



University of
Zurich ^{UZH}

Agent-based Financial Economics

Lesson 13: Presentations and Wrap-up

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

- Richard Feynman

Today

- Presentation by Team 2
- Presentation by Team 3
- Production with memory
- Simulation analysis
- What next? Career ideas.

Production with memory

Standard case:

$$\begin{aligned}\Pi(h) &= p h^{\alpha} - w h \\ L &= 1 \\ \frac{d\Pi}{dh} &= \alpha h^{\alpha-1} - w \stackrel{!}{=} 0 \quad \Rightarrow \quad wh = \alpha h^{\alpha} \quad \text{labor share} \\ \Rightarrow \quad \Pi &= h^{\alpha} - \alpha h^{\alpha} = \underbrace{(1-\alpha)}_{\text{profit share}} h^{\alpha}\end{aligned}$$

Production with memory

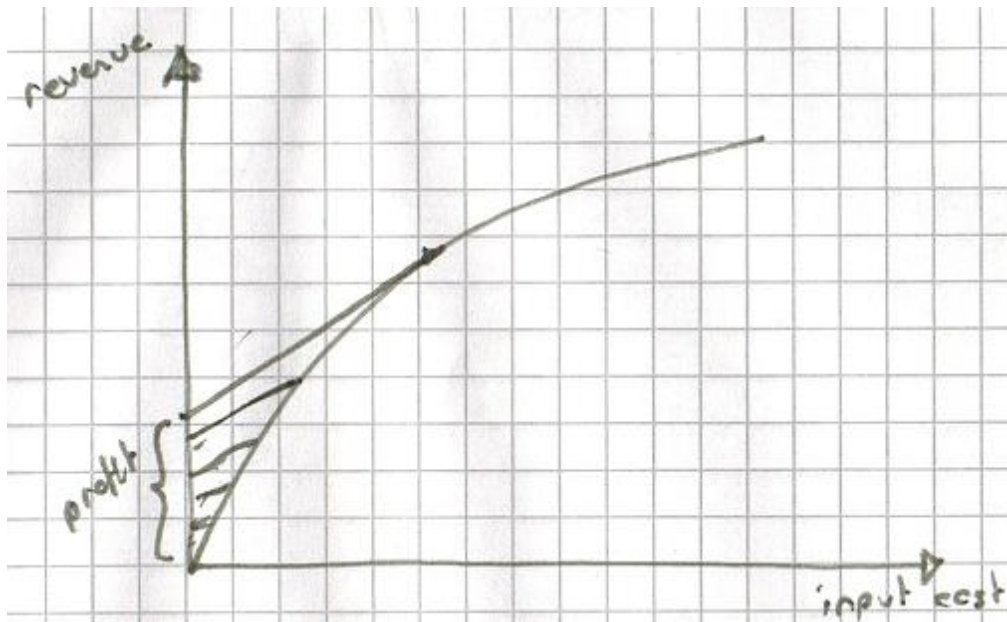
With memory:

$$\Pi(h) = \underbrace{(h+h_c)^\alpha - h_c^\alpha}_{\text{incremental production}} - wh$$
$$\frac{d\Pi}{dh} = \alpha(h+h_c)^{\alpha-1} - w \stackrel{!}{=} 0$$
$$\Rightarrow w(h+h_c) = \alpha(h+h_c)^\alpha \quad \Rightarrow wh = \underbrace{\alpha(h+h_c)^\alpha}_{\text{total revenue so far}} - wh_c$$

labor share is total revenue so far minus total cost

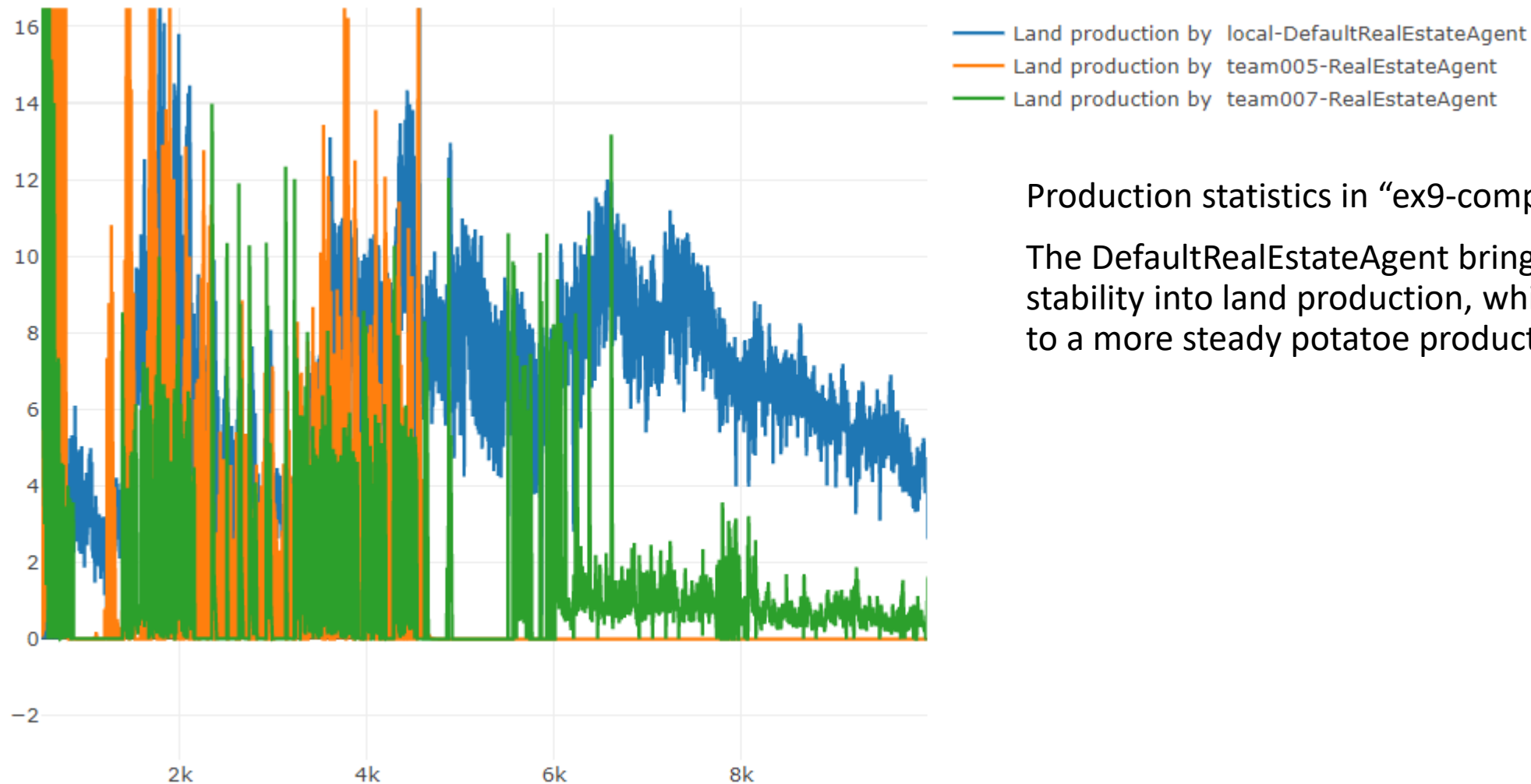
Production with memory

With memory:



