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# Coordination and allocation on land markets under increasing scale economies and heterogeneous actors – an experimental study

Presentation at the SiAg research seminar
Halle, December 10, 2009

Balmann/Kellermann/Larsen/Sandri/Schade



## Introduction

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- Economies of scale often not exploited in Western agriculture
  - dominance and persistence of small family farms (Balmann 1994, 1995)
  - „too little“ participation in collaborative arrangements that allow small firms to exploit economies of size (Aurbacher, Lippert, Dabbert 2007)



## Introduction

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- Explanations for unexploited increasing returns
  - transaction costs limit, e.g., access to financial resources
  - naïve expectations prevents inefficient farms from exit
  - insufficient market mechanisms
    do not ensure appropriate re-allocation to more efficient structures
  - coordination failures among heterogeneous actors
- This study focuses on the last two explanations
  - Balmann (1994,1995)
    - establishing large arable farms can require price differentiation on land market
  - Aurbacher, Lippert, Dabbert (2007)
    - establishing machinery cooperation can require price differentiation for use



## Introduction

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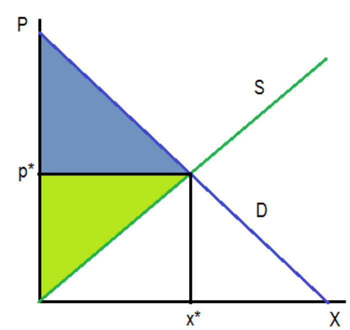
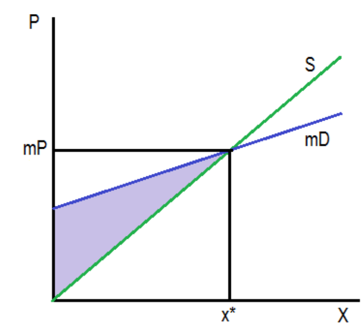
- The problem of increasing returns / economies of scale

neoclassical market




increasing returns market




  - exploitation of increasing returns often requires price differentiation!
  - specific problem: private information of suppliers!

# Objective

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- Question
  - Can the coordination and allocation problem be solved?
  - Application to the land market problem of Balmann (1995)
- Hypothesis
  - Auctions enable price differentiation
  - Auctions create incentives to reveal private information
- Approach
  - Laboratory experiments with students
  - Agent-based model with computationally intelligent agents using genetic algorithms provides normative benchmark solution (game theoretic equilibrium)



# Outline

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- Description of land market example
- Experimental setting
- Benchmark case – simulations with ABM/GA
- Experiment results
- Conclusions and further research



# A land market example

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Imagine the following situation

- A profit maximizing entrepreneur characterized by increasing returns wants to „take over“ a certain number of smaller farms in a certain region
- The existing small farmers are assumed to
  - be equally large in terms of land
  - have land with identical physical properties
  - have heterogeneous reservation prices (opportunity costs) for their land
  - have private information on their reservation prices



# A land market example

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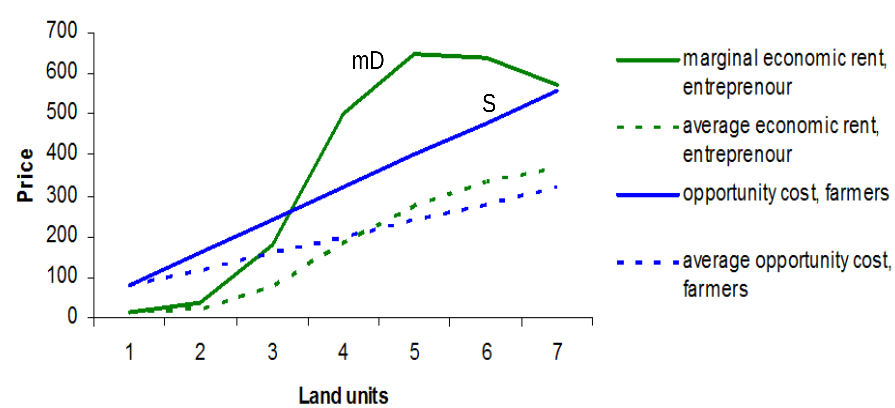
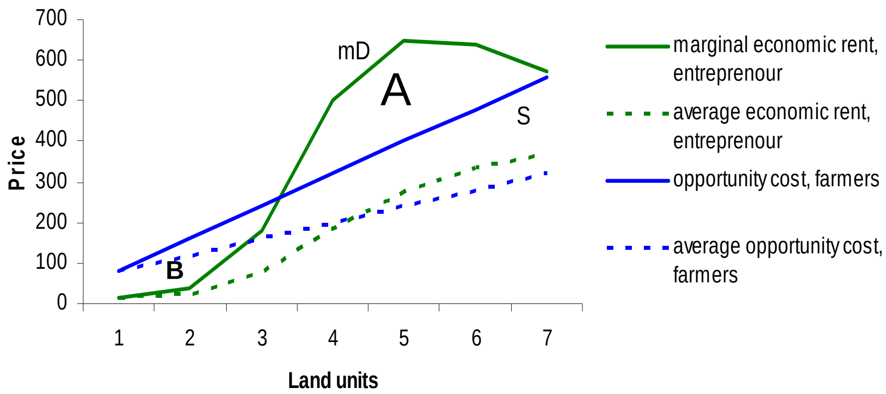


