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Agent-based model in labor market as a third way to micro/macro relation: a new paradigm?

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Agent-based model in labor market as a third way to micro/macro relation: a new paradigm?

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Abstract

This paper presents an agent-based model where is shown in which circumstances cooperation appears from a heuristic process and how equilibrium endogenously emerges from the decentralized interactions of adaptive and autonomous agents. This modeling strategy is presented as a promising way to avoid the burdens of traditional rational agent conceptualization, for instance, the link between micro and macro level, a fragility overtaken by the idea of "aggregation" and the ubiquitous concept of "representative agent".

A human subject experiment inspired this agent-based computational model in labor market. The model defines two sorts of agents – firms and workers – with different payoff functions and learning abilities which allow them to develop a behavior rules repertoire selectively activated. In a frame of incomplete contracts each wage offered by the firm will be associated to an effort level chosen by the employee. According to the obtained payoffs, rules will be redefined and new payoffs will arise in the next iteration. This process is repeated a large number of iterations.

Then, slight changes will be introduced to the model (e.g., reciprocity, diversity and unemployment) for the purpose of comparing outcomes. How do different features create an efficient coordination among divergent micromotives? Agent-based computational simulations can help explaining the complex relations between micro and emergent macro realities and, consequently, give another perspective about interaction structures, their heterogeneity and agents evolutionary and adaptive processes. This work broad aim is to show that bridging the analysis of individual agents and system behavior is where the promises of gains are.

This work is organized as follows: Section 1 introduces a methodological and conceptualization overview. Section 2 brings in Labor Computational Economics. Section 3 introduces the formal model. Section 4 provides the implementation details. Section 5 exposes the simulation results. In Section 6 we summarize.

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1. Overview

The concept of methodological individualism is widespread throughout economics as a common principle of explanation, based on a particular methodological orientation – the representative agent paradigm -, which has general equilibrium as a characteristic. The rationality concept is applied in economic science as a tautology of maximizing behavior, through the definition of the set of solutions that constitutes the solution to the maximization problem of a restriction. Aggregate behavior is the result of individual choices made in accordance with the paradigm of rational choice, which assumes a central role in bridging the hiatus between individual actions and aggregate behavior. However, “deviations of actual behavior from the normative model are too widespread to be ignored, too systematic to be dismissed as random error and too fundamental to be accommodated by relaxed system” (Tversky e Kahneman, 1986: 252).

A small niche of economic literature is critical to theoretical conception of a normative model of an idealized agent – not descriptive of individuals’ behavior -, and although is intellectual elegance and deductive rigor, neoclassical general equilibrium is only possible by means of the adoption of extremely sparse model of the individual. Therefore, the normative power of the canonical model is questioned by the instability of the matrix of decisions and preferences. These preferences, steady and consistent, are the basis to evaluate individual wellbeing, but if individuals do not have unique preferences, once different decision frames can determine different preferences, these shouldn’t be presented as a steady consequence of individuals’ wellbeing. Consequently, aggregate preferences might not represent the best measurement of aggregate wellbeing.

Agent-based models do not need to suffer from the same problems that often beset individual behavior standard models.

Rationality and Equilibrium

Game theory studies multiagents decision problems. This definition could be applied to computational models, although a decisive conceptual difference separates them: there is an assumption in game theory saying that each agent knows how other agents behave when agent-based models use heterogeneous agents. This divergence in behavioral analysis rests on a different interpretation of rationality concept. According to Weibull (1997: 11), “a basic rationality postulate in noncooperative game theory is that ‘rational’ players never use strictly dominated strategies”. But in a situation of strictly dominated strategies elimination, as occurs in game theory, players have to know each others payoff functions and must not be only rational but also share a common knowledge of rationality. In computational modeling, bounded rationality eliminates that agents’ omniscient characteristic and confers a descriptive role to them.

But basic distinctions subsist between game theory approach and computational simulations, namely in the use of rationality and equilibrium concepts. The imposition of restrictions by game theory to individual action, aiming to reach equilibrium, determines the use of subjective probabilities defining the strategy that overtake imperfect information and decision problems. Game theory does not predict Nash equilibrium to Bayesian games, unless all individual strategies are define, by player “nature”, for every players’ types. As Gibbons refers (1992: 179) quoting Kreps and Wilson (1982)[1] “beliefs are elevated to the level of importance of strategies in the definition of equilibrium”, which means that given its beliefs players’ strategies must be sequentially rational. Computational models do not fit in this notion of equilibrium and choice process; the adopted strategy is not necessarily a best response to other individuals’ strategies and the agent will find it through a learning process.

Economic theory was conceived as a normative model of an ideal agent, not as a description of people’s behavior. Tversky e Kahneman (1986) showed that the logic of the choice in standard economics doesn’t provide the adequate assumptions for a descriptive theory of choice, due to framing effects ubiquity and to inherent invariance violations. Once invariance is a normative indispensable requisite, no prescriptive theory may allow its breaking and, consequently, normative and descriptive approaches are not reconcilable.

Computational economics differs from standard models for being descriptive and to try to explain preferences, either rational or not. Recent experimental studies have shown that individual preferences are far from traditional predictions of self interest behavior, proving that human beings are not simple maximizers but their behavior mirror their lives framing effects. Some laboratory experiments underline iniquity aversion (Fehr e Schmidt, 1999) or reciprocity (Rabin, 1993; Silva, 2002), but other explanations may be found in every day live. In his referential paper, Akerlof (1982) demonstrates in the light of efficiency wages theory how standard economics doesn’t

[1] Kreps, D. and R. Wilson (1982); *Sequential Equilibrium*; Econometrica 50, pp. 863-94.

explain workers and firms' behavior, respectively to work above minimum effort levels and to offer wages above market equilibrium.

2. Labor Computational Economics

Policymakers face the definition problem of labor institutions effects on macroeconomic performance. However, it has not been easy to economic science to get conclusive empirical evidence that corroborates the influence of labor institutions in the performance of the economy (Freeman, 1998). Situations where human choices or behaviors depend on other people attitudes do not allow the linkage to the aggregate, then, will the institutions be capable to create an efficient coordination between a myriad of micromotives? The solution to overtake the endogeneity problem might pass through a system of interactions between individuals and society or, in Schelling (1978) words, all human activities are characterized by individual behaviour influenced by others behaviour, the importance attributed to others attitudes, or both. Experiments on individual behavior have a potential heuristic value for the development of new empirical models and to surpass the difficulties found in standard models.

A decentralized methodology has emerged in economic science, Agent-based Computational Economics (ACE), determinative for modern mathematical approach to social sciences and based on long term interactions between autonomous and bounded rational individuals. The challenge is to constructively demonstrate how some regularities can appear from consecutive interactions of agents operating in artificial environments. The decentralized market economies rest on innumerable local interactions originating emergent macroeconomic regularities that, in turn, determine local interactions. In short, social phenomena are not the sum of the individual behaviors and this fact requires that the analysis goes down for a level below system, to interdependent behavior.

This investigation has two basic concerns: a descriptive one, focused on a constructive explanation of emergent global behaviour from the bottom up - from individual choice and agents interactions; and the second, how emergent features influence individual action.

According to this frame, the coordination is mentioned not as equilibrium but as a dynamic of routines, part of a simultaneously evolving and adaptive process intrinsic to societies. In this direction, the experiments are excellent comparative elements to individual learning under different conditions - the decision process (Devetag and Louçã, 2003).

This simulation is based on a laboratory experiment carried out by Silva (2002). This experiment main goal was to explain reciprocity as a behaviour constraint – in the form of an equity norm term introduced into agents' function - in a labor market context. The author refers as his main purpose "to show that reciprocity facilitates labor contracts accomplishment and explains wage differentials" (Silva, 2002: 44). Parallel experiments between human subjects and computational agents may be used to specify the simulation learning process, but computational agent behaviour can also be useful in the formulation of human behavior hypothesis.

A central model (MDR) reproducing the experiment of Silva (2002) is presented in this work and the effects of memory (M), diversity (D) and reciprocity (R) are studied. To this model are then introduced slight changes: 1) the reciprocity absence – MD model; 2) fixed-matching – MR model; and 3) fixed-matching with no reciprocity – M model. A fifth model confirms that reciprocity emerges from agents' interaction. To the first four models is added the possibility of worker wage rejection and, concomitantly, the existence of unemployment and firm vacancy.

