Firms adaptation in dynamic economic systems

Lilia Rejeb[1], Zahia Guessoum[1,2]

[1]MODECO-CRESTIC, University of Reims

[2]LIP6, University of Paris 6

Outline

- Introduction
- Economic model
- XCS
- Adaptive firms
- Experiments
- Conclusion

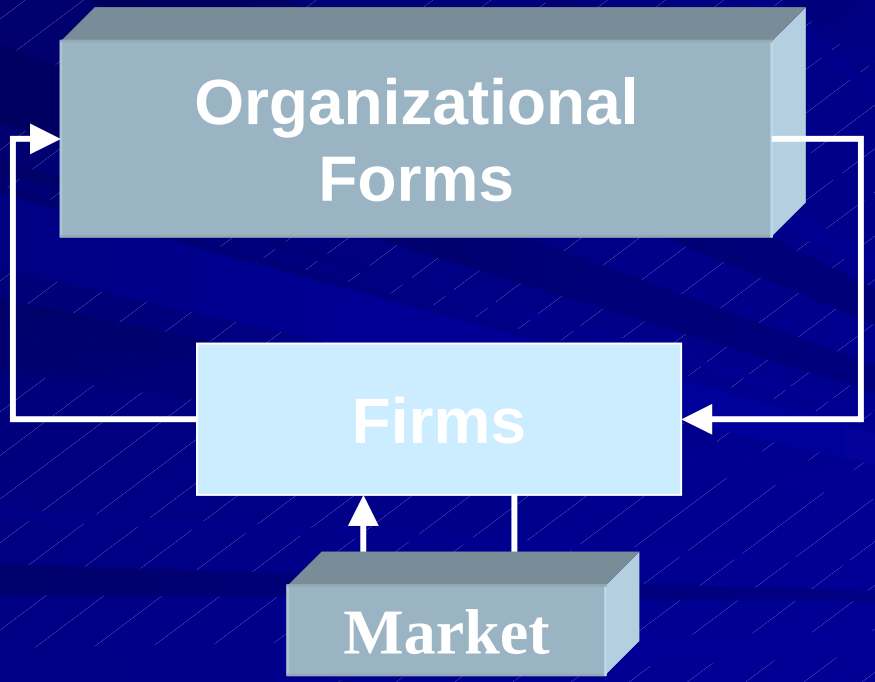
Introduction

- Economic systems are very complex:
  - open
  - large scale
  - strong competition
  - …
- Well known problem: relationship between firms adaptation and their dynamic environment

Adaptive multi-agent system

Our Solution: Adaptive MAS

- Firms adapt to the varying environment characterized by the other firms (micro level) and also by the organizational forms (macro level)



Economic model (1)

- Each firm is defined by:
  - resources X which may be physical (equipment, grounds, raw materials...) or human (administrative staff, technical...),
  - capital K,
  - budget B,
  - performances Y,
  - strategies,
  - …
- Firm's decision process
  - select the most suited strategy in a given context: internal parameters, perception of the other firms, perception of the organizational forms.

☞ It's not easy to define the decision rules

Economic model (2)

Adaptation is needed to:

- use previous experience to disambiguate the environment state
- anticipate the consequences of a strategy before using it
- evaluate the strategies after their use

