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Improved beta modeling and forecasting: An unobserved component approach with conditional heteroscedastic disturbances

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ABSTRACT

Recent research on time-varying systematic-risk (beta) modeling reveals significant advantages in utilizing daily financial data and unobserved-component models. This research proposes a state-space market model with conditional heteroscedastic errors, thus addressing the leptokurtosis of the unconditional distribution of the disturbances and reducing the influence of outliers in the estimation process. This approach outperforms the conventional models, providing better levels of in-sample goodness of fit and more accurate point- and interval-dynamic assets returns forecasts. The proposed model provides better levels of empirical, conditional, and unconditional coverage and independence of its interval returns forecasts and reaches lower loss-function scores. Therefore, our model allows improving financial strategies, such as stock pricing, determining the companies' cost-of-equity, evaluating the performance of managed-investment and pension funds, making portfolio-rebalancing processes and computing the value at risk (VAR) of investment portfolios.

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1. Introduction

Modeling asset's beta has played a crucial role in financial strategies during the last two decades. This process is essential to estimate a stock's sensitivity to the overall market, to identify stock mispricing, and to evaluate the performance of asset or funds managers (Caporin & Lisi, 2013). In fact, He and Kryzanowski (2007) and Faff, Brooks, and Kee (2002) reveal the importance of accurately estimate the stocks betas for determining the companies' cost-of-equity. The most known model to estimate an asset-beta parameter is the "market model," derived from the Capital Asset Pricing Model (CAPM) proposed by Sharpe (1964) and further discussed by Lintner (1965). Although the market model supposes that the beta coefficient is stable over time, the literature in this field contains many papers that question this assumption (Benson, Faff, & Nowland, 2007; Blume, 1971; Collins, Ledolter, & Rayburn, 1987; Ferson & Harvey, 1991, 1993; Holmes & Faff, 2004; Lee & Rahman, 1990), indicating that the systematic risk associated with a wide range of financial assets around the world is time-varying. This criticism is also extended to other advances in the field, such as the static Fama and French (1993) three-factor market model and the Carhart (1997) four-factor market model. This is due to that, among other reasons, the financial time series are generally non-stationary and frequently present regime changes or structural breaks (Aloui & Hamida, 2014; Bos & Newbold, 1984; Brooks, Faff, & Lee, 1992; Faff, Lee, & Fry, 1992; Groenewold & Fraser, 1999). To overcome this limitation, several econometric approaches have been developed to model the stochastic dynamic behavior of stock betas. Among these are the following: (a) Fabozzi and Francis (1977) and Faff and Brooks (1998) split the evolution of the beta coefficient into a constant and a variable component with the latter depending on market conditions; (b) Schwert and Seguin (1990) present a dynamic beta model defined according to market volatility; (c) Yu (2002) uses stochastic volatility models; (d) Bollerslev, Engle, & Wooldridge (1988) use the GARCH models; (e) Huang (2000) uses the Markov Switching regression models; (f) Ferson and Harvey (1999), Jagannathan and Wang (1996), and Lettau and Ludvigson (2001) propose a conditional market model in which the beta coefficient is a function of several state variables; and finally, (g) other authors (Andersen & Bollerslev, 1998; Andersen, Bollerslev, Diebold, & Ebens, 2001; Andersen, Bollerslev, Diebold, & Labys, 2001; Andersen, Bollerslev, Diebold, & Labys, 2003; Barndorff-Nielsen & Shephard, 2002, 2004; Fleming, Kirby, & Ostdiek, 2003; Ghysels & Jacquier, 2005; Liu, 2009; Reeves & Wu, 2012) use realized volatility and realized covariance measures to do this task.

However, the literature indicates that the state-space specification of the market model (used in Adrian & Franzoni, 2009; Black, Fraser, & Power, 1992; Groenewold & Fraser, 1999; Holmes & Faff, 2008; McKenzie, Brooks, & Faff, 2000; Mamaysky, Spiegel, & Zhang, 2007; Mamaysky, Spiegel, & Zhang, 2008; Wells, 1994; and among others) provides a more precise measurement of the stock's systematic risk than those given by the other models mentioned above (Brooks, Faff, & McKenzie, 1998; Faff, Hillier, & Hillier, 2000; Wells, 1994). This issue is more remarkable when daily financial databases are analyzed. This is due to the fact that recent advances in the field have demonstrated substantial improvements in beta measurement by computing betas from returns measured at a higher frequency than monthly (Andersen, Bollerslev, Diebold, & Wu, 2005; Andersen, Bollerslev, Diebold, & Wu, 2006; Barndorff-Nielsen & Shephard, 2004; Hooper, Ng, & Reeves, 2008; Reeves & Wu, 2012). Specifically, Mergner and Bulla (2008) investigated the time-varying behavior of beta for eighteen pan-European sectors over the 1987–2005 period and considered six different modeling techniques. They concluded that ex-ante forecast performances of the different models show that the state-space market model is the preferred model to describe and forecast the time-varying behavior of sector betas in a European context. Moreover, Choudhry and Wu (2009) investigated the forecasting ability of three different GARCH models and the state-space market model. The main results overwhelmingly supported the state-space market model to forecast the stock returns (based on time-varying beta) of twenty UK companies.

The general state-space specification of the market model assumes that the disturbances of its observation equation are homoscedastic. However, this assumption might be incompatible with the empirical evidence in favor of conditional heteroscedasticity in the daily financial time series, mainly due to the appearance of the volatility-clustering effect (Bollerslev, Chou, & Kroner, 1992). Given this controversy, this paper aims to contribute to the literature by extending the traditional state-space market model using conditionally heteroscedastic disturbances in its observation equation. As far as