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Generalized filter-based EM algorithm and applications to calibration

The Kalman filter has been applied to a wide variety of financial models where the underlying stochastic processes driving a price are unobservable directly. Maximum likelihood parameter estimation for these models is challenging due to the recursive nature of the Kalman filter as well as the complicated interdependence of the signal and observation equations on multiple parameters. An alternative to direct numerical maximization of the likelihood function is the Expectation Maximization (EM) algorithm producing a sequence of parameter estimates involving two steps at each iteration: the Expectation step (E-step) and Maximization step (M-step). The filter-based approach developed in Elliott and Hyndman [J. Econom. Dynam. Control 31 (2007), no. 7, 2350–2373] requires only a forward pass through the data and is therefore potentially twice as fast as the smoother-based algorithm. The filter-based algorithm is expressed in terms of decoupled filters that can be computed independently in parallel on a multiprocessor system allowing for further gains in efficiency. In this paper we derive new finite-dimensional filters which allow the EM algorithm to be implemented for certain multi-factor commodity price models, generalizing the results of Elliott and Hyndman [op. cit.]. In the cases under consideration the solution to the M-step does not exist in closed form. However, it is possible to approximately solve the M-step by applying one-iteration of Newton's method to the high degree polynomials characterizing some of the updated parameters resulting in a Generalized EM algorithm. The method is illustrated by application to a two-dimensional commodity price model.