The labor market frame of incomplete contracts and imperfect information is the basis for these models. Thus, after create and associate firms and workers exogenously, a rule of sequential matching is played: the firm selects amongst its repertoire of rules a wage and the associated worker, after "interpret" this offer, answers with an effort level chosen from its set of rules. The rules are selectively activated and constructed through an evolving and adaptive learning process based on past experiences. For this reason the Genetic Algorithm (GA) assumes particular relevance in agents' behavior understanding.

The computational experiments show three distinct effects: a) diversity or competition impact; b) the existence of reciprocal behaviors; and, finally, c) unemployment and firm vacancy. The implementation of treatments with emergent unemployment partially follows Pingle and Tesfatsion (2003) approach. Net income is the difference between average levels of agents' utility and average non-employment payments (NEP) paid to workers. The efficiency concept is determined by the ratio of current net income and income maximum level. To social welfare measurement two functions are used: 1) Sen's function (1974); and 2) the utilitarian linear function. All the outcomes are analyzed in a generational perspective: short, intermediate and long term. According to Pingle and Tesfatsion (2003), despite the doubts whether computational experiments is capturing the same economic and temporal structure that is reported in experimental economics, the “shadow of the past" has a weight for labor market that, inevitably, experimental economics cannot assume. Then, computational simulations can offer better predictions about labor market behaviors over time.

3. Model

Introduction

Models are written in Java, in an object-oriented language and implemented by means of RePast. Labor market consists of a constant population of 24 agents - 12 firms and 12 workers - through the 75000 generations that make the experiment. As Tables in Annex demonstrate, models’ outcomes are divided in 3 generational periods: short, intermediate and long term. Once the agents created, only once and in the first iteration, each generation is composed by a cycle divided in the following stages: (1) agents matching and its offers selection; (2) computation of utility functions; (3) gathering firms and workers statistical data; and (4) agents’ rules repertoire renewal. Assumed the importance of GA-simulation[2] in labor market simulation context a detailed presentation is justified.

Details of Implementation

The GA is the simplified evolutionary mechanism used to represent this particular socioeconomic context. The GA was inspired by computational studies of adaptive processes by which artificial learning abilities (efficiency) and heuristic procedures are attributed to multiagents simulation. The GA general concept was defined by Caldas (2001: 98) as follows:

- there is a population of individuals, each one represented by a finite alphabet by a string of characters called chromosome;

[2] v. Caldas (2001) for a reading on the main differences between the GA-simulation and the GA-optimization.

- each individual has a fitness and its meaning changes with the context. Here, fitness corresponds to individuals' utility;
- the GA is initialized with the creation of a population (usually by a random process) and individual fitness determination;
- in each iteration (generation) GA operates a generational transition in two stages:

- firstly, in selection, a reproduction pool is constituted and is integrated by a copy of current population chromosomes, selected according to a established criterion[3];

- finally, reproduction pool chromosomes (or part of them) are modified by recombination with other chromosomes of the same pool – crossover - or by random changes – mutation (as in nature, descendants keep some of their ancestors features).

Population

This computational labor model population is composed by firms and workers, whose profiles are constituted by a multiplicity of methods and variables used in the decision process. Each agent is constituted by 20 rules - each rule is a chromosome -, that can be interpreted as its genoma. Chromosomes have a determined length constituted by Boolean characters - genes - that can assume values 0 or 1. Firms' chromosomes length is 7 genes while workers' rules are formed by 20 genes, a difference explained by workers' effort function[4]. Each gene value is selected by a pseudo-random[5] and Uniform distribution and this process occurs $n\,rules \times n\,genes$ times for each agent. Next step is the calculation of agents' rules fitness - the utility. Fitness values start to be updated at the end of the first iteration, so the initial fitness values for each rule are predefined and correspond to the maximum value that the rules fitness can assume, in order to assure their updating, as will be shown later in selection process.

Matching and Rules Selection

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[3] v. sub-section Rules Renewal

[4] $e = a + b \times \left(\frac{1-a}{100}\right) \times \left(w - 20\right)$, where a=[0.1,1] is determined by the first 10 genes of the chromosome and b=[0,1] is determined by the last 10. Notice that to facilitate effort programming its value is always an integer (e=[1,10]), but the outcomes are presented according to the described function.

[5] From now on all the pseudo-random numbers will be called random.

After the initial population has been constituted the matching process begins. Each firm and worker are randomly matched and each firm can be matched only with a worker in each generation. Then, agents select their rules from their repertoire of rules by a random process. For each rule a bid value is randomly generated and the highest bid rule is the selected one[6]. This function, with their historical term (fitness) and present evaluation (ε), introduces an appropriate element of randomness to a context of uncertainty (Caldas, 2001: 138). After decoding binary rules into an integer, wages and effort levels are found and payoffs determined - a new fitness value for each active rule is defined. In an individual learning model, rules repertoire is private information (not socially shared), and exists a long term memory.

Rules Renewal

Cyclically, rules are renewed according to a Darwinian principle - elitist selection - and through two genetic operators: crossover and mutation. Each 4 generations period, individual rules are sorted by decreasing order according to its fitness value and split into two equal parts. Half of old rules, those with the biggest fitness values, will integrate part (first half) of the new rules population, keeping the old fitness values. However, from random recombination of current population pairs of rules - father and mother[7] - are generated new population rules - son and daughter (second half). In crossover process a random number is generated (between 1 and respective chromosome length minus 1) determining the crossover position, or where father and mother rules are broken and recombined. Therefore, son's rules are born from the merging of father's head chromosome and mother's tail chromosome and, inversely, daughter's from father's tail chromosome and mother's head chromosome, each one assuming the average fitness of its parents fitness values. Crossover can be seen as a heuristic process of improvement based on past experiences.

Mutation can be interpreted as a "lapse of memory" (Caldas, 2001: 139) or "representing trembles or experimentation" (Duffy, 2004: 31) and is a random change in

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[6] $bid = fitness \times (1+\varepsilon)$, where ε has a Normal Distribution with 0 mean and variance 0.075 (cf. Caldas, 2001: 141).

[7] The family metaphor facilitates the explanation.

a gene value - from 1 to 0 or vice versa. Mutation occurs when a random process generate, for each gene, a number in the interval [0,1] higher than the value, necessarily small, defined as the mutation probability (0.001 in the base treatment). These genetic operator aims to enrich the evolutionary process, modifying what neither crossover nor selection could change.

This selective process isolates and changes poor performance rules, conferring better rules to the agents, then, a better performance, even if a “bad” rule comes in. The “error“will be detected and certainly eliminated in posterior renewal cycles. Agents are capable to learn by own experiences and have the necessary means to find alternative behaviors.

In the end of this process a new population emerges and the process will be repeated from generation to generation until a stopping criterion put an end to it. This evolutionary process starts with a diversified initial population, whose characteristics were randomly determined, but through individual selection, recombinations and mutations tends to be dominated by individuals with better and more homogeneous characteristics (Caldas, 2001: 99).

4. Simulation

This labor market computational experiment consists of a base model with no fixed-matching and a reaction function (MDR). The other models result from slight modifications in MDR with the purpose of analyze the agents’ behavior when facing new scenarios: MDR with no reciprocity (MD); MDR with fixed-matching (MR); and MDR with fixed-matching and no reciprocity (M). Then, to these models is added the possibility of unemployment, respectively: MDRu; MDu; MRu; and Mu. There is another model MR but with “real” emergent reciprocity, which means that the second half of the chromosome, representing the workers’ reaction function, is equal to 0 (b=0).

For each treatment are generated 30 runs, each one with a different seed. Each run has 75000 generations, the only stopping criterion. To better analyze the evolutionary process were created three points of generational analysis - short, intermediate and long term - respectively the averages verified between iterations 21-120, 9901-10000 and the last 100 generations, 74901-75000. Before mentioning the results of all treatments for each model, we’ll show the statistical construction behind them. For each one of the 30 runs, average data on labor behaviors, unemployment and firms vacancies, and utility and welfare, are collected to all three generational periods. These 30 runs average results are the focus of our analysis in the next Section.