# A land market example

Potential welfare gain = A – B






# Experimental setting

- Four scenarios (treatments):
  - two different levels of potential welfare gain: „tight“ and „generous“ room for negotiation.
  - two group sizes: „small“ (7 players) and „large“ (14 players)

| | | Group size | |
|---|---|---|---|
| | | “Small” (7 players) | “Large” (14 players) |
| Potential welfare gain | “Tight” (A-B=352) | *Treatment 1* | *Treatment 2* |
| | “Generous” (A-B=704) | *Treatment 3* | *Treatment 4* |



# Experimental setting

Example of parameters (treatment 1: 7 players, tight room for negotiations)**

| | | Assumptions | | | | |
|---|---|---|---|---|---|---|
| | | Players | | Entrepreneur | | |
| Player | Sum of land units | Opportunity cost of land unit* | Average opportunity cost | Total value of production* | Marginal value of production | Average value of production* |
| 1 | 1 | 80 | 80 | 12 | 12 | 12 |
| 2 | 2 | 160 | 120 | 52 | 40 | 26 |
| 3 | 3 | 240 | 160 | 232 | 180 | 77.3 |
| 4 | 4 | 320 | 200 | 732 | 500 | 183 |
| 5 | 5 | 400 | 240 | 1382 | 650 | 276.4 |
| 6 | 6 | 480 | 280 | 2022 | 640 | 337 |
| 7 | 7 | 560 | 320 | 2592 | 570 | 370.3 |

* Information known to the players
** Total potential welfare gain
= Total value of production (at 7 players) - sum of players opportunity costs
= 2592 – 2240 = 352



# Experimental setting

- Each experiment consists of 40 repetitions of each treatment
- The entrepreneur is computerized and profit-maximising
- In each repetition (round), the opportunity costs are randomly assigned to the participants
- Each player is assumed to have the following information
  - His/her own opportunity costs
  - The distribution of the other players‘ opportunity costs
  - The entrepreneur‘s production function (and average production)
  - ➢ Players are well informed!

## Experimental setting

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- After each round, each player receives feedback on
  - the number of transactions occured
  - acceptance or declines the players own ask
  - the own payoff in the round
- The players are not informed about the other players' asks and payoffs (private information)
- The subject pool consisted of 98 participants (28 in treatments 2, 3 and 4; 14 in treatment 1)



## What should we expect?

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- Benchmark case
  - game theoretic equilibrium for bidding behavior
  - agent-based simulation with genetic algorithm learning



## Benchmark case – simulations with agent-based model

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### Experiment by using an agent-based model

- entrepreneur and small farmers are modeled as agents
  - entrepreneur behaves like in the laboratory
  - small farmers "learn" optimal individual bids for given opportunity costs by applying individually a genetic algorithm (GA), i.e. GA defines optimal bid
- entrepreneur and small farmers interact repeatedly on market
- model converges towards an equilibrium



## Benchmark case – simulations with agent-based model

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### Steps to undertake in a GA

- provide genetic information:
  - encoding a strategy/solution as a string of genes
- define population of *N* genomes for each agent with a certain opportunity costs
- fitness evaluation by repeated simulations of the model
- apply genetic operators: selection, crossover, mutation