$$\begin{aligned}
 wh &= \alpha(h+h_0)^\alpha - wh_0 \\
 &= \underbrace{\alpha((h+h_0)^\alpha - h_0^\alpha)}_{\text{current revenue}} + \underbrace{\alpha h_0^\alpha}_{\text{revenue so far}} - \underbrace{wh_0}_{\text{cost so far}} \\
 &\quad \underbrace{\hspace{10em}}_{> 0 \text{ if optimum not yet reached}} \\
 wh &< \alpha((h+h_0)^\alpha - h_0^\alpha) \\
 \text{labor share is smaller than } \alpha \cdot \text{revenue!}
 \end{aligned}$$

Production with memory



Production statistics in “ex9-competitive-4”.

The DefaultRealEstateAgent brings some stability into land production, which also leads to a more steady potatoe production.

Production with memory

```
@Override
public void offer(IPriceMakerMarket market) {
    IStock money = getMoney();
    IStock land = getLand();

    double marginalCost = getMarginalCost();
    double priceBelief = landPrice.getValue();
    boolean exploration = marginalCost > priceBelief;

    // if we can buy land below marginal costs, buy as much as possible
    Price bidPrice = new Price(LAND, Math.min(marginalCost, priceBelief) * 0.9);
    market.offer(new Bid(this, money, land, bidPrice, bidPrice.getAmountAt(money.getAmount())));

    if (land.hasSome()) {
        Price askPrice = new Price(LAND, priceBelief);
        double amount = exploration ? 0.01 : LAND_SELL_RATIO * land.getAmount();
        currentAsk = new Ask(this, money, land, askPrice, amount);
        market.offer(currentAsk);
    } else {
        currentAsk = null;
    }

    if (exploration) {
        // buy only very little man hours for price exploration
        this.input.createOffers(market, this, getMoney(), 1);
    } else {
        // buy some man-hours to produce additional land
        this.input.createOffers(market, this, getMoney(), getMoney().getAmount() / 3);
    }
}
```

Heuristic based on marginal cost.

- Buy below marginal cost and price if possible.
- Produce when marginal cost lower than price.
- Always do a little bit to sustain reasonable price beliefs (exploration)

Production with memory

Consequences:

- Average labor share until equilibrium is reached is α
- Initially, labor share is smaller and profit share larger
→ When using the standard rule to calculate dividends, we will retain some profits, which is good!
- At some point (before the equilibrium is reached), producing more will drain the cash reserve.
- We will end up at exactly 0 cash reserves once the final level is reached.
→ Paying $(1-\alpha) \cdot \text{revenues}$ as dividend is still an excellent heuristic! It leads us smoothly to the optimum. (But when there is competition, it might make sense to retain even more profits initially.)

Simulation Analysis

Ranking of <http://meissereconomics.com/vis/simulation?sim=ex9-competitive-3>

Rank	Consumer	Utility	Source	Version
1	course-InvestingConsumer	4.59751783196456	source	Luzius Meisser on 2017-12-07T23:20:53Z

Traditionally, firms optimize profits. However, in agent-based simulations, it is more sensible to rank them by total dividends paid to consumer-shareholders. In a world, in which firms are allowed to own each others shares, it would be trivial to create infinite profits just by sending dividends back and forth between two companies that own each other. Thus, we need a more elaborate metric.

Rank	Firm	Dividends	Source	Version
1	team010-InvestmentFund	715660422	source	Robin Stohler on 2017-12-09T08:47:29Z
2	course-DefaultFarm	17841423	source	Luzius Meisser on 2017-12-07T23:20:53Z
3	team002-LandBuyingFarm	16349940	source	claudio on 2017-12-14T22:11:49Z
4	course-MarketMaker	7052034	source	Luzius Meisser on 2017-12-07T23:20:53Z
5	team001-InvestmentFund	3458637	source	Steven Battilana on 2017-12-08T16:28:19Z
6	team007-RealEstateAgent	224920	source	Timothy Zemp on 2017-12-08T13:58:33Z
7	team003-LandBuyingFarm	200325	source	Nico-PC on 2017-12-14T20:46:53Z
8	team005-RealEstateAgent	67415	source	dhivyaCSPro on 2017-12-08T10:02:46Z

Adding some default agents adds stability and improves utility, even though my agents do not perform very well.
 Tag: “ex9-consumer-owned-funds-5” (misleading name, as funds can still buy each other)

Rank	Consumer	Utility	Source	Version
1	course-InvestingConsumer	5.003190241220171	source	Luzius Meisser on 2017-12-11T10:45:46Z

Traditionally, firms optimize profits. However, in agent-based simulations, it is more sensible to rank them by total dividends paid to consumer-shareholders. In a world, in which firms are allowed to own each others shares, it would be trivial to create infinite profits just by sending dividends back and forth between two companies that own each other. Thus, we need a more elaborate metric.

Rank	Firm	Dividends	Source	Version
1	team010-InvestmentFund	203470147	source	Robin Stohler on 2017-12-09T08:47:29Z
2	team002-LandBuyingFarm	8514959	source	claude on 2017-12-14T22:11:49Z
3	course-MarketMaker	6796251	source	Luzius Meisser on 2017-12-11T10:45:46Z
4	course-DefaultFarm	4838643	source	Luzius Meisser on 2017-12-11T10:45:46Z
5	course-DefaultInvestmentFund	1902562	source	Luzius Meisser on 2017-12-11T10:45:46Z
6	team003-LandBuyingFarm	1477818	source	Nico-PC on 2017-12-14T20:46:53Z
7	team001-InvestmentFund	792668	source	Steven Battilana on 2017-12-08T16:28:19Z
8	team005-RealEstateAgent	208774	source	dhivyaCSPro on 2017-12-08T10:02:46Z
9	team007-RealEstateAgent	172772	source	Timothy Zemp on 2017-12-08T13:58:33Z
10	course-DefaultRealEstateAgent	70045	source	Luzius Meisser on 2017-12-11T10:45:46Z

Test: disallowing funds from owning each other. Makes situation even more extreme -> discard change again.

