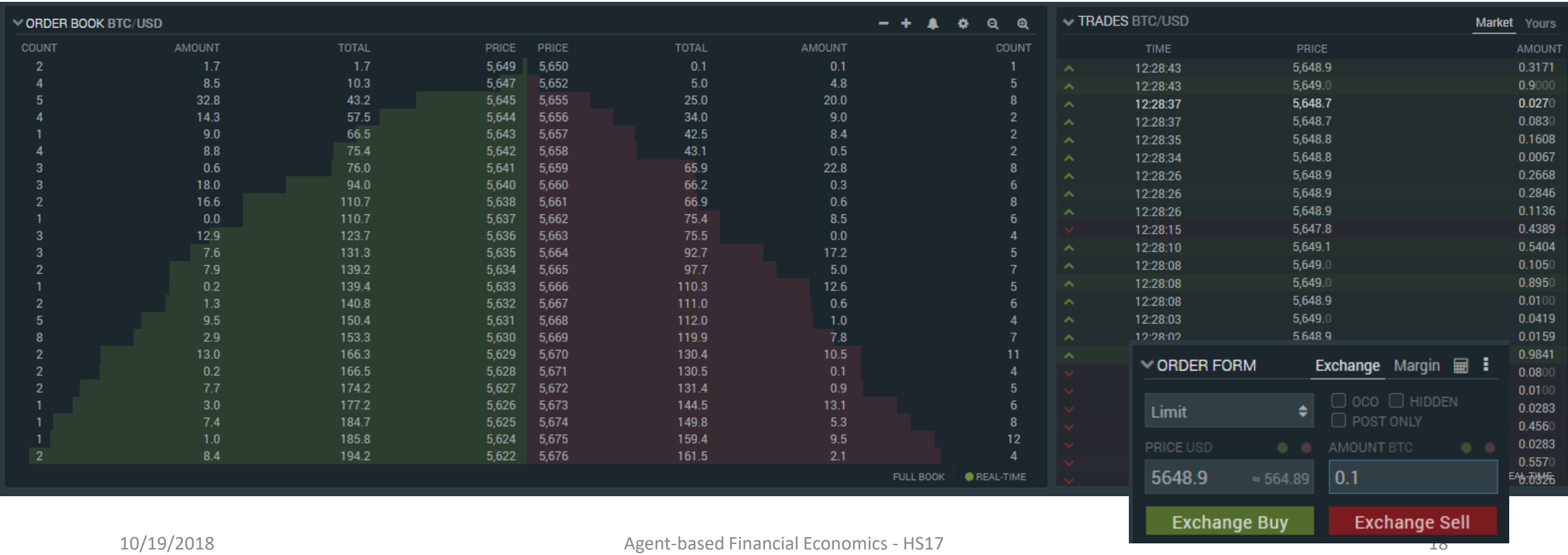
- Stocks, shares: units of account to keep track of who owns which percentage of a company. In our simulation, each company has exactly 100 shares. So 1 share represents 1% of the company. Unlike in reality, our shares are infinitely divisible.
- Dividends: money that is paid from the firm to its shareholders, in amounts proportional to their holdings.
- Dividend yield: the “interest rate” of stocks. Dividend yield = (dividends per share) / (price per share)
- Raising capital: creating and selling new shares, with the proceeds going to the firm.
- Outstanding shares: all the shares that are not owned by the company itself.
- Market capitalization: the total value of a firm, calculated by multiplying the number of outstanding shares with their price.
- Bankruptcy: a firm deciding to stop its business. The leftovers are distributed among the shareholders.

Terms 2/3

- Position: a number of shares owned by a specific investor. I.e. “I have a large position in Nestlé.”
- Portfolio: a collection of positions. Ideally, the positions in a portfolio are chosen such that they complement each other, such that the portfolio as a whole has a better risk-reward structure than each position on its own.
- Portfolio theory: the art/science of managing portfolios.
- Diversification: gets you better returns for the same “risk budget”. One of the very few things you get for free when investing.
- Order book: stock markets keep a book with all open orders for each stock.
- Bid (Geld): an order to buy shares
- Ask (Brief): an order to sell shares
- Spread: the difference between the highest bid and the lowest ask.
- Limit order: an order to buy for at most X $ per share, or to sell for at least Y $ per share.
- Market order: a bid or ask without limit, to be executed immediately regardless of the price.
- Liquidity: the extent to which shares can be bought and sold without moving the price much

Order book example

Bitfinex order book. Knowing the pending order allows to estimate the price impact of a larger trade.
However, there are also “hidden” orders that don’t show up in the order book.

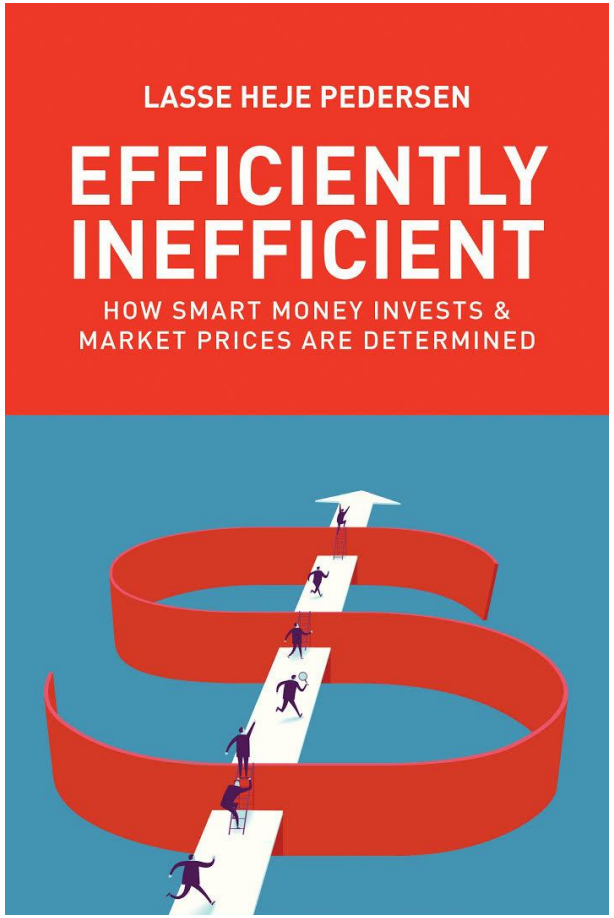


Terms 3/3

- Fund: a firm that owns a portfolio and has no “real” productive business.
- Index fund: a fund that manages its portfolio such that it reflects the whole market.
- Passive strategy: a portfolio management strategy that follows strict, mechanic rules and often only requires a minimal amount of trading.
- Active strategy: a portfolio management strategy in which one actively seeks to exploit market inefficiencies. This only works to the extent markets are not efficient and the manager succeeds in identifying the resulting opportunities.
- Efficient market hypothesis: the hypothesis that markets are efficient and thus prices always “right”. The only valid source of price changes is the arrival of new information, e.g. about a particular firm or the economy. There is no room for behavioral errors.

