

Review of the mater thesis

## Behavioural Breaks in the Heterogeneous Agent Model

by

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The thesis are devoted to the topic which in recent years attracts the attention of many researchers, namely modeling the capital markets. Some researchers were bewitched by fashionability of topic<sup>1</sup>, some were fascinated by possibility to become a member of one of “main” streams of publications<sup>2</sup> and hence also references and finally a few of them were attracted by topic itself. I believe that the present author belong to the last, rather small group of people who are aware that the topic is extremely complicated, that it is difficult to learn well underlying mathematics and not to rely only on the fact that “it works”. There are many approaches, some of them are more assessable to the classical economic theory, some are more modern, having not only economic roots, but taking into account also some ideas of other branches of (social) sciences or even empirical facts.

The introduction collects some literature but mainly it explains the motivation for this very extended work, namely to try to bridge (or may be that better world would be *to merge*) behavioral sources in the finance and on the other hand the model of (heterogeneous) agents on the market. The author supports his point of view by several quotations from the papers which partially touched the same problems as he considers.

The second chapter first of all “defines” two major group of traders on markets, namely the *fundamentalists* and the *chartists*. However, the arguments why just these two groups of traders are usually considered seem to me much more a piece of econometric folklore than being rationally derived from the merit of the situation. One can easy imagine<sup>3</sup> that the combinations of the features (recalled by author - as several types of investors, analysts, speculators, optimist, pessimist, stoics, etc.) can lead to a lot of other type of behavior. Moreover, it seems quite imaginable that the chartist need not to use the increasing model when the market growths. Similarly even when the markets rises above *its fundamentals*, fundamentalist can predict further increase because the real value of just mentioned *fundamentals of the market* is known

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<sup>1</sup>This fact caused that Burton Malkiel (1985) wrote: “*Financial forecasting appears to be a science that makes astrology look respectable.*”

<sup>2</sup>Maybe that just this fact “inspired” James Heckman (2007) when he wrote: “*Nowadays more and more dissertations employ with a decreasing level of knowledge and with a negligible practice econometric methods which required deep understanding.*”

<sup>3</sup>Of course, it is a matter of the amount of imagination. Karl Popper wrote in his famous *Powerty of Historicism* (1957): “*If we cannot imagine that something can be in another way than we are used to, it is not an indication that it cannot be so, but the indication that we have not enough imagination.*”

only to an Omniscience, but we have at hand every time only some estimate (of course, it is not the critique of present author and his work, it targets to the general ideas which are - as after all the author of thesis classified it - a bit *trivial* or even *unwisely simplifying* the human behavior)<sup>4</sup>. The “rest” of chapter brings four pages of an overview over the literature devoted to *heterogeneous agent modeling*. It would not be to surprising in the age of Google, but the author selected the most significant contributions and made some comments on them. Probably the most important comment is at the end of chapter. It reads: *The most of papers on the topic is intellectual games<sup>5</sup> without being tested on the empirical material*.

The next two chapters are of the same character - they offer to reader to became at least a bit familiar with the both already mentioned topics, namely the *behavioral finance* and the HAM models. In the former the author explains what is herding (and its roots and “rationality”), overconfidence (again its sources and consequences) or market sentiment. The latter chapter discusses in details the model introduced in 1998 by Brock and Hommes. Although it is partially done with a help of some patterns of mathematical formalism, I guess that really mathematical approach (with definitions, lemmas and assertions) can still save a lot of space because the explanation why the model is built so and so and that it reflects or corresponds to reality is more or less irrelevant for (mathematical) solution of the problem and it may be even misleading. Of course, when we start to define, in an exact mathematical way, a model we have in mind some inspiration and moreover some field of possible applications. All these things however are to be left aside when we create the framework of our research, i. e. when we establish the definitions of notions and describe the problem to be solved (e. g. some extremal problem). It has at least two reasons. Firstly, if we build a model as a “copy” of the real world, e. g. real capital market, we have finally an impression (at least subconscious) that we “discover” how the world really is and sometimes we can modify some steps of creating the theory, in a way which is wrong, inconsistent from the mathematical point of view, just in the effort to “pursue the reality”. But this pursuit of the reality can be only seemingly O.K. In fact it may be our misleading impression, moreover influenced by the common sense<sup>6</sup>, economic folklore etc. The generations of researchers, starting from Pythagoras of Samos, Thales of Miletus, Euclides of Alexandria or Archimedes of Syracuse (to give some among the many others) recognized that the only way how to be ensured against such temptation to accommodate “arbitrarily” the research is to perform it just in the formalized mathematics. Of course, at the end of our research is to