Rank	Consumer	Utility	Source	Version
1	local-InvestingConsumer	4.99593632057208	source	local version Fri Dec 15 10:23:40 CET 2017

Traditionally, firms optimize profits. However, in agent-based simulations, it is more sensible to rank them by total dividends paid to consumer-shareholders. In a world, in which firms are allowed to own each others shares, it would be trivial to create infinite profits just by sending dividends back and forth between two companies that own each other. Thus, we need a more elaborate metric.

Rank	Firm	Dividends	Source	Version
1	team010-InvestmentFund	549036723	source	Robin Stohler on 2017-12-09T08:47:29Z
2	local-DefaultInvestmentFund	22390543	source	local version Fri Dec 15 10:23:40 CET 2017
3	team002-LandBuyingFarm	15256024	source	claudio on 2017-12-14T22:11:49Z
4	local-DefaultFarm	8137839	source	local version Fri Dec 15 10:23:40 CET 2017
5	local-MarketMaker	5954597	source	local version Fri Dec 15 10:23:40 CET 2017
6	team003-LandBuyingFarm	866185	source	Nico-PC on 2017-12-14T20:46:53Z
7	team001-InvestmentFund	254094	source	Steven Battilana on 2017-12-08T16:28:19Z
8	team005-RealEstateAgent	64483	source	dhivyaCSPro on 2017-12-08T10:02:46Z
9	team007-RealEstateAgent	57465	source	Timothy Zemp on 2017-12-08T13:58:33Z
10	local-DefaultRealEstateAgent	35321	source	local version Fri Dec 15 10:23:40 CET 2017

Additional change: switching to real dividends as a metric (dividing the daily dividend by a price index)

1	local-InvestingConsumer	5.001962510440906	source	local version Fri Dec 15 10:27:49 CET 2017
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(Funds still not allowed to buy each other.)

Traditionally, firms optimize profits. However, in agent-based simulations, it is more sensible to rank them by total dividends paid to consumer-shareholders. In a world, in which firms are allowed to own each others shares, it would be trivial to create infinite profits just by sending dividends back and forth between two companies that own each other. Thus, we need a more elaborate metric.

Rank	Firm	Dividends	Source	Version
1	team010-InvestmentFund	9047839	source	Robin Stohler on 2017-12-09T08:47:29Z
2	local-DefaultInvestmentFund	4460710	source	local version Fri Dec 15 10:27:49 CET 2017
3	local-DefaultFarm	1533009	source	local version Fri Dec 15 10:27:49 CET 2017
4	local-MarketMaker	468306	source	local version Fri Dec 15 10:27:49 CET 2017
5	team002-LandBuyingFarm	422222	source	claudio on 2017-12-14T22:11:49Z
6	team003-LandBuyingFarm	239040	source	Nico-PC on 2017-12-14T20:46:53Z
7	team001-InvestmentFund	88280	source	Steven Battilana on 2017-12-08T16:28:19Z
8	team005-RealEstateAgent	19284	source	dhivyaCSPRO on 2017-12-08T10:02:46Z
9	team007-RealEstateAgent	2295	source	Timothy Zemp on 2017-12-08T13:58:33Z
10	local-DefaultRealEstateAgent	216	source	local version Fri Dec 15 10:27:49 CET 2017

[Backup slide, skip in presentation]

Additional change: switching to real dividends as a metric (dividing the daily dividend by a price index)

Rank	Consumer	Utility	Source	Version
1	local-InvestingConsumer	4.930430571973335	source	local version Fri Dec 15 10:30:51 CET 2017

(Funds allowed to buy each other again.)

Traditionally, firms optimize profits. However, in agent-based simulations, it is more sensible to rank them by total dividends paid to consumer-shareholders. In a world, in which firms are allowed to own each others shares, it would be trivial to create infinite profits just by sending dividends back and forth between two companies that own each other. Thus, we need a more elaborate metric.

Rank	Firm	Dividends	Source	Version
1	team010-InvestmentFund	4823155	source	Robin Stohler on 2017-12-09T08:47:29Z
2	local-MarketMaker	1620503	source	local version Fri Dec 15 10:30:51 CET 2017
3	local-DefaultFarm	1476530	source	local version Fri Dec 15 10:30:51 CET 2017
4	local-DefaultInvestmentFund	838095	source	local version Fri Dec 15 10:30:51 CET 2017
5	team002-LandBuyingFarm	495192	source	claudio on 2017-12-14T22:11:49Z
6	team003-LandBuyingFarm	415638	source	Nico-PC on 2017-12-14T20:46:53Z
7	team001-InvestmentFund	256680	source	Steven Battilana on 2017-12-08T16:28:19Z
8	team005-RealEstateAgent	30831	source	dhivyaCSPro on 2017-12-08T10:02:46Z
9	team007-RealEstateAgent	9953	source	Timothy Zemp on 2017-12-08T13:58:33Z
10	local-DefaultRealEstateAgent	1984	source	local version Fri Dec 15 10:30:51 CET 2017

