

# LEARNING IN CONTINUOUS DOUBLE AUCTION MARKET

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Universidad de Valladolid, Spain



# Goal

- Individual & social learning in convergence and efficiency in Continuous Double Auction (CDA) markets
- Emergence of Nash solutions in strategies proportions

## Index of the presentation

Beyond EE

Learning

Simulations

Our model

Conclusions

1. **Beyond Experimental Economics: soft agents**
2. **Previous learning CDA works (fixed strategy):** Gode & Sunder (1993), Rust et. al (1993), Cliff & Bruten (1997), Gjerstad & Dickhaut (1998), Tesauro & Das (2001)
3. **Some Results of Simulations: heterogenous populations**
4. **Our Model: learning to change the strategy. Results of Simulations. Nash Equilibria** (Walsh *et al.*, 2002).
5. **Conclusions**

# Beyond Experimental Economics

## ENVIRONMENT

Preferences  
Information

## INSTITUTION

Exchanges rules  
Contract

**AGENT  
BEHAVIOUR**  
HUMAN

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# Beyond Experimental Economics

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Beyond EE

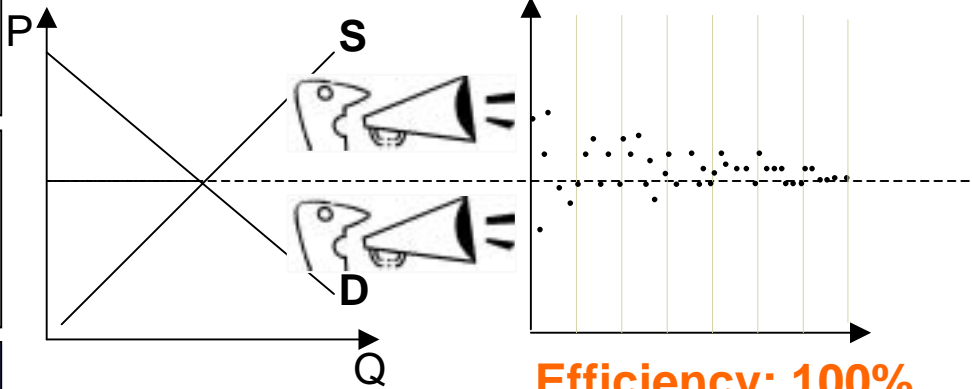
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## CDA (Vernon Smith, 1962)



Efficiency: 100%

Convergence: fast

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HOW MUCH...?

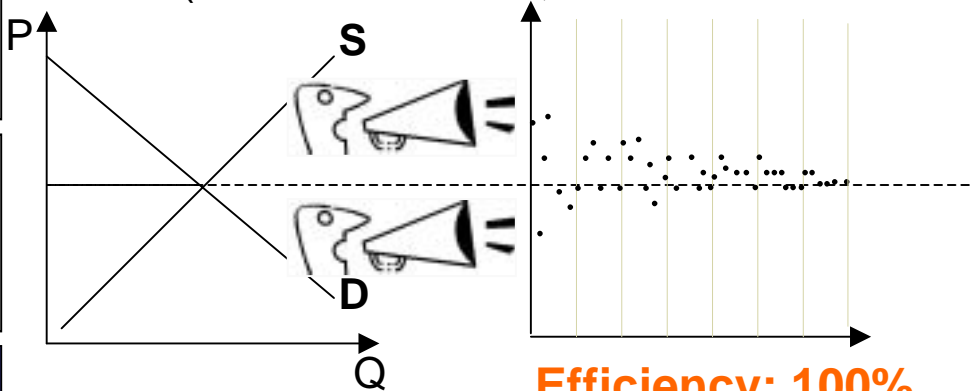
WHEN...?

WHEN...accept?



SOFTWARE

## CDA (Vernon Smith, 1962)



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# Learning in CDA market

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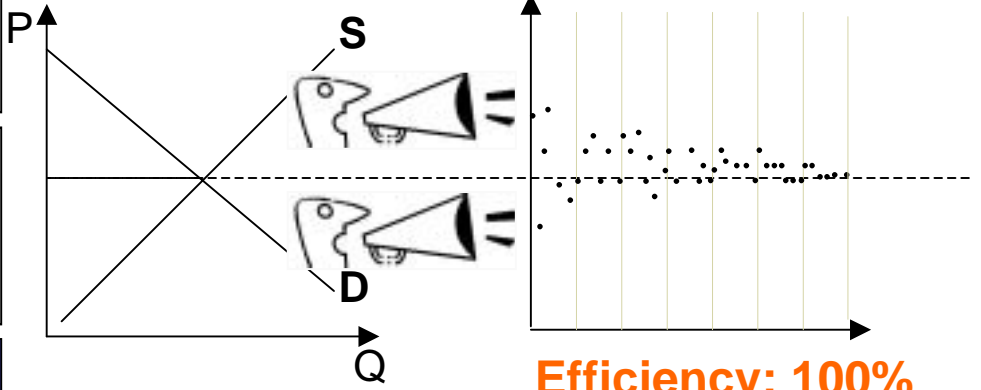
**WHEN...?**

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↓  
**SOFTWARE**

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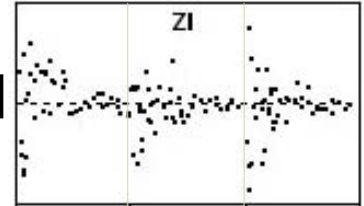
**CDA** (Vernon Smith, 1962)



**Efficiency: 100%**  
**Convergence: fast**

**ZI Agents**

**Random [CMA,cu]**  
 (Gode & Sunder, 1993)



**Efficiency: 100%**  
 (social learning)

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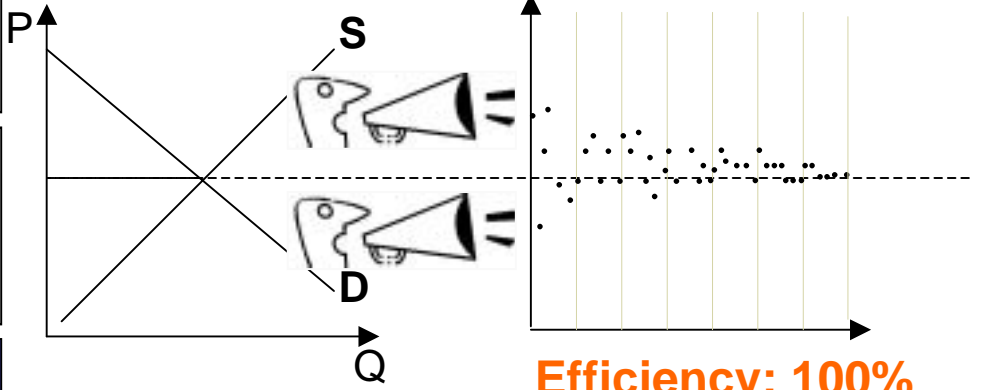
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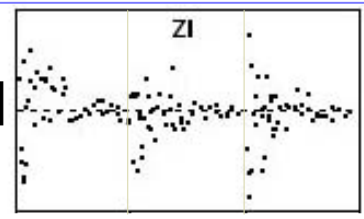


