A Stylized Software Model to Explore the Free Market Equality/Efficiency Tradeoff

Hugues Bersini and Nicolas van Zeebroeck

Abstract. This paper provides an agent-based software exploration of the well-known free market efficiency/equality trade-off. Our study simulates the interaction of agents producing, trading and consuming goods within different market structures, and looks at how efficient the producers/consumers mapping turn out to be as well as the resulting distribution of welfare among agents at the end of an arbitrarily large number of iterations. A competitive market is compared with a random one. Our results confirm that the superior efficiency of the competitive market (an effective producers/consumers mapping and a superior aggregative welfare) comes at a very high price in terms of inequality (above all when severe budget constraints are in play).

Keywords: ABM, free market, equality/efficiency trade-off.

1 Introduction

A classical disputed question regarding the effect of free market economy on the social welfare is the right balance between equality and efficiency called by Okun [1]: the big tradeoff. Part of the problem lies in the difficulty to appropriately define these two notions. The eternal question of equality, famously debated and popularized by, among the most modern thinkers, Rawls, Dworkin, Sen, depends upon 1) the right currency for equality (primary goods, consumers utility, opportunity, capability,) and 2) the right distribution of this currency (pure equality, some form of minmax principles i.e. favoring at a given time a distribution that is to the greatest benefit of the least-advantaged agent or others). On the other hand, the question of

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economic efficiency is even more ambiguous. It was originally framed around the Pareto optimality for which no one well-being should be raised without as a consequence reducing someone else well-being. Many Pareto optima can be obtained on an imaginary axis, going from a pure utilitarian aggregative end (at which what really counts is to maximize the collective well-being) to a more equalitarian end (where what really counts is to maximize the well-being of the worst agent). Indeed Pareto optimum per se is completely unconcerned with the appropriate distribution of the economical profit. It is enough that the agents welfare simply grows in time as a result of the economical interactions, leaving completely unresolved the comparison of economic systems that either promote aggregate welfare, perfect equality or the improvement of the poorer to the expense of the richer.

Another classical definition of efficiency related with multi-agents competitive system is the allocative one, in which the system must guarantee that a resource is being produced by the most skillful producer and goes to someone who draws the greater utility out of it. Not surprisingly, although efficient according to this definition, such a competitive system, likely to promote the best producers and to feed the greediest consumers, may have little chance to equally distribute wealth.

Beyond this historical debate about which economical system (free or regulated) has to be privileged between an aggregative or a distributive one, there is another key efficiency criteria which is often left out of the discussion, originally due to Hayek pioneering insights: his metaphor of the market as a system of telecommunication. Market prices are primarily a means of collating and conveying information for the producers to adequately response to the consumers needs. Thus, though a very high price prevents most of the consumers to acquire a product, it is, in the same time, a very reliable information addressed to the producer that many consumers are desperately in need of such a product. It might well be possible that a distributive economy, flattening the prices and rendering most of the products affordable to all, and although morally very defendable, turns out to corrupt this distributed information transmission mechanism and make all economical agents to see their situation finally degrade in time. In the rest of the paper, we will designate such incapacity of the market to effectively map producers onto consumers as market failures (MF).

In order to address these different issues, a software stylized model is proposed comparing two very different structures of market that potentially should drive the collective welfare to the two extremes: aggregative on one side and distributive on the other. These two structures are first a double auction competitive market (in which buyers and sellers compete to outbid each other) and a random market (in which the matching between buyers and sellers is done in a purely random way). Following the description of the model, many experimental outcomes of many robust runs will be presented along three key dimensions: the Gini indices (regarding equality), the aggregate utility and the probability of market failures (both regarding efficiency).

