INTERNATIONAL JOURNAL OF POLITICAL SCIENCES AND ECONOMICS
Impact Factor (research bib) - 9,78
https://ijmri.de/index.php/ijpse , German international journals company
ISSN 2751-9708

MODELS FOR SECURITY PRICE VOLATILITY: THEORETICAL BASIS AND PRACTICAL ANALYSIS

Rakhimova Umida
Senior lecturer, Department of "Higher Mathematics",
Samarkand Institute of Economics and Service
Urokova Mohigul Nodir kizi
Student of Samarkand institute of economics and service

Abstract

This scientific paper provides an in-depth analysis of the theoretical and practical aspects of applying GARCH (Generalized Autoregressive Conditional Heteroskedasticity) models to assess the volatility of securities prices. The study examines key characteristics of financial time series, including volatility clustering, heteroskedasticity, and asymmetric effects. The mathematical foundations of the GARCH model, the economic interpretation of its parameters, and their role in financial risk assessment are discussed. In addition, various extensions of the model and their practical applications are analyzed.

Keywords

securities, volatility, GARCH model, financial time series, risk, heteroskedasticity, forecasting, investment.

Annotatsiya

Mazkur ilmiy maqolada qimmatli qog'ozlar narxining o'zgaruvchanligini baholashda GARCH (Generalized Autoregressive Conditional Heteroskedasticity) modellarining nazariy va amaliy jihatlari chuqur tahlil qilingan. Tadqiqotda moliyaviy vaqt qatorlarining asosiy xususiyatlari, xususan volatilitet klasterlashuvi, geteroskedastiklik va assimetrik ta'sirlar o'rganilgan. GARCH modelining matematik asoslari, parametrlarining iqtisodiy talqini hamda ularning moliyaviy bozorlardagi riskni baholashdagi ahamiyati yoritilgan. Shuningdek, modelning turli modifikatsiyalari va ularning qo'llanish imkoniyatlari ko'rib chiqilgan.

Kalit so'zlar

qimmatli qog'ozlar, volatilitet, GARCH modeli, moliyaviy vaqt qatorlari, risk, geteroskedastiklik, prognozlash, investitsiya.

Аннотация

В данной научной статье проведён углублённый анализ теоретических и практических аспектов применения моделей GARCH (Generalized Autoregressive Conditional Heteroskedasticity) для оценки волатильности цен ценных бумаг. В исследовании рассмотрены основные свойства финансовых временных рядов, включая кластеризацию волатильности, гетероскедастичность и асимметричные эффекты. Освещены математические основы модели GARCH, экономическая интерпретация её параметров и их значение в оценке финансовых рисков. Также проанализированы различные модификации модели и возможности их применения на практике.

Ключевые слова

ценные бумаги, волатильность, модель GARCH, финансовые временные ряды, риск, гетероскедастичность, прогнозирование, инвестиции.

INTRODUCTION

One of the most important components of the modern financial system is the securities market. This market plays an important role in the efficient allocation of capital, stimulating investment processes and ensuring economic growth. However, the constant fluctuation of securities prices creates a high level of uncertainty for investors. Such price volatility is one of the main sources of financial risk, and its identification, assessment and forecasting are relevant areas of economic research. For a long time, classical econometric approaches have been used in the analysis of financial time series, which mainly assumed constant variance (homoscedasticity). However, real financial data refute this assumption. Practical observations show that securities returns have a time-varying variance and are characterized by such features as volatility clustering, leptokurtic distribution and asymmetry. This situation showed the limitations of classical models and prompted the development of new approaches.

In such conditions, the family of autoregressive conditional heteroskedasticity models, in particular the GARCH (Generalized Autoregressive Conditional Heteroskedasticity) model, emerged as an important tool for analyzing financial time series. This model is an advanced form of the ARCH model first proposed by Engle and generalized by Bollerslev. The main advantage of GARCH models is that they take into account the change in variance over time, thereby allowing for a more accurate assessment of volatility. As financial markets become increasingly complex in the process of global integration, a deep study of price volatility is of not only theoretical but also practical importance. In particular, GARCH models are widely used in portfolio management, risk diversification, valuation of derivative instruments, and macroeconomic policy development. In this context, this article deeply explores the theoretical and practical aspects of analyzing stock price volatility based on GARCH models.

MAIN PART

When analyzing financial time series, it is first necessary to move from price levels to profitability indicators. Because prices are often non-stationary, which complicates econometric analysis. The profitability indicator is expressed in the following logarithmic form:

$$r_t = \ln\left(\frac{P_t}{P_{t-1}}\right) \quad (1)$$

This transformation, while stationary, allows for a more accurate representation of percentage changes. Empirical studies show that although return series usually have a mean value close to zero, their variance varies over time.

One of the most important features of financial time series is volatility clustering. That is, periods of high volatility are followed by periods of low volatility. This is due to the gradual absorption of information by the market. Investors react to new information at different speeds, which leads to a gradual adjustment of prices.

To model this feature, the GARCH model is expressed in the following form:

$$\sigma_t^2 = \omega + \alpha\varepsilon_{t-1}^2 + \beta\sigma_{t-1}^2 \quad (2)$$

This equation describes the dynamics of conditional variance. Here ω is a constant component and denotes the long-term average variance. The coefficient α represents the impact of new information (shock) arriving at the market, that is, the impact of the squared error in the previous period on the current variance. β reflects the inertia of volatility, that is, the impact of the previous variance on the current variance.