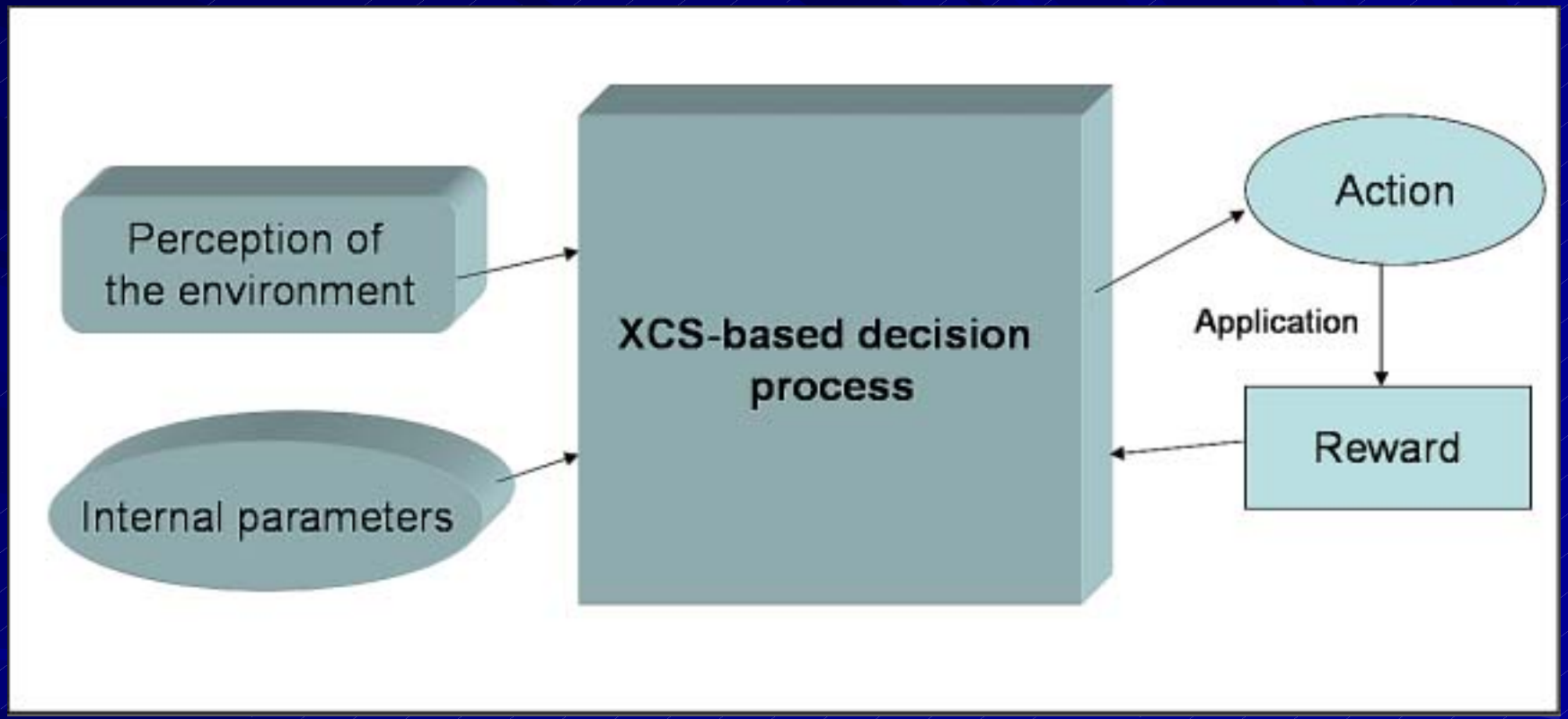
⇨ Endow firms with a learning capacity

XCS

XCS: Learning Classifier System (Wilson 1995)

- Classifiers
  - condition
  - action
  - prediction (p), Error (e), Fitness (f)
- Genetic algorithm
  - update the classifiers population
- Reinforcement learning (Q-Learning)
  - evaluate the classifiers
- Generalization
  - reduce the number of classifiers

Adaptive firms (1)



Adaptive firms (2)

The use of reinforcement learning (XCS) to implement the decision process of firms allow to:

- construct dynamically and automatically the decision rules
- anticipate the strategies consequences
- evaluate these strategies

However:

give rise to some problems such as:

- coding
- delimitation of the nature and level of the reward function
- exploration-exploitation dilemma

Adaptive firms (3)

Coding:

- Classifier condition
  - diversity of the firm context parameters and their type (real, fuzzy)
  - important number of parameters

  ☞A unification method to homogenize the parameters is needed
    - decomposition of the definition domain of each attribute in *n* intervals
    - representation of each attribute by a fuzzy value.
    - representation of the fuzzy value by a binary string of *n* bits