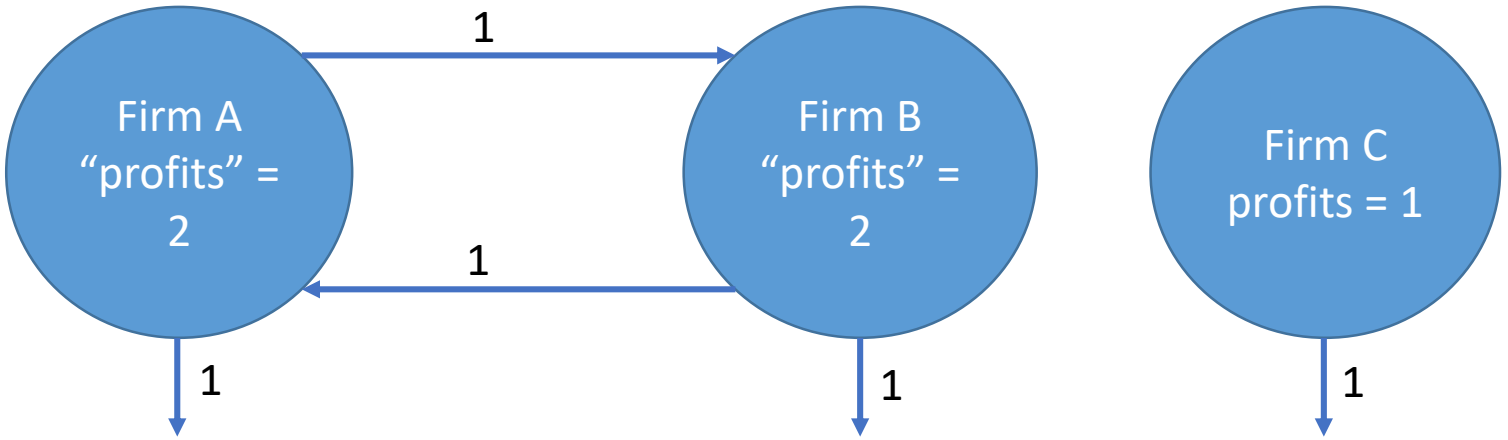
Interesting paper: Grossman, S.J. and Stiglitz, J.E., 1980. On the impossibility of informationally efficient markets. *The American economic review*, *70*(3), pp.393-408.

It says that markets cannot be fully efficient when it is costly to obtain information about what prices are right. Most up to date book on the topic: Efficiently Inefficient by Pedersen.



What should firms maximize?

- Usual assumption: firms maximize real profits
- In our model so far: firms maximize nominal profits
  (This should be equivalent to maximizing real profits as long as the central bank does its job well.)
- However, consider the following setup:



All firms make 1$ profits from real business per year, but A and B own 50% of each other, so they can add the dividends they receive from each other to their profits.
When the flows are in equilibrium, the A and B have doubled their profits in comparison to C!

→ We should rank firms not by the profits they made, but by the dividends they paid to consumers!

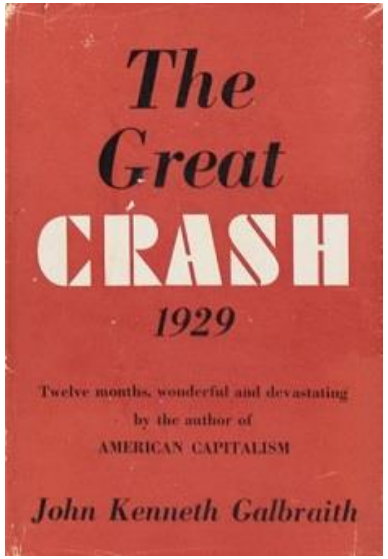
What should firms maximize?

→ We should rank firms not by the profits they made, but by the dividends they paid to consumers!

In economic theory, we do not do that, and we do not need to as long as firms are not allowed to buy each other's shares.
In reality, we do not do that either, leading to double accounting and contributing to the bubble and crash of 1929.

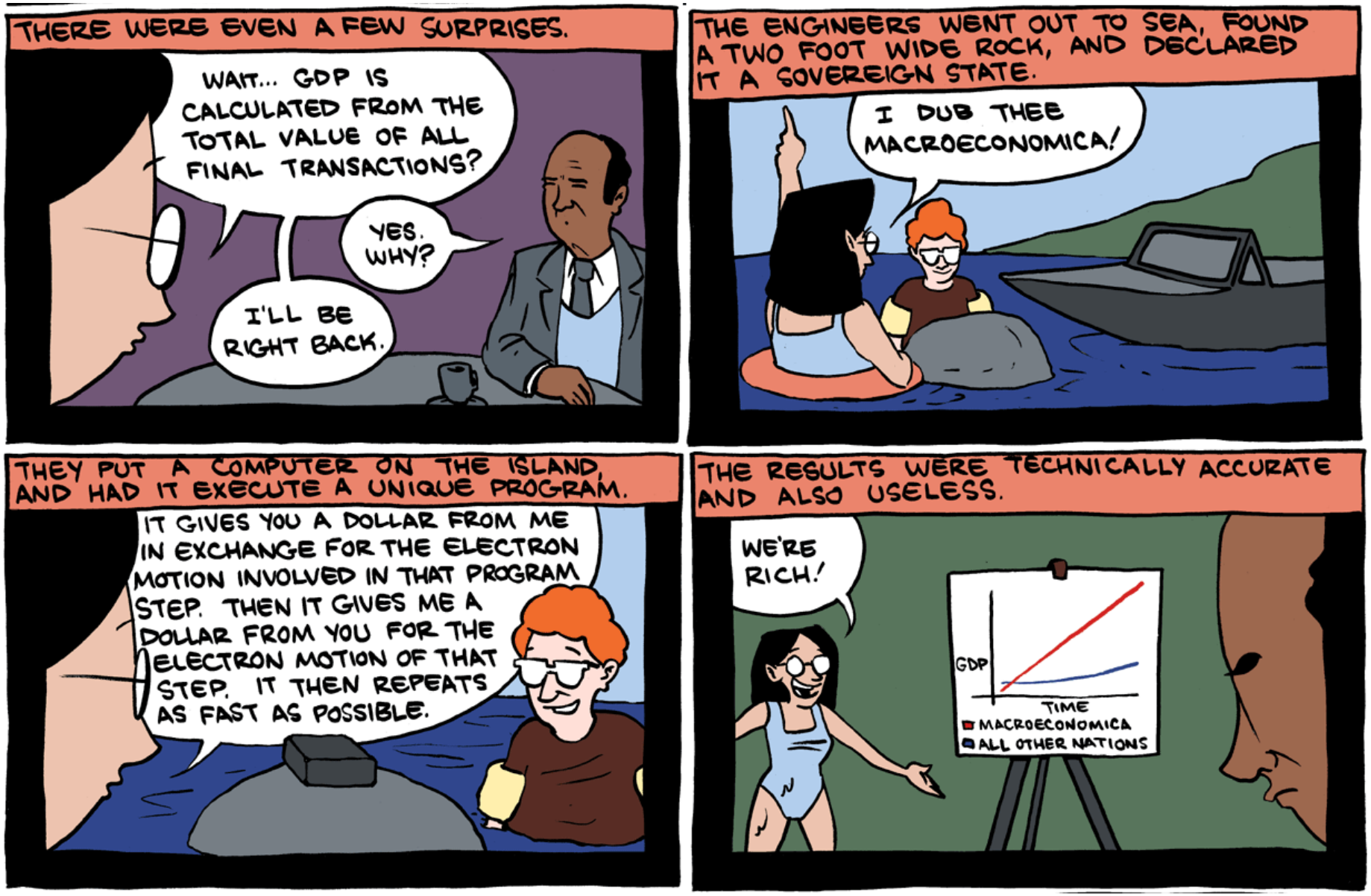
Third quarter[12][note 1]	
	Apple Inc. ▲791,726
	Alphabet Inc. ▲664,550[13]
	Microsoft ▲568,965
	Amazon.com ▼459,435
	Berkshire Hathaway ▲451,840[14]

Most of the market cap of Berkshire Hathaway, the 5th largest public firm in the world, comes from owning stocks of other listed companies, e.g. Coca Cola. So a part of Coca Cola's value is counted twice when calculating the total value of all US stocks.



