



University of  
Zurich <sup>UZH</sup>

# **Agent-based Financial Economics**

## **Lesson 4: Adaptive Behavior**

Luzius Meisser, Prof. Thorsten Hens

[luzius@meissereconomics.com](mailto:luzius@meissereconomics.com)

“What I cannot create, I do not understand.”

- Richard Feynman

# Today

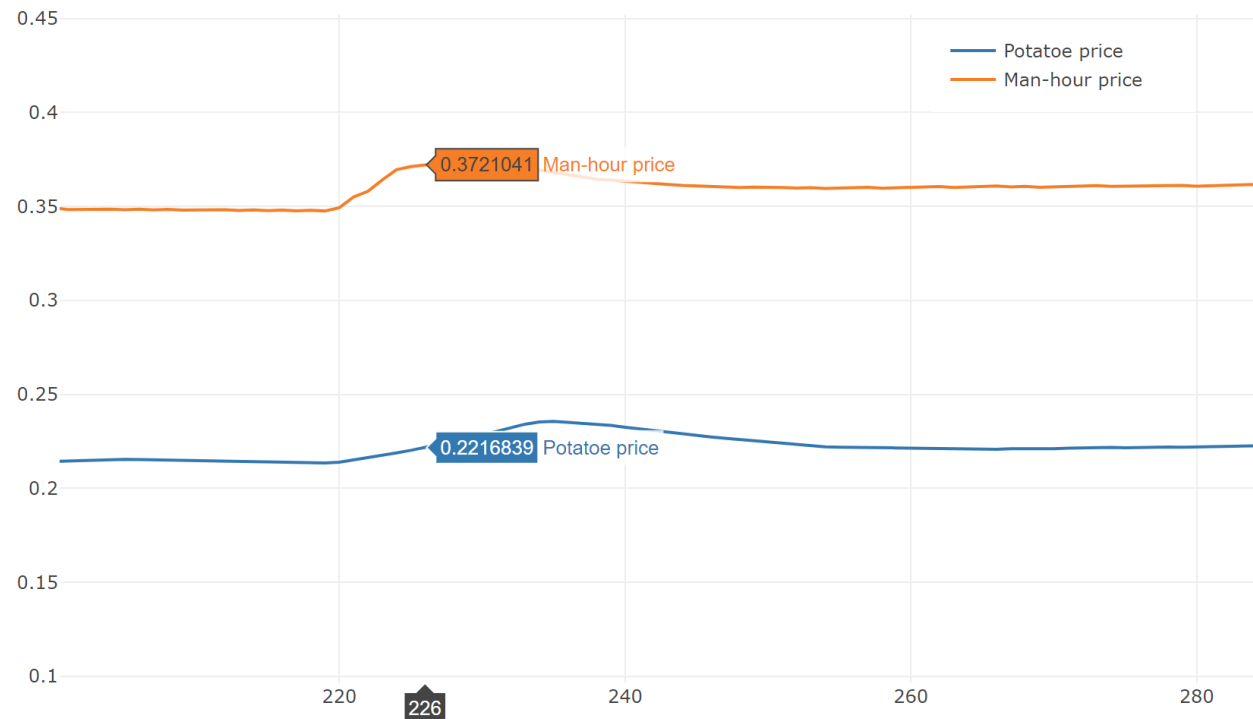
- Discussion of exercise 2
- Methodology: Agile Software Development
- Exercise 3: adaptive behavior



# Exercise 2, Task 1, Helicopter Money

## Findings:

- Helicopter money gives test consumer indeed an advantage, utility goes from 6.1 to 6.16
- Money supply goes from 5000 to 5200, potatoe prices accordingly from 0.215 to 0.224  
→ Neutrality of money holds in the long run, but short term bumps with different timing per good.



