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Partial information about contagion risk, self-exciting processes and portfolio optimization

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ABSTRACT

This paper compares two classes of models that allow for additional channels of correlation between asset returns: regime switching models with jumps and models with contagious jumps. Both classes of models involve a hidden Markov chain that captures good and bad economic states. The distinctive feature of a model with contagious jumps is that large negative returns and unobservable transitions of the economy into a bad state can occur simultaneously. We show that in this framework the filtered loss intensities have dynamics similar to self-exciting processes. Besides, we study the impact of unobservable contagious jumps on optimal portfolio strategies and filtering.

1. Introduction

One of the main contributions in finance over the last 50 years is to point out that correlations have a decisive impact on asset pricing and asset allocation: Risk premia increase with covariances between asset and market returns, optimal portfolio shares depend on correlation structures in portfolios, and prices of portfolio derivatives vary with correlation structures as well. This paper studies a special type of comovement, the so-called contagion or domino effects, and their impact on portfolio decisions. Contagion refers to a situation where losses in certain assets or asset classes (e.g., bank shares, government bonds) trigger a cascade of losses in other assets or asset classes. Since contagion effects heavily influence correlations, capturing them in financial models is crucial. Several approaches to model contagion have been suggested.[1] Important contributions include (hidden) Markov chain models and self-exciting models that have recently been discussed in the literature. Typically, Markov chain models distinguish between good (boom) and bad (depression) states of the world, where in a bad state the probabilities and/or correlations for/between losses are higher than in good states. Additionally, some authors assume that agents are not able to observe the current state of the economy. On the other hand, self-exciting models directly allow for cascades of self-enhancing increases in loss probabilities. More precisely, initial losses temporarily

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[1] A more detailed literature survey can be found below.

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increase the probability of further losses, which formally resembles the above-mentioned intuitive interpretation of contagion effects.

Our paper contributes to the existing literature in several dimensions: Firstly, we introduce a hidden Markov chain model that allows for large negative returns and (unobservable) regime shifts at the same time. This is a relevant model specification since, economically, these losses are particularly significant as they happen at the same time when economic conditions are worsening. We show that exactly this specification induces self-exciting loss intensities. Recent empirical evidence by Ait-Sahalia et al. (2013) suggests that this model class fits stock dynamics very well. Intuitively, our model captures events such as the 'Black Thursday', October 24, 1929. On that day, U.S. markets fell by 11% at the opening bell, which marked the beginning of the Wall Street Crash in 1929.[2] The connection between self-exciting and hidden Markov chain models is a remarkable insight since it links together two model classes that, at first sight, seem to be different. From this point of view, self-exciting models can be interpreted as reduced-form versions of hidden Markov chain models. We compare this specification with other hidden Markov chain models and point out differences between the filtered loss intensities in these models and in our model. Furthermore, as an application we study asset allocation decisions in hidden Markov chain models. We find that optimal portfolio strategies differ significantly depending on whether a regime switching model or a model with contagious jumps is used. In particular, regime switching models lead to noisier strategies, whereas in the latter model the updates upon losses are more pronounced. In a simulation study, we evaluate the performance of several investment strategies relying on different filtering methods. The utility losses from not filtering at all can be substantial. The utility losses from using the wrong filter are moderate, but can become significant if the investment horizon is large (such as 50 years in a life-cycle setting).

There are several ways to capture contagion risk. One strand of literature models contagion as simultaneous Poisson jumps in all assets (e.g., Das and Uppal, 2004). Kraft and Steffensen (2008) extend this approach to bond markets and default risk. Ait-Sahalia et al. (2009) consider a setting with several assets. All these papers abstract from the time dimension of contagion. In particular, the probability of subsequent crashes remains the same after a joint jump. The second strand of literature is regime switching or Markov switching models. Early references in finance and economics include Schwert (1989), Turner et al. (1989), and Hamilton (1989). Ang and Bekaert (2002) apply this approach to a discrete-time asset allocation problem, whereas Honda (2003) focuses on a continuous-time framework. Recent studies with different interpretations, parametrizations, and calibrations of the regimes include Kole et al. (2006) and Guidolin and Timmermann (2007, 2008). Although a regime switching model can capture the time dimension of contagion, regime shifts are still triggered by a process that is not linked to a particular crash in some asset. Apart from these two main ideas of modeling contagion, other approaches have been developed. For instance, Buraschi et al. (2010) focus on the impact of stochastic correlation on an optimal portfolio and suggest contagion risk as one application of their method.

Some recent papers model contagion effects more explicitly. In this respect, our paper is related to Branger et al. (2009). They focus on model risk and show that an investor modeling contagion using joint jumps can suffer severe utility losses once he is confronted with a Markov regime-switching framework. Kraft and Steffensen (2009) develop a similar model and apply it to the bond market, but focus on a complete market only. In contrast to our paper, Branger et al. (2009) and Kraft and Steffensen (2009) assume that investors can observe the state of the economy perfectly. Ding et al. (2009) and Ait-Sahalia et al. (2013) propose a different class of stochastic processes to model contagion effects, the so-called self-exciting processes (Hawkes processes). They find that these can generate the empirically observed amount of default clustering. Our paper is complementary to their studies. More precisely, we find that the filtered jump intensities in a model with contagious jumps follow self-exciting processes with state-dependent coefficients.

Our paper is related to the literature on continuous-time portfolio choice under complete information starting with Merton (1969, 1971). Early models with jump-diffusion processes have been developed by Aase (1984) and Jeanblanc-Picqué and Pontier (1990). Liu et al. (2003) consider a setup with jumps in stock prices and volatilities and solve for the optimal portfolio in an incomplete market. Liu and Pan (2003) and Branger et al. (2008) study related problems with derivatives. Wu (2003) focuses on a stochastic, but predictable investment opportunity set. Davis and Lleo (2013) study a portfolio problem allowing jumps in asset prices and factor processes, as well as stochastic volatility and investment constraints.

Methodologically, our paper also builds on the large amount of literature on learning and incomplete information. The seminal studies of Detemple (1986) and Dothan and Feldman (1986) were among the first applying filtering techniques to asset pricing and asset allocation under partial information. They show that these problems can be decomposed into two parts: First, a filtering problem must be solved, i.e. the current value of the state variable is estimated. Second, conditional on the estimated state variable, the optimal portfolio is determined. In diffusion settings, Honda (2003) studies a portfolio problem with unobservable regimes and Liu (2011) generalizes his results to ambiguity averse investors. In a recent paper, Liu et al. (2010) quantify the value of information in portfolio choice within a diffusion model. Björk et al. (2010) generalize the mathematical framework to compute optimal investment strategies under partial information. However, they still assume that asset prices follow diffusion processes. References on incomplete information about jump processes include Brémaud (1981) and the recent papers by Frey and Runggaldier (2010) and Frey and Schmidt (2012). Bäuerle and Rieder (2007) and Callegaro et al. (2006) use such filters in portfolio theory. A comprehensive overview of models with incomplete information in finance is given by Pastor and Veronesi (2009).

[2] The Dow Jones Industrial Average was 305.85 on October 23, 1929, and decreased to 198.69 on November 13, 1929.