As Galbraith describes, the bubble and the crash of 1929 was partially driven by funds buying each other's shares, creating an illustion of value that quickly deflated once the funds were forced to sell and sold each other's shares again, forcing them to sell even more.

Excerpt from www.smbc-comics.com/?id=2855



Market Making

The problem: individual investors often just want to buy and sell stocks, not having to wait until another investor appears for a counter trade.

Solution: market makers temporarily buy and sell stocks, bridging the needs of the other investors and providing liquidity.

A market, in which all limit orders come from market makers is called “dealer market” or “quote-driven market”. So is the market in our simulation.

By buying stocks without knowing at what price they can sell them again, market makers take a small risk. They are compensated for that risk by earning some money from the spread. The larger the spread, the more money the make by buying and selling a stock again.

Many high frequency trading firms do or claim to do market making, e.g. IMC.

https://www.imc.com/us/blog/2018/04/what-is-market-making

The “International Marketmaking Company” describing itself.

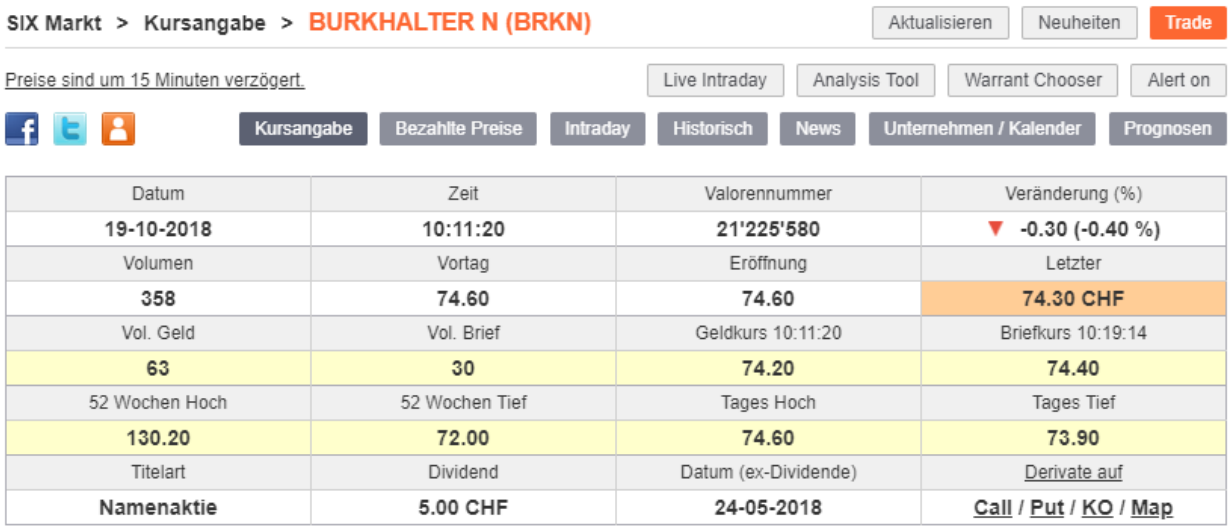
Market Making

Problem with market making today: “penny stocks” (firms with a low market capitalization) often are not very liquid, with daily trading volume in the millions.

For example, Swiss electrician Burkhalter only traded 4445 stocks today by lunch time, worth about 500k CHF.

How can you get rid of your stocks if you own shares worth 5 million?

Takes a long time.