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<sup>4</sup>Leaving aside that from the point of view of modern science, the situation is even more complicated, due to the fact that no *objectively given values of unknown “constants”* exist at all, hence even the Omniscience does not know them. They really exist only in our models.

<sup>5</sup>It need not be completely bad because the most important feature and role of the science is psychological one, namely that it allows the adult men and women to “play” with their “strange” ideas without being assumed to be fools. Nevertheless, when we finish a construction of a theory, especially when the theory is intended to be a tool for some applications, it is to be tested on some empirical material - see also a discussion below.

<sup>6</sup>It was shown by philosophers that the common sense is an inconsistent “harvest” of contemporary prejudices, misleading ideas, not proved surmises, etc.. It is easy to give a lot of examples even from the history of science that many times, when science relied on *common sense* (instead on a derivation of the conclusions by formal logic) that it created theories which later appeared to be at least serene if not stupid at all.

be a model which is to be tested on an empirical material and without any sentiment refused if not working. The second, may be even more important reason can be that we can even fall into the temptation<sup>7</sup> to assume that we have discovered a truth which is necessary to impose to other people. After all, the author of dissertation indicates it indirectly himself by selecting the quotation for this chapter: *“The purpose of science is not to analyze or describe but to make useful models of the world”*, Edward de Bono, 1933, although the modern science would give the sentence in a bit modified form: *“The purpose of science is not to analyze or describe the world but to make useful models”* and then it is on those who apply the models to the real world<sup>8</sup> to select from the offer of models and to decide which are useful. But these are questions which are beyond the scope of this dissertation as well as beyond this opponent report.

The next, fifth chapter collects a bundle of attempts of generalizations of Brock and Hommes model. It is done again with some comments on the ideas which confront the creation with the “reality”. Let us give an example. The high value of one constant of Brock and Hommes model,  $\beta$  produces a chaotic dynamics. In connection with it, the author of dissertation wrote: *“On the other hand, authors find that in the case of time dependent variance of return,  $\beta$  has to be higher compared to constant beliefs to get prices back to fundamental values.”* This pattern demonstrates that such an assertion is so vague that it can be understood in many ways. E. g. either the word *belief* is assumed to be understood in a common way, as in theology, but than it does not belong into the science or (and I guess it) an opposite is true. But than one can imagine many mathematical definitions of *belief*, starting with a conditional expectation up to sophisticatedly invented functions of experiences, profits, etc. So we see that only unambiguous definitions given in mathematical formalism can avoid such a possibility of (nearly) arbitrary interpretation. Objection can arise that then it is not clear whether the theory corresponds to reality. But that is just a goal. Otherwise the theory is perceived by reader as a cook-book, with (may be implicitly) given instructions how to apply it. So, it finally leads to the situation that a man who applies the theory assumes that it is objective description (or even substance) of world and he has no responsibility about the results which he found by applying the theory.

The next chapter (Chapter 7) is introduced by nice quotation by Merton Miller which confirms another saying (unfortunately I have forgotten who said it): *“Who works cannot think and who thinks cannot work.”* But let us return to a serious description of thesis. The seventh chapter establishes benchmark for the results which are collected in the next two chapters and which are core of the thesis. The data (and selected events) are described (and analyzed) in details however sometimes there should be more explanation (especially of abbreviations) for a reader who is not familiar with the capital markets.