Labor behaviors

Workers and firms behaviors are analyzed through wage and effort average levels. Cooperative behaviors exist when average wage and effort levels moves away from minimum values and allow individuals to get higher levels of utility than those that would be obtained if they had opted not to cooperate. However, contrasting with Game Theory, agents can coevolve from a non cooperative state to a cooperative one, eliminating definitive labels. This coevolution is endogenously determined by the fact that agents make use of long term memory, a situation that allows them to evolve from an initial random scenario to reciprocal behaviors through recombination and mutation. This continuous unpredictability confers an extra interest and surprise in the achievement of stable wage and effort distributions.

Utility and social welfare

At the end of each iteration each agent utility level is calculated in accordance with its utility function, as defined in Silva (2002):

- Firms: $\pi = (v - w)e$
- Workers: $u = w - c_0 - c(e) + 18$.

In all experiments, firms' redemption value (v) is 120 and workers' opportunity cost for being in the job (c_0) is 20. Wage offers (w) are between the interval [20,120], while effort levels (e) and associated effort costs $(c(e))$ are determined according to the following costs function: $c = c(e) = (10e - 1)^{1.3}$ [8] and summarized follows:

[8] Defined by Fehr, Kirchsteiger, Riedl (1993: 11) and used in Silva (2002: 49).

Table 1: Effort Costs

e	**0.1**	**0.2**	**0.3**	**0.4**	**0.5**	**0.6**	**0.7**	**0.8**	**0.9**	**1**
c(e)	**0**	**1**	**2**	**4**	**6**	**8**	**10**	**12**	**15**	**18**

Source: Fehr, Kirchsteiger, Riedl (1993)

An additional term was inserted in workers' utility function to prevent negative levels of utility, a possibility when a maximum effort answer (1), with maximum cost associated (18), and a minimum wage offer (20) produce a negative utility level of -18.

Social welfare is considered under two distinct criteria: 1) according to the utility function of Sen (1974): $SW = \mu(1-G)$, where μ is the mean income of the society, workers and firms, and $G = \frac{\sum_{i=1}^{n}\sum_{j=1}^{n}|x_i - x_j|}{2n^2\mu}$, with $0 \le G \le 1$, is the Gini coefficient of the income distribution interpreted as an equity parameter; and 2) USW, a linear function of income[9].

The concept of net income is equal to the adopted in Pingle and Tesfatsion (2003): the difference between workers and firms average levels of utility and the average levels of NEP utility. Efficiency is determined by the ratio of current net income and the maximum value net income can assume.

Unemployment Rate and Firm Vacancy

In treatments with emergent unemployment, workers reject the wage proposal of the firm and receive a non-employment payment of 0, 15 or 30, depending on the treatment. A worker rejects a wage if the utility resulting from that offer and his effort would be equal or less than NEP. Thus, with just one match per iteration and with a single job vacancy to fill, unemployment rate will be equal to firms' vacancy rate. This structural asymmetry gives the workers an advantage in strategic planning (cf. Tables 7-10outcomes for w and e).

5. Results

[9] The Paretian or Rawlsian quarrel is not under the scope of this work.

The simulation outcomes have a notable coherence and regularity. But can cooperation emerge when cheating brings immediate benefits? In a simulation where agents look forward to maximize the utility of their repertoire of rules, these individuals only with long term memory reach, in some circumstances, cooperative outcomes. Cooperation emerges in more diversified and competitive contexts but also with reciprocity, therefore, it is not enough to have memory to cooperate, also interaction and competitiveness are necessary. Axelrod (1997) demonstrated that a learning strategy developed by the GA had better outcomes than the most efficient game theory strategies, tit for tat, since cooperative behaviors were strengthened and outcomes improved.

With emergent unemployment the average wage offers increase for firms' side inactivity pressure, while workers keep its average effort levels. Although the transition from a full employment economy to an unemployment and firms vacancies scenario, average efficiency and social welfare increase.

Memory, Diversity and Reciprocity

Tables 2-6 show the stabilization process of wage and effort levels in each model base treatment[10] from generation 10000 onwards. Amongst these models, MDR presents the best outcomes for the base treatment: in the long term, average wage is 41.63 and average effort 0.37. Consequently, also presents the higher average levels of utility (28.6 and 35.71, respectively for firms and workers), well-being (31.93 or 32.16, it depends on the criterion) and efficiency (54.5%). However, differences between this model's average results and those obtained for other models allow us to identify three important effects: memory (Table 5), diversity (Table 3) and reciprocity (Table 4).

To test the model in its limits we fixed the probability of mutation to an implausible 0.1 and provoked agent rules instability. We verify the chaotic fluctuation of wage and effort standard deviations, comparing to less dispersion base treatment and the results robustness for a mutation probability of 0.0015, as shown in Figures 1-3:

[10] Situation described in the first treatment (probmut=0.001; n=12; renew=4; rules=20) of each model represented in Table 2-6.