## Benchmark case – simulations with agent-based model

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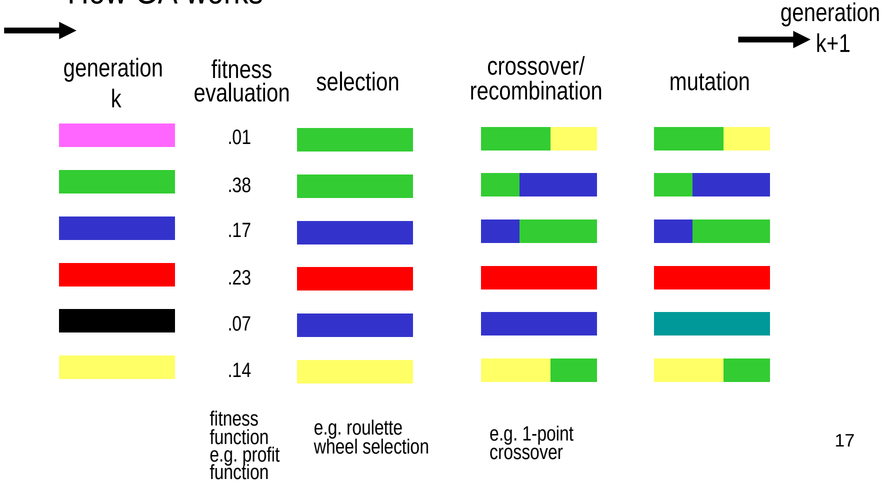
### How GA works






## Benchmark case – simulations with agent-based model

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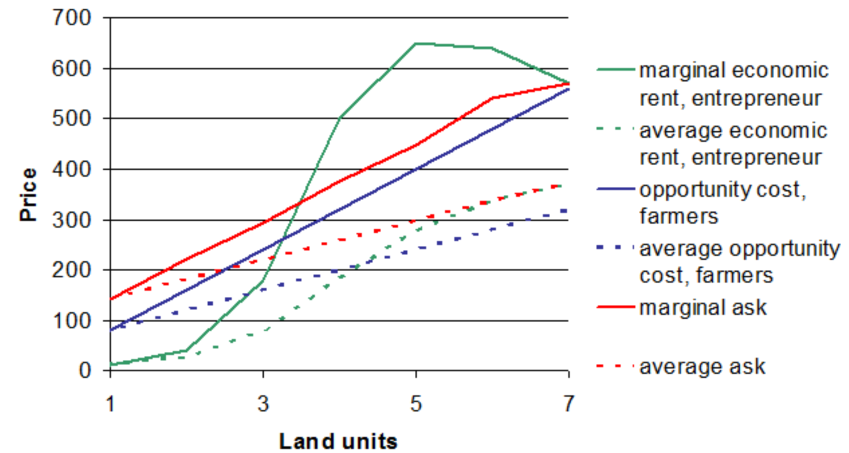
### Outcome of GA: treatment 1




## Benchmark case – simulations with agent-based model

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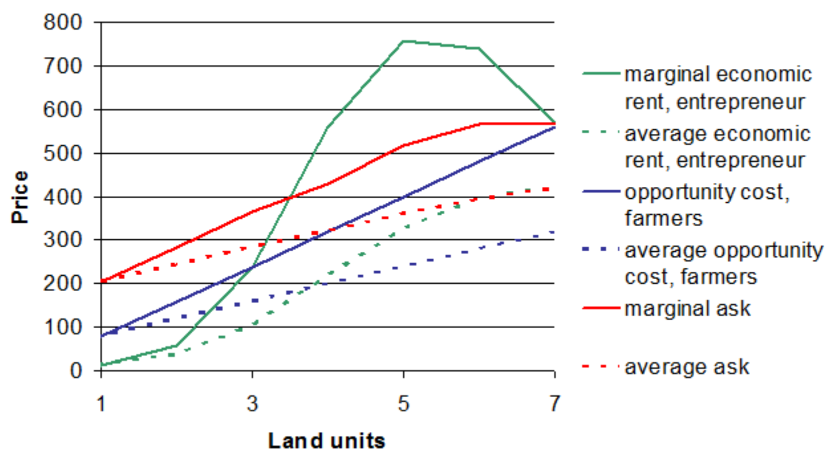
### Outcome of GA: treatment 2