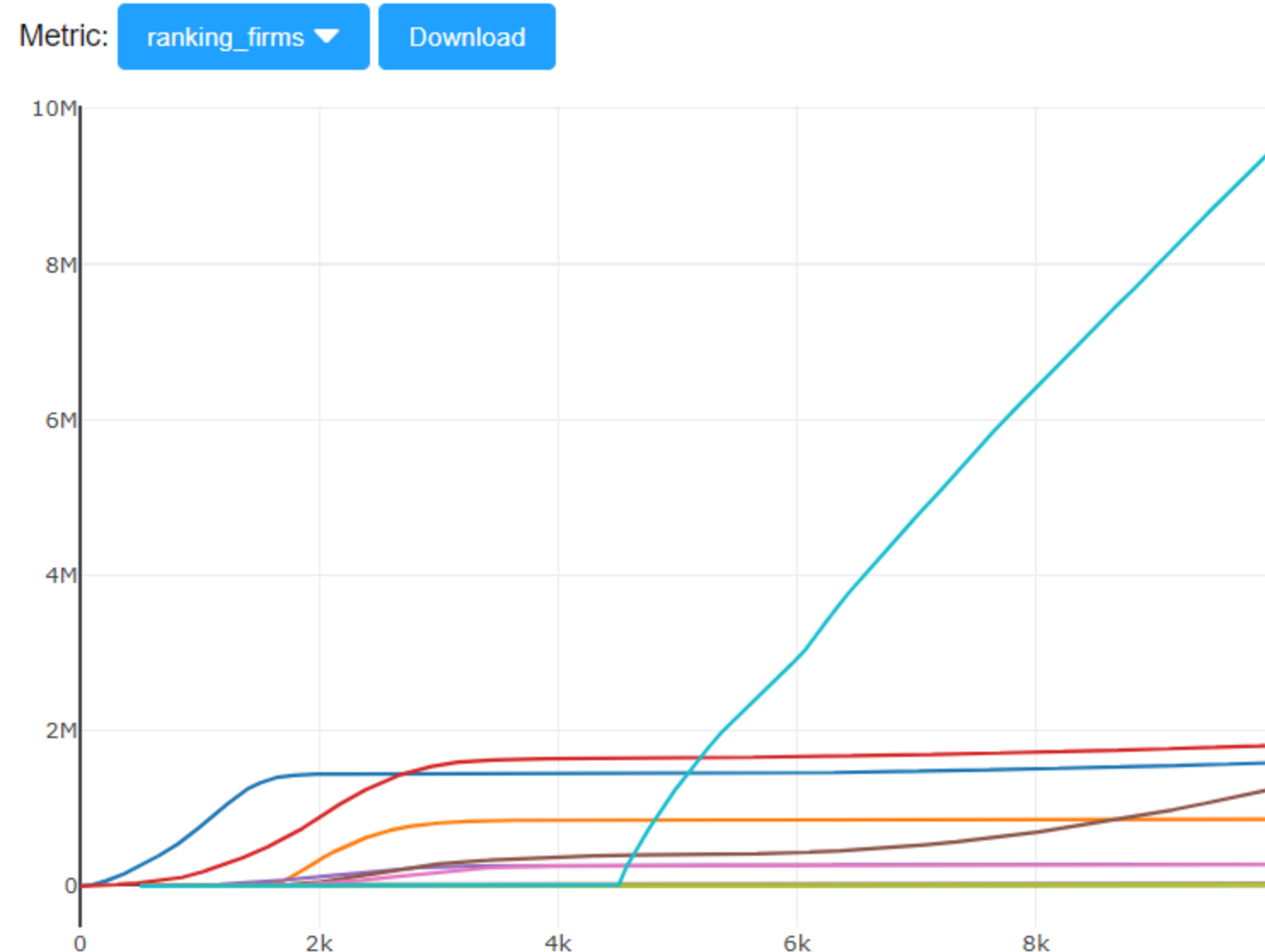
Additional change: extending time horizon to 10'000 days (ex9-competitive-4).

Rank	Consumer	Utility	Source	Version
1	local-InvestingConsumer	5.138283221053767	source	local version Fri Dec 15 10:36:01 CET 2017

Traditionally, firms optimize profits. However, in agent-based simulations, it is more sensible to rank them by total dividends paid to consumer-shareholders. In a world, in which firms are allowed to own each others shares, it would be trivial to create infinite profits just by sending dividends back and forth between two companies that own each other. Thus, we need a more elaborate metric.

Rank	Firm	Dividends	Source	Version
1	team010-InvestmentFund	10197581	source	Robin Stohler on 2017-12-09T08:47:29Z
2	local-MarketMaker	1919658	source	local version Fri Dec 15 10:36:01 CET 2017
3	local-DefaultFarm	1609163	source	local version Fri Dec 15 10:36:01 CET 2017
4	team002-LandBuyingFarm	1388323	source	claudio on 2017-12-14T22:11:49Z
5	local-DefaultInvestmentFund	734177	source	local version Fri Dec 15 10:36:01 CET 2017
6	team003-LandBuyingFarm	288964	source	Nico-PC on 2017-12-14T20:46:53Z
7	team001-InvestmentFund	256060	source	Steven Battilana on 2017-12-08T16:28:19Z
8	team005-RealEstateAgent	35409	source	dhivyaCSPro on 2017-12-08T10:02:46Z
9	team007-RealEstateAgent	13026	source	Timothy Zemp on 2017-12-08T13:58:33Z
10	local-DefaultRealEstateAgent	10762	source	local version Fri Dec 15 10:36:01 CET 2017