# Exercise 2, Task 2, Interest

## Findings:

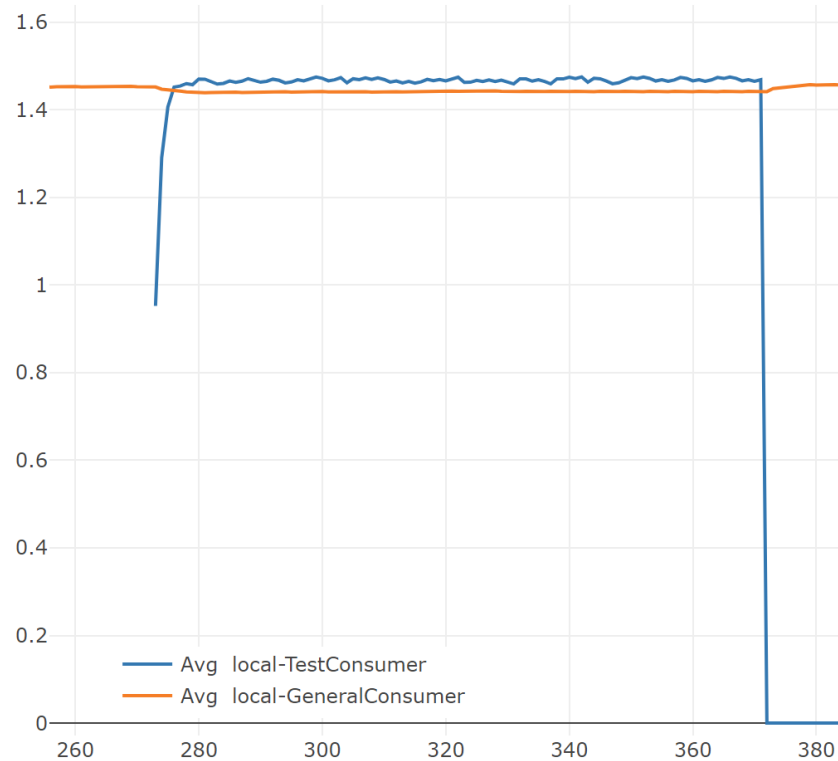
- Interest changes game completely, suddenly there is an incentive to hoard money
  - In equilibrium, the interest rate should equal the discount rate  
Interest rate:  $(\text{dividends}) / (\text{cash held by consumers})$   
Discount rate:  $(\text{probability of death}) = 0.01$
  - When interest rate  $>$  discount rate, it pays off to save more and vice versa
- Equilibrium at around MONEY\_RESERVE = 0.9825 with utility 6.02
- Lower than utility of 6.1 in equal distribution mode or when MONEY\_RESERVE = 0.2 for everyone

What happened?

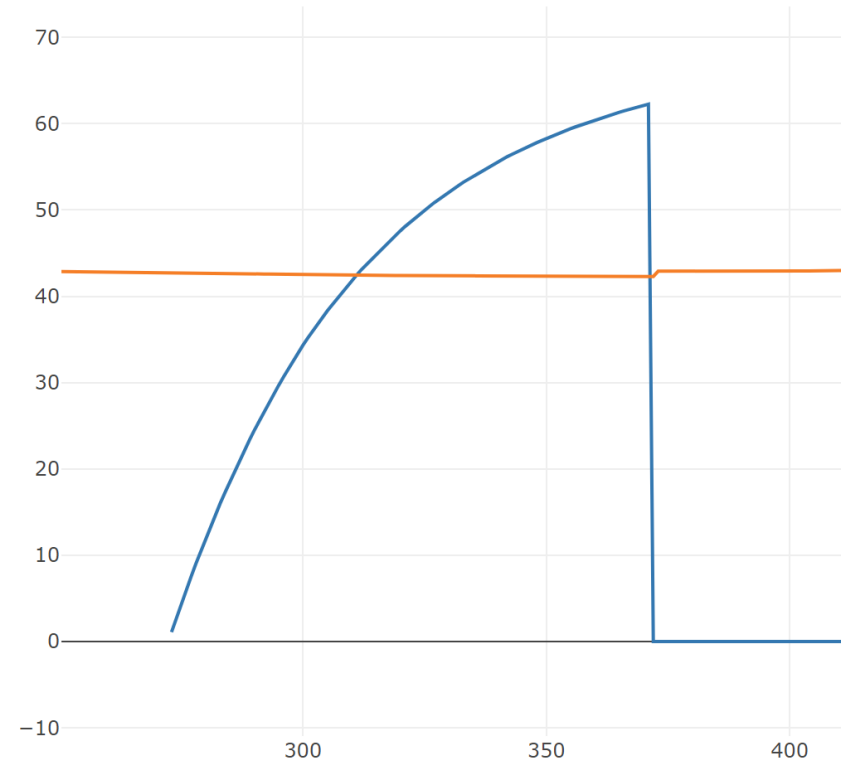
[Discussion]

