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Volatility of stock price as predicted by patent data: An MGARCH perspective ☆

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Abstract

This paper proposes to model stock price volatility and variations in innovation effort using a Multivariate GARCH structure designed to extract information for risk prediction. The salient feature is that the model order, alongside other parameters, is endogenously determined by the estimation procedures. Using stock prices of U.S. computer firms, it is found that the model can pick up the correlation between the two variables and aid in producing accurate Value-at-Risk estimates.

JEL classification: C110; C320; G100; O320
Keywords: Multivariate GARCH; Reversible jump MCMC; Innovation, Patents; Value-at-Risk

1. Introduction

Publicly traded corporations are bundles of assets, both tangible and intangible, whose values are determined everyday in financial markets. Under the efficient market hypothesis, the stock market valuation of a firm can efficiently capitalize the expected future cash flow generated by currently held assets. Generally speaking, both tangible and intangible assets should increase market values. In past literature, innovation is commonly viewed as an investment that can increase the firm's intangible assets. Griliches (1981) uses a panel of 157 U.S. firms and finds a positive association between patenting activity and market value. A series of subsequent studies show similar findings, see, for example, the survey by Hall (1999).

Dukes (1976) finds that investors adjust reported earnings for the full expensing of research and development (R&D). Similarly, Ben Zion's (1978) results suggest that differences between market and book values are cross-

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sectionally correlated with R&D expenditures. Hirschey and Weygandt (1985) and Shane and Klock (1997) observe that Tobin's Q is cross-sectionally correlated with R&D intensity. Hirschey and Spencer (1992), and Chauvin and Hirschey (1993, 1994) find that the coefficients for R&D expenses in cross-sectional valuation models are significantly positive. Using an event methodology, Woolridge (1988) and Chan et al. (1990) demonstrate a positive investor reaction to firms' R&D announcements. Sougiannis (1994) finds that lagged and current R&D expenses are both valued by the market. Green et al. (1996), and Stark and Thomas (1998) find that R&D expenses could improve the ability to explain market values of U.K. companies, and hence, there is a clear R&D component in market value.

This paper offers a methodological framework to extract information intertwined in stock prices and innovation activities of firms and suggests ways to make practical use of the modelling results. Specifically, we propose modelling the variations of stock prices and those of innovation activities using a Multivariate (bivariate, to be precise) GARCH model. Because of the dimensions of variables we try to model, a univariate GARCH specification[1] would not be applicable. We are not interested in the relationship between levels of stock prices and patents granted *per se*, which many of the works quoted above have looked into, but aim more at devising a model that can extract useful information with due predictive power. From a practical perspective, the validity of any reduced form model would be deemed refutable if the estimated results could not produce good prediction performance. In addition, just as other econometric models facilitate forecasting and policy analysis, an empirical financial model like the one proposed here should be accessible to practitioners in the financial industry.

A reduced form model in nature, the suggested structure is not without theoretical underpinnings. Indeed, the relationship between R&D and stock volatility is well studied in past literature. The prospects of many R&D-intensive companies, particularly those that have few tangible assets, are tied to the success of new, untested technologies and hence are highly unpredictable. Fixed expenditures on R&D are usually required at the outset to develop a new technology into a new product, but the outcome is far from certain. The return to R&D, if any, is likely to take a long time to materialize, but the life-cycle of the resulting product may be short in the face of fast-changing technology. A study by Schwert (2002) shows that technology can explain the unusual volatility of the Nasdaq portfolio (relative to the S&P portfolio) since mid-1999, but firm size and immaturity of firms cannot. Hollifield (2002) provides an explanation for this phenomenon: technologies have the flavor of a real option, and the volatility of an option can be much higher than the volatility of the underlying assets because the former represents a highly leveraged position.

Weeds (2002) state that R&D-related risks take two distinct forms: the technological success of a research project is probabilistic and the economic value of an innovation may evolve stochastically over time. Since the costs of inventing a new production process or developing a new product are fixed, these fixed commitments together with uncertain revenues increase the risk of the cash flow to equity. Therefore, the increase in operating leverage resulting from R&D activities may increase the volatility of a firm's performance, a claim that is supported by the empirical findings of Chan et al. (2001).

Asymmetric information on the potential costs and benefits of R&D may also produce a positive relationship between R&D and stock volatility. Under the overreaction hypothesis, [see for example Larson and Madura, 2003; Veronesi, 1999; Jegadeesh and Titman, 1995; Bloom and VanReenen, 2002], uninformed investors tend to overreact to the announcements of technological innovations or new products, and this overreaction will later be corrected by an opposite movement. Implied in this uncertain ultimate cash flow story is that investors will try to infer the distribution of these flows over time, and models that incorporate learning into asset pricing typically show that such a learning process tends to increase the volatility of asset returns [see Brennan and Xia, 2001; Timmerman, 1993; Veronesi, 1999, 2000]. Eden and Jovanovic's (1994) research is in a similar vein. Under standard hidden information settings, as in Akerlof's "lemons" problem, they show that when information is less precise, uninformed investors will value "good" companies higher than they would in the perfectly informed case and thus generate more volatility in the stock prices concerned. This offers a testable proposition in our context if we consider innovative efforts of firms can deliver information regarding their future valuations.

Apart from discussing estimation and testing issues, we also validate the informativeness of the model by conducting a Value-at-Risk (VaR) analysis using the estimates and see if innovations can improve efficiency in risk management. The empirical findings are then compared to those obtained by benchmark methods commonly used in the financial industry. Modelling and estimation are Bayesian in nature. A salient feature is that the model order (the

[1] The acronym GARCH will hereafter refer to a univariate GARCH process, and MGARCH represents the multivariate counterpart.