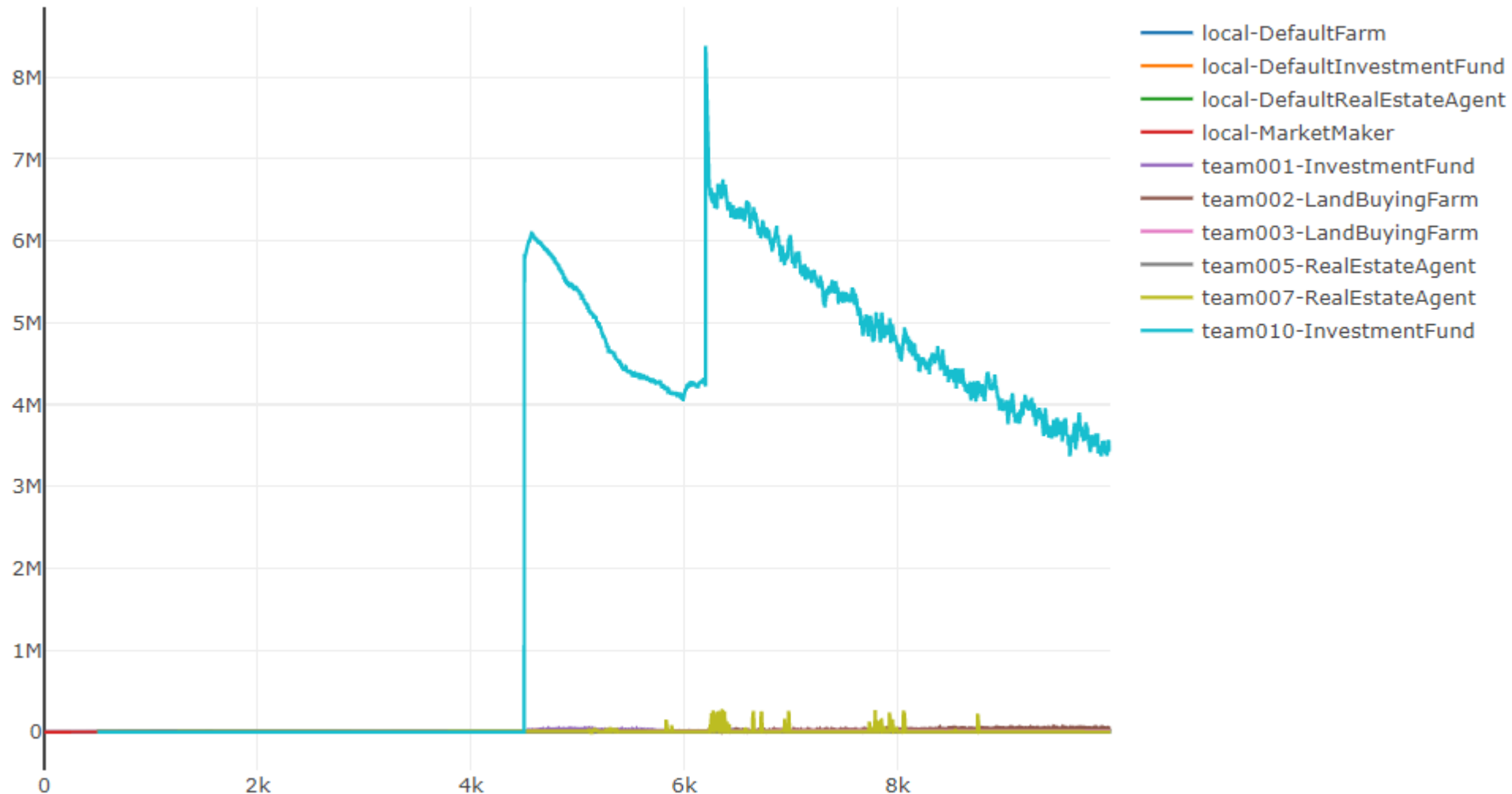
Simulation Analysis (ex9-competitive-4)



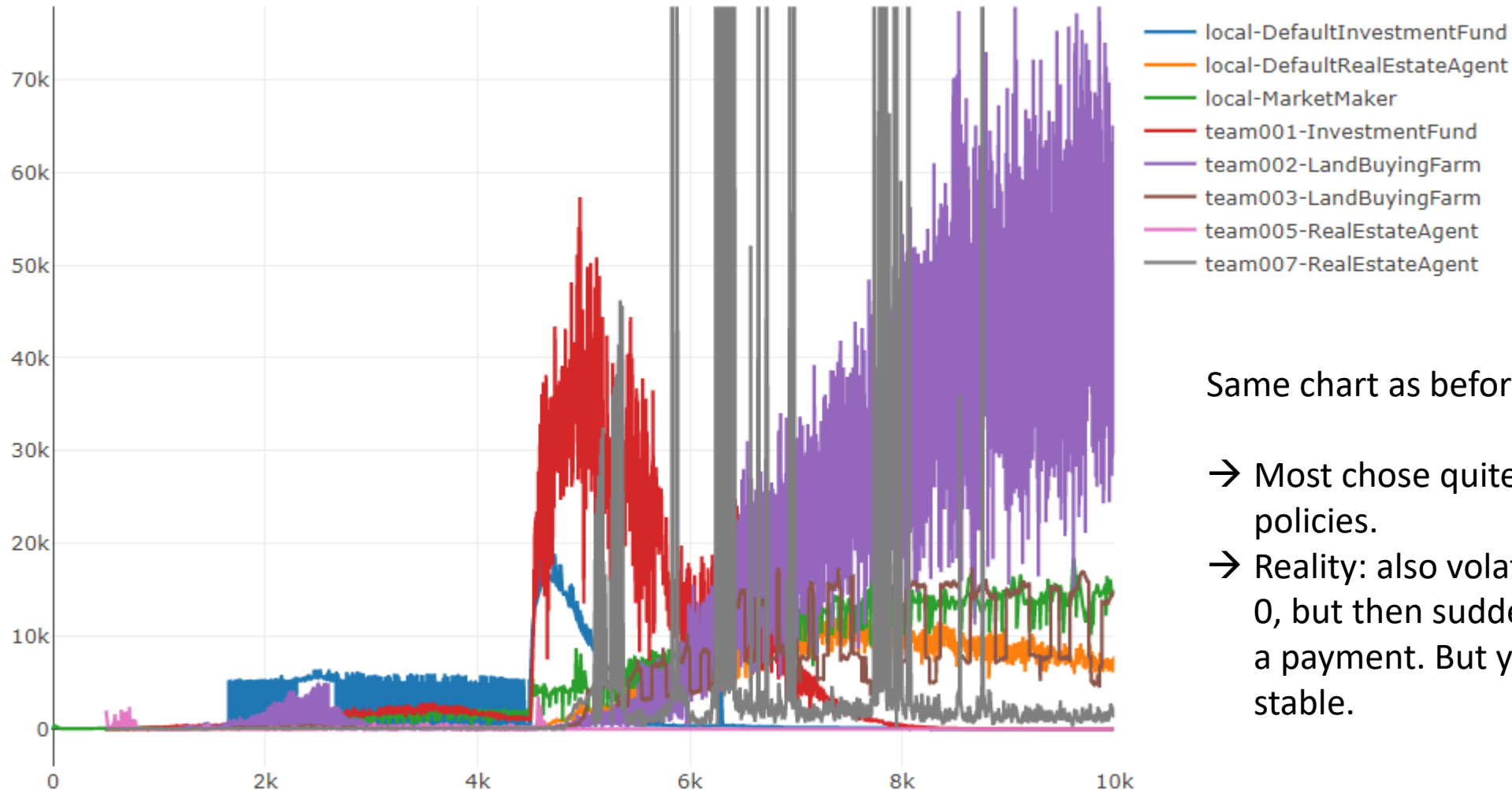
Team010 hoards money until day 4600 and then starts paying a dividend, increasing it at day 6200.

Investment strategy: market-cap-weighted random choice.

