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

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Conclusions and discussion

This thesis explores the modelling and forecasting of time series with mixed causal-noncausal autoregressive (MAR) models. Those models employ not only past values of the process but also future values. They are parsimonious and allow for non-linear dynamics within a strictly stationary setting. That is, they can capture for instance locally explosive episodes, which are often observed in commodity prices, inflation rates, stock prices or cryptocurrencies. While a process depending on its own future values might seem counter-intuitive, some variables do have anticipative characteristics and MAR models offer a large flexibility in modelling stationary series that exhibit nonlinear dynamics. The model is rather simple and proved to provide a better fit than purely causal models in many applications.

Coming back to the example given in the introduction of this thesis, a long lasting increase in various commodity prices will lead to a persistent increase in inflation. Hence, the more information policy makers, investors or applied researchers have regarding the potential downturn of the bubble, the more adequately they can act. From a more financial perspective for instance, investing in a stock which price persistently increases offers great opportunity of profits but also considerable risks. Understanding the extent to which this bubble is likely to go on or suddenly drop can help better perceive the incurred risks. These examples illustrate the importance of not only being able to model such processes but also to forecast them accurately.

Chapter 2 to 4 focus on univariate MAR models with a unique lead and unrestricted amount of lags, namely MAR(r,1). Indeed, a unique lead is sufficient to capture non-linear patterns such as bubbles. Chapter 2 investigates the existing forecasting methods of MAR processes and shows that as a series deviates from central values, its predictive density splits and becomes bimodal, indicating either a further increase or a drop. The information provided by the bimodality of the distribution would not be captured by point forecasts of by purely backward-looking AR models.

MAR models can be employed in various areas of applications and for distinct purposes, as illustrated by Chapters 3 and 4. Chapter 3, after investigating a common issue that applied researchers face, that is the detrending of non-stationary series, employs MAR models to predict probabilities of crash in oil prices. It analyses the COVID-19 pandemic outbreak, a period in which prices were more volatile and predicts probabilities of crash of different magnitudes. Chapter 3 on the other hand proposes the use of the probabilities obtained from MAR models to construct a short-term credibility index of Central banks' inflation targeting system. While during periods of increasing inflation, the targeting system is logically not credible, the index can also be used during rather stable period when inflation is close to the target by providing short-term risks of exiting the tolerance bounds.

Probabilities are sometimes difficult to interpret. For instance, when forecasting the probabilities of a crash, from which threshold should we consider it to be too risky? Chapter 4 suggests the use of receiver operating characteristic (ROC) curves to help determine the adequate threshold, which will depend on the aversion of false positives for a given inquiry. We illustrate their use on the credibility of the Central bank inflation targeting system, but it can naturally be employed in other analyses, such as the probabilities of crash mentioned above.

The thesis also investigates different settings of MAR models for which the literature is still at this date limited. Chapter 5 allows for more leads and pave the way for further research regarding theoretical findings of the predictive density. Various commodity prices in many applications in the literature are identified as MAR processes with more than one lead, emphasising the importance of having more theoretical understanding of general MAR models. The chapter also suggest a new method for forecasting MAR(r, s) processes which, based on the researcher's inquiry and the sample size of the data available, is a suitable alternative to the existing ones.

As illustrated by the oil prices in Chapter 3 or the three commodity indices in Chapter 6, it is common to observe bubble-like patterns at the same time on various time series. The detection of commonalities improves the parsimony of autoregressive multivariate models for which the number of coefficients increases exponentially with the number of variables and lags. Chapter 6 therefore investigates the detection of, what we define as common bubbles, commonalities in the forward looking component of MAR processes, in a multivariate setting. While we have not found yet an example of the detection of such commonalities in practice, we propose a likelihood ratio test and the use of information criteria, to detect the presence of common bubbles.

Overall, this thesis covers different frameworks and features of mixed causal-noncausal models ranging from the forecast of univariate processes to the detection of commonalities in multivariate settings. The wide range of applications of MAR models demonstrate their versatility and their ability to capture non-linear dynamics that are often observed in economic time series. While the interest in MAR models is continually increasing in the literature, these models are still rather new and there are a lot of features and extensions that have not yet been explored. Besides the inquiries of Chapter 5 that could be further investigated, extensions of MAR models could for instance include more complex dynamic structures. Multivariate MAR models could also be used in the construction of portfolios. In line with Chapter 6, different structures of commonalities could be considered, to construct portfolios in which the bubble patterns observed in the individual stocks disappear, hedging against the risks that each of them carries.