



Are correlations constant? Empirical and theoretical results on popular correlation models in finance[☆]



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ABSTRACT

Multivariate GARCH models have been designed as an extension of their univariate counterparts. Such a view is appealing from a modeling perspective but imposes correlation dynamics that are similar to time-varying volatility. In this paper, we argue that correlations are quite different in nature. We demonstrate that the highly unstable and erratic behavior that is typically observed for the correlation among financial assets is to a large extent a statistical artifact. We provide evidence that spurious correlation dynamics occur in response to financial events that are sufficiently large to cause a structural break in the time-series of correlations. A measure for the autocovariance structure of conditional correlations allows us to formally demonstrate that the volatility and the persistence of daily correlations are not primarily driven by financial news but by the level of the underlying true correlation. Our results indicate that a rolling-window sample correlation is often a better choice for empirical applications in finance.

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1. Introduction

Multivariate GARCH models have been designed as extensions of their univariate counterparts. Engle et al. (1984) present an early version as “a bivariate generalization of Engle’s ARCH model”. This view is conceptually appealing and has found widespread use in practice. In this paper, we argue that the nature of dynamic correlations is very different from that of conditional volatilities. While important economic and financial news such as economic activity, interest rate changes, and oil prices affect the volatility of financial assets, the relevance and impact of this news is often similar across firms. As a consequence, volatility is constantly exposed to news and therefore time-varying by nature but correlation changes are only observable after major economic events. For instance, cor-

relations substantially increased for many financial assets following the burst of the Dot-com bubble in 2001 or the default of Lehman Brothers in September 2008 (Ofek and Richardson, 2003; Wied et al., 2012) but correlations are generally insensitive to changes in macroeconomic variables such as interest rates or inflation (King et al., 1994; Karolyi and Stulz, 1996). We demonstrate how current conditional correlation models tend to impose purely artificial dynamics on estimated conditional correlations and show why in empirical applications the estimated parameters governing the dynamics are often statistically significant despite the fact that underlying correlations are constant.

The correlation matrix is the input to many applications in finance and several recent studies seem to believe in the importance of time-varying correlations. For instance, Moskowitz (2003) emphasizes the significance of dynamic conditional correlations during recessions and periods of financial distress. Similarly, Adrian and Brunnermeier (2016) argue that MGARCH models are important for capturing the dynamic evolution of systemic risk. DeMiguel et al. (2009) claim that allowing for time-varying moments could increase the performance of optimal asset allocation. The notion of constant correlations therefore has important implications for financial modeling and practice. Under a constant correlation matrix, international asset portfolios may not have the same

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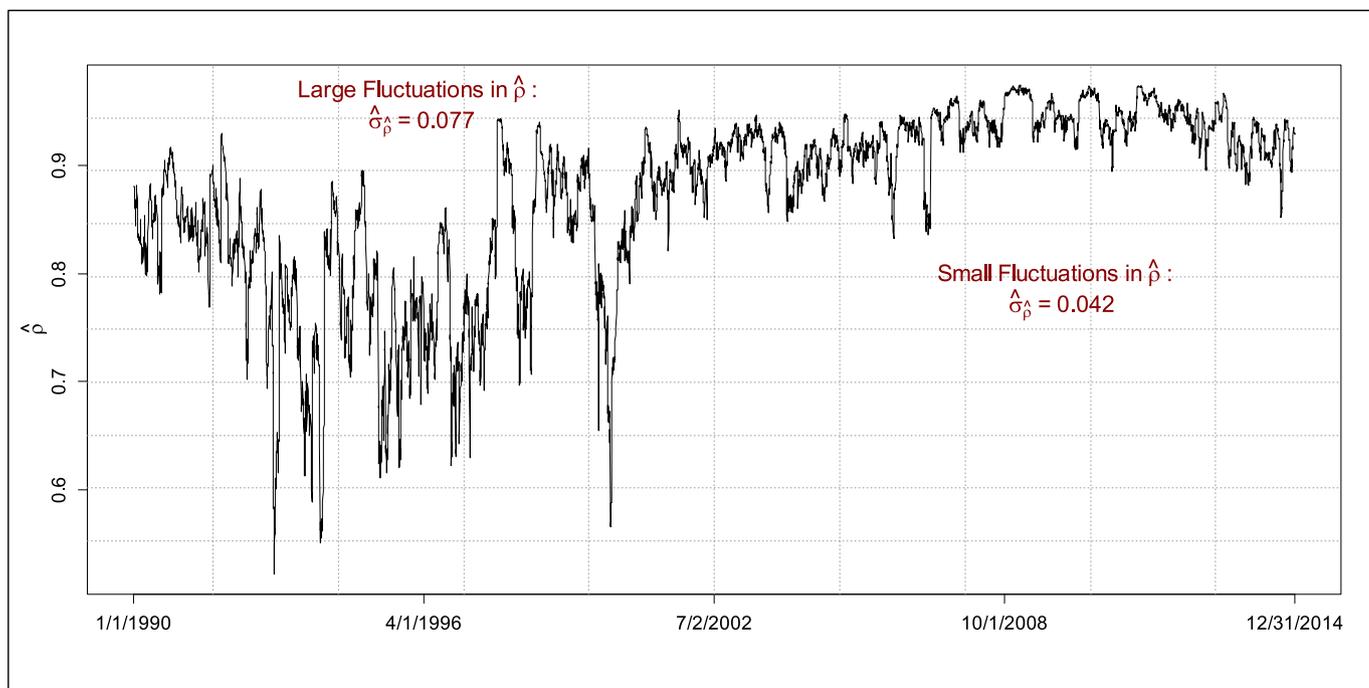


Fig. 1. Daily conditional correlations between S&P 500 and NASDAQ returns.

