A framework for analyzing the reflexive relationship between stock prices and fundamentals

Ciprian Necula a *

a Department of Money and Banking, Bucharest University of Economic Studies, Piata Romana 6, Bucharest 010374, Romania

Abstract

The paper proposes a framework for capturing the insights of the theory of reflexivity about the influence of stock prices on fundamentals. The real economy and the financial markets are modeled as complex systems of interacting heterogeneous agents with bounded rationality. The transmission mechanism that is discussed in the paper is as follows: the stock prices affect the confidence of the economic agents, the confidence affect the aggregate level of consumption and investment, the aggregate level of output and, therefore, the fundamentals. The stock price formation mechanism is subject to herding effect and distortions due to heterogeneous beliefs of traders.

Keywords: theory of reflexivity, stock price models, complex systems, interacting heterogeneous agents;

1. Introduction

In the aftermath of the financial crisis, the failure of the rational expectation hypothesis is generally admitted (Colander et al., 2009) and a new paradigm based on behavioral economics is emerging. Akerlof and Shiller (2009), in their book on behavioral macroeconomics, investigate the importance of confidence and of other psychological factors in influencing the economy contrary to the canons of neoclassical economic theory. Behavioral economics focus on the mispricing of asset prices due to the distortions of the underlying fundamentals by the perceptions of the economic agents. However, Soros’s theory of reflexivity (Soros, 2009) implies that, instead of playing a purely passive role in reflecting an underlying reality, financial markets also have an active role, since they can influence the very fundamentals they are supposed to reflect, a feedback effect that behavioral economics is missing.

The mainstream economics analyzes the interconnections between the financial system and real economy in the context of Dynamic Stochastic General Equilibrium (DSGE) models incorporating various financial market frictions. DSGE models are the current state-of-the-art models of the research program of the neoclassical school, stating that macroeconomics should be explicitly grounded on incorporating the maximizing behavior of microeconomic agents. However, to reduce the complexity of the problem, the interaction between agents is neglected and the dynamics of the aggregate is reduced to that of a representative agent, which is assumed to have rational expectations, complete information, and who can choose to implement an individually optimal behavior. Typically one analyzes the behavior of microeconomic agents in sophisticated dynamic models, for example, in the case of consumers, using the classical Ramsey (1928) model. This model was originally meant to be normative, not

* Corresponding Author. Tel.: +40213191900/321
E-mail address: ciprian.necula@fin.ase.ro
descriptive. However, as the economic profession has turned macroeconomics into a neoclassical equilibrium theory, the Ramsey model is now taken as a descriptive model (Blanchard and Fischer, 1989).

However, “heterodox” economists believe that standard approach represented by DSGE models is simplistic and misguided, since macroeconomic regularities emerge not from microeconomic behavior of the representative agent but from stochastic interactions of a large number of agents. Therefore, a fundamentally different approach is necessary to analyze the interconnections between the financial system and the real economy. Such an approach should be based on the principles of statistical physics, which are commonly used in biology and other natural sciences, when one studies a system consisting of a large number of entities. As the founders of the neo-classical economics explicitly recognized, neo-classical theory is built on concepts and methods imported from classical Newtonian mechanics. In physics, the starting point of statistical mechanics was the recognition that it was meaningless to pursue precise motion of an individual molecule in a gas. Curiously, the methods of statistical mechanics have escaped economists’ eyes for more than a hundred years though they perfectly fit the purpose of studying macroeconomics, as pointed out by Aoki and Yoshikawa (2006). The economy consists of a large number of heterogeneous interacting agents. For example, the number of households is of the order of $10^7$, and the number of firms is of the order of $10^6$. In analyzing a system composed of such a large number of units, it is impossible to pursue precise behavior of each unit, because the constraints differ, and the objectives are constantly changing. This does not mean that economic agents are irrational. They have bounded rationality. As pointed out by Simon (2000), rationality is bounded since the cognitive abilities of economic agents are limited and their behavior is as much determined by the “inner environment” of their minds, as by the ”outer environment” of the world. The point is that the precise behavior of each agent is irrelevant. Rather, one need to accept that microeconomic behavior is fundamentally stochastic. Therefore, proper statistical methods are needed in order to study the aggregate behavior of a large number of economic agents.

This paper develops a modelling framework that captures the insights of the theory of reflexivity (Soros, 2009) about the influence of stock prices on fundamentals. The real economy and the financial markets are modelled as complex systems of interacting heterogeneous agents (households, traders, firms) using tools drawn from statistical physics, mathematics, biology, economics and other social sciences. For example, the stochastic dynamic aggregation technique pioneered by Aoki (1996, 2002) and by Aoki and Yoshikawa (2006) can be employed to derive the dynamics of the aggregate variable form the dynamics of agent-level variables.

2. The modelling framework

2.1. The transmission mechanism

The transmission mechanism that we try to model, depicted in Figure 1, is as follows: the stock prices affect the mood or the confidence of the economic agents, the confidence of economic agents affect the aggregate level of consumption and investment, and, therefore, the aggregate level of output and the level of profit per share, which is the fundamental variable that influences the stock price. The stock price formation mechanism is subject to herding effect and distortions due to heterogeneous beliefs of traders.