As already indicated the chapters eighth and ninth are main part of the thesis. The former

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<sup>7</sup>Especially in the case when our model works. We should keep in mind that any “verification” of any model is a statistical test and it can have only one ultimate decision - rejection of hypothesis. The alternative to it is “not rejected” but it is not a confirmation of correctness.

<sup>8</sup>And these applications are not assumed by some philosophers of science to be really science but just the applications.

determines the models of “behavior” which are analyzed by simulations. So, it describes the inputs of the numerical experiments and their output, i. e. their results. It is again done in words rather in the formalism which would not only save the space but also time to learn what features (situations, factors) will be considered. The latter chapter then discusses the results of simulations and interpret them. It also offers some generalization of the views how to interpret results. The chapter is concluded by proposals of the problems for further research.

The last chapter, the tenth one, summarizes the sources of inspirations of the research, the employed framework, the results of simulations and their discussions and interpretations. Of course, the papers of the this type are extremely useful and challenging in the time of crises and after it, analyzing by numerical experiments the behavior of the participants of the markets. The more we will know about the roots of their beliefs and methods of their decisions the better the markets can serve to their goal - to allocate the most rationally, i. e. the most profitably (in the sense of the profit of the whole society) the capital. In this sense the papers of this type bring still mainly one unintentional result: *“The participants of the market play without the sufficient knowledge and experiences, without reliable information and probably even without sufficiently (by law declared) accountability<sup>9</sup> a game in which some of them become rich and some poor but which at the end - from time to time leads to a catastrophe which is, after all, paid from money of all tax payers.”* An objection can be that in the period between the successive catastrophes the markets increase the wealth of the society. But it was not never proved - probably it was not never formalized as an extremal problem. May be that even a formalization of a game would reveal that the increase of the common wealth is much more due to the work of tax payer than due to “optimality” of allocation of capital. Nobody probably hesitates that the people who are at the center of creating the wealth know the best how and where to allocate the capital, surely not the clerks of any state or representatives of political parties. But as the bitter experience of the past recent years demonstrated, the capital markets are not a way how to solve the problem. They surely allocate the capital in an inefficient way, sometimes exactly speculatively, i. e. in a devil-may-care way.

The thesis represent an exceptional work - by the extend of work they required, by the carefulness with which it was written, by the “bird’s-eye view” with which the problems are discussed and treated. Every among the first five chapters in fact represent a small compilation and discussion of one topic. The rest of thesis is then an example how numerical simulations (experiments) can substitute a formalized derivation of conclusion in the case when we solve so tricky problem that the analytical solution would be very complicated or at the present time still impossible due to insufficient development of mathematical tools. On the our hand, even when we use simulations as a “crutch” instead of formalized solution, we should formulate the “input” conditions and “input” framework in as much formalized way as possible.

All my above given comments are either comments based on my personal point of view on

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<sup>9</sup>Frequently we may hear the argument that the penalty for a wrong decision is the loss of capital of the investor, who made the decision. As recent years proved, the unjustifiable (moral) hazard, which the “investors” dare, cannot be reasonably regulated by this penalty.

mathematical modeling (and hence are not obligatory to anybody else except to me) either they were of philosophical character (and in this case even more - they cannot be, principally, imperative to anybody except to me). All these comments and remarks in any sense do not express any substantial critique, just opposite. They nevertheless may provoke the author of it to think once again about the form when transforming the thesis into a (working) paper.

The thesis is written so that the reader is provoked to think himself about the topics and it is good. So, finally summarizing all what I wrote up to now, I have to appreciate the work of the author. As I already mentioned the thesis is the exceptional work.

**Hence I strongly recommend the committee to accept it as the master thesis without any discussion. I also propose to committee to consider a possibility to offer it for a special compliment by the dean of faculty - of course I reviewed only one thesis so the committee has much better position to compare it with many others.**

Prague, June 7, 2010

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#### **References**

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