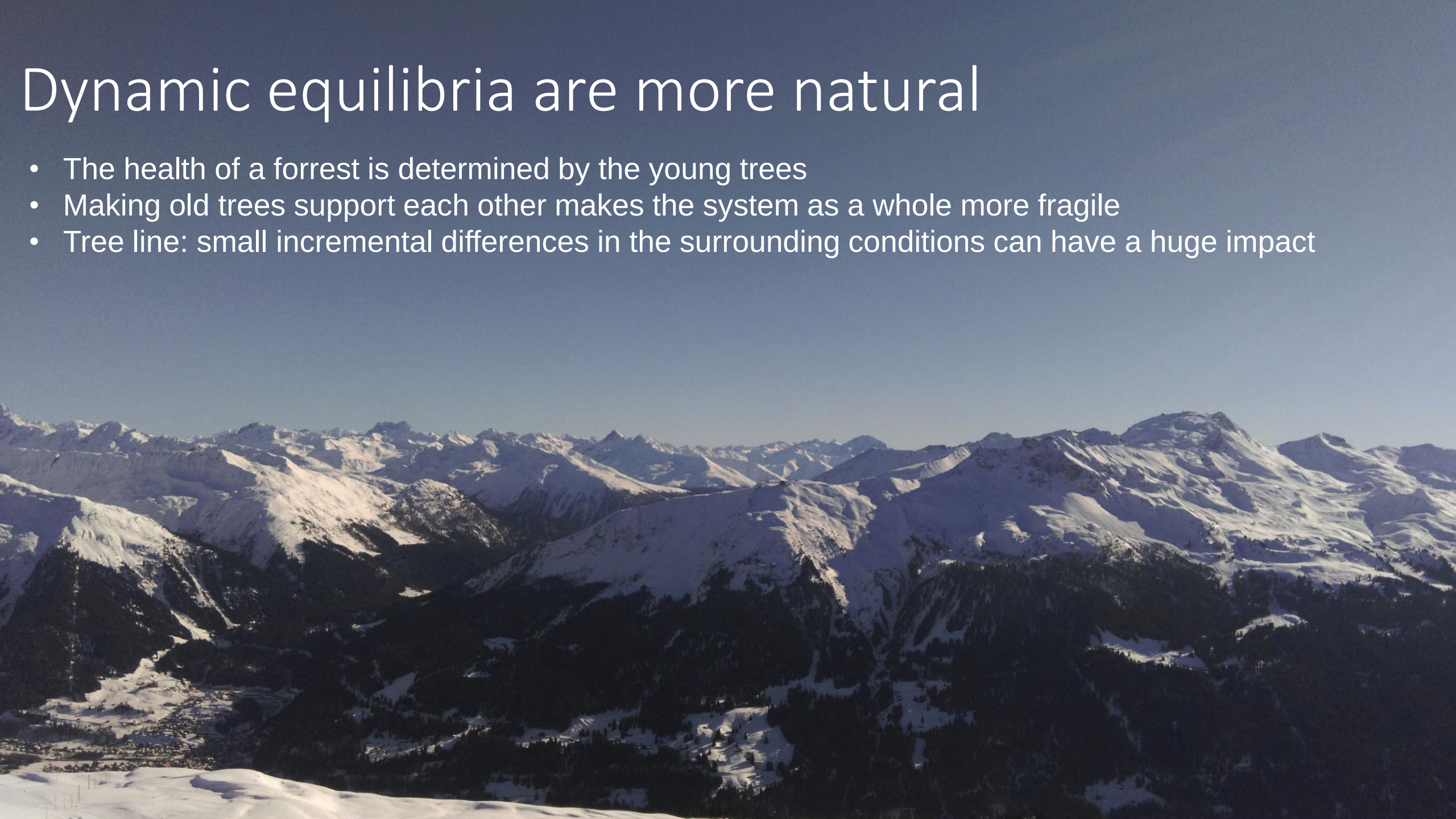


Datum	Zeit	Valorennummer	Veränderung (%)
19-10-2018	10:11:20	21'225'580	▼ -0.30 (-0.40 %)
Volumen	Vortag	Eröffnung	Letzter
358	74.60	74.60	74.30 CHF
Vol. Geld	Vol. Brief	Geldkurs 10:11:20	Briefkurs 10:19:14
63	30	74.20	74.40
52 Wochen Hoch	52 Wochen Tief	Tages Hoch	Tages Tief
130.20	72.00	74.60	73.90
Titelart	Dividend	Datum (ex-Dividende)	Derivate auf
Namenaktie	5.00 CHF	24-05-2018	Call / Put / KO / Map

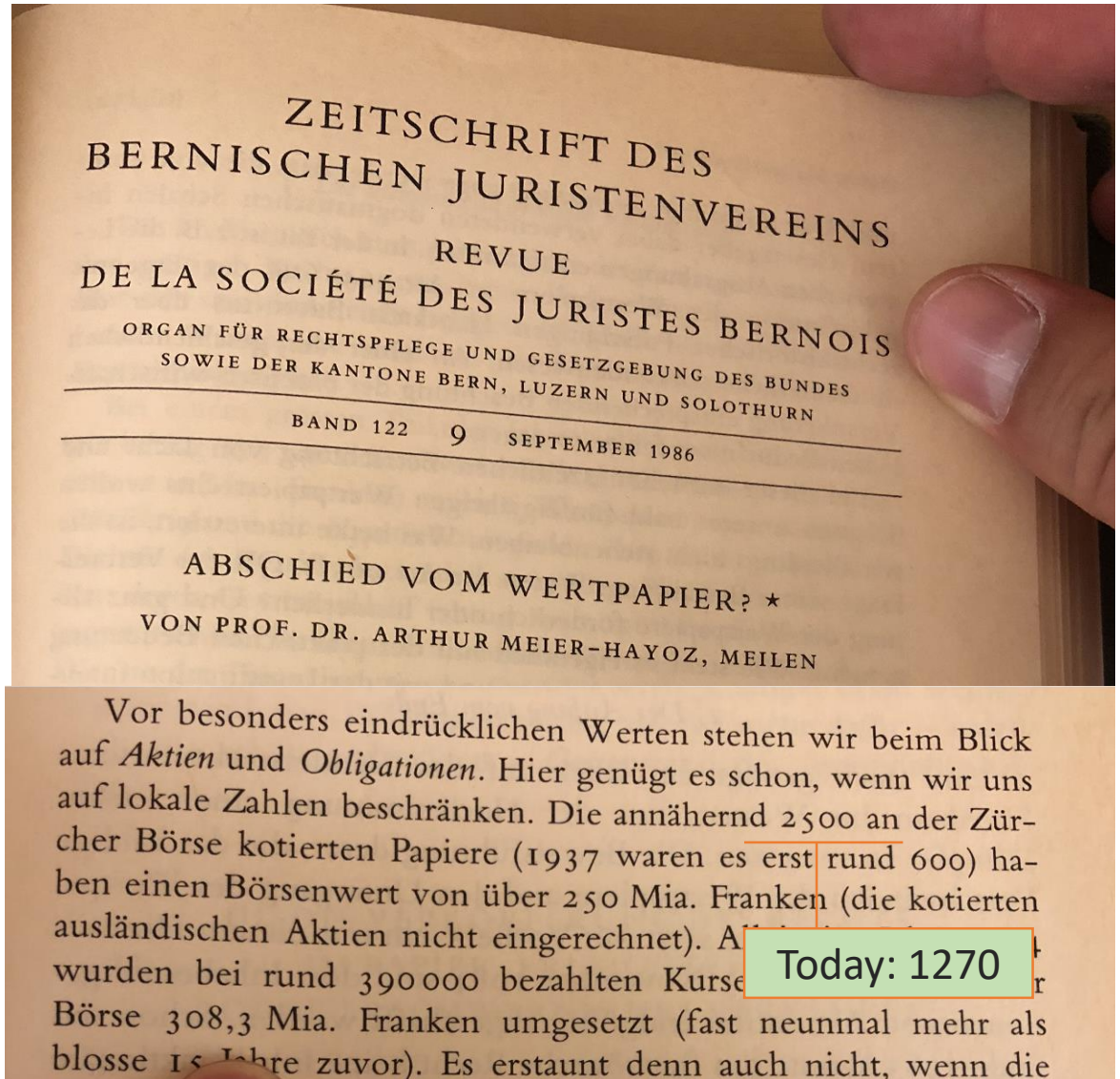
Note that regulation that aimed at making the markets safer by restricting banks from trading for their own accounts made markets for such stocks even less liquid than they used to be! (And therefor markets more volatile and less safe.)
In Switzerland, “stamp duties” (0.15% on every trade) also reduce liquidity. (Only 15% of our volume is high-frequency trading.)

Dynamic equilibria are more natural

- The health of a forrest is determined by the young trees
- Making old trees support each other makes the system as a whole more fragile
- Tree line: small incremental differences in the surrounding conditions can have a huge impact



A Declining Tree Line?



ZEITSCHRIFT DES
BERNISCHEN JURISTENVEREINS

REVUE
DE LA SOCIÉTÉ DES JURISTES BERNOIS

ORGAN FÜR RECHTSPFLEGE UND GESETZGEBUNG DES BUNDES
SOWIE DER KANTONE BERN, LUZERN UND SOLOTHURN

BAND 122 9 SEPTEMBER 1986

ABSCHIED VOM WERTPAPIER? *

VON PROF. DR. ARTHUR MEIER-HAYOZ, MEILEN

Vor besonders eindrücklichen Werten stehen wir beim Blick auf *Aktien* und *Obligationen*. Hier genügt es schon, wenn wir uns auf lokale Zahlen beschränken. Die annähernd 2500 an der Zürcher Börse kotierten Papiere (1937 waren es erst rund 600) haben einen Börsenwert von über 250 Mia. Franken (die kotierten ausländischen Aktien nicht eingerechnet). A
wurden bei rund 390000 bezahlten Kurse
Börse 308,3 Mia. Franken umgesetzt (fast neunmal mehr als
blosse 15 Jahre zuvor). Es erstaunt denn auch nicht, wenn die

