Synopsis of the Thesis

Learning, Heterogeneity and Monetary Policy – an application to inflation targeting regimes

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October 15, 2015

My thesis analyses the performances of a specific monetary policy framework, namely inflation targeting, from a theoretical point of view, using a complex system modelling approach. This thesis combines two research areas: on the one hand, it is in line with the debate about the economic effects of central banks' transparency, especially within an inflation targeting regime and, on the other hand, it aims at modelling learning and expectations formation of private agents in a complex system (Tesfatsion (2006), Miller & Page (2007)).

In order to do so, the thesis develops a *macroeconomic agent-based model*, which is inspired by the functioning of the New Keynesian baseline model (Woodford (2003, chap. 4)). This model is presented in details in Salle et al. (2013). Briefly, an agent-based model is an artificial economy embedded in a computer simulation, and the modeller simulates "histories" of this artificial economy.[1] It is populated by heterogeneous agents, whose behaviour is guided by heuristics, in line with the principle of procedural rationality (Simon (1971)). These agents cannot see the whole picture of the economy in which they evolve and have to make economic decisions, and they only interact at a local level. Macroeconomic patterns emerge from those local interactions, following a bottom-up approach. Those patterns are recorded and analysed each time the economy is simulated, according to various configurations of the economy, e.g. various policy scenarios.

Agent-based models allow to depart from the controversial assumptions which are necessary to the derivation of analytical models (i.e. representative agent, complete information, rational expectations, market clearing, exogenous volatility). This feature is interesting because these

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[1]See the very furnished website of Prof. Leigh Tesfastion for a review of all the published academic papers in that field: http://econ2.econ.iastate.edu/tesfatsi/amulmark.htm.

assumptions have been increasingly criticized, especially since the beginning of the Great Recession (see, for instance, Colander (2006), Trichet (2010), De Grauwe (2012)). Agent-based models operate at a lower degree of abstraction than the usual analytical models do, but they also encompass more degrees of freedom concerning assumptions, behavioural rules and parameter values (the so-called *wilderness of bounded rationality*). Therefore, a whole chapter of the thesis is dedicated to the *validation* process of the model, in order to adopt disciplinary devices in the model's construction, to limit the use of *ad-hoc* ingredients and to increase the reliability of the model's outcomes. This step shows that the functioning of the model is consistent with what has been observed empirically, or what can be expected from a theoretical point of view. This procedure is based on an innovative protocol, which comes from engineering and computer sciences, and relies on efficient sampling algorithms and interpolation models.[2]

The first contribution of the thesis is with no doubt a methodological one, because it proposes a guide towards the construction, the validation and the analysis of agent-based models for (macro)economic issues. Once the model has been validated, it becomes a framework, a "lab", in which various experiments can be conducted.

The second contribution of the thesis is therefore to assess the robustness of the well-established results in the DSGE macroeconomic literature to the departure from the most demanding assumptions of DSGE modelling, which are model-consistent expectations, the representative agent framework, and the focus of the analysis on small disturbances around equilibrium states. More particularly, we choose to focus on the investigation of inflation targeting properties for two reasons. First, inflation targeting has become a quite popular framework to conduct monetary policy, both in developed and emerging countries, both among practitioners (central banks and international organizations such as the IMF) and academic researchers. To that respect, the first chapter of the thesis surveys all the contributions which attempt to model those regimes (see also Salle (2013)). Second, these regimes imply a particularly strong degree of transparency and communication of the central banks with the public. The emphasis on communication has been proved to find further rationale in a world where agents hold heterogeneous beliefs and need to coordinate, or in a world where agents do not know the underlying economic model and cannot therefore hold model-consistent expectations, but rather need to perpetually learn how to behave and how to forecast. Communication with the public may also find further rationale in a world which is characterized by a high degree of uncertainty and

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[2]Those tools have been described and applied to various economic models in Salle & Yıldızoğlu (2014).

endogenous variability, which may make the stabilization of the economy by the central bank more challenging. Making monetary policy more predictable and understandable for the agents appears then important if the agents form heterogeneous expectations and need to coordinate, and evolve in a highly uncertain world and have to make economic decisions and learn how to optimize (how to set their desired wage, consumption, savings, production plans...) and how to forecast the relevant variables.

Interestingly, in the simulated economy, agents' inflation expectations can be specified in a very flexible way. For instance, the modeller can control the amount of information that agents receive, the quality of this information, the sequence of transmission of this information regarding monetary policy decisions, the heterogeneity of this information among the agents, etc. Therefore, the main research question which is investigated with the agent-based model can be stated as follows: to what extent may disclosing the inflation target to the public, and more broadly, the central bank's projections about future economic outlooks and future interest rates allow agents' expectations to coordinate, and hence favour macroeconomic stabilization?

In that respect, we investigate the interplays between inflation expectations, endogenous volatility and optimal monetary policy strategies within the agent-based model. By monetary policy strategies, we mean not only the setting of the interest rate, but the communication policy as well. The main results are the following.[3]

We first show how heterogeneous expectations or mismatches between agents' beliefs and the CB's target considerably deteriorate macroeconomic stabilization in face of shocks, by producing more heterogeneous agents' behaviour, and alter the CB's power on the economy, even if the CB implements hawkish monetary policy rules. This result should warn us against the potential changes in theoretical conclusions that have be drawn from a representative agent framework.

Secondly, we show how adaptive expectations, which may prevail if expectations are unanchored, create cumulative dynamics. Those dynamics strongly disturb the ability of the central bank to offset demand shocks and to react to cost-push shocks, creating or strengthening the trade-off between the two objectives.

Thirdly, we demonstrate that an inflation targeting regime performs well in a stable environment, like the Great Moderation period, but its performances are not robust to the occurrence of shocks or model uncertainty. In that case, failures to keep inflation close to the announced rate

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[3]They are summarized in Salle et al. (2013),Salle et al. (2014) and Salle (2015).

result in a quick loss of credibility, and hence expectations become unanchored, and macroeconomic instability arises. In other words, the publicity of the inflation target may create a loop between monetary policy success and credibility under favourable economic circumstances, but this loop may turn into a vicious circle between monetary policy failures, credibility loss and expectations unanchoring if an economic downturn prevents the CB from fulfilling its objectives. In that case, the central bank should limit the publicity of its target, and optimal monetary policy rules are hawkish ones.

Fourthly, when considering a broader communication policy, including disclosure of the CB's inflation, output gaps and interest rates forecasts, the benefits from a high degree of transparency appear clearly. In that case, transparency acts as a (partial) substitute for monetary policy actions, and loosens the optimal monetary policy reaction: complying with the Taylor principle (i.e. implementing a hawkish monetary policy rule) is even not always a requirement any more. This theoretical result is strongly in line with empirical evidence regarding transparency and optimal monetary policy rules. Related to the recent debate on inflation targeting after the crisis, we also investigate macroeconomic stabilization with various levels of the inflation target, and we find mitigated results, depending on the type of shocks hitting the economy, the disclosure regime of the CB and the way agents form their inflation expectations.

These last two results should warn us against the theoretical conclusions that may be drawn from rational expectations models, because their results appear to be strongly sensitive to the type of expectations mechanism that is implemented.

Finally, we should underline that the thesis introduces a dynamic model of expectations formation based on artificial neural networks, which allows to include any information that the CB wants to disclose. It further models forward-looking, while still adaptive, expectations and in a very flexible way. This model appears promising and could be applied in a wide range of (macro)economic models.[4]

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[4]A first use of this model can be found in Yıldızoğlu et al. (2014).

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