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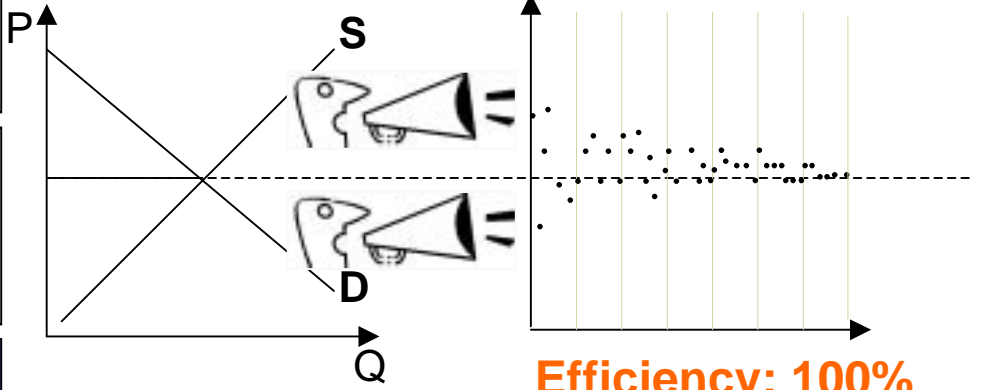
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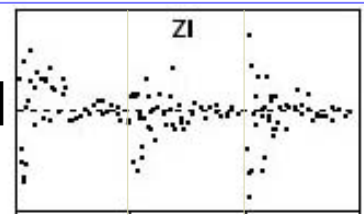


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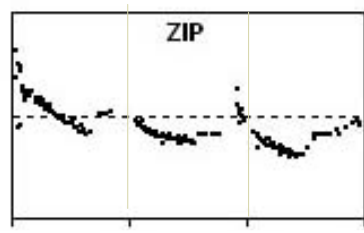
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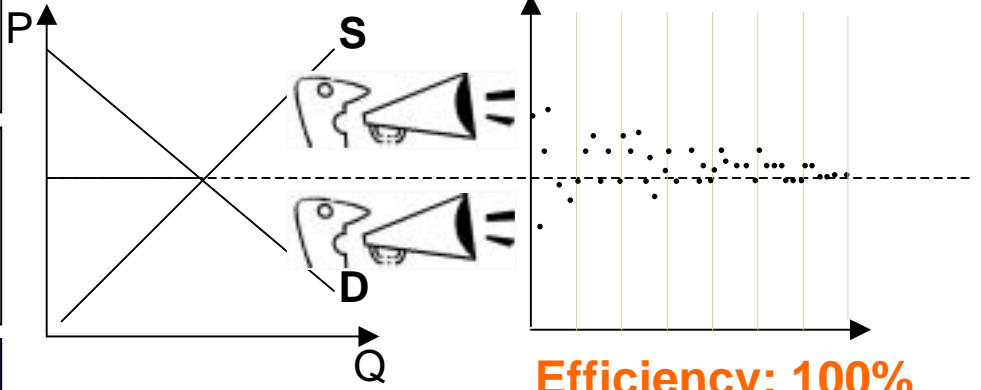
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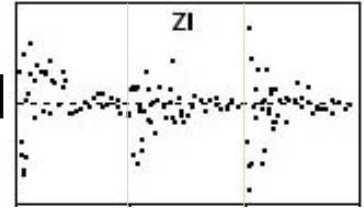


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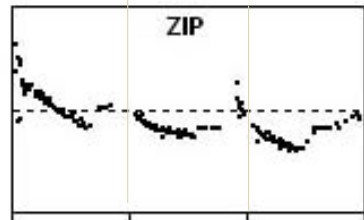
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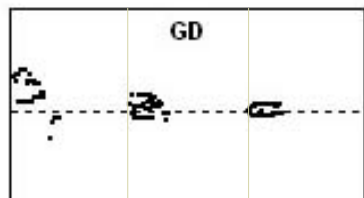
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**Convergence**  
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**GD Agents**

**Max (p-Cma)f(p)**  
 (Gjerstad & Dickhaut, 1998)



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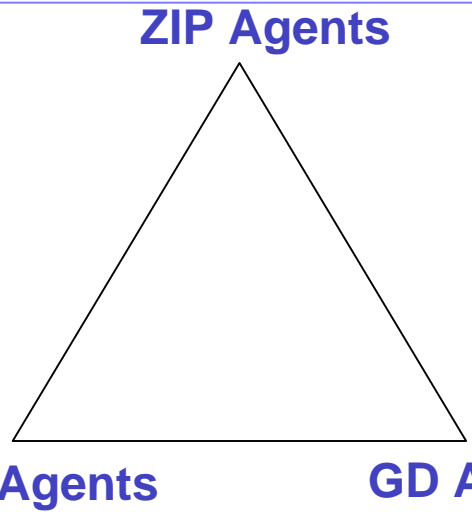
**AGENT BEHAVIOUR**

**HOW MUCH...?**

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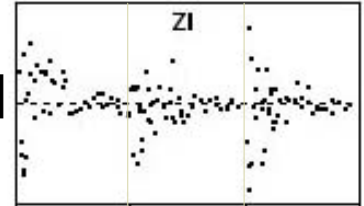


