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Risk-free rate effects on conditional variances and conditional correlations of stock returns

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ABSTRACT

This paper investigates whether the risk-free rate may explain the movements observed in the conditional second moments of asset returns. Original results are derived, within the C-CAPM framework, that attest the existence of a channel connecting these seemingly unrelated quantities. The empirical results, involving 165 time series of stock returns quoted at the NYSE, show that the risk-free rate does contain information that is relevant in predicting the 165 conditional variances and 13,530 conditional correlations. These findings are particularly pronounced at lower frequencies where the persistence of the conditional second moments is significantly weaker.

1. Introduction

Models of the conditional second moments of stock returns successfully fit and predict the underlying unobservable variables by making use of the information contained in the corresponding time series. While these models accurately describe and replicate the phenomena, they do not provide further understanding of the latent mechanism and the possible determinants behind it. Specifically, whether time varying volatilities and correlations are, to some extent, driven by observable economic variables.

Various studies have investigated the link between the conditional variance of financial returns and exogenous explanatory variables. Factors that may potentially influence stock volatility have been considered by Schwert (1989). In particular, with respect to the linkages between financial and macro volatility "*the puzzle highlighted by the results* [..] *is that stock volatility is not more closely related to other measures of economic volatility*." Nonetheless, economic recessions are found to be the primary factor that drives fluctuations in volatility, a finding that is consistent with a later study by Hamilton and Lin (1996). Economic recessions aside, King et al. (1994) find that "…*only a small proportion of the covariances between national stock markets and their time-variation can be accounted for by* observable *economic variables. Changes in correlations between markets are driven primarily by movements in* unobservable *variables*." Engle and Rangel (2008), separately model fast- and slow-moving components of equity volatilities and find that the latter "…*is greater when the macroeconomic factors of GDP, inflation and short-term interest rates are more volatile or when inflation is high and output growth is low*."

Other studies have considered the effects of news announcements on volatility. Cutler et al. (1990) find that contemporaneous news events explain only a fraction of volatility *ex post*. With respect to scheduled macroeconomic news announcements on

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interest rate and foreign futures markets, Ederington and Lee (1993) observe that "…*volatility remains substantially higher than normal for roughly fifteen minutes and slightly elevated for several hours*." Similarly, in Balduzzi et al. (2001) it is found that "*public news can explain a substantial fraction of price volatility in the aftermath of announcements*…" and that "…*volatility increase*[*s*] *immediately after the announcements and persist[s] for up to 60 min after the announcements*." Fleming and Remolona (1999) distinguish between a first and a second stage after the release of a major macroeconomic announcement and find that, in the latter, the announcement induces price volatility persistence. Using intra-daily data, Andersen and Bollerslev (1998) "… *conclude that these effects* (*release of public information and*, *in particular*, *certain macroeconomic announcements*) *are secondary when explaining overall volatility*."

This paper investigates whether the risk-free rate may explain the movements observed in the conditional variances and correlations of stock returns. A possible explanation for the connection between these seemingly unrelated quantities is put forward within the Consumption Capital Asset Pricing Model (C-CAPM) framework. The results are derived under the unique assumption that the product of the relative risk aversion coefficient and the marginal utility is a monotonic function of consumption. A logical connection is shown to exist between the conditional expectation and the conditional variance of the stochastic discount factor, henceforth SDF. Through the well established inverse relationship between the risk-free rate and the expected value of the discount factor, it is then possible to characterize the SDF's conditional variance as related to the risk-free rate. An analysis of the degree of association between asset returns conditional second moments and the conditional variance of the discount factor completes the description of the channel linking risk-free rate variations to movements of variances and correlations. Under the stated assumption, no restriction is imposed on the sign of the response of the conditional moments to changes in the risk-free rate. However, it is possible to identify the (exogenous) conditions for which these quantities will move in the same or in the opposite direction.

The approach followed for the parametrization of the conditional variance and covariance matrix as a function of the risk-free rate is that of the Sequential Conditional Correlations (SCC) methodology introduced by Palandri (2009) which ensures positive definiteness of the conditional correlation matrix under the necessary and sufficient condition that each correlation and partial correlation is bounded between plus and minus one.[1] The associated bivariate Autoregressive Conditional Correlation (ACC) model, based on the Fisher transformation of the correlations, satisfies the required bounds by construction and can therefore effortlessly accommodate the inclusion of exogenous variables.

The empirical study is based on 165 time series of stock returns quoted at the NYSE, involving 165 conditional variances and 13,530 conditional correlations. A previous study by Glosten et al. (1993) found that short term interest rates positively predict stock market volatility. However, using a large number of stocks observed for more than 40 years, this paper finds that the relationship between risk-free rate and assets' volatility is nonlinear. Specifically, at low frequencies more than three quarters of the stocks considered exhibit volatilities that are concave functions (here approximated by negative quadratic functions) of the risk-free rate. Similarly, the sign of the risk-free rate effects on the conditional correlations is found to differ for different pairs of assets.

Furthermore, the results highlight the relevance of the informational content of the risk-free rate at low frequencies. Key to the success of the purely dynamic autoregressive models is the persistence in the conditional volatilities and correlations. However, over longer horizons such persistence gradually vanishes until the variances and correlations of consecutive observations are essentially uncorrelated as implied by stationarity. Accordingly, the findings in this paper feature the evanescence of the purely dynamic GARCH and GARCH-like specifications accompanied by the simultaneous rise of the risk-free rate to relevant predictor.

The paper is organized as follows. Section 2 presents the theoretical analysis leading to the identification of the relationship between the risk-free rate and the conditional second moments of assets' returns. The data set is described in Section 3 followed by the description of the econometric model specifying the conditional second moments as functions of exogenous variables in Section 4. Details on the estimation are contained in Section 5 and the empirical results are discussed in Section 6. Section 7 concludes. Appendix A and B contain proofs and derivations of results needed in the Section 2. A preliminary analysis of the relation between the risk-free rate and the conditional second moments of the SDF in the case of Epstein and Zin (1989) and Weil (1989) recursive preferences may be found in Appendix C. Appendix D lays out the conditions for uniform ergodicity of the Autoregressive Conditional Correlations model.

2. Information content of the risk-free rate

This section tries to identify the theoretical connections between the risk-free rate and the conditional variances and correlations of risky assets within the C-CAPM framework. The argument made is quite simple: assets loading on the SDF will exhibit conditional variances and correlations that respond to changes in the conditional variance of the SDF itself. Under the fairly general assumptions (i) and (ii) below, conditional mean and variance of the SDF respond monotonically to changes in the consumption process. Hence, movements in the risk-free rate, which is the conditional mean of the SDF, proxy movements in the conditional variance of the SDF which is a component of the conditional second moments of the risky returns. It must be

[1] The specification of a Multivariate GARCH model suited for the inclusion of exogenous variables brings about a series of complications due to the necessity of preserving positive definiteness of the conditional variance–covariance matrix. As a result, in most specifications, the vector of exogenous determinants enters the dynamic equations through some quadratic form. Clearly, this amounts to the imposition of arbitrary restrictions on the functional form and the set of parameters.