Simulation Analysis – Absolute dividends



Simulation Analysis – Absolute dividends



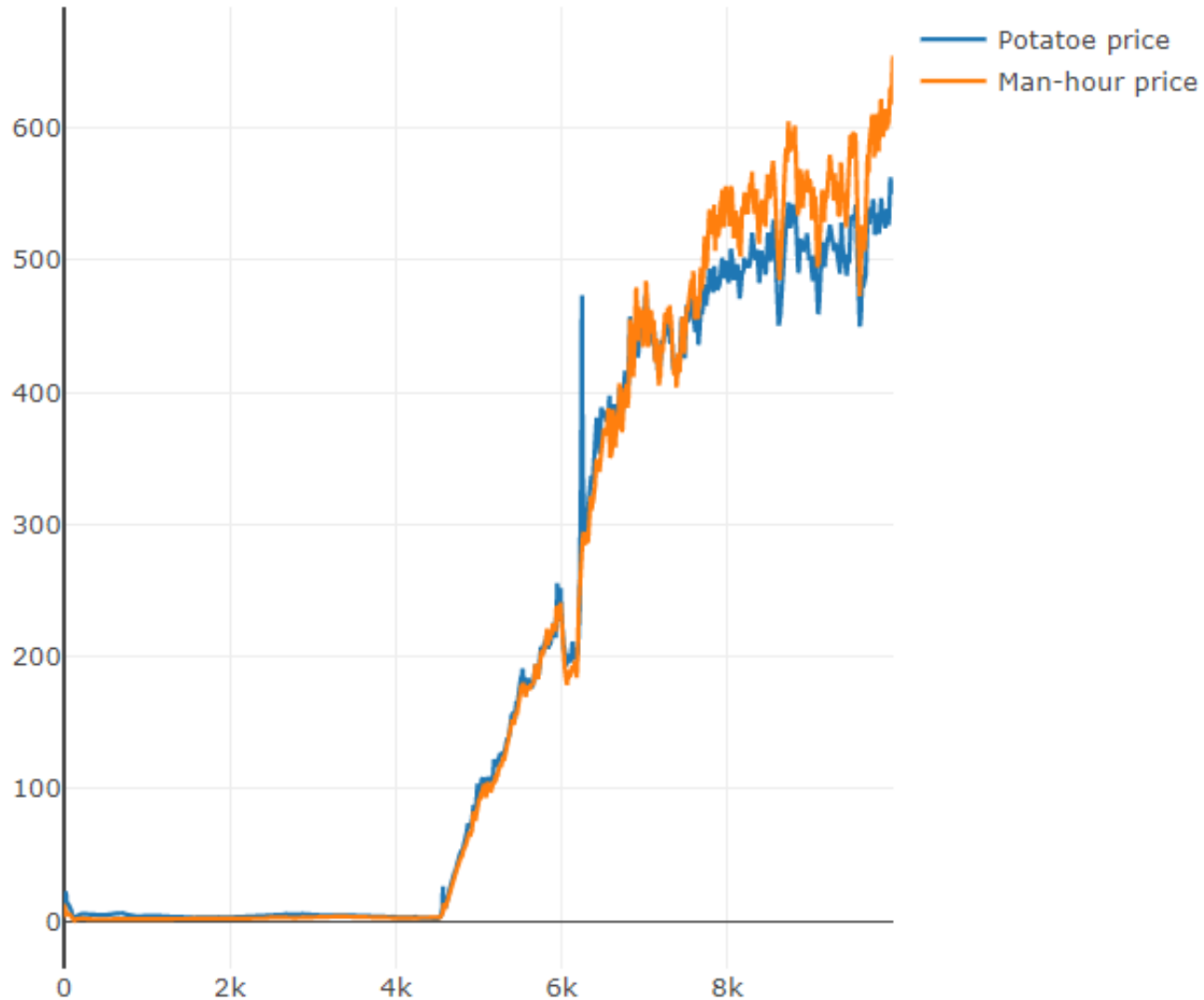
Same chart as before but without team 10.

- Most chose quite volatile dividend policies.
- Reality: also volatile. On most days, it is 0, but then suddenly once a year there is a payment. But yearly dividends are very stable.

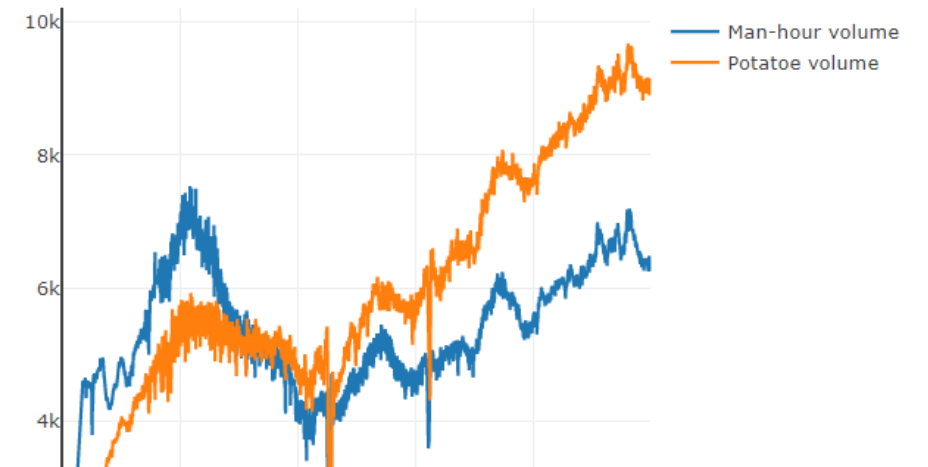
Source of dividend volatility are rules like:

```
@Override
protected double calculateDividends(int day) {
    double cash = getMoney().getAmount();
    if (cash < 10000) {
        return 0.0;
    } else if (cash < 50000) {
        return cash * 0.01;
    } else {
        return cash * 0.1;
    }
}
```