**K Agents current**  
 (Rust *et al*, 1993)

**GD Agents**

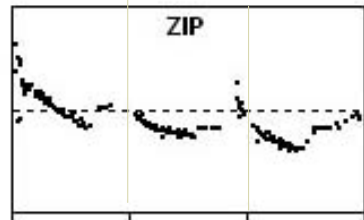
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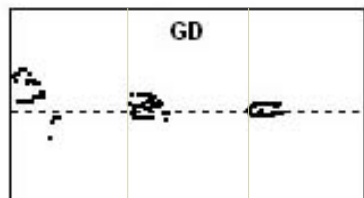
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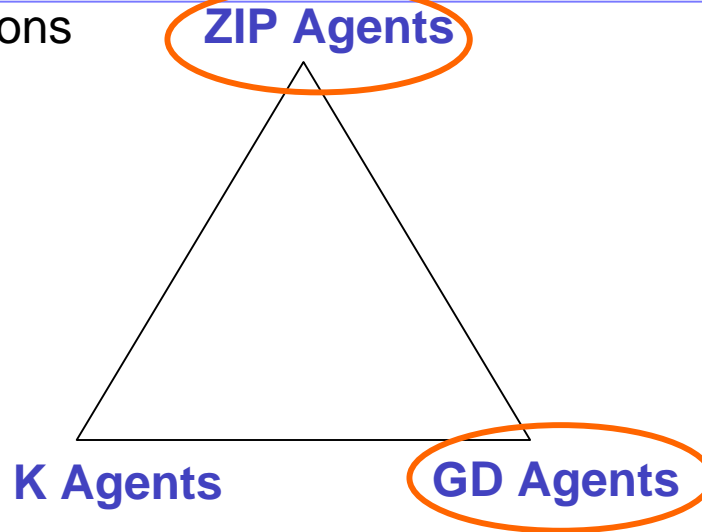
**Efficiency: 100%**  
 (social learning)

**Convergence**  
 we need individual & social learning

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# Simulations: fixed strategy

20 Agents: 231 populations



Beyond EE

Learning

Simulations

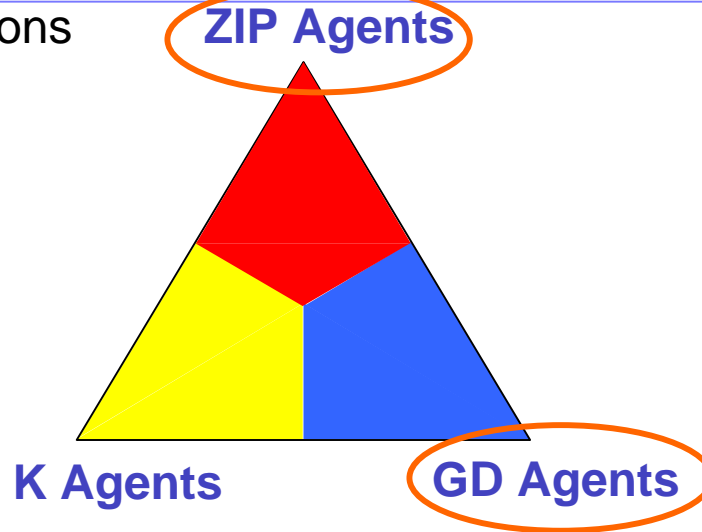
Our model

Conclusions

**We have reproduced the convergence and efficiency results for homogeneous populations**

# Simulations: fixed strategy

20 Agents: 231 populations



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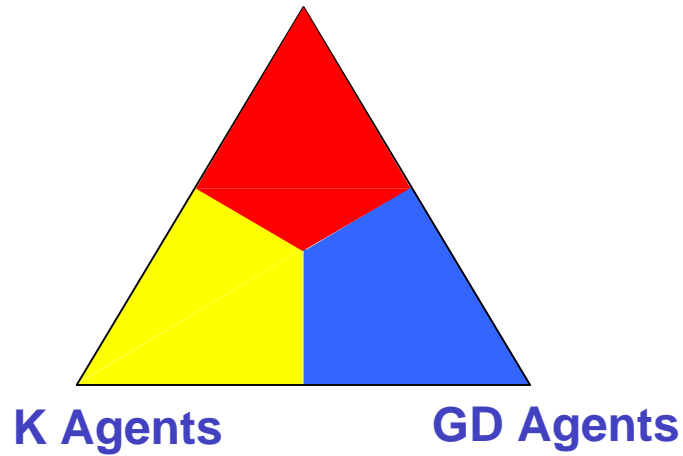
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# Simulations: fixed strategy

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ZIP Agents



Beyond EE

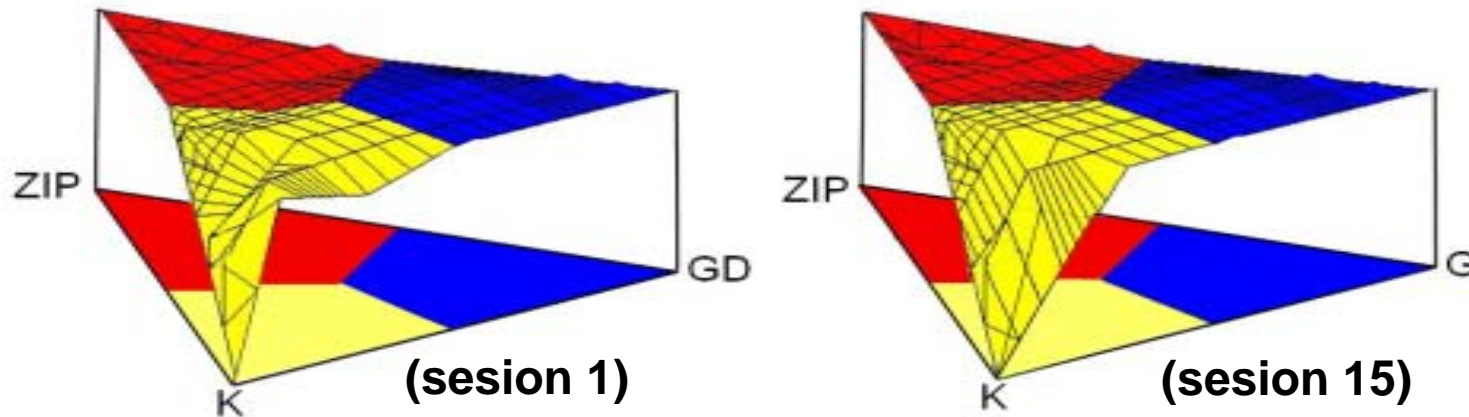
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## Market Efficiency