Figure 1: probmut 0.001

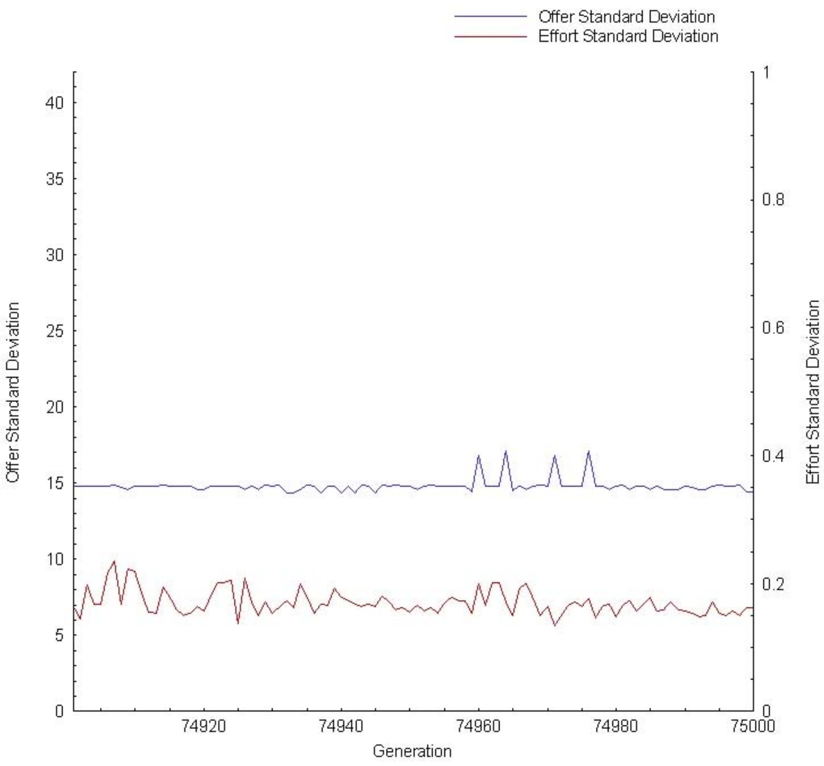


Figure 2: probmut 0.1

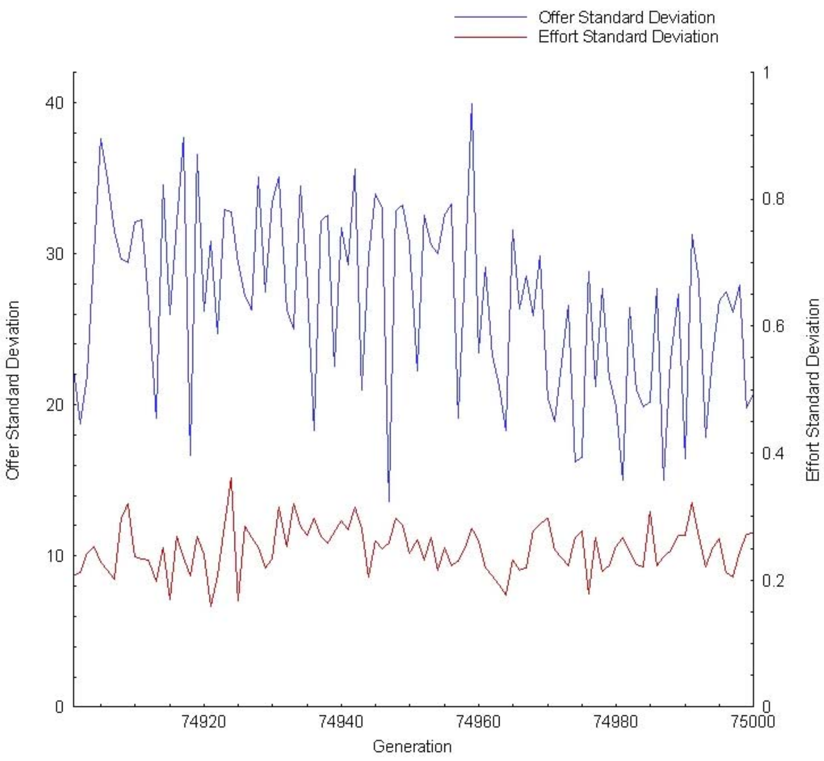
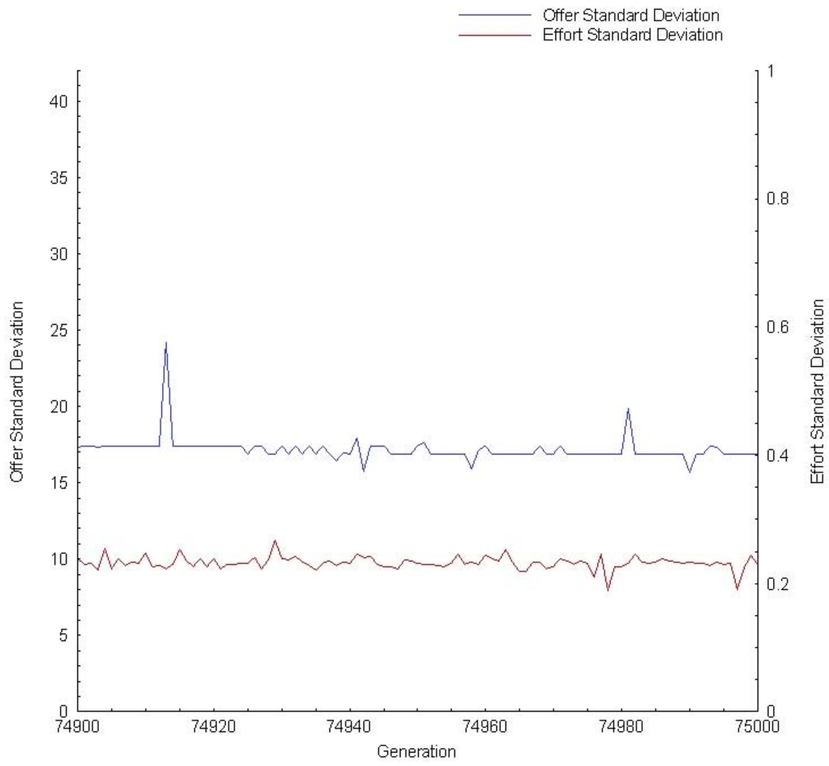


Figure 3: probmut 0.0015



When we reduce the number of agents to n=1, a single worker and firm, short term similarities with other treatments are substituted by a wage average (33.19) and effort average levels (0.16) divergence. Average wages and effort reduction is justified by diversity absence in a fixed-matching labor relation reflected in social welfare levels (19.49 and 21.86). Reducing the number of agents to 6 dissipate differences to the base treatment.

The rules renewal parameter – renew - and the number of rules - rules - are defined in a discretionary way, however, the radical variation implemented provoke a random process. Testing renew parameter we see that the biggest renew parameter is the slower will be the learning process. This treatment clarifies why GA does not tend to minimum values, and the explanation inhabits in the fact that renewal rules regularity is a basic component of individual evolutionary system – the individual learning capabilities. Imposing a longer period to learning process, in each iteration agents will answer with their best response until it become mediocre. Why? If the choice fell over the best rule, only when a bad matching changes a good rule into a bad one another rule would be chosen. But isn't always so? In fact it is, but drawing out the learning stage, the persistent choice of the same rules without a reproduction process, extinguishes the good rules and its characteristics. The biggest the period between crossovers is the greater the rule repertoire impoverishment, since crossover can be seen as a heuristic process of improvement based on past experiences. A rule with good characteristics To survive has to, obviously, exist or to perpetuate its characteristic through lineage. With renew=20, a good rule does not have much to do except to survive to successive matching, otherwise will be an extinguished rule.

Good rules prevail in a consistent learning process. The advantage of the base treatment is in the learning frequency procedure allowing, or not, the best characteristics of each individual to spread before these are depleted and substituted for worse quality rules. Renew=5 treatment proves that in a small scale effect.

The number of rules must obey to a crossover demanding: rules must be divisible by 4. To reduce the number of rules confers more internal stability to individuals' repertoire, due to its dimension. And with a set of rules equal to 8, wage and effort rapidly reach a steady value superior to that of the base treatment, justified by crossover, because the average obtained by lineage is less diversified than the one verified for 20 rules. Rules=16 treatment contains the diversity assumptions. Population diversity gives a more varied lineage, but this high values stability is obtained by three features: memory, diversity and reciprocity. In absence of any of these characteristics the values assume a decreasing trend.

Were implemented debug tests consisting in run all models with constant average wage and fixed effort in its minimum values, respectively w=20 and e=0.1. The other matching agent "learn" and its offers rapidly converge to the minimum. These treatments generate average utility, well-being and efficiency values below the obtained when these parameters are free.

The described agents live in society, permanently interacting and their options are not supported by traditional economy aphorism "less is more", as confirmed by Tables 2-6. Between this agent and the representative agent, whom we use to live with, there is an abyssal difference.

Memory and Diversity

MD base treatment reflects the effect of diversity that can also be interpreted as competitiveness. The difference between this model and the MDR model is the fact that workers' utility function omits the reaction function to firms' wage offers[11]. This slight change affects both agents offers: in the long term, average wage is 34.62 and average effort 0,32, which are values inferior to those found in MDR. But the main result is that obtained in 2 agents treatment, where offers converge to minimum values, a typical situation in models with no reciprocity that become identical to M model treatment with 2 agents. All other treatments follow the same behavior found in model MDR, despite the lowest values, justified by reciprocity absence.

Memory and Reciprocity

In this model each firm is associated to the same worker and this relation lasts until the final generation. The effect of reciprocity in the average wages is similar to the effect of diversity (32.73), however, consequences on effort levels are discreet (0.16). So, diversity and reciprocity have an identical effect on wages, but on effort is diversity that demonstrates a more relevant role. In the 2 agents' treatment, where treatment proper nature imposes diversity absence, the effect of reciprocity on the average wage is higher than other models effects (27.79).

Outcomes demonstrate the impact of cooperative behaviors in labor relations with incomplete contracts. Workers' propensity to reciprocate is proportional to the value of their effort function component, b, and to the slope of the wage reaction term. However, although firms do not have any term that reflects a cooperative behavior, workers' effort level influences the firms' utility by conditioning, through the fitness value, the future choice of that rule. Thus, firms' actions are not a reaction but are not completely independent of workers' behavior either.

In this model and in the previous one, although firms and workers diminish its average offers, we might verify that both individual and social outcomes are lower than those of MDR experiment.

In Table 6, with emergent reciprocity, the results are in line with those of Table 4 in spite of different initial settings in agents propensity to reciprocate. Concluding, reciprocity really emerges from interactions.

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[11] $e = a + b \times \left(\frac{1-a}{100} \right)$

Memory

According to Schelling (1978), human activities are influenced by others behaviorand in this model is possible to hold back the essential of this sentence. Agents' interactions are based solely on their memory, since there is not diversity or reciprocity, so the outcomes in the long term converge to minimum values, except the "random" treatment with probability of mutation equal to 0.1.

A possible conclusion is that is not enough to have memory to get good results and competition and a reaction function are necessary to make offers, individual utilities and social welfare go up.

Unemployment

In the long term and in an emergent unemployment situation is the high non-employment treatment (NEP30) that reaches high average outcomes. In the short term, lower NEP treatments get the best social outcomes. In MDRu model, long term efficiency, social welfare and workers' utility conquest is reached in detriment of average profits and the small percentage of unemployed workers and firm vacancy.

