**Panta rhei, measurement and discovery of change in financial markets**

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# Summary

This thesis consists of four self-contained essays in finance and financial econometrics. Our main focus in this research is on modelling and detecting change in financial markets. The word 'change' can be understood in various ways and depending on the chapter we have subsequently considered modelling the changing yield curve, time-varying relative risk aversion, different forms of time-varying risks, or the reaction of market players to the changing environment in the hedge fund industry.

In Chapter 2, *Dynamic Term Structure Models with Score-Driven Time-Varying Parameters: Estimation and Forecasting*, we consider score-driven time-varying parameters in dynamic yield curve models and investigate their in-sample, out-of-sample, and forecasting performance. We gradually relax the restrictive distributional assumptions which are usually imposed on dynamic yield curve models and which are cumbersome to relax in the parameter-driven framework. The considered models involve time-varying parameters in means, variances, and covariances. The time-varying volatility structures are possibly driven by common components. Furthermore, apart from having disturbances from a multivariate Gaussian distribution, we also allow disturbances to come from fat-tailed distributions. Finally, we allow the pricing errors to be correlated in the cross-sectional dimension. The chapter includes an extensive Monte Carlo study. We find that in the multivariate setting, the generalised autoregressive score models of Creal, Koopman, and Lucas (2013) produce similar in-sample fit as correctly specified state-space models while offering superior out-of-sample performance when the aforementioned distributional assumptions are violated. Gains in performance are mostly visible for short-term maturities which load on multiple latent factors responsible for

the movements in the levels. This finding is most applicable to periods when the time-varying volatilities are considerably above or below their unconditional means. The chapter also proposes a novel forecasting procedure which can be used to quickly and efficiently construct multiple-period-ahead predictions and corresponding out-of-sample confidence intervals for score-driven models. Finally, we study the dynamics of yield curves in the U.S. and in Poland.

Chapter 3, *Generalised autoregressive Method of Moments,* introduces a new estimation framework which extends the Generalised Method of Moments of Hansen (1982) to settings where a subset of the parameters vary over time with unknown dynamics. The approach provides a unified framework for estimation of time-varying parameters using only a vector of moment conditions. We call the approach the Generalised autoregressive Method of Moments (GaMM) as it endows parameters that are identified via standard GMM (conditional) moment conditions with autoregressive dynamics based on local deviations of those same (conditional) moment conditions. Our approach is completely observation driven, rendering inference straightforward. The method encompasses many of the previous observation-driven models found in the literature, including the generalised autoregressive score approach of Creal, Koopman, and Lucas (2013) and Harvey (2013). We provide examples of increasing complexity to highlight the advantages of our method.

In Chapter 4, *Filtering With Confidence: In-sample Confidence Bands For GARCH Filters,* we propose a novel bootstrap procedure which allows us to compute in-sample confidence bands for misspecified GARCH filters. We label the approach the Local In TimE (LITE) bootstrap. The method accounts for various sources of uncertainty, including parameter and filtering uncertainty. The parameter uncertainty which stems from the fact that 'pseudo-true' parameters are unknown and merely estimated. More importantly, the LITE procedure also accounts for the filtering uncertainty which comes into play when the GARCH filter is not the true data-generating process. We illustrate the method by applying it to S&P 500 returns. Moreover, we investigate finite

sample properties of the confidence bands and their convergence in a range of simulation experiments. We find that the average coverage is close to the nominal level in finite samples and that it converges to the nominal level as the sampling frequency is increased. The procedure can be used as a smoother to substantially reduce average root mean square error of GARCH paths. The new method is easy to implement and does not significantly increase the computational burden. Finally, although the chapter focuses on the family of GARCH filters, the method itself can be potentially applied to other observation-driven or parameter-driven models.

Chapter 5, *Hedge Fund Innovation,* is devoted to finding out how institutional investors react to the changing market conditions. We look at the hedge fund industry in which managers are able to quickly change exposures in reaction to (or in anticipation of) such changes. They can be seen as an innovative force in seeking out new profit opportunities and achieving diversification for investors. We are interested in identifying factors that motivate fund managers to innovate. To this end, we cluster hedge funds based on the type of assets and instruments they trade in as well as their sector, geographical, and investment focus. A cluster in this chapter represents a separate product category which is more specific than the traditionally used hedge fund investment styles. We find that early entry in a cluster is associated with higher excess returns, longer survival, higher incentive fees, and lower management fees compared to funds that arrive later. The effects are found for individual clustered funds as well as for portfolios sorted on entry time in the cluster. The innovators are not able to sustain the out-performance which we take as evidence that there is an ultra competitive market for hedge fund assets, with decreasing returns to scale. Managers' motives to innovate seem to be clear—by creating new product categories (strategies) they are able to not only earn higher returns but also to keep a bigger portion of these for themselves. Moreover, investors may prefer innovative funds as they on average offer better performances than funds which imitate established strategies. In other words, innovation signals skill of the manager.