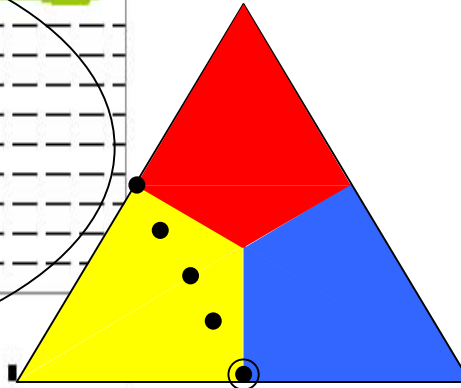
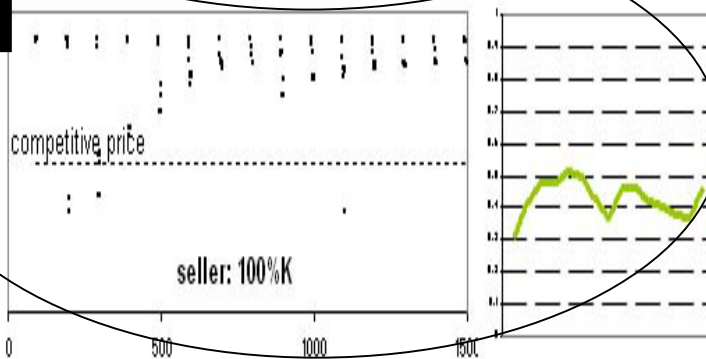
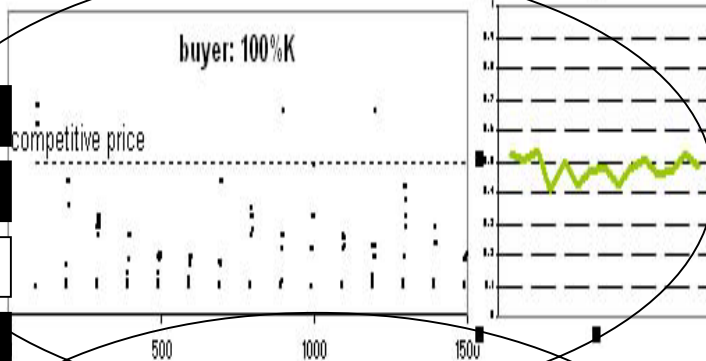
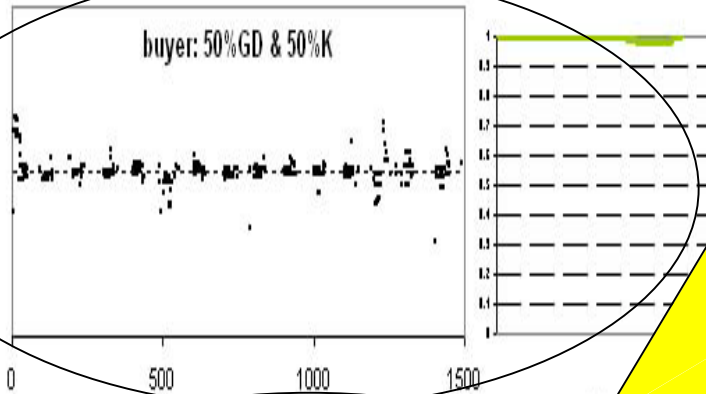
near 100% in almost populations

very low & high volatility when most of the agents are K agents

# Simulations: fixed strategy

ZIP Agents

GD Agents



Beyond EE

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Our model

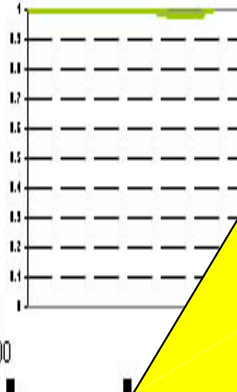
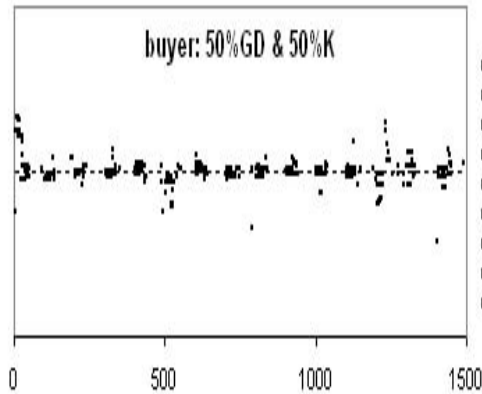
Conclusions

Market Efficiency

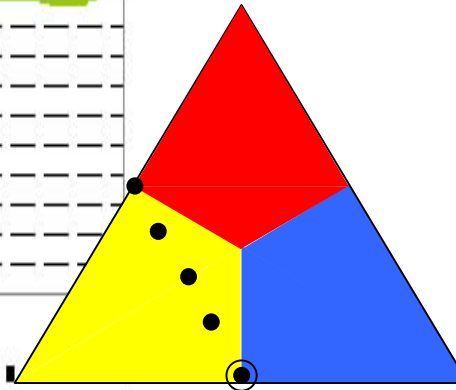
Convergence

Strategy mix matters but the buyer –sellers rate matters as well

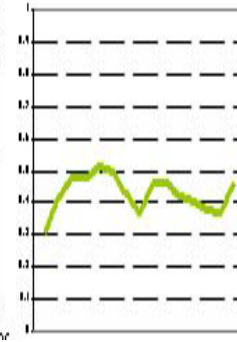
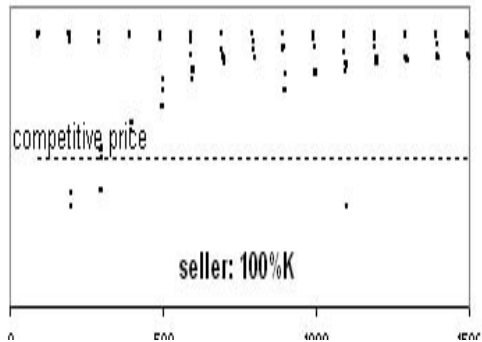
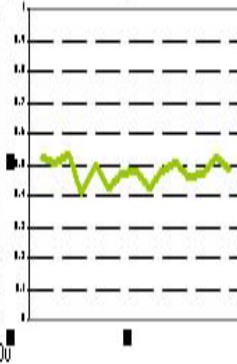
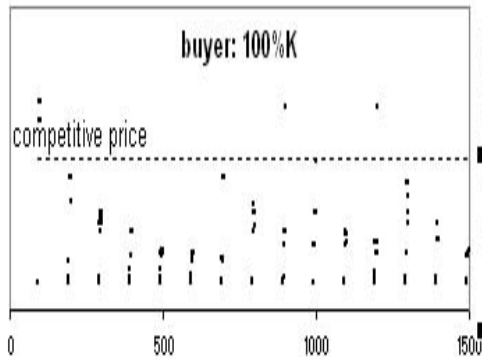
# Simulations: fixed strategy



ZIP Agents



GD Agents



Beyond EE

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What will happen if the agents have freedom to change their strategies?  
Is there strategy mix that leads to a Nash equilibrium?