Table 7-10 outcomes indicate that although a higher NEP level corresponds to a higher unemployment rate, also average well-being and efficiency outcomes are superior to those of MDR model. A reasonable justification is that firms are much more sensible to workers' rejections and, therefore, exclude bad rules, which provoke firm vacancy and the consequent null utility, from its rules repertoire. The learning process that eliminates lower wage offers makes average wages to increase to levels higher than those of MDR model with no unemployment. Consequently, social welfare and global efficiency evaluation indicate that, in the long term, a higher NEP is better than lower NEP value or even its inexistence.

We can easily conclude that the existence of a social mechanism as non-employment payments drives to a change in individual behaviors, with consequences for a labor market systemic analysis.

6. Final remarks

As referred by Roth (2002), the recent advances of experimental methods and game theory that use individuals and computational agents permit to economists to study a multiplicity of complex phenomena associated to decentralized market economies. The exploitation of synergies between laboratory experiments and computational agents' simulations, through parallel experiments, can stimulate economic science to a yet unknown level. Thus, other experiments must be studied to calibrate, through a valid comparison, computational experiments to empirical evidence.

Converging to experimental results in general and to those obtained by Silva (2002) in particular - even if in his experiment Silva had obtained an average wage of 60 at the end of 12 periods, which is in line with our short term outcomes -, individual behavior is not solely explained by self interest. The exclusively use of individual memory as maximizing process is not a good strategy. In the labor market context presented in this work, diversity, reciprocity and the emergence of unemployment have a positive effect over average well-being and efficiency outcomes, what induces firms and workers cooperation.

Interactions aggregation emerges spontaneously in these models, far from what the "armchair economist" could imagine, to use Simon's (1986) expression. The computational model searches in outcomes an adaptable standard to empirical evidence, namely to cooperative behaviors, to competition and unemployment and does not have to necessarily include a steady equilibrium. Schelling (1978) argues that do not have to exist a self-serving behavior that leads to collective satisfactory results. Also Axtell (1999) says that the equilibrium existence becomes trivial in these models and the most important achievement is the selection of equilibrium, and since equilibrium is always idiosyncratic it can vary from interaction to interaction. The ACE models have bounded rationality and the unstable equilibrium as common characteristics, however, if it is difficult to analytically study the unsteady equilibrium these models have the capacity to exceed this question and to study the dynamics. According to Rust quoted in Axtell (2000):

"The reason why large scale computable general equilibrium problems are difficult for economists to solve is that they are using the wrong hardware and software. Economists should design their computations to mimic the real economy, using massively parallel computers and decentralized algorithms that allow competitive equilibria to arise as 'emergent computations'...[T]he most promising way for economists to avoid the computational burdens associated with solving realistic large scale general equilibrium models is to adopt an “agent-based” modeling strategy where equilibrium prices and quantities emerge endogenously from the decentralized interactions of agents.”

The computational simulation of complex behaviors is of doubtless importance since that allows the increasing interaction of variables and non-linearity. Considering that the models are underdetermined comparing with social reality that they look to describe, it is possible to reconstitute reality by a more sophisticated model of action, which confers structure to its components and underlying assumptions: the micro principle of purposive action, through a simple model of action; and the complex, but simplified, behavioral system of individuals’ action.

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MDR - Table 2

	SHORT TERM										INTERMEDIATE TERM										LONG TERM									
	w		**e**		**π**	**U**	**SW**	**USW**	**Net earn**	**Effic**	**w**		**e**		**π**	**U**	**SW**	**USW**	**Net earn**	**Effic**	**w**		**e**		**π**	**U**	**SW**	**USW**	**Net earn**	**Effic**
probmut=0.001; n=12; renew=4; rules=20	58,00	(28,20)	0,62	(0,24)	36,56	47,25	41,49	41,91	83,81	71,0%	38,66	(14,78)	0,37	(0,19)	29,82	32,74	31,07	31,28	62,57	53,0%	41,63	(14,96)	0,37	(0,19)	28,60	35,71	31,93	32,16	64,32	54,5%
probmut=0.1; n=12; renew=4; rules=20	61,23	(28,80)	0,63	(0,24)	34,73	50,33	42,11	42,53	85,06	72,1%	53,90	(26,13)	0,59	(0,24)	37,47	43,70	40,22	40,59	81,17	68,8%	52,87	(25,86)	0,58	(0,24)	37,13	42,93	39,67	40,03	80,06	67,8%
probmut=0.001; **n=1**; renew=4; rules=20	58,68	(0,00)	0,63	(0,00)	38,63	47,61	37,79	43,12	86,25	73,1%	39,49	(0,00)	0,21	(0,00)	15,83	36,06	22,68	25,95	51,89	44,0%	33,19	(0,00)	0,16	(0,00)	13,19	30,53	19,49	21,86	43,72	37,1%
probmut=0.001; **n=6**; renew=4; rules=20	59,64	(27,07)	0,60	(0,23)	34,60	49,24	41,10	41,92	83,84	71,0%	40,51	(16,17)	0,35	(0,19)	26,90	35,03	30,48	30,96	61,92	52,5%	41,60	(14,34)	0,33	(0,18)	25,33	36,40	30,40	30,87	61,73	52,3%
probmut=0.001; n=12; **renew=20**; rules=20	50,63	(18,90)	0,53	(0,22)	35,95	41,68	38,54	38,81	77,63	65,8%	43,46	(14,85)	0,29	(0,15)	20,94	38,91	29,69	29,92	59,85	50,7%	24,50	(5,00)	0,12	(0,03)	10,89	22,22	16,43	16,55	33,11	28,1%
probmut=0.001; n=12; renew=4; **rules=8**	50,25	(20,23)	0,56	(0,23)	37,75	40,76	38,97	39,26	78,52	66,5%	48,17	(16,80)	0,40	(0,20)	27,39	41,84	34,36	34,62	69,23	58,7%	49,16	(16,57)	0,37	(0,18)	25,33	43,40	34,10	34,37	68,73	58,2%
probmut=0.001; n=12; **renew=5**; rules=20	54,05	(25,79)	0,60	(0,24)	38,14	43,60	40,49	40,87	81,74	69,3%	43,09	(16,17)	0,39	(0,19)	29,07	36,93	32,76	33,00	66,00	55,9%	44,56	(15,34)	0,30	(0,16)	22,41	39,86	30,88	31,13	62,26	52,8%
probmut=0.0015; n=12; renew=4; rules=20	59,15	(28,41)	0,61	(0,24)	35,14	48,57	41,44	41,85	83,71	70,9%	41,34	(16,33)	0,40	(0,20)	30,46	34,96	32,48	32,71	65,42	55,4%	44,20	(16,98)	0,37	(0,20)	27,32	38,29	32,55	32,80	65,61	55,6%
probmut=0.001; n=12; renew=4; **rules=16**	53,22	(24,43)	0,60	(0,24)	38,76	42,81	40,43	40,79	81,58	69,1%	43,83	(15,12)	0,38	(0,18)	27,85	37,91	32,66	32,88	65,76	55,7%	44,93	(16,66)	0,39	(0,20)	28,31	38,75	33,28	33,53	67,06	56,8%
w=20	20,00	(0,00)	0,54	(0,26)	53,94	10,77	31,90	32,36	64,71	54,8%	20,00	(0,00)	0,10	(0,01)	10,36	17,96	14,08	14,16	28,33	24,0%	20,00	(0,00)	0,10	(0,01)	10,30	17,97	14,05	14,13	28,26	24,0%
e=0.1	67,87	(29,51)	0,10	(0,00)	5,21	65,87	34,91	35,54	71,08	60,2%	20,08	(0,28)	0,10	(0,00)	9,99	18,08	13,95	14,04	28,07	23,8%	20,08	(0,28)	0,10	(0,00)	9,99	18,08	13,95	14,04	28,07	23,8%