## Benchmark case – simulations with agent-based model

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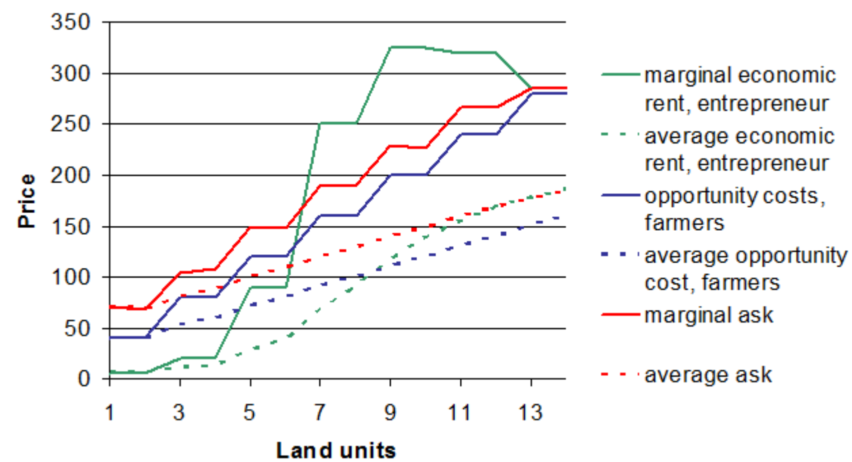
### Outcome of GA: treatment 3



## Benchmark case – simulations with agent-based model

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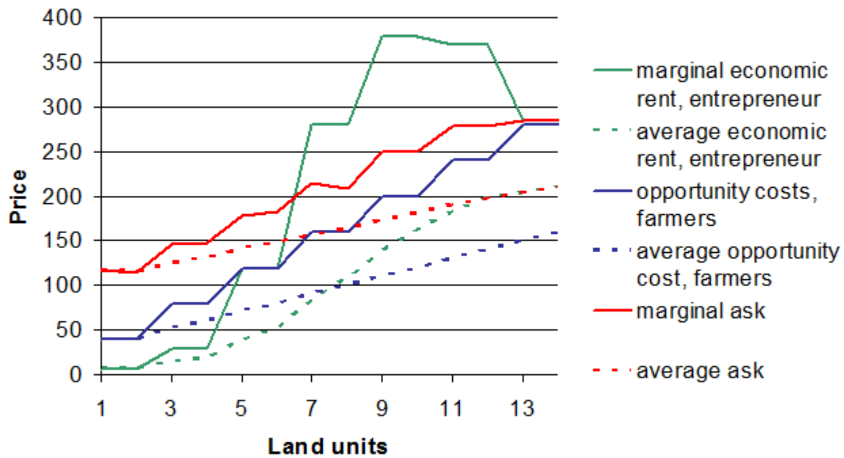
Outcome of GA: treatment 4




## Benchmark case – simulations with agent-based model

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The results from the genetic algorithms suggest:

Players add a value **c** to their reservation price (**top-up**)
this can be found by solving the following optimization problem:

$$\max_{ask_{1,\dots,n},C} c$$

subject to the constraints

$$ask_i = \min\{oc_i + c;\, p_{\max}\} \quad \text{and} \quad \sum_i ask_i \le TV$$

where
*ask$_i$* is the ask of player *i*,
*oc$_i$* is the opportunity cost of player *i*,
*p$_{max}$* is the maximum price accepted (the market price) and
*TV* is the total net revenue if the entrepreneur can buy all land



# Experiment results

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- Experiments were carried out in September and October 2009 with students
- Some comments to the data
  - There are some exceptionally high/low asks
  - The subjects are not always acting rationally:
    in each session there is a number of cases with asks lower than the opportunity cost of player (varies between 0.4% - 8.9%)



# Experiment results

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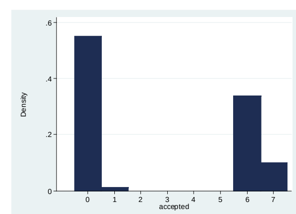
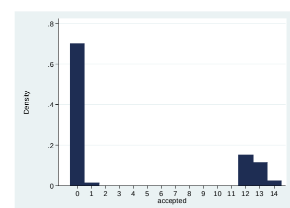
Distributions of number of accepted asks per round

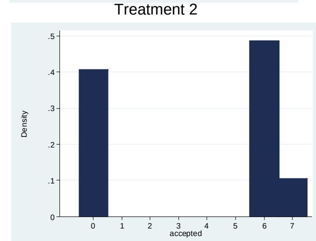
Treatment 1



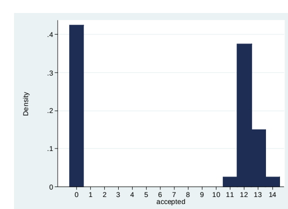
Treatment 3



Treatment 2



Treatment 4



# Experiment results

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Average number of accepted asks by treatment

| | Treatment | | | |
|---|---|---|---|---|
| | 1<br>7 players, tight room<br>(N=80) | 2<br>7 players, generous room<br>(N=160) | 3<br>14 players, tight room<br>(N=80) | 4<br>14 players, generous room<br>(N=80) |
| Average # accepted asks (standard deviation) | 2.74<br>(3.11) | 3.67<br>(3.06) | 3.62<br>(5.73) | 7.08<br>(6.14) |
| P-value, Mann-Whitney U-test* | 0.054 | | 0.0024 | |