- Classifier's action = Firm's strategy

Adaptive firms (4)

Firm classifier	Classifier in XCS
K is small	0001
B is medium	0010
X = {x_1 is very small, x_2 is small,	0000, 0001,
x_3 is medium, x_4 is very small,	0010, 0000,
x_5 is very small, x_6 is very small,	0000, 0000,
x_7 is very small, x_8 is very small}	0000, 0000,
Y = { y_1 is small, y_2 is small}	0001, 0001,
Average_K is large	0011
Average_B is very large	0111
NbFirms is very small	0000
Average_Y = Aver_y_1 is medium, Aver_y_2 is small}	0010, 0001
Form = Form1	0000, 0001,0010, 0000, 0000, 0000,0000, 0000,
Best_Form = Form2	0010, 0011,0110, 0100, 0000, 0001,0000, 0000,
Worst_form = Form6	0001, 0001,0100, 0000, 0001, 0000,0000, 0000,
Action =Strategy 1	1 (p)=0.5, (e) = 0.01, (F) = 100

Adaptive firms (5)

The reward function:

- Usually discrete

➢ In the firm context a great improvement of the performances is different from small one

☞ A reward function varying with the context.

- Is it profitable to consider the other firms in the definition of the reward function ? (Peres- Uribe 04)

Adaptive firms (6)

- Individual reward function

$$reward = aggreg\left(\frac{Y_t[1]-Y_{t-1}[1]}{Y_t[1]}, \frac{Y_t[2]-Y_{t-1}[2]}{Y_t[2]}\right)$$

- Collective reward function
  - variation of the relative performance of the firm

$$reward = relative\_perf_t - relative\_perf_{t-1}$$

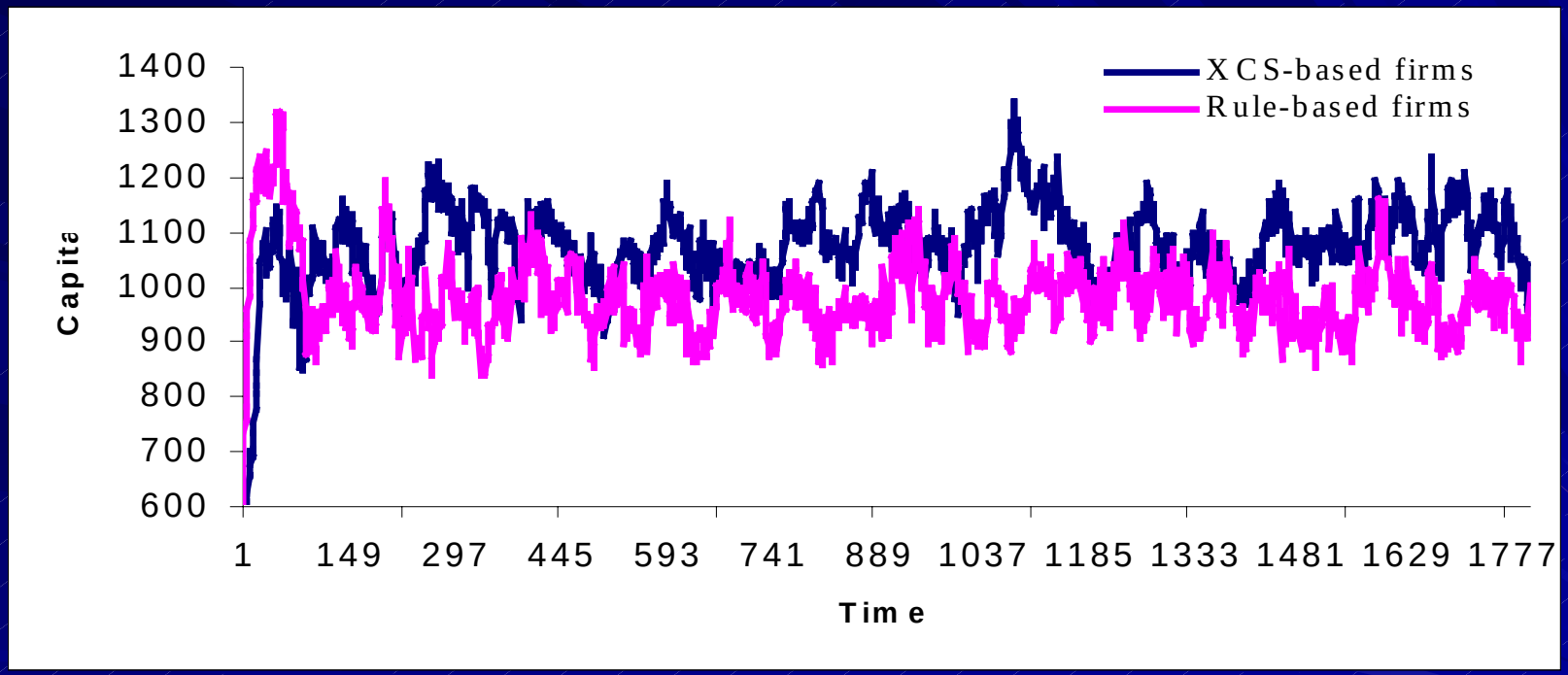
where Relative_performance$_t$ considers the past performances of the firm and the competition state.