Our main focus is on the interconnections between the financial system, the confidence of economic agents and the level of private investment and consumption. Therefore, to keep the model parsimonious, we consider a closed economy consisting of households, firms, banks, the government, and the central bank.

2.2. The accounting equations or the conservation laws

Contemporary mainstream macroeconomics is based on the National Income and Product Accounts (NIPA), a system of concepts that is seriously incomplete since there is no room to discuss some important features, such as the changes in financial stocks of assets, and their relation with the transactions occurring in the current or the capital accounts of the various agents of the economy. Therefore, mainstream macroeconomic models lack the integration between the flows of the real economy and its financial side. Backus et al. (1980) pointed out that, by
combining the Flow-of-Funds Account and NIPA, this kind of integration can be accomplished. Several countries, including the United States, have complete flow-of-funds accounts or financial flows accounts, but it seems that most mainstream macroeconomists are unwilling to incorporate these financial flows and capital stocks into their models.

![Figure 1. The interconnections between stock price and fundamentals](image)

In contrast to the mainstream economic models, we propose the usage in the framework of a *stock-flow consistent model* (Godley and Lavoie, 2007), type of model specific to the Post-Keynesian School. The philosophy of this class of models can be summarized in the catch-phrase stating that “everything comes from somewhere and everything goes somewhere”, therefore, recognizing the existence in the economy of a set of *conservation laws*. This integrated framework is based on the transactions flow matrix, and the balance sheet matrix. The *balance sheet matrix* measures the levels of all stock variables at some given point of time. The *transactions flow matrix* describes changes in stock variables between the beginning and end of the analyzed period.

2.3. The behavioural equations or the dynamics of the system

While it is crucial to have coherent accounting and stock-flow consistency, the behaviour of the model also depend on the closure and the causality, that is, on the behavioural equations that will be associated with the accounting equations. In contrast to neo-classical economics we do not assume that firms maximize profit or that agents optimize the utility function, nor do we assume that agents have perfect information or know perfectly how the macroeconomic system behaves. In other words, there is no need for the representative agent or for the rational expectations hypothesis. Agents in our framework are heterogeneous, are interacting, and have bounded rationality.

To keep the model parsimonious, but without reducing its generality, one should focus on binary models, the agents being allowed to have two states. Therefore, there will be *optimistic or pessimistic firms*, *optimistic or pessimistic households*, and *optimistic or pessimistic banks*. The level of confidence of the economic agents will influence the aggregate level of investment, the aggregate level of consumption, and the aggregate level of lending respectively. Additionally, households in their capacity of financial investors will be classified into two groups, respectively *chartist and fundamentalists*. Such binary models, although the simplest possible in their class, are
suitable to illustrate the interconnections that we wish to investigate, and will not limit the generality of our model. For example, Aoki and Yoshikawa (2006) have pointed out that the classification of traders into only two clusters (chartist and fundamentalists) accounts for almost 95% of different strategies employed in the financial markets.

The number of optimistic firms, of optimistic households, and the number of optimistic banks could to be modeled as continuous-time Markov processes with finite state space. Therefore, although the dynamics of macroeconomic variables is set in discrete time, we consider that the confidence of the agents may change at any time, not necessarily at the equally spaced discrete points of discrete dynamics. A further simplification of the model consist in the assumption of independence between the fraction of optimistic firms, that of the optimistic households, and that of optimistic banks.

To model the dynamics of confidence a simple social interaction model similar to Lux (1995, 1998) could be employed. More specifically, the mood of economic agents is assumed to be influenced by the overall mood in their sector, captured by an opinion index quantified as an average of their fellow agents’ mood. Such an overall influence allows studying the macroscopic dynamics more easily via the so-called mean-field approximations. Aoki (1996, 2002) and Aoki and Yoshikawa (2006) give a good account of this type of approach, which is based on studying the so-called master equation of the stochastic process under investigation. More specifically, economic agents are assumed to revisit their choice of opinion from time to time and to have a tendency to switch to the majority opinion. With an overall field effect, the group pressure can be modeled via some feedback effect from the macroscopic configuration on individual decisions. This feedback leads to migration of individuals between groups under the influence of the overall field of the average opinion. Moreover, it could be assumed that the transition probabilities are influenced, besides the herd effects, by the perceived changes in some relevant macroeconomic variables or combination of macroeconomic variables. One possibility of modeling this influence is to employ the insights of the Weber–Fechner law that describes the relationship between the physical magnitudes and the perceived intensity of a stimulus. For example, these macro variables could be for firms the aggregate consumption, the aggregate output, or the stock price, for households the aggregate output, or the stock price, and for banks the aggregate output or the stock price. Therefore, the transition probabilities of agents between the two states are going to be endogenously determined.

