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Rethinking the Social Contract: An Agent-Based Model approach

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Abstract The actual crisis has brought to a forefront the failure in wealth distribution and it has questioned market with democracy. It has vividly demonstrated the deficiencies in the outdated current economic theories, calling for rethinking Economics. Agent Based Modelling (ABM) applied to this economic rethinking is a choice, a challenge and a promise. Market efficiency has received attention from ABM experts and the authors. However they have not studied the wealth distribution problem. In this paper, using an agent-based model approach, we study the sensitivity of wealth distribution to the agents' behavior in a Continuous Double Auction market. We find that the inequality on wealth distribution increases as the percentage of *parasitic* agents grows.

Keywords: Artificial Economics. Continuous Double Auction. Behavioral Economics. Social Contract. Growth and Welfare.

1.1 Introduction

Economic Theory is concerned with two issues: wealth generation and its distribution. In the last 50 years the advanced countries have been very successful in generating wealth, but not so much in its distribution. In the last decade many economists wrote about a new era where the cycle was over and prosperity was secured, because the effects of massive global trade and information technology. The distribution of wealth issue was shaded by this prosperity. The actual crisis has brought to a forefront the failure in wealth distribution. Just one example: *"Since Ronald Reagan became President in 1981, America's budget system has been geared to supporting the accumulation of vast wealth at the top of the income distribution. Amazingly, the richest 1% of American households now has a higher net worth than the bottom 90%. The annual income of the richest 12,000 households*

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is greater than that of the poorest 24 million households… The problem is America's corrupted politics and loss of civic morality" (Sachs 2010).

Business magnates as W.Buffet are showing deep concern about the lack of a proper distribution of wealth. The great destruction that is causing our recent global financial crisis has vividly demonstrated the deficiencies in our outdated current economic theories. G.Soros has just created the *Institute for New Economic Thinking* to broaden and accelerate the development of new economic thinking that can lead to solutions for the great challenges of the 21st century. ABM has been selected as both, a challenge and a promise. Classic economists were very concerned with both sides of market properties: efficiency in wealth generation and a fair distribution. Adam Smith's, *An Inquiry into the Nature and Causes of the Wealth* and *The Theory of Moral Sentiments.* Providing answers to these questions, would strengthen civilization, by helping the poor, advancing the arts and education, thus rendering peace trough democracy.

It is worth noting that Adam Smith set on these tasks using Hume's ***experimental method*** (appealing to human experience) to replace the specific *moral sense.* The authors have promoted this experimental method both with human and artificial agents (ABM) since 1999: The time has come to go back to the classics with the power of resolution of nowadays social simulation (ABM).

In previous works (Posada and López, 2008; Posada et al, 2008) we have addressed the questions linked with the market as an spontaneous efficient way to coordinate agents to solve problems of scarcity an choice that are common to both Economics (wealth generation) and to Management Engineering (job shop coordination and holistic manufacturing). The market capability to achieve coordination and wealth generation can be hindered by transaction costs. We have shown that ABM can also help to understand this issue.

Adam Smith was well aware of the last and more relevant question: Does the market achieve a fair distribution of wealth? And he advanced the core of a proper answer: "*A regulation which enables those of the same trade to tax themselves, in order to provide for their poor, their sick, their widows and orphans, by giving them a common interest to manage, renders such assemblies necessary. An incorporation not only renders them necessary, but makes the act of the majority binding upon the whole.* ***In a free trade, an effectual combination cannot be established*** *but by the unanimous consent of every single trader, and it cannot last longer than every single trader continues of the same mind".* Trade is a non-zero sum game, but the share of wealth can not be solved by the game itself.

In ABM, the influence of alternative agents' behavior on market efficiency can be evaluated because the agents' behavior can be controlled. However, the wealth distribution on markets has not received the same attention. In this paper, using an ABM approach, we study the sensitivity of wealth distribution to the agents' learning on Continuous Double Auction markets. We find that both the market efficiency decreases and the inequality on wealth distribution increases as the percentage of *parasitic* agents grows.

