Decentralized Trading Processes and Disequilibrium Dynamics

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January 18, 2004

The research project is part of the program: "Equilibrium, Expectations and Dynamics" lead by Cars Hommes at the Department of Quantitative Economics at University of Amsterdam, The Netherlands. The central question of the research project is this:

> "What is the dynamic behavior of decentralized trading processes when trade is taking place at disequilibrium prices?"

One of the most important unresolved problems in economic theory is the question of stability and how equilibrium is reached. It is often assumed that equilibrium prices are generated by a market mechanism that is driven by the law of supply and demand, a model described by the Walrasian tâtonnement process, in which a pivotal role is played by the Auctioneer, or market maker, who adjusts prices on all markets simultaneously, based on the demand and supplies of market participants. It is essentially a nonlinear dynamical system. It is often remarked that the tâtonnement process should be considered as a fictitious process that does not take place in real-time, but rather should be interpreted as an argument for Neoclassical economic theory to consider only equilibrium states without the need to deal with dynamics outside of equilibrium. It is also clear that the tâtonnement model is not a satisfactory model of price formation in the real economic system, since (i) in reality, the price mechanism is not centralized (ii) market prices need not be equilibrium prices, and (iii) trade takes place all the time, even at disequilibrium prices. Even if the tâtonnement process would be a correct description of the dynamics of price formation in the real world, it is well known that numerous counter-examples can be found which produce cyclical and/or chaotic behavior under not too unrealistic assumptions, as was already shown by Scarf (1960), Saari (1985) and Bela and Majumdar (1992). On the other hand, however, the conditions under which the tâtonnement process *does* converge, such as the gross substitutability and non-inferiority assumptions, are very restrictive for the structure of the economy. Therefore, in general chaotic and cyclical

behavior can not be excluded, which would imply that trade can never take place at all, if trade is only allowed in equilibrium.[1]

A more realistic process of price adjustments would take into account at least the following:

(1) Price adjustments and trade take place simultaneously, such that if no equilibrium has been reached trade takes place at disequilibrium prices (so called 'false' prices).

(2) The trading process is decentralized: there is no co-ordinating device between agents on different markets and co-ordination failures may persistently drive the economy away from equilibrium.

(3) The agents trade on markets sequentially, instead of on all markets at once. This implies that the transactions on one market influence the perceived trading possibilities on the other markets, through spill-over effects.

Concerning the trading process multiple possibilities can still be considered: a centralized market for each commodity (anonymous trading), or trade between separate parties (matching models). With respect to the pricing process the question arises who sets prices: individual agents (monopolistic competition) or the market as a whole (perfect competition).

The project consists of two parts:

(1) Computational economics: Computer simulations provide insight into the various types of behavior that can occur in a decentralized trading setting under different institutional arrangements.

(2) Mathematical economics: The use of dynamical systems theory to investigate the dynamics of complex adaptive systems and development of economic theory.

The thesis is a synthesis between these two parts, a theoretical and a computational part. In Part 1 the theoretical framework is introduced, and the mathematical concepts are defined that are needed in order to formalize the dynamic models. In Part 2 we report simulation studies on several variants of this model. We investigate both flexible-price and fix-price versions under different market rules. The aim is to make a comparison between the monetary institutions and other market mechanisms. We look at how changing the institutions affects the behavior of individual economic agents and the aggregate behavior of the economy as a whole.

The model belongs to the class of so called non-tâtonnement processes in economic theory, since the individual cash holdings change along the process, due to the transactions outside of equilibrium. It deviates from this type of process in two important respects. First, we allow for the markets to be visited *in sequence*, instead of simultaneously. Second, the agents use a *moving*

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[1]Methodologists often like to point out that this line of attack on Neoclassical economics, i.e. the point of view that Walrasian tâtonnement is based on unrealistic assumptions, is kicking a dead horse. However that may be the case, it still remains the starting point for any investigation towards more *'realistic'* (less unrealistic) assumptions on the dynamics of prices.

horizon optimization technique, which means that agents' consumption plans are re-optimized at every step of the process.

An agent-based computational model is set up in which trade is taking place at disequilibrium prices. The market mechanisms include quantity rationing, sequential trading and an accounting mechanism for debts and claims, to take into account the wealth effects that play a role outside of equilibrium. The monetary institutions include a cash in advance constraint and an income constraint.

We study the dynamic process in terms of prices and the quantities transacted. Non-Walrasian equilibria appear as the fixed points of this process, but a multitude of nonlinear dynamic phenomena (cycles, quasi periodic behavior) are found as well. The results are illustrated by computer simulations.