To study the dynamics of the stock price (considered as an average index) an ant rationality model (Kirman 1991, 1993) could be employed. Each agent in the household sector, as a financial investor, is assumed to adhere, at any point in time, to one of two alternatives, respectively chartist or fundamentalist. We consider that the current stock price is equal to the sum between current profit per share and the discounted value of the market-wide expectation of the future stock price. Contrary to the mainstream models of asset price formation that employ rational expectations, it is assumed that the market-wide expectation of the future stock price is a weighted average, with weights that change stochastically due to herding, of the non-rational expectations of chartists and fundamentalists. Again, although the price dynamics is set in discrete time, the herding mechanism is specified as a continuous time Markov chain.

Firms produce a good that can be used either for consumption or investment. Prices are set accordingly to a simple Post-Keynesian mark-up rule. Contrary to the households and banks that are assumed closed systems, in the case of firms, an open model should be considered, and therefore, besides the transition rates between the two states, we model the entry and the exit rates. Adverse macroeconomic conditions increase the pool of firms in financial distress. Hence, the exit probability is counter-cyclical and proportional to the debt to GDP ratio. On the other hand, the entry probability is pro-cyclical. The initial capital requirement of a new firm is financed entirely by issuing new shares at the current stock price. To simplify the model we assume that additional investments are financed entirely using loans from the banks. A firm decides the level of autonomous investment based on its confidence in the economy. We employ two different levels of possible autonomous investment corresponding to optimistic and pessimistic firms. Hence, the aggregate level of investment depends on the mood of the firms as well as on the interest rate.

Households choose between two levels of possible autonomous consumption depending whether they are optimistic or pessimistic. The aggregate level of consumption depends on the mood of the consumers as well as on
their disposable income. To keep the model simple, it could be assumed that households do not have access to credit. They allocate their wealth between money, interest bearing deposits, and stock market investments.

Banks employ the deposits from the households to provide loans to the firms to finance investments. The autonomous part of the supply function of loans has two levels depending on the state of confidence. The interest rate is determined from the equilibrium conditions on the equities and credit markets.

3. Concluding remarks

The paper proposed a modelling framework that captures the insights of the theory of reflexivity about the influence of stock prices on fundamentals. In contrast to neo-classical economics we do not assume that firms maximize profit or that agents optimize the utility function, nor do we assume that agents have perfect information or know perfectly how the macroeconomic system behaves. Hence, there is no need for the representative agent or for the rational expectations hypothesis. Agents in our framework are heterogeneous, are interacting, and have bounded rationality. Therefore, the real economy and the financial markets are modelled as complex systems of interacting heterogeneous households, traders, firms and banks. The dynamics of such a system can be modelled using tools drawn from statistical physics, mathematics, and biology. This modelling framework will allow a deeper investigation of the interconnections between the financial system, the confidence of economic agents and the real economy.

Acknowledgements

This work was supported by CNCSIS-UEFISCSU, project number PN II-RU PD_583/2010.

References

Akerlof, G.A., & Shiller, R. J. (2009). Animal Spirits. How Human Psychology Drives the Economy, and Why It Matters for Global Capitalism. Princeton University.

Aoki, M. (1996). New approaches to macroeconomic modeling. Cambridge University Press.

Aoki, M. (2002). Modeling aggregate behaviour and fluctuations in economics. Cambridge University Press.

Aoki, M. & Yoshikawa, H. (2006). Reconstructing Macroeconomics. Cambridge University Press.

Backus, D., Brainard, W.C., Smith, G., & Tobin, J. (1980). A model of U.S. financial and nonfinancial economic behavior. *Journal of Money, Credit, and Banking*, 12, 259–93.

Blanchard, O.J. & Fischer, S. (1989). Lectures on Macroeconomics. MIT Press.

Colander, D., Goldberg, M., Haas, A., Juselius, K., Kirman, A., Lux, T., & Sloth, B. (2009). The Financial Crisis And The Systemic Failure Of The Economics Profession. *Critical Review*, 21, 249 – 267

Godley, W., & Lavoie, M. (2007). Monetary Economics: An Integrated Approach to Credit, Money, Income, Production and Wealth. Palgrave MacMillan.

Kirman, A. (1991). Epidemics of opinion and speculative bubbles in financial markets. In M. Taylor (Ed.), *Money and Financial Markets* (pp. 354-368). MacMillan.

Kirman, A., (1993). Ants, rationality, and recruitment. *Quarterly Journal of Economics*, 108, 137-156.

Lux, T., (1995). Herd Behaviour, Bubbles and Crashes. *Economic Journal*, 105, 881-896.

Lux, T., (1998). The socio-economic dynamics of speculative markets: Interacting agents, chaos, and the fat tails of return distributions. *Journal of Economic Behaviour and Organization*, 33, 143-165.

Ramsey, F. (1928). A Mathematical Theory of Saving. *Economic Journal*, 38, 543–559.

Simon, H., (2000). Bounded Rationality in Social Science: Today and Tomorrow. *Mind & Society*, 1, 25-39.

Soros, G. (2009). General Theory of Reflexivity, Lecture Notes, CEU.