Experimentation protocol

- Fixed XCS parameters
  - Population size = 6000
  - Exploration probability = 0.5
  - Activation of the genetic algorithm each 20 periods
  - Learning rate = 0.001
- Results correspond to the average values of 20 simulations
  - Populations of 300 firms having the same initial parameters and differing by their decision process

Experiments

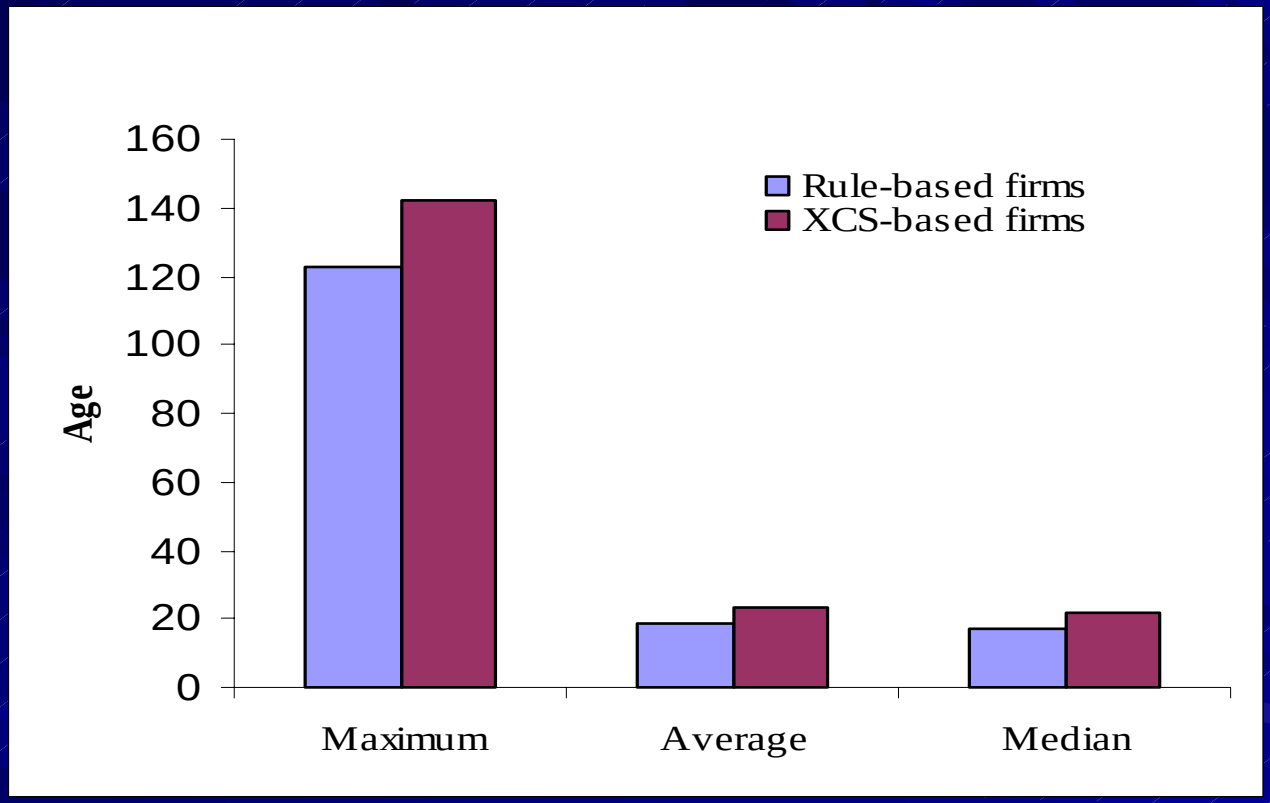
Rule-based vs. adaptive firms



- Adaptive firms have a greater capital
- Adaptive firms have a first difficult phase → empty initial base