MD - Table 3

	SHORT TERM										INTERMEDIATE TERM										LONG TERM									
	w		**e**		**π**	**U**	**SW**	**USW**	**Net earn**	**Effic**	**w**		**e**		**π**	**U**	**SW**	**USW**	**Net earn**	**Effic**	**w**		**e**		**π**	**U**	**SW**	**USW**	**Net earn**	**Effic**
probmut=0.001; n=12; renew=4; rules=20	59,84	(28,43)	0,52	(0,26)	31,56	50,94	40,80	41,25	82,50	69,9%	35,32	(14,00)	0,30	(0,18)	25,67	30,54	27,88	28,11	56,21	47,6%	34,62	(14,51)	0,32	(0,20)	27,14	29,52	28,10	28,33	56,65	48,0%
probmut=0.1; n=12; renew=4; rules=20	61,21	(28,63)	0,53	(0,26)	30,92	52,25	41,12	41,59	83,17	70,5%	52,75	(26,26)	0,51	(0,26)	34,42	44,06	38,84	39,24	78,48	66,5%	51,62	(25,76)	0,51	(0,26)	35,02	42,92	38,58	38,97	77,95	66,1%
probmut=0.001; **n=1**; renew=4; rules=20	59,35	(0,00)	0,55	(0,00)	34,82	49,83	36,56	42,32	84,65	71,7%	21,01	(0,00)	0,12	(0,00)	11,95	18,75	14,14	15,35	30,69	26,0%	20,70	(0,00)	0,15	(0,00)	14,84	18,10	15,30	16,47	32,94	27,9%
probmut=0.001; **n=6**; renew=4; rules=20	60,25	(28,58)	0,52	(0,25)	31,24	51,38	40,40	41,31	82,61	70,0%	33,36	(12,20)	0,27	(0,15)	23,22	29,12	25,77	26,17	52,33	44,4%	33,54	(13,93)	0,28	(0,18)	24,37	28,94	26,19	26,66	53,31	45,2%
probmut=0.001; n=12; **renew=20**; rules=20	46,34	(19,79)	0,45	(0,24)	33,20	38,85	35,71	36,03	72,05	61,1%	21,41	(3,13)	0,11	(0,02)	10,83	19,30	14,97	15,06	30,13	25,5%	20,05	(0,17)	0,10	(0,01)	10,20	18,03	14,03	14,12	28,23	23,9%
probmut=0.001; n=12; renew=4; **rules=8**	47,57	(20,94)	0,50	(0,25)	36,10	39,17	37,30	37,64	75,27	63,8%	33,59	(13,95)	0,24	(0,13)	21,01	29,77	25,20	25,39	50,78	43,0%	24,99	(6,02)	0,15	(0,05)	14,00	22,39	18,08	18,20	36,39	30,8%
probmut=0.001; n=12; **renew=5**; rules=20	54,43	(26,33)	0,52	(0,26)	34,20	45,55	39,46	39,88	79,75	67,6%	34,63	(13,52)	0,26	(0,16)	22,32	30,47	26,19	26,40	52,80	44,7%	30,52	(11,97)	0,23	(0,13)	20,49	26,89	23,52	23,69	47,38	40,2%
probmut=0.0015; n=12; renew=4; rules=20	58,09	(28,21)	0,53	(0,26)	33,06	48,97	40,57	41,02	82,04	69,5%	35,41	(14,52)	0,33	(0,20)	27,66	30,15	28,67	28,91	57,81	49,0%	34,49	(14,48)	0,32	(0,19)	27,47	29,38	28,19	28,42	56,85	48,2%
probmut=0.001; n=12; renew=4; **rules=16**	52,53	(25,21)	0,51	(0,26)	34,35	43,94	38,75	39,14	78,29	66,3%	35,66	(13,70)	0,32	(0,19)	27,00	30,59	28,57	28,80	57,59	48,8%	33,74	(12,20)	0,28	(0,18)	24,27	29,27	26,57	26,77	53,54	45,4%
w=20	20,00	(0,00)	0,52	(0,26)	52,47	11,04	31,31	31,75	63,51	53,8%	20,00	(0,00)	0,10	(0,01)	10,44	17,95	14,11	14,19	28,39	24,1%	20,00	(0,00)	0,10	(0,01)	10,37	17,96	14,08	14,17	28,33	24,0%
e=0.1	67,25	(28,58)	0,10	(0,00)	5,27	65,25	34,64	35,26	70,53	59,8%	20,10	(0,35)	0,10	(0,00)	9,99	18,10	13,96	14,05	28,09	23,8%	20,08	(0,28)	0,10	(0,00)	9,99	18,08	13,95	14,04	28,07	23,8%

MR - Table 4

	SHORT TERM										INTERMEDIATE TERM										LONG TERM									
	w		**e**		**π**	**U**	**SW**	**USW**	**Net earn**	**Effic**	**w**		**e**		**π**	**U**	**SW**	**USW**	**Net earn**	**Effic**	**w**		**e**		**π**	**U**	**SW**	**USW**	**Net earn**	**Effic**
probmut=0.001; n=12; renew=4; rules=20	60,24	(29,24)	0,59	(0,23)	34,12	50,12	41,67	42,12	84,24	71,4%	32,92	(16,61)	0,17	(0,10)	13,88	30,15	21,81	22,02	44,03	37,3%	32,73	(16,92)	0,16	(0,09)	13,21	30,02	21,42	21,62	43,23	36,6%
probmut=0.1; n=12; renew=4; rules=20	61,41	(29,02)	0,61	(0,23)	34,06	50,82	42,01	42,44	84,88	71,9%	51,93	(26,00)	0,57	(0,24)	37,78	42,10	39,57	39,94	79,88	67,7%	51,95	(25,64)	0,58	(0,24)	38,46	41,95	39,83	40,20	80,41	68,1%
probmut=0.001; **n=1**; renew=4; rules=20	61,51	(0,00)	0,65	(0,00)	36,77	50,06	38,00	43,41	86,82	73,6%	34,95	(0,00)	0,14	(0,00)	11,10	32,58	19,09	21,84	43,67	37,0%	27,79	(0,00)	0,16	(0,00)	14,34	25,12	17,89	19,73	39,45	33,4%
probmut=0.001; **n=6**; renew=4; rules=20	59,41	(27,87)	0,61	(0,23)	36,25	48,75	41,61	42,50	85,00	72,0%	33,61	(15,42)	0,18	(0,09)	14,64	30,69	22,26	22,67	45,34	38,4%	32,07	(15,41)	0,15	(0,08)	12,91	29,45	20,79	21,18	42,36	35,9%
probmut=0.001; n=12; **renew=20**; rules=20	49,87	(18,91)	0,54	(0,22)	36,48	40,89	38,41	38,68	77,37	65,6%	27,77	(13,77)	0,12	(0,05)	10,70	25,56	17,97	18,13	36,26	30,7%	20,40	(1,38)	0,10	(0,01)	10,32	18,36	14,25	14,34	28,68	24,3%
probmut=0.001; n=12; renew=4; **rules=8**	47,19	(19,83)	0,47	(0,19)	33,65	39,61	36,34	36,63	73,26	62,1%	24,35	(9,89)	0,11	(0,03)	10,48	22,22	16,22	16,35	32,69	27,7%	22,55	(6,77)	0,10	(0,01)	10,08	20,50	15,18	15,29	30,58	25,9%
probmut=0.001; n=12; **renew=5**; rules=20	53,46	(26,14)	0,60	(0,23)	39,01	43,07	40,64	41,04	82,08	69,6%	28,84	(15,57)	0,14	(0,07)	11,80	26,43	18,95	19,12	38,23	32,4%	30,06	(17,38)	0,14	(0,08)	11,70	27,57	19,46	19,64	39,27	33,3%
probmut=0.0015; n=12; renew=4; rules=20	58,77	(28,58)	0,60	(0,24)	35,35	48,50	41,49	41,92	83,85	71,1%	35,65	(17,66)	0,19	(0,11)	14,95	32,63	23,57	23,79	47,58	40,3%	34,43	(17,97)	0,19	(0,11)	15,32	31,38	23,14	23,35	46,70	39,6%
probmut=0.001; n=12; renew=4; **rules=16**	51,38	(25,00)	0,57	(0,23)	38,47	41,63	39,67	40,05	80,10	67,9%	30,24	(16,33)	0,14	(0,08)	11,82	27,79	19,62	19,80	39,61	33,6%	30,96	(17,91)	0,14	(0,08)	11,99	28,45	20,03	20,22	40,45	34,3%
w=20	20,00	(0,00)	0,53	(0,26)	52,77	10,98	31,42	31,87	63,74	54,0%	20,00	(0,00)	0,10	(0,01)	10,44	17,95	14,11	14,20	28,39	24,1%	20,00	(0,00)	0,10	(0,01)	10,28	17,97	14,04	14,12	28,25	23,9%
e=0.1	68,90	(28,92)	0,10	(0,00)	5,11	66,90	35,36	36,01	72,01	61,0%	20,16	(0,53)	0,10	(0,00)	9,98	18,16	13,99	14,07	28,14	23,8%	20,08	(0,29)	0,10	(0,00)	9,99	18,08	13,95	14,04	28,07	23,8%

