Modelling and forecasting economic time series with mixed causal-noncausal models

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This thesis focuses on one particular type of non-linear dynamics: bubbles. They are defined as episodes of persistent increase followed by a sudden crash. Bubbles are commonly observed in many economic and financial data. Naturally, they come in different magnitudes, some have mild impact while others have dramatic global consequences. Among the most notorious bubbles that have occurred, there are for instance the tulip mania of the 1630s in the Netherlands, the Japanese asset price bubble in the late 1980s, the dot-com bubble of the 1990s or the U.S. housing bubble of the 2000s. The consequential repercussions that bubbles can have accentuate the importance of being able to model and predict such episodes. Bubbles occur regularly and we nowadays observe what seem to be the boom phases of bubbles in various real estate markets across the world for instance as well as surges in inflation rates all around the world. There is therefore a need for simple models that can capture such complex patterns. Indeed, the simpler the model, the easier it is to estimate and the less requirements and uncertainty are added to the forecasts.

Mixed causal-noncausal autoregressive (MAR) models, that are employed in this thesis, are simple models that can capture non-linear dynamics. Within the framework of MAR models, a variable can be explained by its own past and future values. In their simplest form, namely with a unique regressor being the future value of the variable, the model is already able to capture bubbles. Nonetheless, these models are still rather novel and there is thus room for further research and developments which could help understand the complex dynamics of various economic and financial time series.

In the second chapter of this thesis, MAR models are used to predict the probabilities of crash along a bubble in Nickel prices during the extreme episode of the 2007 crisis. Density forecasts, from which we

can derive much more information than from point forecasts, allows to foresee the potential magnitude of an upcoming crash. We find that at the top of the bubble in 2007, although predicted probabilities indicated a large probabilities of a crash, it was suggested that the initial crash would not be larger than 40%, which turned out to be correct. While we present only one empirical example in this chapter, many other commodity prices are characterised by the same dynamics, and the crisis of 2007 generated a bubble in almost all commodity prices.

In the third chapter, oil prices are forecasted during the COVID-19 pandemic outbreak. Although we cannot predict the end of COVID-19, we are able to capture valuable information carried by the past and current dynamics in the data. For instance, we find that after the initial impact of the implementations of the numerous worldwide lockdown, the probabilities of a further decrease in prices were at that point smaller than before, yet that the magnitude of the decrease would be larger. Nowadays, the economic situation with the war in Ukraine, triggering a surge in oil prices and many other commodities stresses the importance of building and developing models that can capture the dynamics of these processes. Indeed, commodity prices are at the core of inflation rates, which are currently surging all around the world and while wars are difficultly predictable, policy makers could employ the information derived from MAR models.

In the fourth chapter of this thesis, we investigate the inflation rate of Brazil, with a focus on a rather stable period. Brazil has undergone periods of hyperinflation in the past and the credibility of its Central Bank is therefore of the utmost importance for the population as persistent deviations from the target could trigger a new hyperinflation episode. We employ the probability forecasts to construct a short-term credibility index of the central bank over time, consisting of the probability that the inflation rate meets the target announced by the central bank. We find that the short-term index, which can be employed as an early warning of exiting the target bounds, is complementary to the long-term indices that are based on people's beliefs over longer period of times. Naturally, this index can be constructed for any country

which central bank applies an inflation targeting approach.

In the fifth chapter we consider metals price index, which presents a different dynamic structure than nickel or oil prices mentioned above as it is identified as an MAR(0,2), namely including 2 leads of the variable. This chapter shows that MAR models allows to capture more complex dynamics with the inclusion of more leads. In this chapter we propose to combine existing forecasting approaches to limit the drawbacks of these methods in certain conditions. We offer this as an alternative, especially when the sample size is too small, which is often the case with quarterly or yearly data sets that are often employed in macroeconomic analyses for instance.

In the sixth chapter of the thesis we investigate commonalities in the forward-looking component (defined as common bubbles) within groups of variables, which paves the way to further research in that direction. Detecting common bubbles could be used to significantly decrease the risks incurred by each of the individual component of the group and drastically limit the consequences of bubble bursts within investment strategies for instance.

The versatility of MAR models implies that they can be of relevance for a wide range of practitioners, from policy makers to investors. Overall, MAR models offer an adequate and easy-to-implement alternative to complex models in the presence of various types of non-linear dynamics in a time series. The current economic situation stresses the importance of building and developing models that can help predict and anticipate potential upcoming bubbles and bursts. This therefore asserts the relevance of analysing, both theoretically and empirically, MAR models.