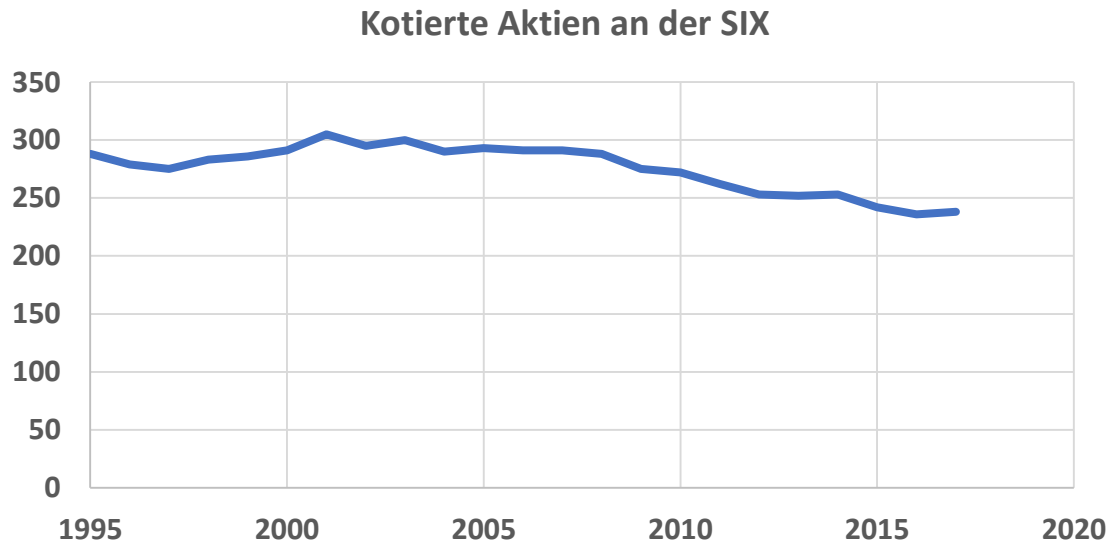
Today: 1270

Tabelle 1

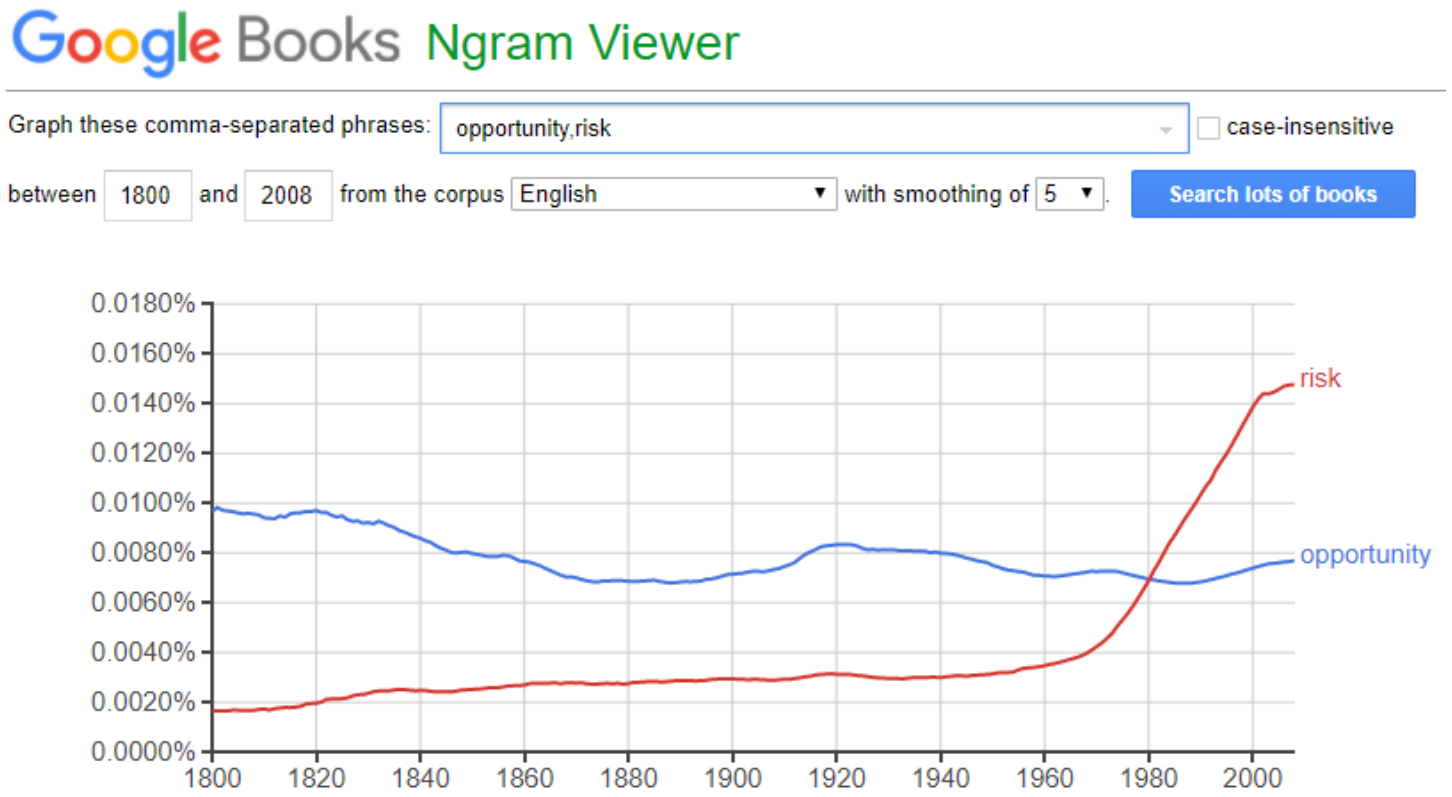
Wertschöpfung, in Mio. Franken

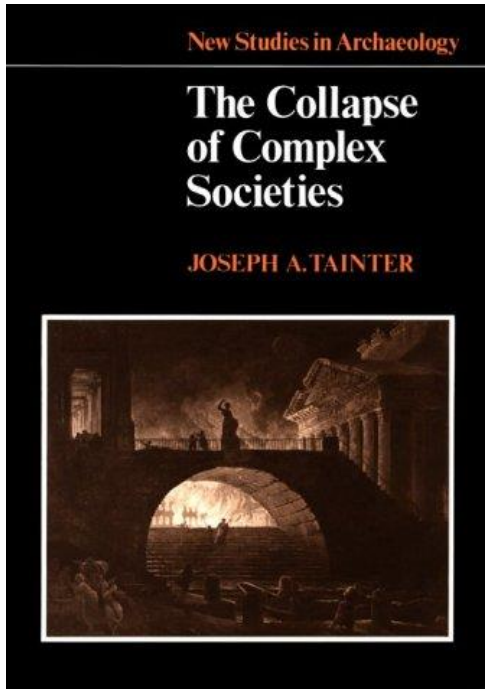
	2007	2012	2017
Finanzdienstleistungen	47 068	34 581	30 787
Versicherungsdienstleistungen	26 777	28 429	29 951
Total Finanzstandort	**73 845**	**63 010**	**60 738**
in % des BIP	**12,8**	**10,1**	**9,1**
BIP Schweiz	576 088	626 414	668 149

Daten: BFS / SECO, Jahresaggregate des BIP, Produktionsansatz (Jahreswerte).