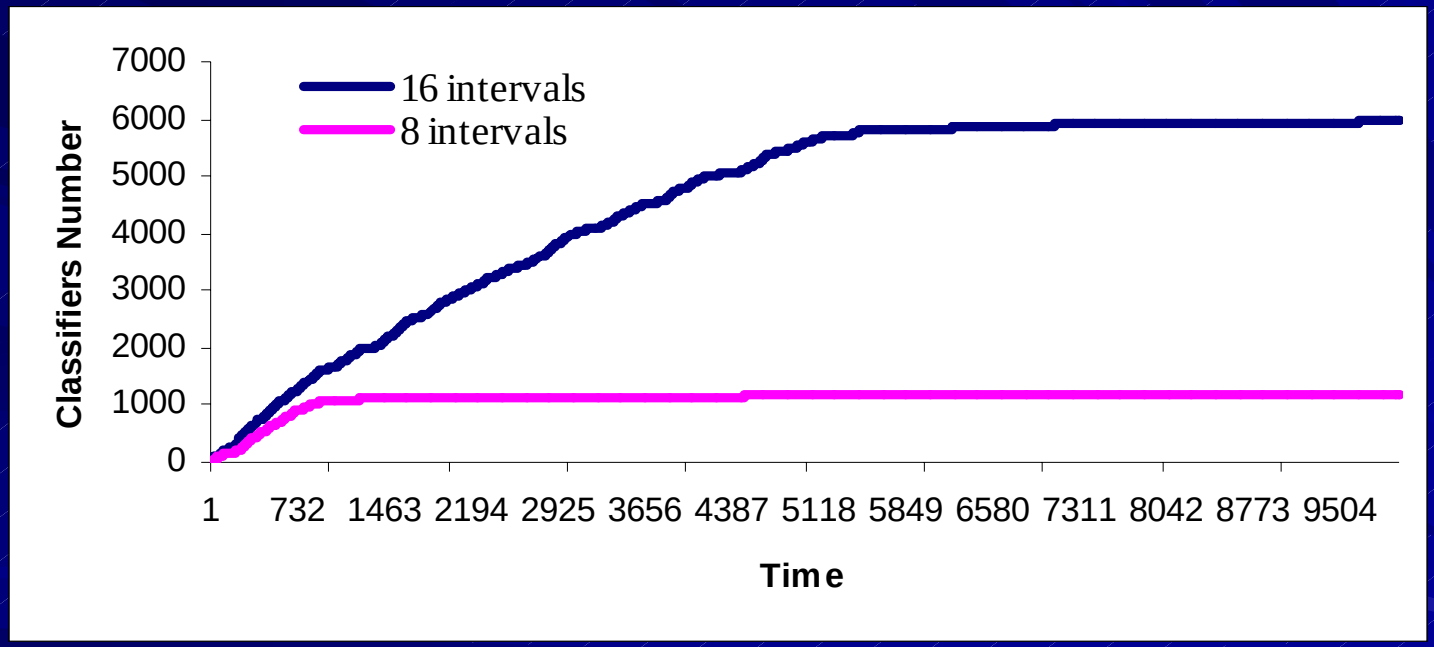
Experiments

Greater resistance of adaptive firms



Experiments

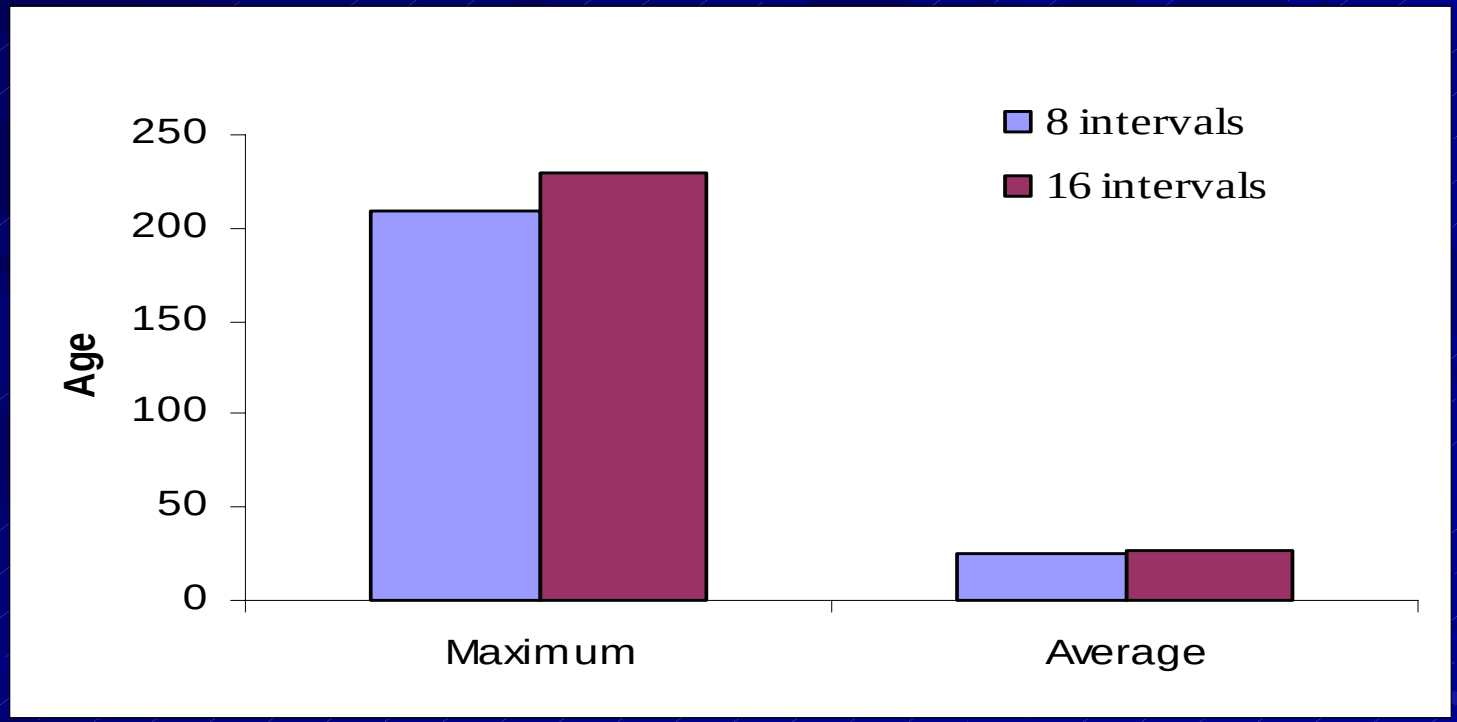
Easier learning with less precise coding and richer classifiers population with more precise coding



- The convergence when using 16 intervals is at ~ 9000
- The convergence when using 8 intervals is at ~ 5000