M - Table 5

	SHORT TERM										INTERMEDIATE TERM										LONG TERM									
	w		**e**		**π**	**U**	**SW**	**USW**	**Net earn**	**Effic**	**w**		**e**		**π**	**U**	**SW**	**USW**	**Net earn**	**Effic**	**w**		**e**		**π**	**U**	**SW**	**USW**	**Net earn**	**Effic**
probmut=0.001; n=12; renew=4; rules=20	59,04	(28,82)	0,52	(0,26)	32,38	50,27	40,85	41,33	82,66	70,0%	22,65	(6,06)	0,13	(0,07)	12,72	20,28	16,38	16,50	32,99	28,0%	22,20	(4,80)	0,12	(0,05)	12,17	19,92	15,94	16,05	32,09	27,2%
probmut=0.1; n=12; renew=4; rules=20	61,14	(28,75)	0,53	(0,26)	31,33	52,15	41,27	41,74	83,48	70,7%	50,72	(26,09)	0,50	(0,26)	35,04	42,29	38,26	38,67	77,33	65,5%	51,35	(26,48)	0,49	(0,25)	34,17	43,09	38,22	38,63	77,26	65,5%
probmut=0.001; **n=1**; renew=4; rules=20	59,20	(0,00)	0,44	(0,00)	28,16	51,82	34,44	39,99	79,98	67,8%	22,23	(0,00)	0,13	(0,00)	13,16	19,82	15,21	16,49	32,98	27,9%	22,65	(0,00)	0,12	(0,00)	11,74	20,42	14,73	16,08	32,16	27,3%
probmut=0.001; **n=6**; renew=4; rules=20	61,81	(29,34)	0,50	(0,27)	29,45	53,35	40,40	41,40	82,81	70,2%	22,80	(5,43)	0,14	(0,06)	13,13	20,36	16,51	16,75	33,49	28,4%	22,82	(5,87)	0,13	(0,06)	13,15	20,40	16,53	16,77	33,55	28,4%
probmut=0.001; n=12; **renew=20**; rules=20	46,23	(0,00)	0,44	(0,00)	32,45	38,89	35,36	35,67	71,33	60,5%	20,27	(0,00)	0,10	(0,00)	10,45	18,22	14,25	14,34	28,67	24,3%	20,05	(0,00)	0,10	(0,00)	10,17	18,03	14,02	14,10	28,20	23,9%
probmut=0.001; n=12; renew=4; **rules=8**	40,88	(18,64)	0,42	(0,23)	33,62	34,00	33,50	33,81	67,62	57,3%	20,23	(0,76)	0,10	(0,01)	10,39	18,18	14,20	14,29	28,57	24,2%	20,07	(0,25)	0,10	(0,00)	10,07	18,06	13,98	14,07	28,13	23,8%
probmut=0.001; n=12; **renew=5**; rules=20	54,13	(26,53)	0,49	(0,26)	33,30	45,78	39,11	39,54	79,08	67,0%	20,71	(2,09)	0,11	(0,03)	10,92	18,58	14,66	14,75	29,50	25,0%	21,10	(3,19)	0,11	(0,04)	11,22	18,93	14,98	15,07	30,15	25,6%
probmut=0.0015; n=12; renew=4; rules=20	60,31	(29,38)	0,52	(0,26)	31,77	51,54	41,16	41,65	83,31	70,6%	23,93	(7,96)	0,14	(0,09)	13,79	21,40	17,47	17,59	35,19	29,8%	22,73	(6,03)	0,14	(0,08)	13,63	20,25	16,82	16,94	33,88	28,7%
probmut=0.001; n=12; renew=4; **rules=16**	52,13	(25,67)	0,49	(0,26)	34,41	43,76	38,66	39,08	78,17	66,2%	21,36	(3,79)	0,12	(0,04)	11,35	19,17	15,16	15,26	30,51	25,9%	21,19	(3,45)	0,13	(0,06)	12,28	18,86	15,47	15,57	31,14	26,4%
w=20	20,00	(0,00)	0,53	(0,26)	53,24	10,89	31,61	32,06	64,13	54,3%	20,00	(0,00)	0,11	(0,02)	10,64	17,93	14,20	14,28	28,57	24,2%	20,00	(0,00)	0,10	(0,01)	10,26	17,97	14,03	14,11	28,23	23,9%
e=0.1	69,81	(28,85)	0,10	(0,00)	5,02	67,81	35,76	36,41	72,82	61,7%	20,08	(0,26)	0,10	(0,00)	9,99	18,08	13,95	14,03	28,07	23,8%	20,08	(0,27)	0,10	(0,00)	9,99	18,08	13,95	14,04	28,07	23,8%

probmut: mutation probability; n: number of workers/firms; renew: renewal period; rules: number of rules; NEP: non-employment payment

w: average wage; e: average effort; π: profit; U: worker utility; SW: social welfare (Sen); USW: social welfare (utilitarian); u: unemployment; net earn: net earnings; effic: efficiency

M_emerg_rec - Table 6

	SHORT TERM								INTERMEDIATE TERM								LONG TERM							
	w	**e**	**π**	**U**	**SW**	**USW**	**Net earn**	**Effic**	**w**	**e**	**π**	**U**	**SW**	**USW**	**Net earn**	**Effic**	**w**	**e**	**π**	**U**	**SW**	**USW**	**Net earn**	**Effic**
probmut=0.001; n=12; renew=4; rules=20	59,28 (29,22)	0,52 (0,26)	32,69	50,42	41,07	41,55	83,11	70,4%	33,02 (17,11)	0,17 (0,09)	13,62	30,30	21,76	21,96	43,92	37,2%	34,35 (17,99)	0,17 (0,10)	13,59	31,56	22,36	22,57	45,15	38,3%
probmut=0.1; n=12; renew=4; rules=20	60,22 (28,58)	0,59 (0,24)	34,06	50,14	41,66	42,10	84,20	71,4%	52,31 (26,01)	0,58 (0,24)	37,75	42,43	39,71	40,09	80,18	67,9%	51,98 (26,13)	0,58 (0,24)	37,94	42,09	39,64	40,01	80,03	67,8%
probmut=0.001; **n=1**; renew=4; rules=20	64,33 (0,00)	0,46 (0,00)	25,90	56,67	35,44	41,28	82,57	70,0%	31,83 (0,00)	0,20 (0,00)	16,79	28,54	20,30	22,66	45,33	38,4%	34,77 (0,00)	0,17 (0,00)	13,77	32,00	20,34	22,88	45,77	38,8%
probmut=0.001; **n=6**; renew=4; rules=20	59,56 (0,00)	0,52 (0,00)	32,40	50,79	40,59	41,59	83,19	70,5%	31,55 (0,00)	0,18 (0,00)	14,74	28,61	21,30	21,68	43,35	36,7%	33,29 (0,00)	0,16 (0,00)	13,64	30,55	21,68	22,09	44,19	37,4%
probmut=0.001; n=12; **renew=20**; rules=20	59,56 (0,00)	0,52 (0,00)	32,40	50,79	40,59	41,59	83,19	70,5%	20,42 (1,39)	0,11 (0,02)	10,44	18,37	14,32	14,40	28,81	24,4%	20,27 (0,92)	0,10 (0,00)	10,10	18,25	14,09	14,17	28,35	24,0%
probmut=0.001; n=12; renew=4; **rules=8**	43,19 (20,43)	0,42 (0,23)	32,33	36,39	34,05	34,36	68,72	58,2%	21,96 (6,34)	0,11 (0,03)	10,57	19,86	15,12	15,22	30,43	25,8%	22,36 (6,41)	0,11 (0,03)	10,43	20,26	15,24	15,34	30,69	26,0%
probmut=0.001; n=12; **renew=5**; rules=20	52,68 (26,69)	0,50 (0,25)	34,76	44,18	39,04	39,47	78,94	66,9%	28,71 (14,96)	0,13 (0,07)	11,49	26,34	18,75	18,92	37,83	32,1%	28,88 (15,45)	0,13 (0,07)	11,47	26,52	18,82	18,99	37,99	32,2%
probmut=0.0015; n=12; renew=4; rules=20	59,70 (28,78)	0,51 (0,26)	31,53	51,04	40,81	41,28	82,57	70,0%	33,02 (17,03)	0,17 (0,10)	14,29	30,19	22,04	22,24	44,48	37,7%	34,47 (18,10)	0,17 (0,10)	14,29	31,59	22,72	22,94	45,89	38,9%
probmut=0.001; n=12; renew=4; **rules=16**	50,42 (24,93)	0,52 (0,26)	37,49	41,55	39,10	39,52	79,04	67,0%	29,01 (16,23)	0,14 (0,07)	11,84	26,60	19,05	19,22	38,44	32,6%	30,49 (16,61)	0,15 (0,09)	12,63	27,90	20,08	20,27	40,53	34,3%
w=20	20,00 (0,00)	0,54 (0,26)	53,70	10,81	31,80	32,26	64,51	54,7%	20,00 (0,00)	0,10 (0,01)	10,46	17,95	14,12	14,21	28,41	24,1%	20,00 (0,00)	0,10 (0,01)	10,27	17,97	14,04	14,12	28,24	23,9%
e=0.1	69,19 (29,11)	0,10 (0,00)	5,08	67,19	35,49	36,14	72,27	61,2%	20,15 (0,50)	0,10 (0,00)	9,99	18,15	13,98	14,07	28,13	23,8%	20,08 (0,28)	0,10 (0,00)	9,99	18,08	13,95	14,04	28,07	23,8%