Note: results might be numerically a little different in your version of the exercise.

# Exercise 2, Task 2, Interest



Buffer = 0.2, equilibrium level of savings is quickly reached, everyone gets the same interest.



Buffer = 0.9825, TestConsumer struggles all his life to accumulate savings. Lots of money, but lower utility due to skewed consumption (the old consume more).

# Exercise 2, Task 3, Ranking

Rank	Consumer	Utility	BUFFER
	team202- 1GeneralConsumer	5.688186009	0.972
	team203- 2GeneralConsumer	5.590249804	0.4
	team205- 3GeneralConsumer	5.562341747	Golden Ratio Search
	team201- 4GeneralConsumer	5.498744615	0.97
	team207- 5GeneralConsumer	5.490555934	0.9523
	team208- 6GeneralConsumer	5.412354075	0.96
	team210- 7GeneralConsumer	5.40331905	0.85

Official setting. Not sure what is going on.

# Exercise 2, Task 3, Ranking

Rank	Consumer	Utility	BUFFER
1	team201-GeneralConsumer	6.263505967	0.97
2	team202-GeneralConsumer	6.247368871	0.972
3	team208-GeneralConsumer	6.120155917	0.96
4	team207-GeneralConsumer	6.062996441	0.9523
5	team210-GeneralConsumer	5.816803435	0.85
7	team205-GeneralConsumer	5.713784053	Golden Ratio Search
8	team203-GeneralConsumer	5.700209242	0.4

Simplified setting with constant life-spans of 100 days. → We get the expected result.

# Interest Experiment

What happens when printing new money in addition to the distributed amounts?

It looks like higher nominal interest rates lead to higher inflation!

In fact, in our simulation, it holds that interest rates = inflation rate.

This is exactly the opposite of what can be observed in reality, where national banks lower interest rates to increase inflation and vice versa.

Why is that? Our model has no credit yet. In reality, lower interest rates make firms borrow more money from the central bank, thereby increasing money supply, at least for as long as the debt is not repaid.

Excellent thoughts by John Cochrane on this issue can be found here:

Cochrane, J.H., 2016. Do higher interest rates raise or lower inflation?. *Unpublished paper, February*, <https://faculty.chicagobooth.edu/john.cochrane/research/papers/fisher.pdf>



# Interest Experiment

An interesting question you might have asked yourself while doing task 2 is: if interest is being paid on cash holdings, can an agent gain an advantage by hoarding cash?

The answer is: no! As long as the inflation rate is the same as the interest rate, hoarding cash is futile.

However, inflation rate could fall below interest rate as soon as negative cash balances are allowed. In such a scenario, net money supply and thus also inflation grows at a slower rate than the interest rate. This is equivalent to agents being in debt with other agents.

Generally, money should be neutral if everyone acts rationally. I.e. the nominal amount of money in circulation should make no difference for real economic activity. (But the way newly printed money is distributed does.)

Neutrality of Money (Patinkin, D. (1987). Neutrality of money, *The New Palgrave: A Dictionary of Economics* v.3, 639–644.)

# The Code is the Model

- How to apply principles from modern software engineering to building computational economic models
  - Published in the Journal of Microsimulation, 2018
  - Very mixed feedback, from fierce resistance to enthusiastic agreement 😊
- See separate slide deck

# Exercise 4: Adaptive Behavior

See task file.