* Tests whether the data comes from two different populations (the null hyphothesis is that the two samples are drawn from identical populations)



# Experiment results

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Share of accepted asks by treatment

| | Treatment | | | |
|---|---|---|---|---|
| | 1<br>7 players, tight room<br>(N=80) | 3<br>14 players, tight room<br>(N=80) | 2<br>7 players, generous room<br>(N=160) | 4<br>14 players, generous room<br>(N=80) |
| Average share accepted asks (standard error) | 0.39<br>(0.41) | 0.26<br>(0.41) | 0.52<br>(0.44) | 0.51<br>(0.44) |
| P-value, Mann-Whitney U-test | 0.74 | | 0.96 | |



# Experiment results

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- Findings (I)
  - In general the share of accepted asks is surprisingly low!
    - < 50 % in treatments with tight room for negotiation
    - ~ 50 % in treatments with high room for negotiation
    - ➢ highly inefficient outcome!
  - Smaller groups are (slightly) more successful!
  - Rate of acceptance does not increase over time!
    - players do not learn to coordinate (even after 40 rounds)!



# Experiment results

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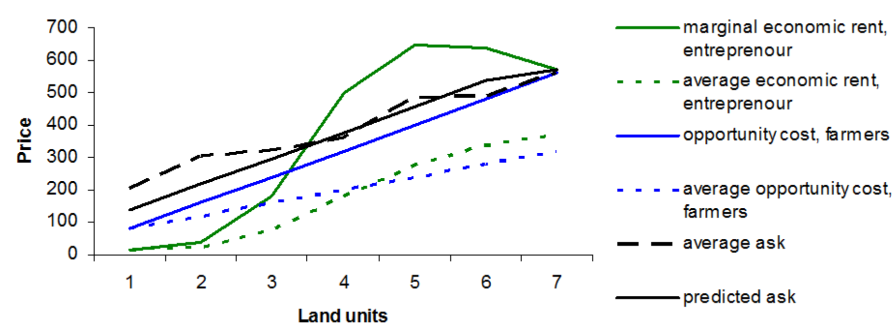
Comparison with benchmark case – Treatment 1




➢asks correlated with opportunity costs (holds for all experiments)

➢in average far too high asks for low opportunity costs! (not just outliers!)

# Experiment results

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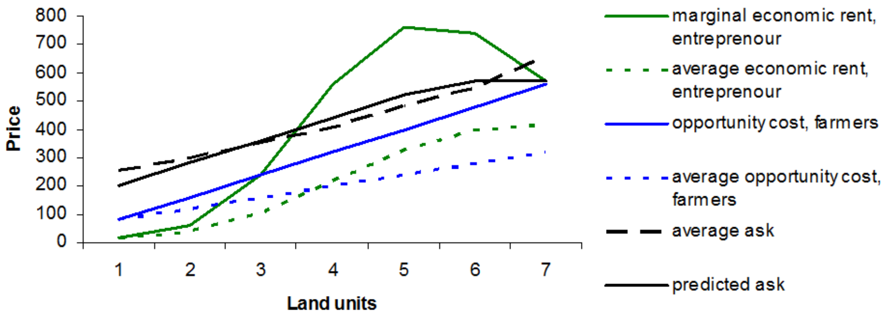
## Comparison with benchmark case – Treatment 2




➢in average too high asks for low and very high opportunity costs!

➢bidding more efficient as too high asks are more costly!