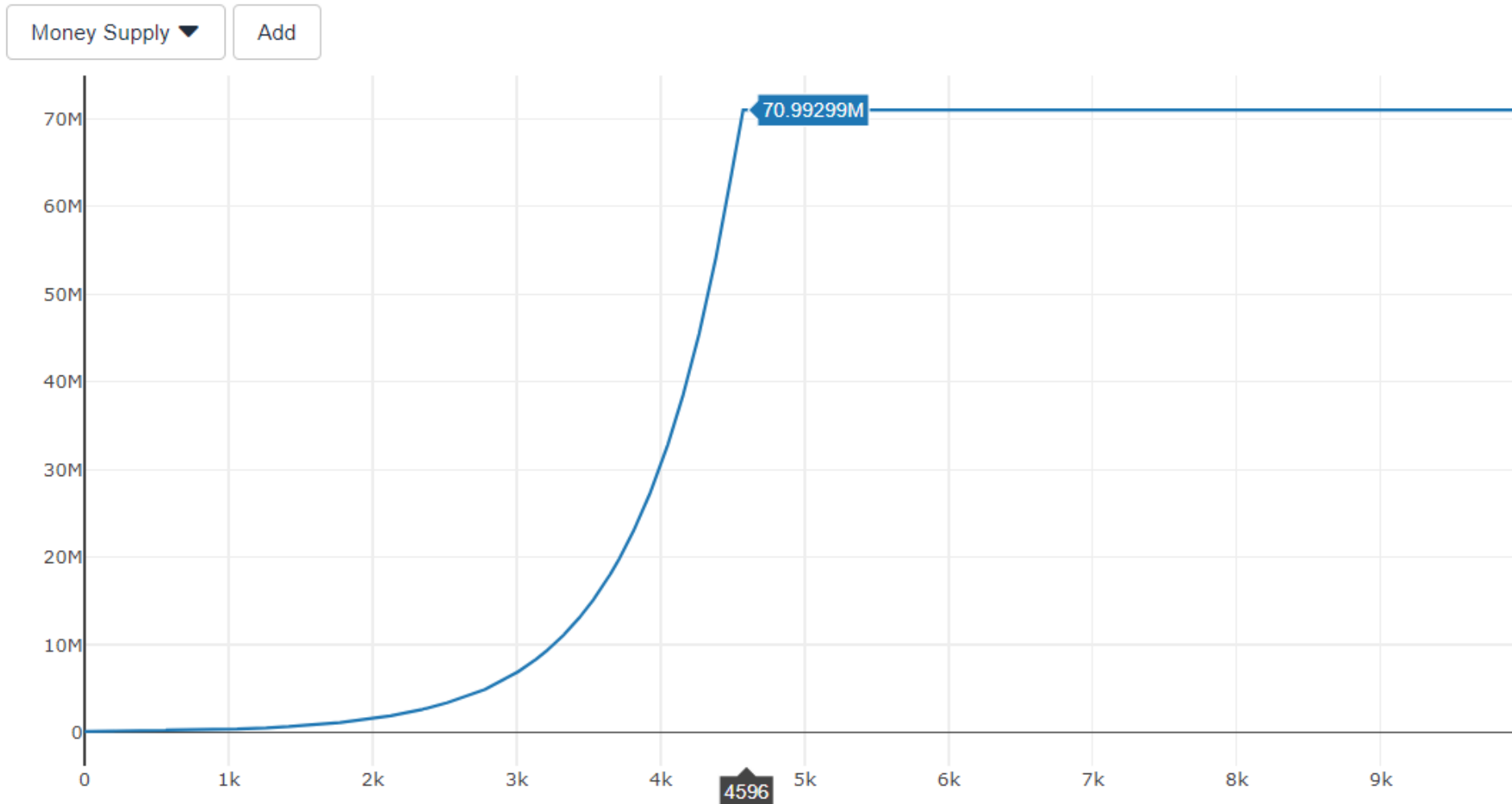
Simulation Analysis



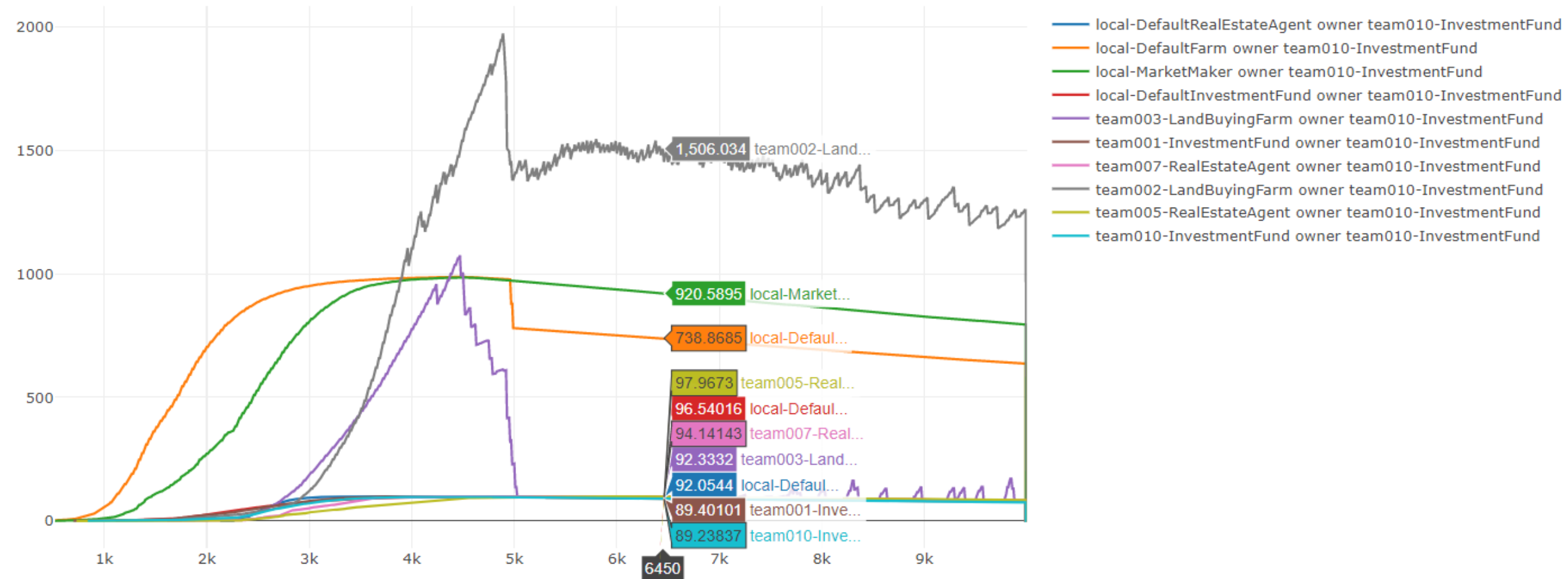
- The hoarding of team 10 suppresses prices until they start paying a dividend.
- Man-hours get more expensive relative to potatoes over time as more and more capital (land) is available, allowing to produce more with less.