2 The Model

The model maps onto a C# object oriented software. The main encompassing class, the World, contains one Market, either competitive or random, where a given number of agents have the opportunity to successively produce, sell, buy and consume. This world evolves through discrete ticks. At every tick, a randomly selected agent is given a chance to produce one unit of one product among n possible ones. In the absence of financial means (producing cost money and this money leaks out of the system, all other processes leading to money transfers between agents), another random agent is selected until the production occurs. The market then attempts to execute one transaction that involves one buyer and one seller marketing one unit of a given product. If no transaction turns out to be possible, on account of an impossible pairing between buyers and sellers, the model raises a market failure (equivalent to an exception in the C# program). Once acquired by the buyer, the product is immediately consumed during the same tick and converted into utility according to his associated taste. Every agent starts with the same amount of money at the beginning of the simulation (allowing him to produce goods). Agents are distinctively characterized by two crucial factors which are their skills (influencing their producing behavior, production prices amount to the skills) and their tastes (imprinting their consuming behavior, utility increase amount to the tastes). While individual skills and tastes, taken randomly between 0 and 1, vary among agent, the initial total amount of skills and tastes are normalized to 1. This is the departing point of agents differentiation during the simulation and the only initial cause for any further inequality growing among the agents. Both producer and consumer behaviors are strictly similar in the competitive and the random markets whereas seller and buyer behaviors are fundamentally different.

Once randomly selected, the producer first has to decide which product to make. Two factors influence his decision: his skills and the average price of the last m transactions. Knowing his skills to produce each product unit and the average price in the market (memorized during the m previous ticks), it is obvious to compute his expected profit for each product. After x productions of the same product, an agent can further specialize himself making the production cost randomly diminishing within a moving range. Skills are then renormalized to 1 with all other skills proportionally rising up. Once an agent buys a product, it is immediately consumed, with effect to increase the agent utility by the value of his taste for this product. Two versions of the simulation are considered. In the first one, the utility does not decrease with the consumption and the preference of the agents keeps constant in time. In such a case, a competitive simulation, just based on the expression of the utility, should ease the demarcation of the agents along the simulations. In a second version, and in line with basic microeconomics concept of diminishing marginal utility, the taste associated to the product just consumed decreases for the next consumption. All tastes are then renormalized to 1 with all other products taste rising up accordingly.

The competitive market is akin to a continuous double auction market in which agents bid to buy and sell products units. During a succession of steps, the market repeatedly invites two randomly selected agents to place asks and bids on one product they want to sell or purchase. At the first tick, the market is initialized with best-buying and best-selling offers for all the products on the market (bids at price null and asks at price max). Then a random seller is selected to place an ask for the most profitable product he has in stock (the proposed price should be below the best-selling offer and incurring the least expense (i.e. selecting the product with the highest skill), this price is finally set between the producers skill and the current best-selling offer). The market then looks whether this ask crosses the current best-buying offer on that particular product. If so, the transaction occurs, if not, the ask becomes the best-selling offer and the market turns to the buying part. The randomly selected competitive buyer shows the very symmetrical behavior. He first selects the most desirable product (one with the highest taste above the best-buying offer) and places a bid limited by his reservation price (the proposed price is set between the best-buying offer and the reservation price). The market looks whether this bid crosses the current best-selling offer. Once two offers cross, the transaction price is fixed as the buying offer price. If following a determined number of trials, no transaction is to be found, a market failure is reported.

The random market is much simpler, since the sellers and the buyers behave without particular interest. In this version, a random seller places an ask on a random product, on which a random buyer is invited to react. If the buyer reservation price is higher than the price asked by the seller, a transaction takes place, the price being randomly set between the two offers. Here again, if following a determined number of trials, no transaction turns possible, a market failure is reported.

Finally, in order to impose a budgetary constraint on the buyers behavior, the reservation price for any product is fixed as the taste multiplied by the current money endowed by the agent multiplied by a time index (the agent portion of the budget he wills to engage at every tick). Of course, in all cases, bids and asks are only posted if the agent has, respectively, enough money to cover it or has a unit of the product in stock (as a result of previous productions). Whatever initial conditions being set: number of agents, number of products, vector of tastes and skills for every agent, initial endowment of money for all agents, they are obviously exactly equal for both market simulations, the objective being to compare the competitive version of the market (supposedly more efficient) with the random one (supposedly more equalitarian).