MDRu- Table 7

	SHORT TERM									INTERMEDIATE TERM									LONG TERM								
	w	**e**	**π**	**U**	**SW**	**USW**	**u**	**Net earn**	**Effic**	**w**	**e**	**π**	**U**	**SW**	**USW**	**u**	**Net earn**	**Effic**	**w**	**e**	**π**	**U**	**SW**	**USW**	**u**	**Net earn**	**Effic**
NEP0	57,60 (27,98)	0,62 (0,24)	36,97	46,75	41,45	41,86	0,1%	83,72	71,0%	38,95 (14,69)	0,40 (0,20)	31,52	32,63	31,85	32,07	0,1%	64,14	54,4%	41,65 (16,45)	0,37 (0,19)	28,18	35,83	31,76	32,00	0,0%	64,01	54,2%
NEP15	63,16 (28,26)	0,58 (0,26)	29,66	53,64	41,26	41,65	3,8%	82,72	70,1%	46,56 (15,39)	0,39 (0,19)	27,81	40,47	33,92	34,14	1,0%	68,12	57,7%	49,84 (16,32)	0,41 (0,20)	27,84	43,42	35,37	35,63	1,0%	71,12	60,3%
NEP30	64,15 (33,51)	0,54 (0,30)	22,36	59,37	40,49	40,87	15,1%	77,20	65,4%	58,89 (15,84)	0,38 (0,19)	22,38	53,66	37,68	38,02	2,7%	75,24	63,8%	57,27 (15,94)	0,36 (0,19)	21,57	52,38	36,64	36,98	2,6%	73,17	62,0%

MDu- Table 8

	SHORT TERM									INTERMEDIATE TERM									LONG TERM								
	w	**e**	**π**	**U**	**SW**	**USW**	**u**	**Net earn**	**Effic**	**w**	**e**	**π**	**U**	**SW**	**USW**	**u**	**Net earn**	**Effic**	**w**	**e**	**π**	**U**	**SW**	**USW**	**u**	**Net earn**	**Effic**
NEP0	60,08 (29,12)	0,54 (0,26)	32,19	50,94	41,10	41,57	0,1%	83,13	70,5%	36,26 (14,46)	0,33 (0,20)	27,75	30,93	29,10	29,34	0,0%	58,68	49,7%	33,36 (12,90)	0,28 (0,17)	24,00	28,92	26,26	26,46	0,0%	52,92	44,8%
NEP15	62,38 (29,02)	0,48 (0,27)	26,09	54,89	40,06	40,49	4,3%	80,33	68,1%	41,47 (16,83)	0,32 (0,19)	24,39	36,89	30,40	30,64	3,2%	60,80	51,5%	39,47 (16,20)	0,30 (0,18)	23,52	35,24	29,16	29,38	3,7%	58,21	49,3%
NEP30	62,97 (34,12)	0,41 (0,29)	17,98	60,92	39,03	39,45	16,3%	74,02	62,7%	55,61 (17,45)	0,30 (0,18)	18,41	51,99	34,85	35,20	3,7%	69,30	58,7%	53,84 (16,06)	0,27 (0,16)	17,05	50,57	33,46	33,81	3,1%	66,70	56,5%

MDRu- Table 9

	SHORT TERM									INTERMEDIATE TERM									LONG TERM								
	w	**e**	**π**	**U**	**SW**	**USW**	**u**	**Net earn**	**Effic**	**w**	**e**	**π**	**U**	**SW**	**USW**	**u**	**Net earn**	**Effic**	**w**	**e**	**π**	**U**	**SW**	**USW**	**u**	**Net earn**	**Effic**
NEP0	59,61 (28,61)	0,61 (0,23)	35,71	49,10	41,96	42,41	0,1%	84,81	71,9%	33,42 (17,77)	0,17 (0,11)	13,86	30,56	22,00	22,21	0,0%	44,43	37,7%	32,26 (17,34)	0,17 (0,10)	14,16	29,46	21,61	21,81	0,0%	43,63	37,0%
NEP15	61,95 (29,72)	0,58 (0,26)	30,79	52,51	41,25	41,65	4,6%	82,62	70,0%	34,37 (17,84)	0,17 (0,11)	13,54	31,68	22,40	22,61	1,0%	45,07	38,2%	35,42 (19,74)	0,18 (0,12)	13,83	32,61	23,01	23,22	1,0%	46,29	39,2%
NEP30	61,44 (33,51)	0,51 (0,31)	22,95	57,56	39,90	40,25	16,5%	75,55	64,0%	51,12 (16,25)	0,18 (0,11)	11,62	48,92	29,89	30,27	2,4%	59,83	50,7%	51,62 (16,49)	0,18 (0,11)	11,84	49,40	30,23	30,62	2,5%	60,50	51,3%

Mu- Table 10

	SHORT TERM									INTERMEDIATE TERM									LONG TERM								
	w	**e**	**π**	**U**	**SW**	**USW**	**u**	**Net earn**	**Effic**	**w**	**e**	**π**	**U**	**SW**	**USW**	**u**	**Net earn**	**Effic**	**w**	**e**	**π**	**U**	**SW**	**USW**	**u**	**Net earn**	**Effic**
NEP0	59,92 (29,42)	0,52 (0,27)	32,70	50,93	41,32	41,82	0,0%	83,63	70,9%	22,17 (5,01)	0,13 (0,07)	12,88	19,80	16,23	16,34	0,0%	32,67	27,7%	21,96 (4,75)	0,13 (0,06)	12,32	19,63	15,87	15,98	0,0%	31,95	27,1%
NEP15	61,97 (28,78)	0,49 (0,27)	27,18	54,40	40,36	40,79	4,3%	80,94	68,6%	23,35 (8,47)	0,14 (0,08)	12,64	21,12	16,77	16,88	1,4%	33,55	28,4%	23,16 (9,11)	0,13 (0,08)	12,36	21,07	16,60	16,71	2,0%	33,13	28,1%
NEP30	63,83 (34,07)	0,44 (0,30)	19,67	61,01	39,92	40,34	15,3%	76,10	64,5%	50,72 (16,22)	0,16 (0,10)	10,59	48,73	29,27	29,66	2,4%	58,59	49,6%	50,39 (14,77)	0,15 (0,09)	9,84	48,21	28,63	29,02	1,3%	57,66	48,9%

probmut: mutation probability; n: number of workers/firms; renew: renewal period; rules: number of rules; NEP: non-employment payment

w: average wage; e: average effort; π: profit; U: worker utility; SW: social welfare (Sem); USW: social welfare (utilitarian); u: unemployment; net earn: net earnings; effic: efficiency