# Experiment results

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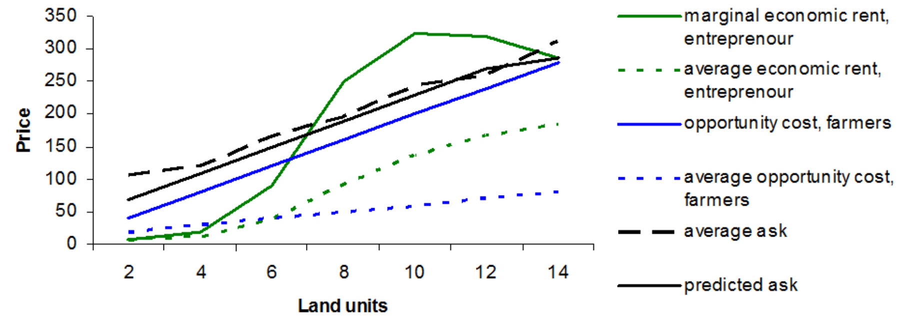
## Comparison with benchmark case – Treatment 3




➢in average far too high asks for most opportunity cost levels! (not just outliers!)



# Experiment results

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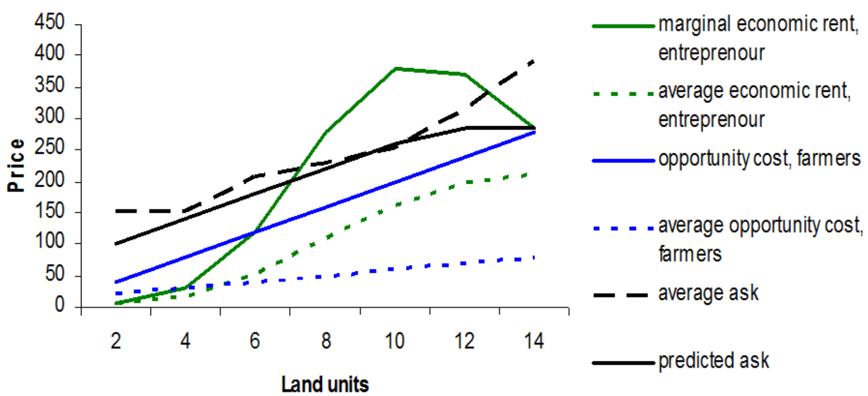
## Comparison with benchmark case – Treatment 4




➢in average far too high asks for lower and high opportunity costs! (not just outliers)

# Experiment results

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## Regression results

| | Dependent variable: Ask | | | |
|---|---|---|---|---|
| | 7 players | | 14 players | |
| | Tight room | Generous room | Tight room | Generous room |
| Constant | 160900***<br>(22000) | 167000***<br>(15200) | 60600***<br>(6570) | 89300***<br>(19300) |
| Opportunity cost | 0.72***<br>(0.061) | 0.82***<br>(0.042) | 0.88***<br>(0.037) | 0.96***<br>(0.11) |
| R-square | 0.20 | 0.25 | 0.34 | 0.07 |

# Experiment results

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## Regression results

| | Dependent variable: **Profit** | | | |
|---|---|---|---|---|
| | 7 players | | 14 players | |
| | Tight room | Generous room | Tight room | Generous room |
| Constant | 51900*** (7150) | 78100*** (4190) | 10600*** (1410) | 60400*** (3150) |
| Opportunity cost | -0.14*** (0.020) | -0.12*** (0.042) | -0.035*** (0.037) | -0.24*** (0.018) |
| R-square | 0.085 | 0.012 | 0.0080 | 0.15 |



# Experiment results

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- Findings (II)
  - Individuals consider their opportunity costs
    - asks proportional to opportunity costs!
  - Problem: top-ups too high!
    (most likely not just result of errors/trials!)
  - ➢ Players are too greedy!
  - ➢ Players suffer from greed!
  - ➢ Probably “fairness problem”
    - i.e., players with lower opportunity costs expect equal price
  - ➢ Question: Are players playing some kind of “tit for tat”?
    - in some treatments weak evidence that ask is lower if last asks successful



# Conclusions

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- Auctions do not guarantee for Pareto optimal solutions!
  - Players do not reveal information although this is costly!
  - Players with low opportunity costs generally ask for „too much“ (compared to the benchmark case)
  - When potential gain is larger, the number of accepted asks is higher, i.e., when too high asks are more costly
- Experiments provide evidence for
  - market failures
  - cooperation deficits

  as reasons for unexploitet increasing returns

➢ Other coordination strategies are probably more successful



# Further research

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- Deeper analysis of results
  - Comparing the individual strategies of the players (e.g. panel analysis)
  - Looking at the effects of learning
- Conduct the experiments with individualized opportunity costs
- Conduct the experiments with farmers instead of students
- Conduct the experiments with other auction schemes
  - eventually spectrum auctions

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Thank you for your attention!