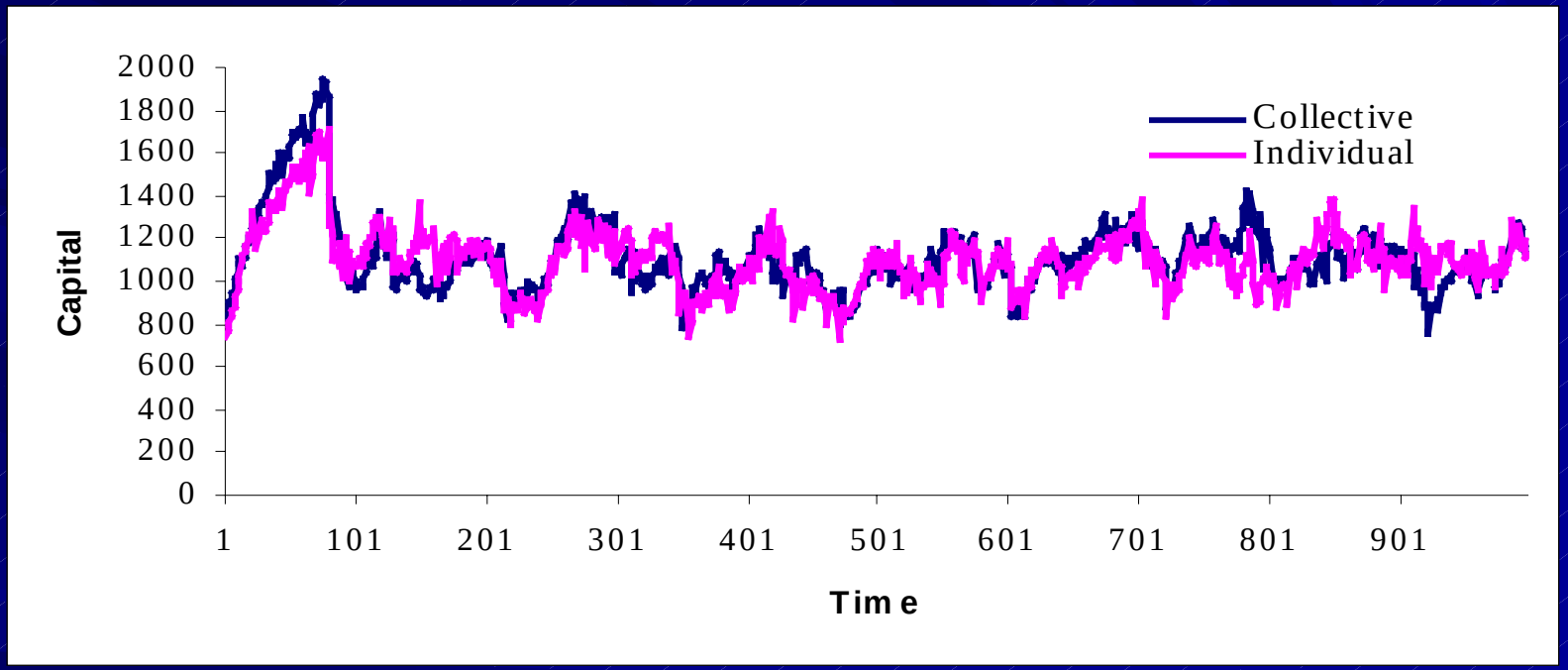
Experiments

Greater resistance with more precise codification



Experiments

Considering the other firms only in the perception is sufficient to make good decisions



– The average improvement given by collective reward is of 1%

Conclusion

- An adaptive multi-agent model
  Firms adapt according to:
  - their perception of the other firms (micro level)
  - their perception of the organizational forms (macro level)

- An operational simulator
  - simulate complex models
  - highlight the advantages and problems of using XCS in dynamic multi-agent environments

➢ Several interesting open problems
  - ➢ Coding
  - ➢ The exploration-exploitation dilemma
  - ➢ Influence of the organizational forms on the associated firms
  - ➢ ...