Risk: Risk-Aversion (personal, unscientific hypothesis)





«Compliance is not a product.» - Daniel Aegerter, Fintech-Investor

«Die grösste Sorge bereitet mir, dass wir als Gesellschaft keine Risiken mehr eingehen. Darunter leidet unsere Wirtschaft und unsere Bildung. Angst tötet die besten Ideen.» - Patrick Aebischer, EPFL

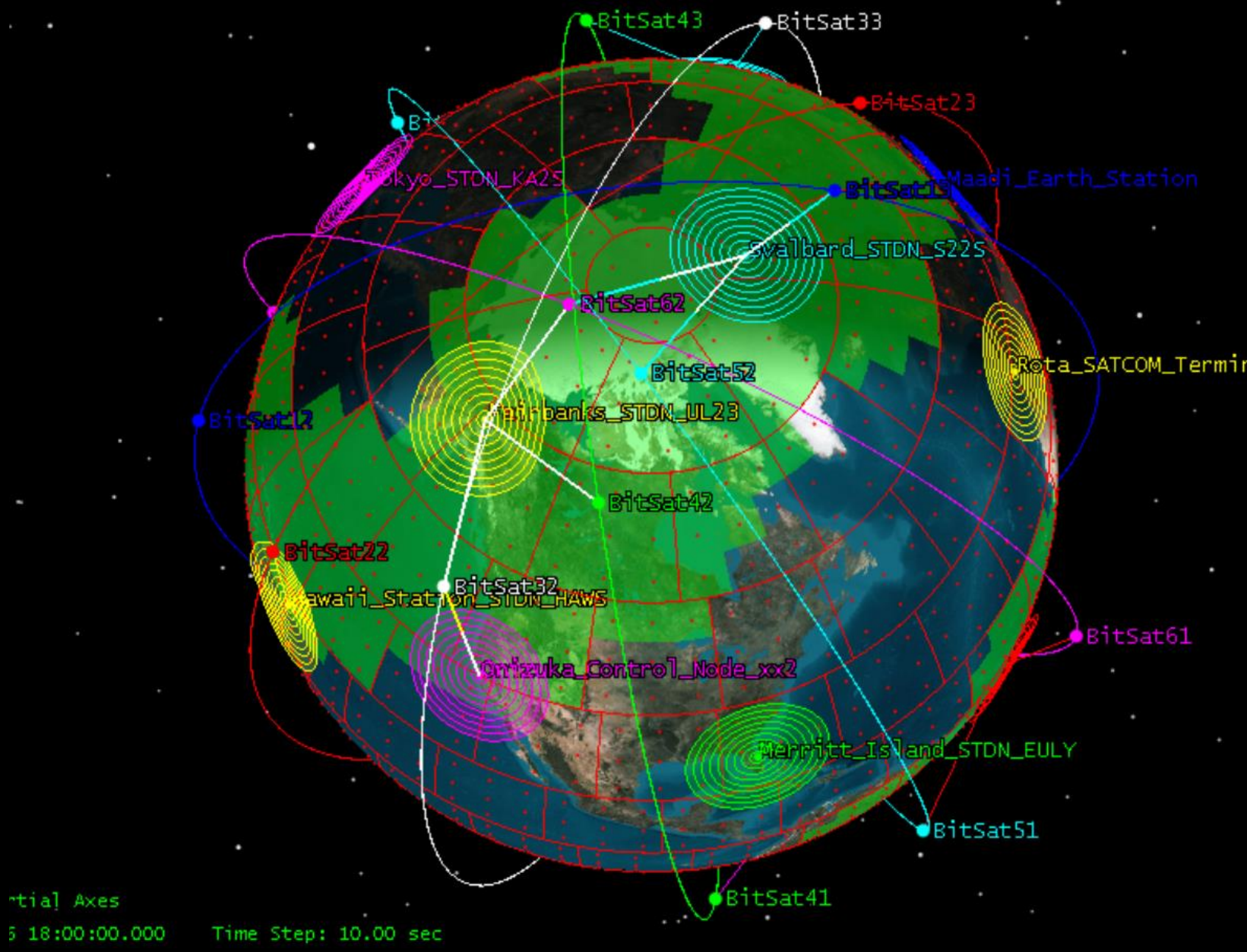
«Ältere Menschen neigen dazu, Risiken zu vermeiden. Sie wollen nicht verlieren, was sie in den letzten 30 oder 40 Jahren aufgebaut haben. Doch ohne Risiken gibt es keine Innovation, kein Wachstum, keinen Wohlstand. Wenn eine ganze Gesellschaft Risiko-avers wird, bleiben wir stehen." – Oswald Grübel

BITCOIN VISION

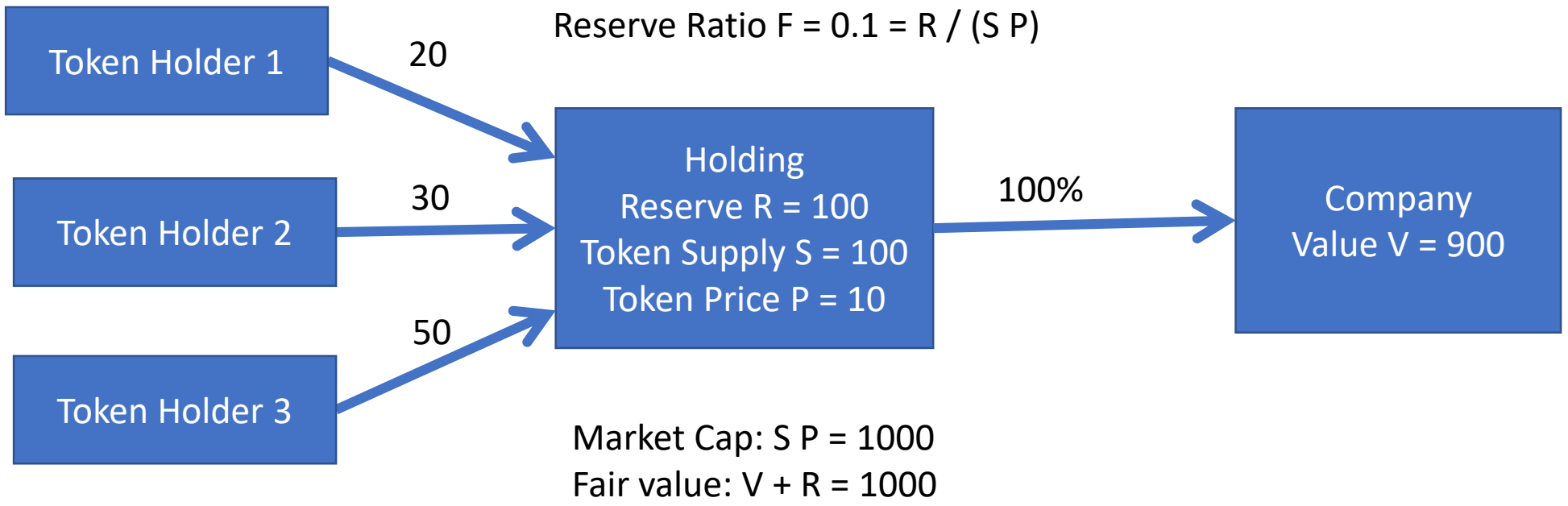
A decentralized, world-wide and free financial system.