3 The Results

Four key metrics can be measured out of the different simulations: utility (increasing by consumption), money (leaking out by production and then fluctuating according to the transactions), added value (the difference between the price earned by the seller and the production cost) and market failures. For the first three, the aggregate value over all agents is used as an indicator of the market efficiency while the Gini coefficient (computed again for all three) testifies of how unequal this market turns out to be. The market failures (labeled MF in the following) is also used as an indicator of the market efficiency, but in the sense originally given by Hayek. Our simulations are always executed in the presence of 50 agents, 10 products and during 50000 simulation steps.For the first set of simulations, each agent is endowed with 500 units of money (so no budgetary constraint is imposed at all) and the number of past transactions kept in memory to inform the producer on the most valuable products is 1000. Additionally the consumers do not see their taste decreasing in time as an outcome of their consumption. Typical and quite robust experimental results follow, first for the random market then the competitive one.

Random Market: Total Utility: 5390, Total Money: 24312, Gini Utility: 0.04, Gini Money: 0.007, MF: 0

Competitive Market: Total Utility: 9755, Total Money: 24491, Gini Utility: 0.27, Gini Money: 0.08, MF:0

The competitive market turns out to be much more efficient in aggregative terms but this superior efficiency comes at a very high price in terms of inequality, compared with a random market (the utility Gini index is seven times greater as a result of the competition). Distortions in utility and money tend to grow over time. The competitive market favors those with skill in demand and those with taste skillfully satisfied. If this difference in taste can be continuously expressed over the simulation, a self-amplifying pairing happens between the greedy consumers and their dedicate competent producers. In the case of a marginally decreasing consuming utility, results become quite different, now making the competitive and the random markets rather comparable.

Random Market: Total Utility: 5152, Total Money: 24244, Gini Utility: 0.02, Gini Money: 0.007, MF: 0

Competitive Market: Total Utility: 5424, Total Money: 24488, Gini Utility: 0.042, Gini Money: 0.004, MF:0

In the absence of any budgetary constraint and if the same tastes cannot be differentially expressed all over the simulation (since being alternatively up and down as a result of the consumption), the competitive and random markets turn out to be very equivalent both in terms of efficiency and equality.

For the remaining of the simulations and in agreement with classical economics, the agents will see their taste decreasing in time as an outcome of their consumption.

The next aspect that deserves a dedicate treatment is the impact of information on the competitive market, evaluated by gradually varying the number of past transactions taken into account during the production process (fixed to 1000 so far) i.e. the quality and the reliability of the information available to the producers to guide their productions towards the real consumers needs. Many simulations have been run where the producers exploit an increasing number of past transactions: 0, 1, 5, 10, 50, 100, 500, 1000, 5000, 10000, 50000. In the previous simulations discussed so far, this number has been settled to 1000. We compute the average aggregate utility as a function of this number and, surprisingly, the resulting curve is not monotonous. Below 100 past transactions available to the producers, the resulting competitive markets show an important number of failures with a pick at 10, demonstrating, unexpectedly, that a total ignorance of the past is even better than a very little knowledge. An increasing amount of information first dilutes the effective signal upon which producers base their decisions. Producers in those cases may be better off only focusing on their own costs than on their expected profits. We finally can observe the relevance of sufficient information for the competitive market to efficiently allocate the available resources (and 1000 past transactions seem to be an appropriate minimal threshold above which no improvement is observed).The last aspect of the model to be explored is the influence of the budgetary constraint on the behavior of the market. While maintaining all other features constant (50 agents, 10 products, information based on 1000 past transactions), the initial money endowment is being decreased: 100, 80, 60, 50, 25, 20, 15, 10. After showing many difficulties in running until the end of the simulation, the random version of the market simply stops executing at around an initial endowment of 25. Many agents go bankrupt and the simulation is being constantly interrupted by market failures. Both facts once again testify of the

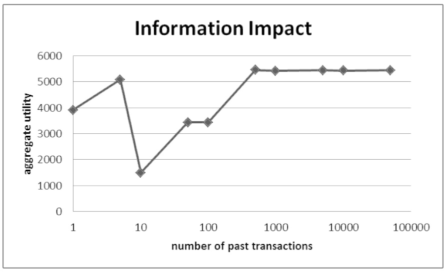

Fig. 1 Effect of the number of past transactions taken into account to optimize the production on the aggregate utility of the market

inefficiency of the random market to map the producers onto the consumers. The producers waste their money making products that the consumers are definitely not interested in.