# Our Model: *learning to change the strategy*

ENVIRONMENT

INSTITUTION  
CDA

AGENT  
BEHAVIOUR

HOW MUCH...?

K

ZIP

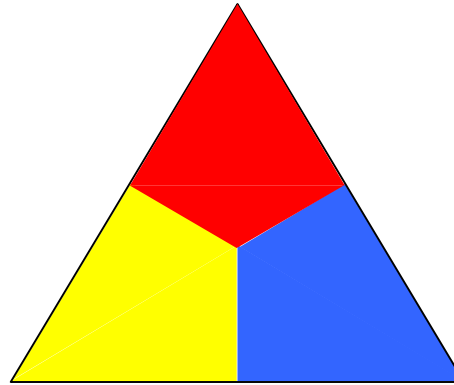
GD

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WHEN...?

WHEN...accept?

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Learning

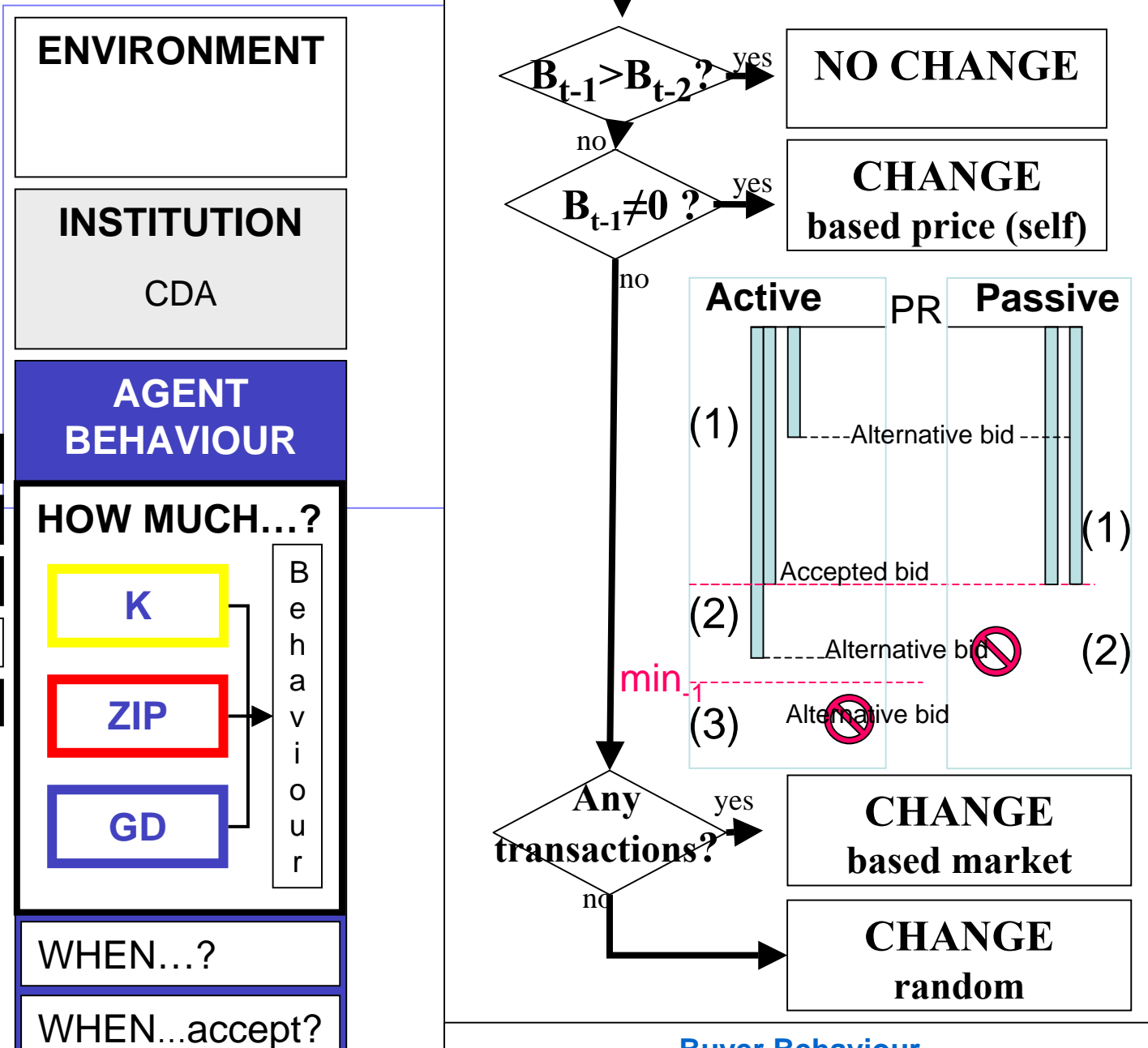
Simulations

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# Our Model: *learning to change the strategy*



