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**Essays in nonlinear dynamics in economics and econometrics with applications to monetary policy and banking**

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# Chapter 6

## Summary

In this thesis we aim at exploring the captivating and highly nonlinear profile of the modern world and assess its relevance in monetary policy conduct and macroprudential supervision. In particular, we focus on three different aspects of possible nonlinearities, i.e. as arising from (i) heterogeneous and boundedly rational expectations, (ii) probability distribution irregularities and (iii) complex network structures in the globalized economy.

We propose formal practical tools for central bankers and financial authorities to assess nonlinear structures among various institutions and system as a whole. In times of very non-standard policy actions, these tools might prove to be of great importance as they may reveal existing nonlinear relations and dependencies which standard econometric models cannot capture.

Highlighting the detailed outcomes from individual chapters, in Chapter 2 we investigate the possible irregularities arising from the presence of boundedly rational agents in the economy. We show that, in the setting with an active banking sector and extrapolative heuristics, the range of determinate policy instruments is narrowed. In fact this might have significant consequences for the real world. Pfajfar and Zakelj (2011) suggest that the fraction of extrapolative agents might be as high as 30%, which is even larger than in our setting. Given the fact that the estimated Taylor rule parameters vary usually in the region of (0,1) for the output gap weight and of (1,2) for the inflation weight (Taylor, 1999; Woodford, 2003), this may suggest that the

system is very close to indeterminacy, if not indeterminate already, which is the consequence of financial intermediation. This, in fact, is an interesting topic for further detailed investigation.

Chapters 3 and 4 propose formal methodologies to assess the influence of nonlinear causal structures in time series. We correct for these nonlinearities by assuming no underlying parameter structure but we test for the equivalence in conditional probability distribution instead. A clear advantage of such an approach lies in its generality. Chapter 3 reveals the intriguing relationships in the US grain market. Besides highlighting the role of nonlinearities, we discover a dual role of weather forecasts. Firstly, they seem to drive the causal relation from wheat to corn in the pairwise setting as they serve as a common factor, i.e. they affect both variables at the same time. Secondly, they are masking the causal relations from corn to beans and from beans to wheat in the system setting. Correcting for the common factor, we reveal the nonlinear Granger casual relations in the US grain market, suggesting that the causality runs from bigger, i.e. deeper and more liquid, to smaller markets. Chapter 4 tests the co-risk relations in the euro area financial sector. The results suggest that (i) only a few financial institutions pose a serious *ex ante* threat to the systemic risk, whereas, given that the system is already in trouble, there are more institutions which hamper its recovery and (ii) there are intriguing nonlinear structures in the euro zone systemic risk profile.

Chapter 5 treats nonlinearities from a network's perspective. Interestingly, our model highlights a few stylized facts observed over the past decade. We show how competing features of safe havens (highly interconnected sovereign bond yields versus stabilizing bank-sovereign links) combine to accelerate shock propagation in global bond and bank equity prices. We also show how feedback loops amplify shocks in the highly interconnected sovereign bond yield network. We speculate that these feedback loops may have been short-circuited by policy measures to contain contagion from GIIPS sovereign bond stress during the euro area crisis of 2010-12, supporting the actions of the European Commission, ECB and IMF.

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## **A view to the future**

The general conclusion arising from this thesis underpins the relevance of the nonlinear dynamics in economics and econometrics. The complexity of the real world has proven to play an important role in economic constructions since the very first models. As pointed out by Blinder (2013), this complexity has increased substantially, being one of the core reasons for the financial malaise during the crisis in the years 2007-2009. Therefore, even though the role of a model is to simplify the real world, it can cause severe consequences if it simplifies the reality by too much.

This thesis provides the tools and general directions on how to incorporate more complex structures into the existing economic methodologies. One should never claim that the ideas contained on these pages are ultimate as they arose as an answer to the recent financial crisis. With the technological advance and rapidly changing global environment, it is just a matter of time that these tools would not be enough. The same as the telescopes evolved satisfying the constantly rising curiosity about the mysteries of the deep universe, the methodologies describing complex and highly nonlinear economic structures should change in line with the advances in their fields.

Even though it is not possible to predict the stance of economic modeling in ten years from now, heterogeneous agents and network models constitute a very promising direction. With the support from behavioral economics and natural sciences, they create a natural horizon for future study of the main questions raised in this thesis.

The common conclusion, arising probably not only from this, but from many theses around the world, is to ask the right questions. This ultimately drives a researcher towards right answers, and right answers are likely to improve the world. But when a right questions is asked, a researcher can apply the question-specific methodology and work therefore more efficiently. This thesis advertises nonparametric statistics and econometrics, proposing novel approaches of assessing the role of nonlinear dynamics in the financial world. Although designed through a prism of a policy maker, the advances of these pages can be viewed as question-specific

methodologies so that to a large extent they rely on the ability to ask right questions.

The beginning of *modern monetary policy*, advertised in the Introduction, signalled the importance of macroprudential supervision and regulation. Hopefully, it will also encourage economists to look outside the box and to ask the right questions. For such researchers, the ideas contained in this thesis offer a powerful set of tools on how to capture the complexity around us.