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Dynamic correlation structure and security risk

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ABSTRACT

We investigate the relationship between changing correlation structure of returns, security risk, and mean return. According to our results, securities that were highly correlated with the market-wide risk factors in the past are likely to have high systematic and idiosyncratic risk at present. Correlations with the risk factors, however, are not directly related to the mean return of securities, nor can they consistently explain the puzzling relationship between idiosyncratic risk and return. We demonstrate further that the effect of past correlations on security risk is more likely among less transparent securities.

1. Introduction

Finance literature has long recognized the dynamic nature of the correlation structure of security returns (see, for example, Ang & Chen, 2002; Engle, 2007; Kallberg & Pasquariello, 2008; Lee, Lin, & Yang, 2011). Among the first models, which account for the time variation in the second moments of security returns is the Autoregressive Conditional Heteroskedasticity (ARCH) (Engle, 1982) and its generalized version – GARCH models (Bollerslev, 1986; Engle & Bollerslev, 1986). In the GARCH specification, variance of security return changes over time and is influenced by its own past values and the past (squared) disturbances. This behavior can be explained by stochastic information arrival,

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which introduces time dependency in the second moments of returns (see Egloff, Leippold, & Wu, 2006; Ghysels, Santa-Clara, & Valkanov, 2005; Guo & Whitelaw, 2006; Hong, Tu, & Zhou, 2007; Irvine & Pontiff, 2009; Krishnan, Petkova, & Ritchken, 2009; Lamoreaux & Lastrapes, 1990). The model has a great empirical success when it comes to explaining the variance of individual securities. However, at the heart of numerous finance models, such as the Capital Asset Pricing Model (CAPM) and Arbitrage Pricing Model (APT), is the analysis of the total covariance structure of returns, whereas the original ARCH/GARCH models only account for the behavior of variances.

This issue has been recognized and received considerable attention in literature. Numerous versions of the multivariate GARCH model have been proposed (see Bauwens, Laurent, & Rombouts, 2006; Bollerslev, Engle, & Nelson, 1994 for extensive surveys of this literature). Among the first papers in this area is Bollerslev, Engle, and Wooldridge (1988), which specifies a multivariate GARCH model for several index portfolios, in which an index variance and covariances are influenced by their own past values, as well as by the second moments of the remaining indexes. A common problem in most of these models is the need to estimate a large number of parameters. As R. Engle (2007) points out "only a few of these models are amenable to estimating correlations for more than half a dozen assets" (p. 3).

Several attempts have been made to efficiently address the above dimensionality problem. A reduction in the number of parameters can be achieved by imposing certain restrictions on the model, which includes assuming the covariances are integrated, using additional moment conditions in the first order conditions of the likelihood function, or imposing a factor structure on returns within a Factor ARCH framework (Engle, 2007). Factor ARCH models in particular, such as Engle, Ng, and Rothschild (1990), Bollerslev and Engle (1993), and Vrontos, Dellaportas, and Politis (2003), have become especially popular since the core asset pricing models, the CAPM and APT, suggest that security returns are linear functions of risk factor(s).

The advantage of the reduction in the number of parameters in the above models comes at the expense of a potential specification error if the covariance structure of returns does not follow pre-specified models in reality. Of particular concern is the fact that securities tend to be more correlated during economic downturns and less so during periods of economic boom (see Ang & Chen, 2002; Ang & Bekaert, 2002). The latter empirical regularity implies that the "relative"[2] riskiness of returns is changing, which is not fully incorporated in the existing GARCH models.

Given the above concern, we propose a different approach to account for the dynamic correlation structure of returns. Specifically, we estimate correlations of returns with market-wide risk factors and use estimates as the input variables in the GARCH model. The advantage of this approach is that covariances with the risk factors are allowed to change arbitrarily, so the specification error in the covariance structure is reduced. This advantage potentially comes at the expense of an estimation error since the covariances are estimated. To mitigate this issue, we use a rolling estimation on daily data to ensure large sample size. Furthermore, we focus on individual securities' correlations with the market risk factors, rather than securities' pair-wise correlations, because these covariances are the most relevant to investors as they define systematic (relevant) risk.

We offer the following intuitive interpretation of our approach: we expect that a security that was highly correlated with the rest of the market (i.e. had high correlations with the market-wide risk factors) is likely to be influenced by shocks to the other securities at present, since it is more integrated with the rest of the market. Consequently, it should have a high systematic and idiosyncratic risk. We find that the data tends to confirm this hypothesis.

Specifically, we observe that systematic or idiosyncratic risk is significantly related to past correlations of returns with risk factors, such as market, size, value, and momentum, in about one third of the market securities. This relationship is typically positive, i.e. high past correlation of return with the market leads to a high present systematic or idiosyncratic risk. Our results also suggest that the risk of less transparent securities as measured by size, analysts' coverage, and share turnover is more likely to be associated with past correlations. We hypothesize that correlations' shocks should have long last-

[2] We adopt here the terminology of Engle et al. (1990), which refers to the "relative riskiness", represented by the covariance matrix eigenvectors and the "total riskiness", represented by the matrix eigenvalues.