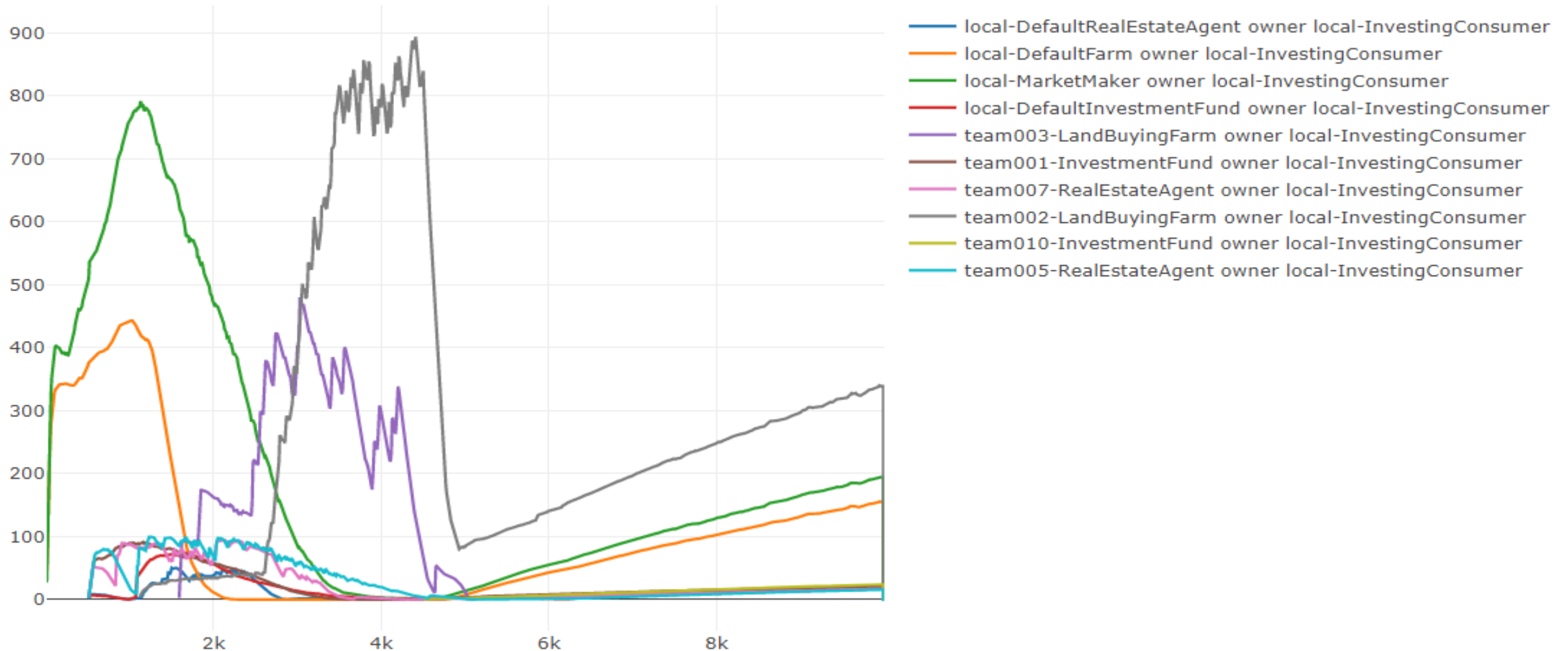
Simulation Analysis – Money Supply



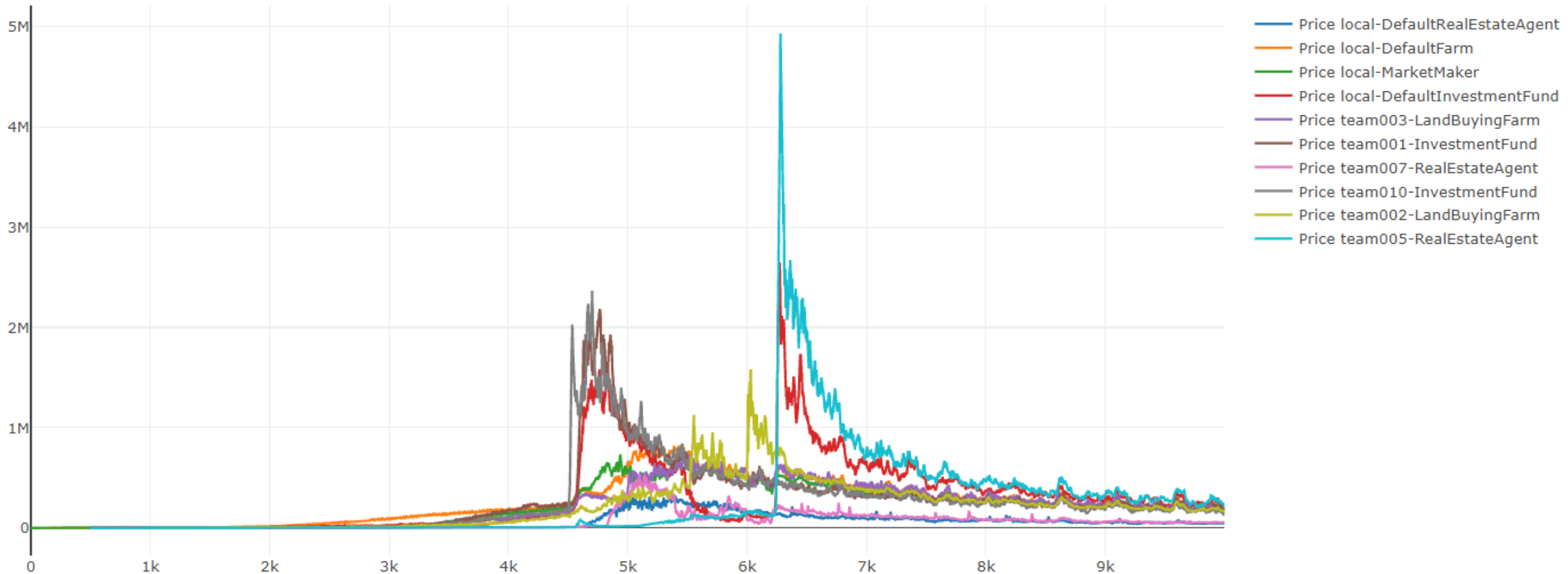
Simulation Analysis – Team 10 Ownership



Simulation Analysis – Consumer Ownership



Simulation Analysis – Stock Market



Simulation Analysis – Potatoe Production