Beyond EE

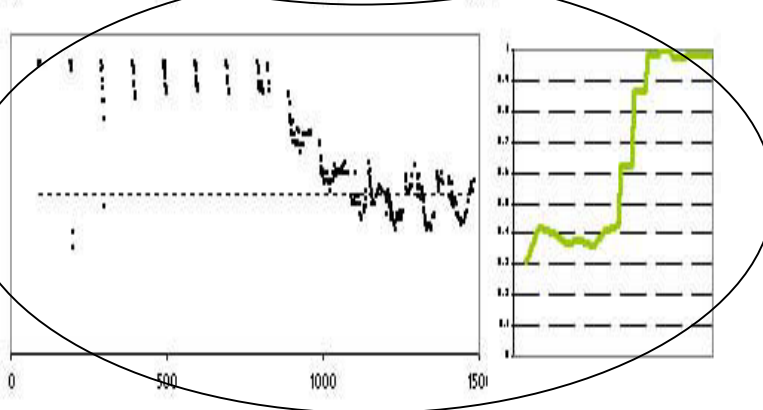
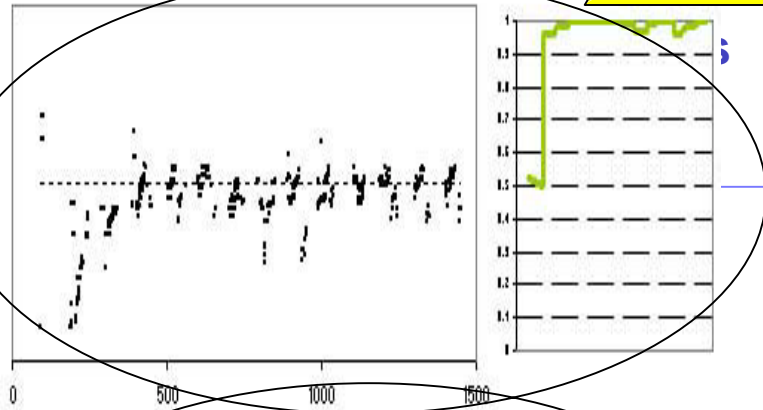
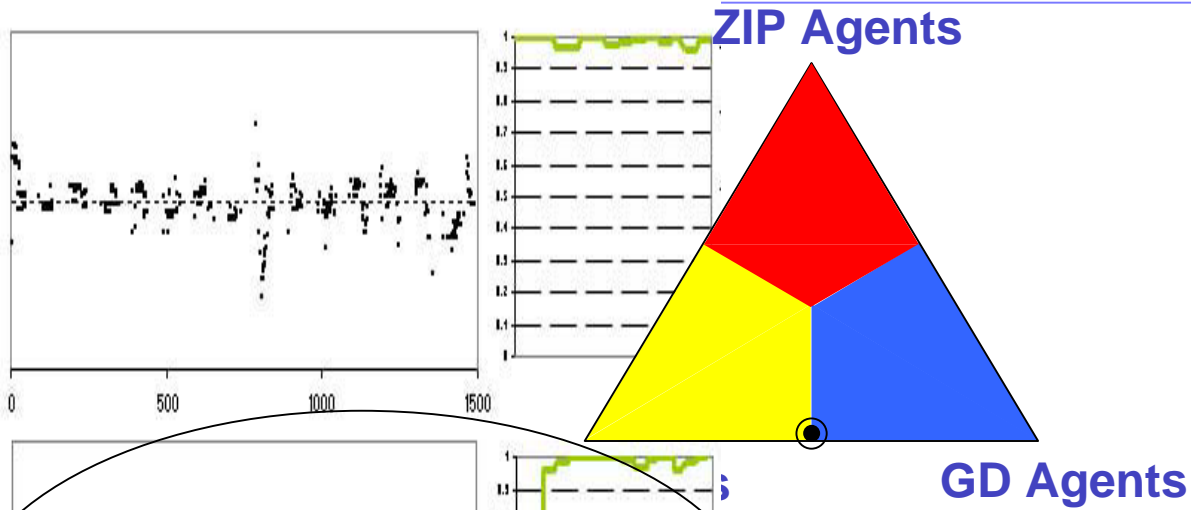
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Beyond EE