As regards the competitive version, the table below indicates how the budget constraint really impacts the model as the initial endowment decreases. Although an initial budget of 20, 15 or 10, entails a few intermittent market failures, the model can now always keep running over the 50000 simulation ticks. The most striking fact of this table is the evolution of the utility Gini index as well as the added value one (for instance they respectively reach a pick of 0.25 and 0.20 for an initial budget of 10 by agent) that clearly shows a growing inequality as the money becomes scarcer. Again the market keeps being efficient but now to the large expense of equality. The competitive regime becomes much more selective towards the most skillful producers, the only ones who are effectively able to compete in the market. Budget constraint and money scarcity decrease the potential gains for producers but above all redirect them towards the best producers. Moreover, specialization acts as given the best producers even more marketing power. Budget constraints make the competition so severe that the smallest difference in skills is identified and reinforced. Figure 3 interestingly shows the correlation between the added value of the producer and his final utility as a consumer (i.e. established over all 50 agents). A clear positive correlation is observable between the added

Money	100	80	60	50	25	20	15	10
Utility	5465	5340	5464	5452	5433	5401	5330	5246
Money	4182	3275	2093	1735	494	284	83	17
Ad. Val.	3680	3720	3264	3380	2675	2400	1817	1424
G(Util)	0.05	0.061	0.077	0.070	0.088	0.12	0.16	0.25
G(Mon)	0.006	0.007	0.013	0.010	0.016	0.017	0.014	0.08
G(AV)	0.08	0.092	0.11	0.10	0.13	0.15	0.17	0.20
MF	0	0	0	0	0	26	270	914

Fig. 2 Summary of results (aggregate and Gini) obtained by gradually decreasing the initial budget possessed by every agent

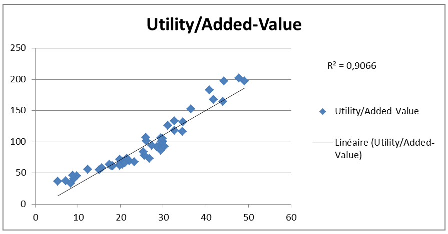

Fig. 3 Correlation between the added value of the producer and his final utility as a consumer (established over all 50 agents)

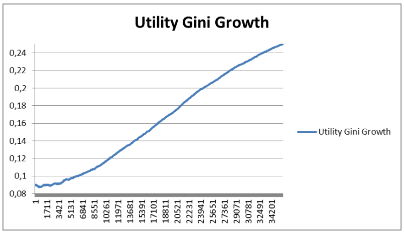

Fig. 4 Evolution in time of the Utility Gini Index for an initial budget of 10

value of the producer and his consumption (90% of the utility distribution is explained by the added value distribution). The greediest consumers turn out to be the best producers. As observable in fig.4, showing the evolution of the utility Gini index, inequality among the agents is on a fast growing trend. Competitive market acts in self-reinforcing the market dominance of producers who can benefit from the tiniest initial comparative advantage.

4 Conclusions

This paper describes a stylized simulation exercise in which we compare a double auction, quite aggressive, competitive market with a pure theoretical abstraction that represents a market in which producer and consumer matching is purely made on a random basis (under a natural set of constraints: budget constraint, no sale at loss rule for the producers)). Our main simulation results confirm the higher efficiency generally attributed to competitive markets first to simply map the consumers onto the producers then in maximizing the aggregative welfare. However in most of the studies of competitive markets, very little attention is paid to the equality in welfare distribution. Our results equally show this inequality explosion, above all in the case of budgetary constraints, when only the best producers can survive, make money and consume. Interestingly enough, at the starting of our simulation, all agents can be considered as equally ready and gifted to take part in the market, but its inherent competitive structure (in contrast with the random one) make an even negligible difference in skills to be greatly amplified with time. In line with most of the ethical philosophers, we can easily argue about the immoral nature of such an inequality amplifier mechanism (even when equality of opportunity is fully guaranteed) and the definitive need for a complementary equalizing system.

Reference

1. Okun, A.K.: Equality and efficiency, the big tradeoff. The Brookings Institution (1975)