This figure shows daily DCC correlations between the S&P500 Composite index and the NASDAQ Composite index from 01/01/1990 to 12/31/2014 (6532 obs.). Fluctuations in time-varying correlations are generally high and can change substantially over time. During the period from January 1990 to March 2000 the volatility of daily correlations was 0.077 (122% on an annualized basis) but decreased in the following period (March 2000 to December 2014) to 0.042 (66% annualized).

degree of diversification than comparable portfolios based on dynamic correlations, portfolio optimization could generate different weights, and risk measures may indicate different levels of risk. The aim of our research is not to dismiss dynamic correlation modeling altogether, but to provide a critical perspective on popular models that are routinely used to generate estimates of dynamic asset correlations.

The analysis in this paper is based on Engle's (2002) Dynamic Conditional Correlation (DCC) model. The main advantage of the DCC approach is its parsimonious specification which simplifies interpretation and allows even large asset portfolios to be estimated within seconds. Over the last years, the DCC model has therefore become well-established in both research and practice.¹ In Appendix A of the Online Appendix, we show that our results also hold for other popular MGARCH models, which tend to generate very similar dynamics.² To illustrate its behavior, consider the conditional correlations between the daily returns of the S&P 500 and the NASDAQ index from 1990 to 2014 shown in Fig. 1. Two characteristics that are typical for conditional correlations generated by MGARCH models stand out. First, conditional correlations undergo large swings over a short period of time. In the 1990s, correlations frequently moved within a wide range between 0.52 in July 1993 and 0.94 in November 1997. In the literature, this observation has been sometimes interpreted as evidence that the underlying cor-

relation structure is a highly volatile process (e.g., Pukthuanthong and Roll, 2011; Sadorsky, 2012). Second, the fluctuation in conditional correlations often changes over time. In Fig. 1, correlations are highly volatile during the 1990s but enter a more tranquil period in 2000. During this time, the daily volatility of correlations dropped approximately by half. In this paper, we show that the large fluctuations during the 1990s and the small fluctuations during the 2000s have no fundamental economic cause but are purely artificial results generated by the DCC model. In the following, the discussion and the empirical results of our paper are based on typical bivariate correlations. Simulation results in Pakel et al. (2014) suggest that in the multivariate case, correlations become constant as the number of assets increases.³

We demonstrate that the volatility of estimated conditional correlations $\hat{\rho}$ is a negative function of the underlying true correlation level ρ : The fluctuations in conditional correlations $\hat{\rho}$ are large when the correlation level ρ is close to zero and small when ρ approaches ± 1 .⁴ In Fig. 1, this causes the volatility to decrease drastically as conditional correlations reach values of 0.9 and beyond. In fact, we argue that for financial assets, underlying true correlations ρ are generally constant and that the fluctuations generated by autoregressive-type multivariate GARCH models are spurious. They are caused by infrequent economic disruptions that shift the level of correlations. We recognize that correlations can and do change from time to time. For instance, Longin and Solnik (1995), Bera and Kim (2002), and Forbes and Rigobon (2002) show that correlations among financial assets increase during economic crises and times of financial distress. However, our claim is that these

¹ For instance, the DCC model has been used in value-at-risk estimation (Pérignon and Smith, 2010), the analysis of asset class comovements (You and Daigler, 2010; Heaney and Srikanthakumar, 2012), the implementation of hedging strategies (Chang et al., 2011), and the examination of correlation responses to announcement effects (Brenner et al., 2009), among others.

² Only models that have become accepted in practice and can be applied with reasonable effort and speed are part of our robustness section. This includes MGARCH models with autoregressive covariances such as the corrected DCC model of Aielli (2013), the diagonal VECH model of Bollerslev et al. (1988), or the diagonal BEKK model of Engle and Kroner (1995). It excludes more complex MGARCH specification such as the regime-switching model of Pelletier (2006). For a classification of MGARCH models we refer the reader to Bauwens et al. (2006).

³ We thank an anonymous reviewer for pointing this out.

⁴ In the following, we assume that there exists a true but unobserved correlation ρ . From a statistical viewpoint, our empirical estimates $\hat{\rho}$ are only meaningful if there is a true but unobserved correlation ρ . From an economic perspective, there should be a true correlation coefficient that reflects the way common economic factors lead to comovement between any two financial assets.

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