The paper is organized as follows. In section 2 we revise the role of ABM to solve the relevance of institutional market design to achieve economic efficiency under heterogeneous agent's behavior and previous work about the wealth distribution problem. In Section 3 we describe our agent-based model. In Section 4 we calibrate the model and describe the experiments and the main results. In Section 6 we report the main conclusions of the paper.

1.2 ABM and market behavior

We choose as market the Continuous Double Auction (CDA) because there is a lot of previous experience in both experimental economics and artificial economics. CDA is a double sided auction where buyers and sellers announce and accept bids and asks at any time. The information is held separately by many market participants (in the form of privately known reservation values and marginal costs). The analytical game approach has been unable to explain its properties. Other alternative approaches have been Experimental Economics (EE) and ABM. These approaches analyze CDA distinguishing the following three dimensions (Smith 1982): the institution (I) (the exchange rules, the way the contracts are closed, and the information network), the environment (E) (agent endowments and values, resources, knowledge) and the agents' behavior (A).

Observing the agents' behavior (A) dimension, EE has established that fast price convergence and the allocative market efficiency is almost 100%. Smith (1962) first demonstrated these properties, and subsequent researches have replicated them under alternative environment `s conditions.

A major limitation of EE is the lack of control for the human participant's behaviour. Why don't we take a step further and replace human traders by soft agents that could allow us to control the A dimension?

Controlling the A dimension, ABM has established that high market efficiency (closed to 100%) can be achieved even if the artificial agents are zero intelligent (Gode and Sunder, 1993; Licalzi and Pellizari, 2008). Price convergence and individual surplus depend on the agents' learning have been shown by the authors (op.cit) explaining the paradox that a perfect market does not preclude intensive agents competition.

However, little attention has been paid to the wealth distribution on CDA markets. Bersini and van Zeebroecck (2011) first evaluated it using Zero-Intelligent agents. The purpose of this paper is to study the wealth distribution on CDA markets when alternative agents' learning is considered. We show how the invisible hand can lead to disastrous outcomes in the wealth distribution when, for example, there are too many *parasitic* agents in the market.

1.3 Our agent-based market model

We describe our model in terms of the essential dimensions of any market experiment: IxExA.

1.3.1 The institution: CDA

There are several variations of the double auction exchange rules to simplify its implementation. However, simplifications of the CDA rules matter (LiCalzi and Pellizari 2008). We consider that traders randomly place offers on the books. Orders are immediately executed at the outstanding price if they are marketable. Otherwise, they are recorded on the books and remain valid until either the end of the trading session or the agent improves its offer (to buy or to sell).

1.3.2 The environment

There are 12 sellers and 12 buyers in the market. Each agent has fifteen units to trade and their valuations are those reported in Noussair et al (1998). The result of their aggregation are the following demand and supply: D(x)=1535-10x and S(x)=35+10x, respectively. Competitive equilibrium exists at any market price between 780 and 790 and a quantity of 75. The total surplus is 57105 which is the sum of the consumer (27375) and the producer surplus (29730).

1.3.3 The agents' behaviour

Traders in CDA markets face three non-trivial decisions: How much should they bid or ask? When should they place a bid or an ask? And when should they accept an outstanding order? Bidding strategies corresponds to particular answers for these decisions. Learning has a relevant role in market efficiency and price convergence in CDA markets (Posada et al 2008; LiCalzi and Pellizari, 2008).

Submit an order. Traders learn to decide on how much should they bid or ask following the GD bidding strategy (Gjerstad and Dickhaut 1998), and they submit their orders 25 times the percentage. Each agent chooses the order which maximizes his expected surplus, defined as the product of the gain from trade and the probability for an offer to be accepted. The main point is to estimate this probability. GD agents estimate and modify this probability using the history of the market (the last 8 rounds).