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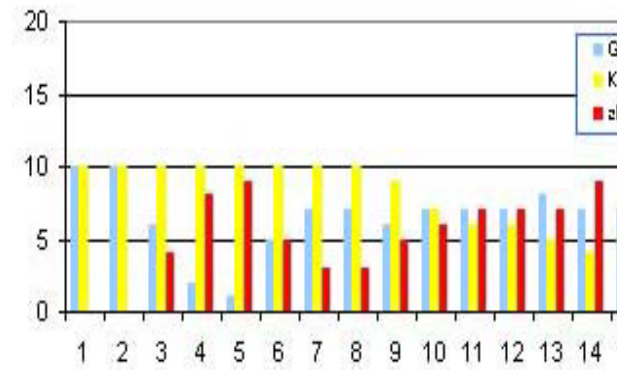
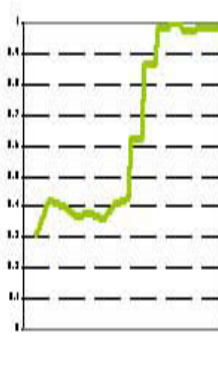
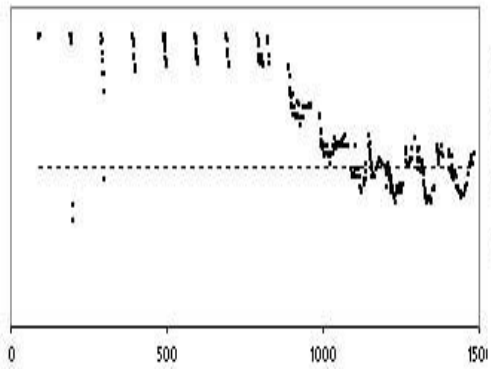
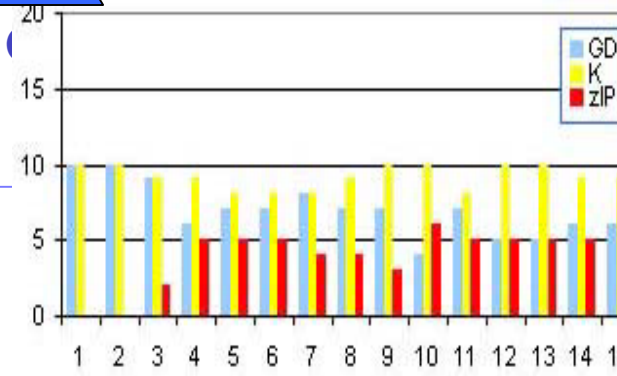
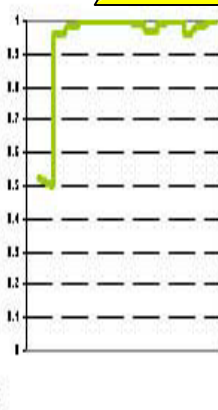
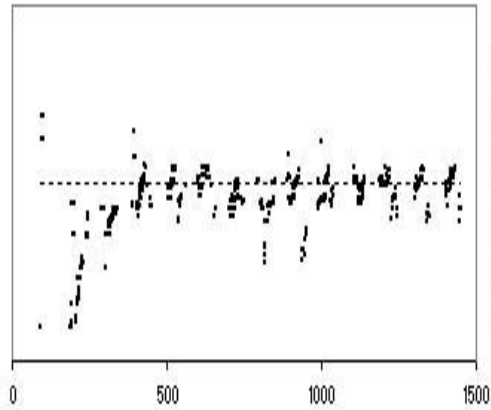
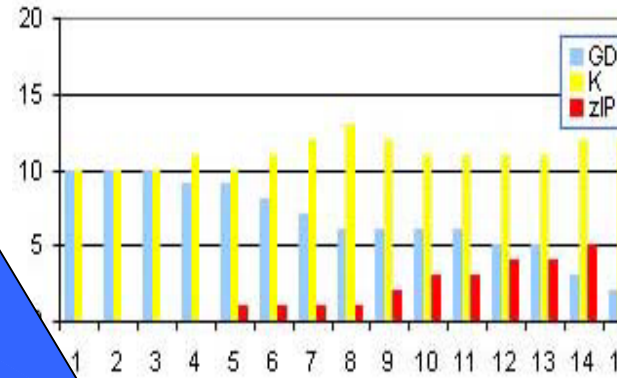
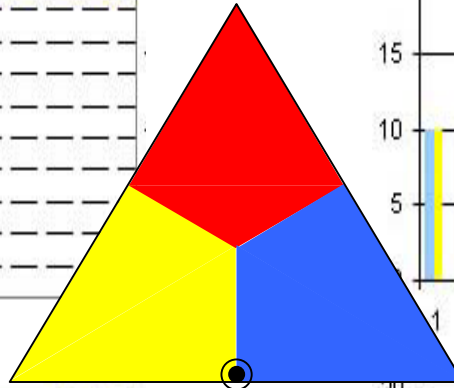
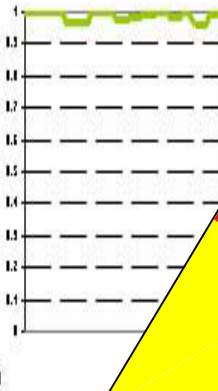
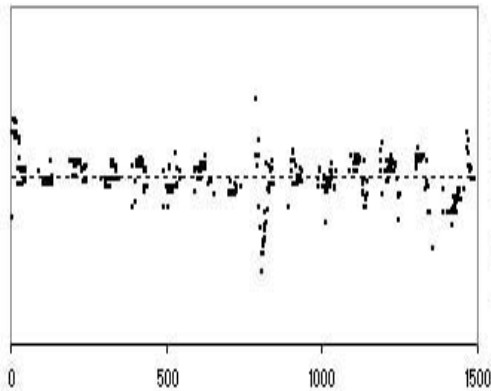
Simulations

Our model

Conclusions

Convergence and efficiency market have increased

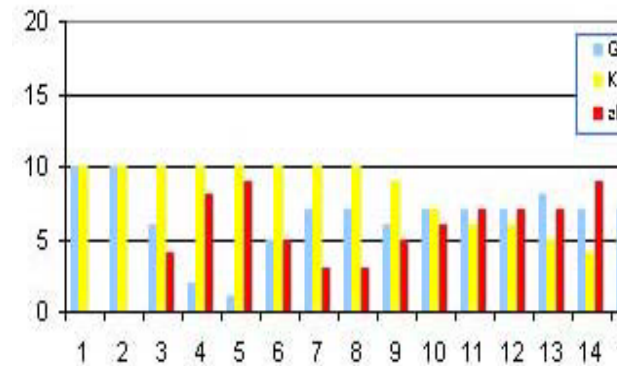
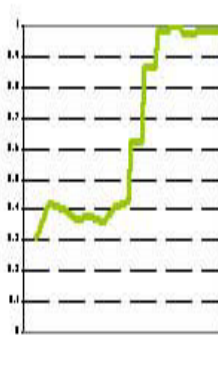
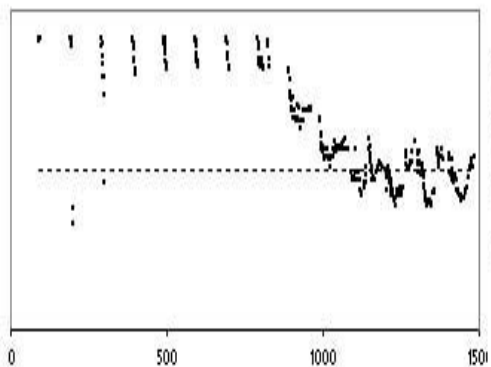
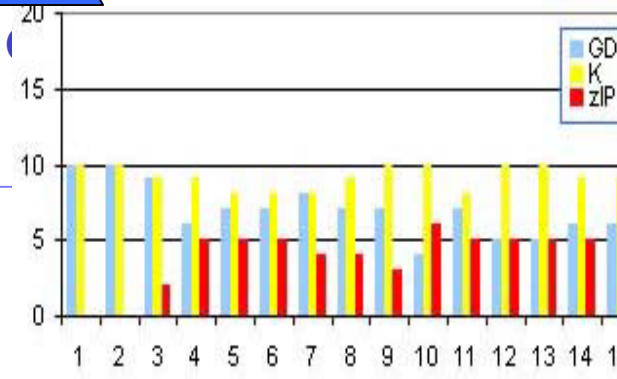
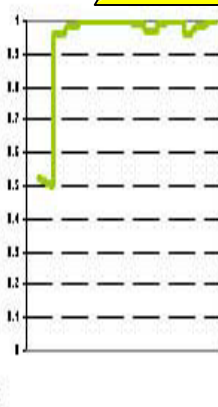
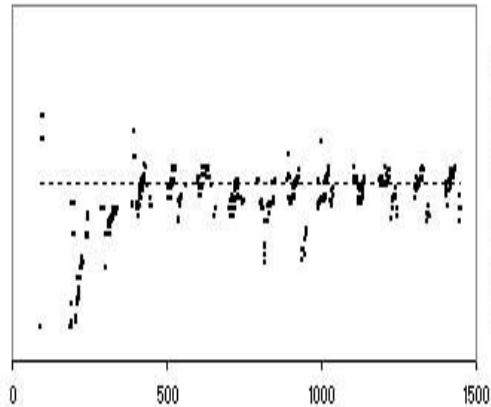
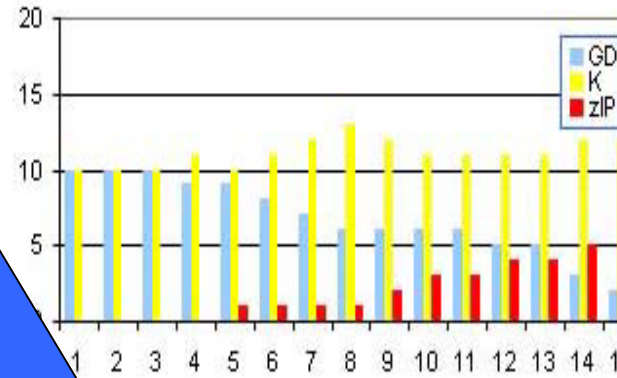
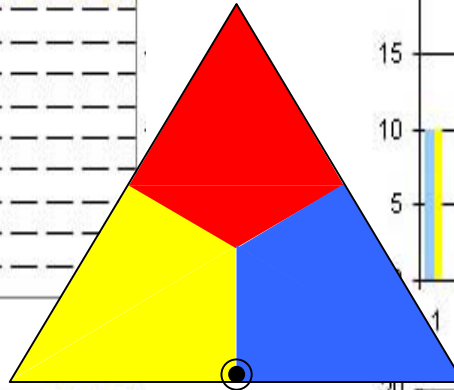
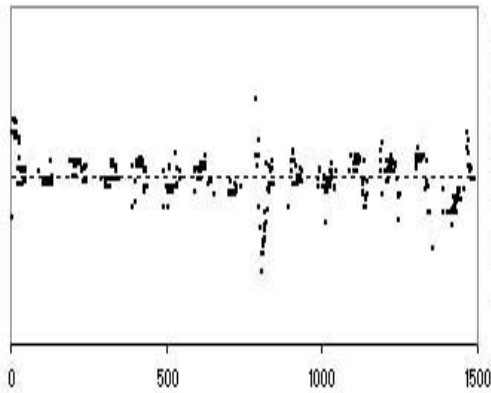
# Our Model: *learning to change the strategy*