An Internet of Finance.

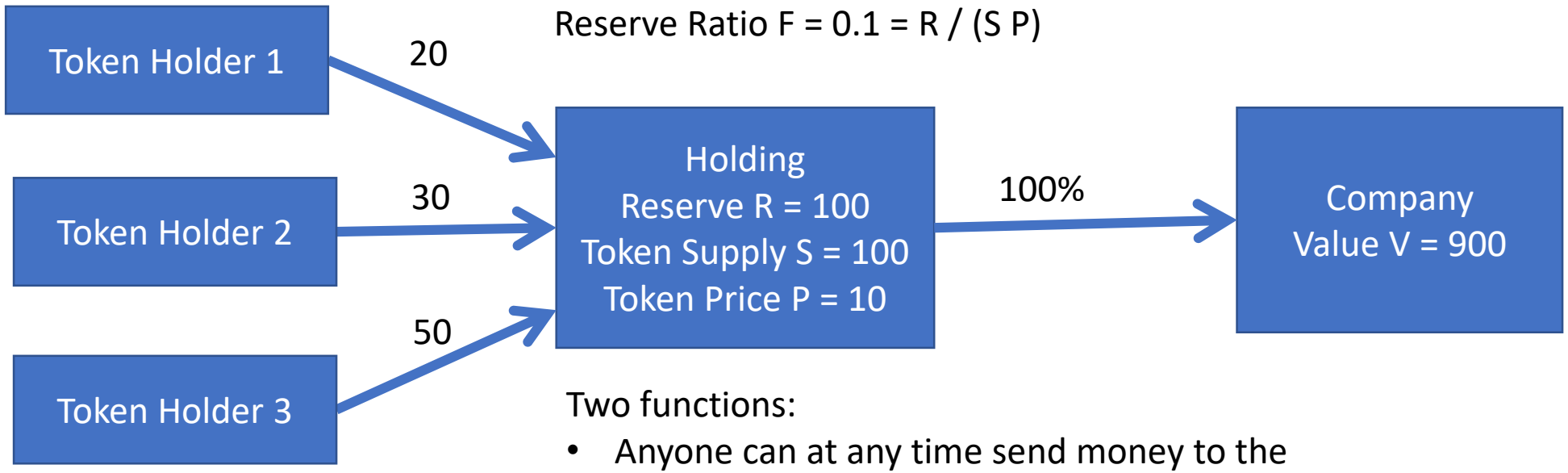
Anyone can transact with anyone else at any time.



Bancor


Token Holder 1
Token Holder 2
Token Holder 3
20
30
50
Reserve Ratio F = 0.1 = R / (S P)
Holding
Reserve R = 100
Token Supply S = 100
Token Price P = 10
100%
Company
Value V = 900
Market Cap: S P = 1000
Fair value: V + R = 1000

Bancor



Two functions:

- Anyone can at any time send money to the Holding and get newly minted tokens in return
- Any token holder can at any time send tokens to the Holding to destroy them and get money in return

→ The Holding guarantees liquidity.
But how is the price calculated?

Bancor: Buying and Selling

R: Reserve
P: Price per token
S: Token supply
F: Reserve ratio
dS: marginal amount of Tokens to be bought