Accept an order. Traders can use either the GD bidding strategy or the K bidding strategy (Rust et al. 1993). When traders follow the GD bidding strategy, they accept an outstanding offer to sell if it is less than its calculated offer to buy (submitted or not) and they accept an outstanding offer to buy if it is greater than its calculated offer to sell (submitted or not). The K bidding strategy consists in: "wait in the background and let others negotiate. When an order is interesting, accept it". An order is interesting when both the ratio between the outstanding bid and the outstanding offer is less than a percentage range between 1,25% and

3,75%, and the surplus achieved in the transaction is greater than a percentage range between 1% and 3%. Nevertheless, if the time is running out, any order (which provides benefits) is interesting. The K agents are *parasitic* on the intelligent agents to trade and to obtain profit.

1.4 Simulations and main results

We analyze CDA market efficiency and wealth distribution performance in the following six scenarios, where different percentage of two kinds of learning agents (GD and K) are considered, and *parasitic* agents are always in the demand side: 100%GD-0%K, 75%GD-25%K (buyers), 66,7,5%GD-33,3%K (buyers), 58,3%GD-41,7%K (buyers), 54,2%GD-45,89%K (buyers), and 50%GD-50%K (buyers). Each run consists of a sequence of ten consecutive trading periods, each one lasting 100 time steps

1.4.1 Market efficiency

We define allocative market efficiency as the total profit actually earned by all the traders divided by the maximum total profit that could have been earned by all the traders (i.e., the sum of producer and consumer surplus) (Smith 1962). We have obtained that the market efficiency is closed to 100% when all traders in the market use a GD bidding strategy (see Figure 4.1). Market efficiency decreases as the percentage of K bidding strategy increases. However, the market accepts some *parasitic* agents (around 40%) without a relevant decrease of market efficiency. If all traders in the market are K agents no trade will take place and market efficiency is zero.

1.4.2 Wealth distribution

We use the Lorenz curve and Gini index to quantify the wealth distribution. The Lorenz curve is a graphical representation of the cumulative surplus distribution function. It shows for the x% of market traders, what percentage y% of the total surplus they have. The Gini coefficient is the area between the line of perfect equality and the observed Lorenz curve, as a percentage of the area between the lines of perfect equality and inequality. The higher the coefficient, the more unequal the distribution is. A Gini coefficient of one expresses maximal inequality. It is calculated by equation 1.1:

$$G = \left| 1 - \sum_{i=1}^{N} (\sigma Y_{i-1} + \sigma Y_i)(\sigma X_{i-1} - \sigma X_i) \right| \tag{1.1}$$

where N is the number of traders, σY is the Y accumulated percentage of the surplus, and σX is the X accumulated percentage of the population.

The wealth distribution is near the perfect equality when all traders in the market use a GD bidding strategy. The Gini index increases (inequality) as the percentage of K bidding strategy increases (see Figure 1.1). Moreover, as the inequality wealth distribution increases, the total surplus which is shared, decreases (see Figure 1.2). The inequality in wealth distribution has a big jump when the percentage of *parasitic* agents is greater than 40% (see Figure 1.3).