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Is there strategy mix that leads to a Nash equilibrium?

# Our Model: *learning to change the strategy*



Beyond EE

Learning

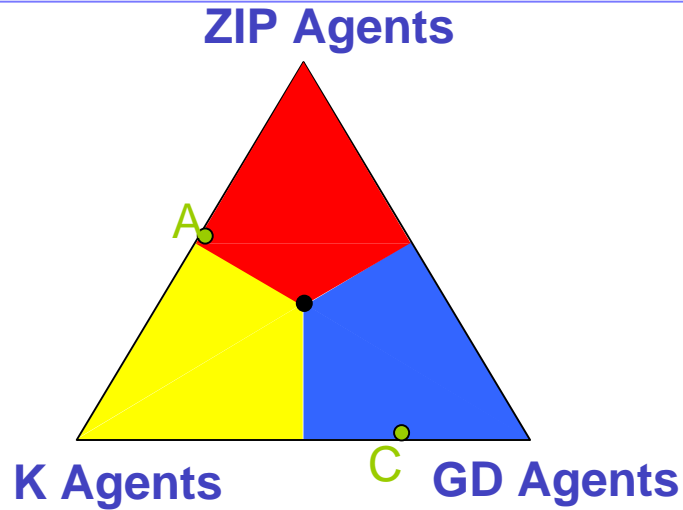
Simulations

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do not emerge Nash equilibria points with our bottom-up approach

# Our Model: *learning to change the strategy*



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Previous work of Nash equilibrium in CDA market (Walsh *et al.*, 2002)

**Top-down approach: Two Nash equilibrium points (A y C)**

**The Nash equilibrium is forced by the modeller and does not come out from the agents behaviour**

**We do not find Walsh's Nash equilibria points with our bottom-up approach**

# Conclusions

1. Experimental Economics deals with real uncontrolled agents. We need soft agents that can be controlled and designed.
2. We have developed an ABM model that allows to simulate CDA performance under different agents strategies.
3. Our model allows both, individual and social learning.
4. Adaptive agents beat fixed strategy agents and lead to greater market efficiency.
5. There are a lot of interesting results when we change the mix of agents proportions and how many of them are sellers or buyers.
6. In the CDA market we do not find a strategy-mix of agents that leads to Nash equilibria with our bottom-up approach (ABM).

Beyond EE

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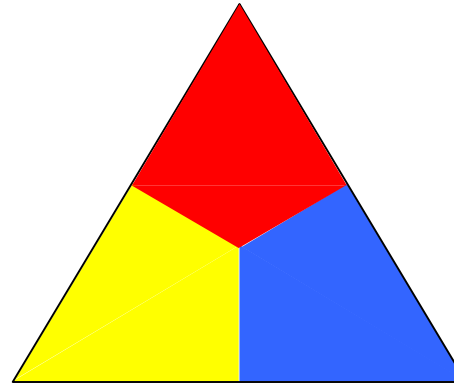
Our model

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Thank you very much for your patience

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ZIP Agents



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Previous work of Nash equilibrium in CDAmarket (Walsh *et al.*, 2002)

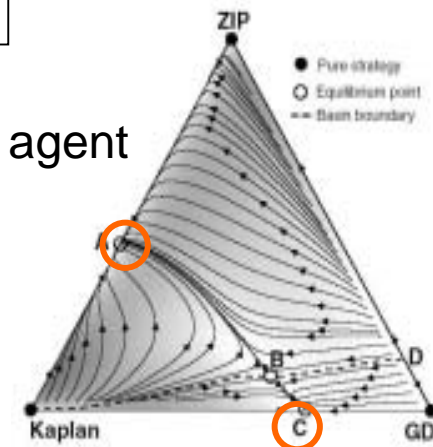
**Run:** Fixed strategies during CDA auction

**Ones run have finished**

**Results:** Average profit by type agent

**New Run:** Average profit by type agent and rule

**New Run Results:** Change in population



We do not find Walsh's Nash equilibria points with our bottom-up approach