E: Amount sent to the Holding
T: Tokens returned to the buyer

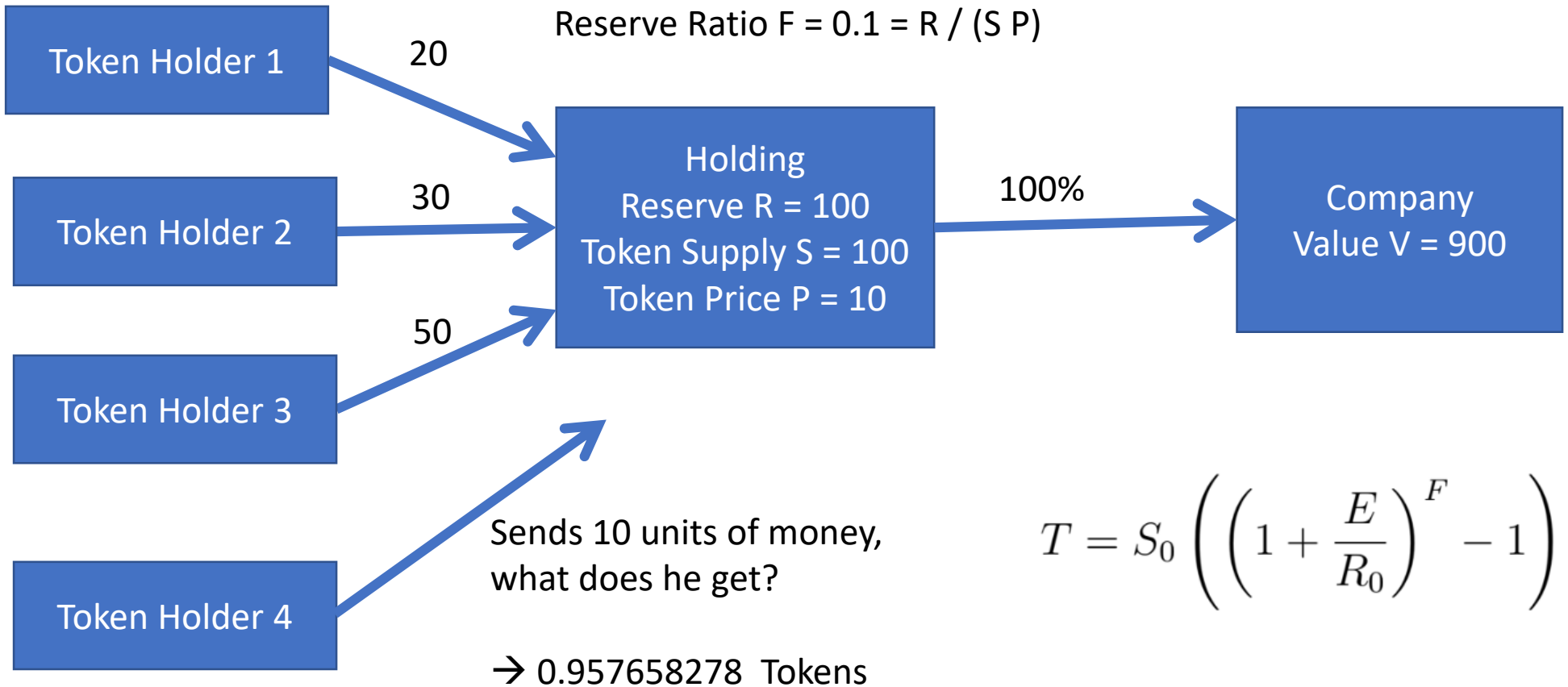
$$P\ dS = dR = F(S\ dP + P\ dS)$$

$$P\ dS(1 - F) = FS\ dP$$

$$E = R_0 \left(\sqrt[F]{1 + \frac{T}{S_0}} - 1 \right)$$

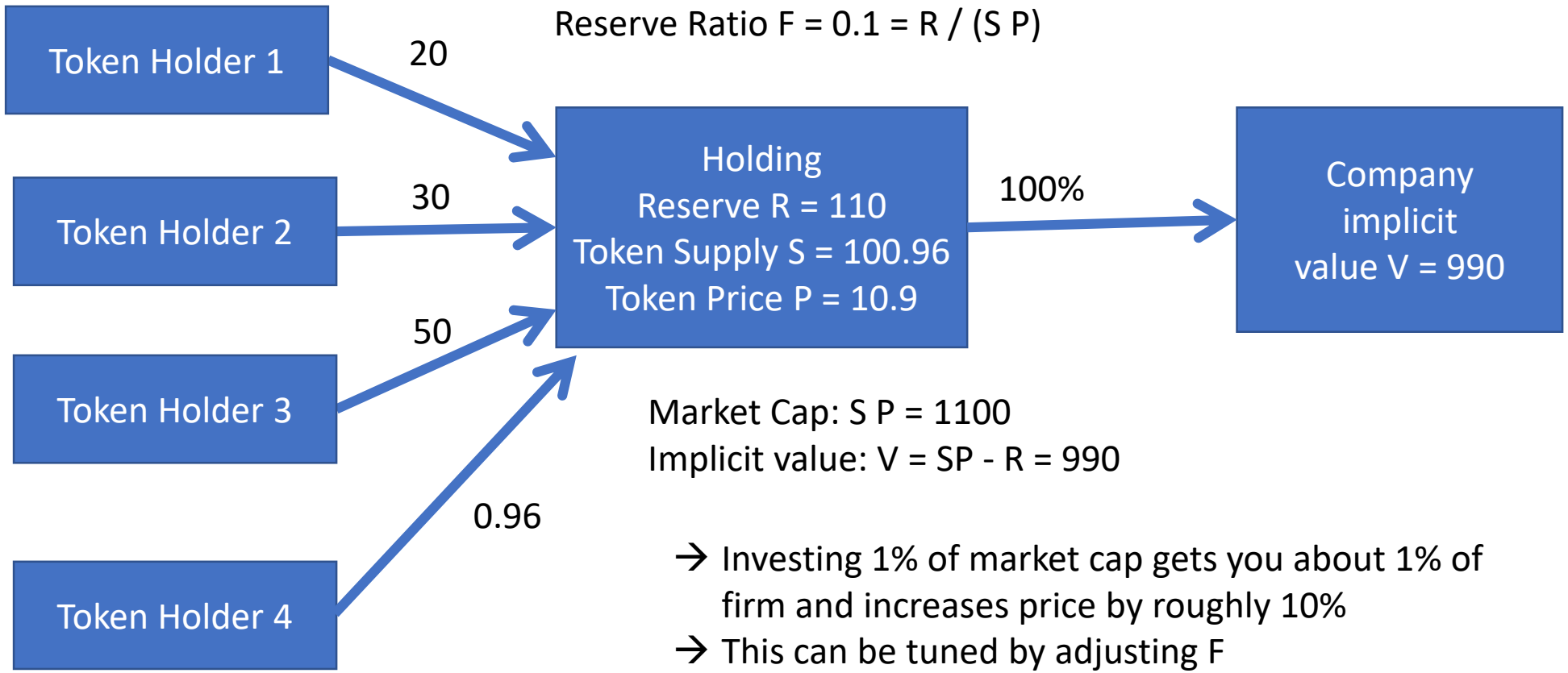
$$T = S_0 \left(\left(1 + \frac{E}{R_0} \right)^F - 1 \right)$$

Example: Before Buying



$$T = S_0 \left(\left(1 + \frac{E}{R_0} \right)^F - 1 \right)$$

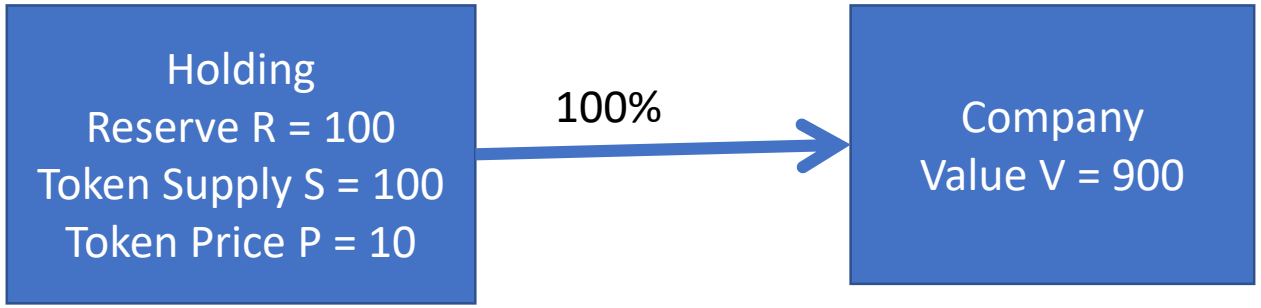
Example: After Buying



Properties

- Lower volatility
- Firm is always liquid (to a certain degree). Is this enough to reap the liquidity premium of 25%?
- Incentivizes active shareholders (holders get diluted when not buying undervalued stocks)
- If everyone sells everything, they will get about 10% of the official price at average.
- Short squeezes become impossible (or at least much harder)
- Anyone can buy shares at any time, but thanks to price adjustment, a hostile take-over (buying 51%) costs 100x current market cap.
- Also implies: if a founder owns a growing company, he will lose his majority after it has grown 100-fold, unless he keeps buying shares himself
- Costs for economy as a whole is 0, as the reserve is nominal and does not bind physical capital. Printing CHF and putting them into a Bancor-style reserve does not affect inflation as the monetary velocity declines accordingly.

What if the Company can access the reserve?



Four possible cases:

- Firm can “push” money into the reserve. This is equivalent to dividend payments or share buybacks.
- Shareholders can “pull” money out of the firm: this is probably a bad idea and might even be illegal.
- Firm can “pull” money out of the reserve. This is equivalent to a small capital increase. Not sure if that is desirable as it might send a bad signal.
- Shareholders can “push” money into the firm: e.g. whenever someone buys a token, let him choose what % of the proceeds should go into the reserve and what into the company.
  → Allows fast growing companies like Tesla to better finance themselves without the stigma of a capital increase.

Properties of Capital Push Option

- Financial markets have more direct influence over capital allocation in real economy by pushing money into promising sectors
- Bubbles probably less extreme as part of the inflow is redirected into company instead of pushing price upwards
- New IPO model: just list existing shares and raise capital slowly over time
- Many more companies could get listed and tap into capital markets, not just 0.1% like today.
- Thanks to the Bancor incentives, prices are could be fairer for small investors?

Is anyone aware of any relevant literature?
Seems an underresearched topic…

Exercise 5: Stock market

- Invest in the stock market instead of saving
- How to choose the right stocks?

github.com/meisser/course/blob/master/exercises/journal/exercise05-task.md