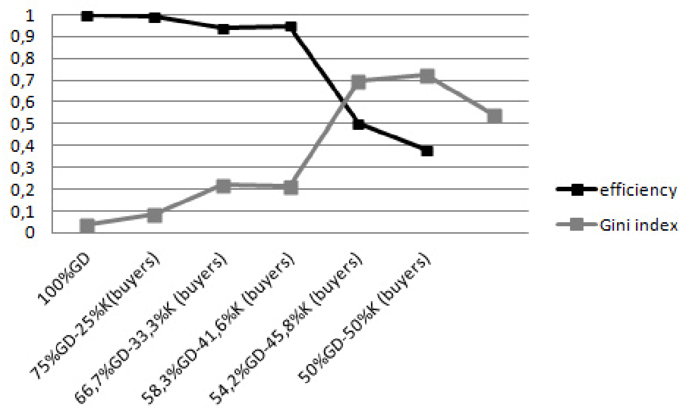

Fig. 1.1 Market efficiency and Gini index for different populations

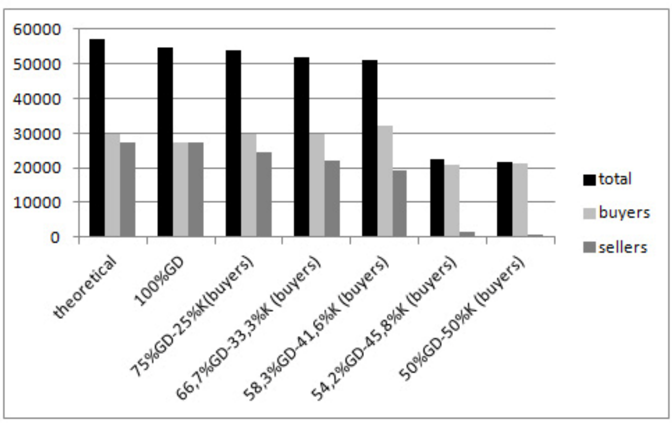

Fig. 1.2 Total surplus, buyer surplus, and seller surplus for different populations

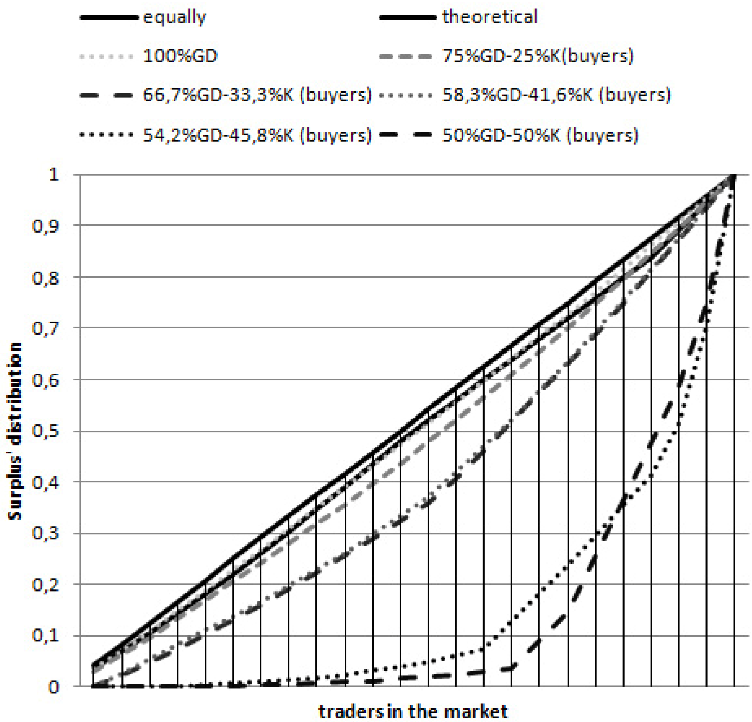

Fig. 1.3 Lorenz curves for different populations

1.5 Conclusions

The crisis has vividly demonstrated the deficiencies in the outdated current economic theories, calling for rethinking Economics. One should try alternative Economic approaches such Experimental Economics with humans or artificial agents. Not relying only in the full rational citizen or on his moral sentiments.

To this end, we have tested with artificial agents, the fact observed with human experiments: ***the invisible hand*** can lead to undesirable outcomes in terms of wealth distribution. Market efficiency does not imply fair wealth distribution. We have illustrated the origin of the problem and consequently how to avoid it, by introducing parasitic agents with free riding behaviour. We observe that both market efficiency and wealth distribution decrease as the percentage of *parasitic* agents increases. This result holds for different values of the model parameters.

To assure a fair distribution and market efficiency one has to properly design the institution (I) (the exchange rules, the way the contracts are closed, and the information network), the environment (E) (agent endowments and values, resources, knowledge) and the agents' behavior (A). ABM helps to design the triplet (IxExA).

The paper is a sample of ongoing research to develop an ABM frame to serve Institutional Economics and to rethink economics. A suitable Social Contract that will achieve wealth generation (market) and fair distribution (democracy) is imperative and feasible. ABM can provide guidance to achieve this social goal.

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