An important feature of the GARCH model is that it simultaneously takes into account short-term shocks and long-term trends. If α is large, the market is very sensitive to new information. If β is large, volatility persists for a long time. In applied research, the sum of α + β is often close to 1, which indicates a high degree of persistence of volatility.

ISSN 2751-9708

Another important phenomenon in financial markets is the asymmetric effect, i.e. the leverage effect. In this case, negative news (price decline) causes stronger volatility than positive news. The standard GARCH model does not take this effect into account, so various modifications of it have been developed. For example, the EGARCH model reflects asymmetry through logarithmic variance, while the TGARCH model introduces separate parameters for negative and positive shocks.

The scope of application of GARCH models is very wide. They are widely used in risk assessment, in particular, in determining the Value-at-Risk (VaR) indicator. VaR represents the maximum loss of an investor at a certain probability level. An accurate forecast of volatility is very important in determining this indicator, and the GARCH model effectively performs this task. In addition, GARCH models play an important role in portfolio optimization. In modern portfolio theory, the balance between risk and return is key. By accurately assessing volatility, investors have the opportunity to build an optimal portfolio. At the same time, the GARCH model is also one of the main tools in the valuation of derivative instruments, in particular options.

Empirical studies show that there are significant differences between developed and emerging markets. In emerging markets, the level of volatility is also high due to high political and economic uncertainty. This is reflected in the parameters of GARCH models. In particular, high values of the coefficients α and β indicate strong clustering and persistence of volatility. Volatility also increases sharply during periods of global financial crises. For example, during financial crises, investors tend to avoid risk, which leads to sharp changes in asset prices. The GARCH model is especially important in forecasting volatility during such periods. In a deeper study of the behavior of financial time series, not only the mean and variance are important, but also their probability distribution. Empirical observations show that security returns do not fully correspond to a normal distribution. On the contrary, their distribution is "fat-tailed" and the probability of extreme values is high. This creates serious problems in assessing financial risk and further strengthens the need to use GARCH models.

To better understand how the GARCH model works, it is necessary to focus on its probability basis. The model usually consists of two stages: the mean equation and the variance equation. The mean equation is often expressed through the ARMA model, which allows for autocorrelation in returns. The variance equation reflects the dynamics of the conditional variance over time.

Another important aspect of the GARCH model is its stationarity condition. For the model to be stable, the parameters must satisfy the following condition:

$$\alpha + \beta < 1 \tag{3}$$

If this condition is met, the model will have a stable variance in the long run. Otherwise, volatility can increase indefinitely, which limits the practical application of the model.

Another important feature observed in financial markets is the leverage effect, that is, the effect of negative returns on volatility is stronger than that of positive returns. This phenomenon is explained by the psychological behavior of investors: when the market falls, panic increases and trading volume increases, which increases volatility. To take this effect into account, the EGARCH model is expressed in the following form:

$$\ln(\sigma_t^2) = \omega + \beta \ln(\sigma_{t-1}^2) + \alpha \frac{\varepsilon_{t-1}}{\sigma_{t-1}} + \gamma \left| \frac{\varepsilon_{t-1}}{\sigma_{t-1}} \right| \tag{4}$$

The use of the logarithmic form in this model ensures that the variance is always positive and more accurately reflects asymmetric effects.

Parameter estimation methods are also important in the practical application of GARCH models. Typically, the Maximum Likelihood Estimation method is used. This method selects model parameters in such a way that they maximize the likelihood of the observed data. If the data do not fit the normal distribution, it is recommended to use alternative distributions such as Student-t or GED (Generalized Error Distribution). Diagnostic tests are also used to check the adequacy of the model. For example, the Ljung-Box test is used to detect autocorrelation in the residuals, and the ARCH-LM test checks for heteroskedasticity in the residual variance. If the model is chosen correctly, the residuals should have the property of “white noise”.

Another important area of application of GARCH models is the analysis of high-frequency financial data. In modern financial markets, trading operations are carried out at the level of seconds or even milliseconds. In such conditions, volatility changes very quickly, and its accurate forecasting requires the use of complex models. Extended versions of the GARCH model, for example, the IGARCH and FIGARCH models, allow you to take into account the properties of long memory. In addition, multivariate GARCH models are also widely used. These models allow you to analyze the change in covariance and correlation between several assets over time. This is important for more accurate assessment of portfolio risk and development of diversification strategies. Volatility forecasts obtained using GARCH models serve as an effective tool for making financial decisions. For example, these models are widely used in determining the level of capital adequacy in risk management, in the formation of insurance funds, and in optimizing investment strategies. At the same time, GARCH models have some limitations. They often do not take into account structural changes (structural breaks). For example, abrupt changes in economic policy or financial crises can disrupt the stability of model parameters. Therefore, modern research is developing approaches such as Markov switching GARCH and regime-switching models.

Another important direction is the integration of GARCH models with artificial intelligence and machine learning methods. For example, it is possible to increase forecast accuracy by optimizing GARCH parameters using neural networks or creating hybrid models. These approaches are especially effective in conditions where large amounts of data (big data) are available. In general, GARCH models have a deep theoretical basis and wide practical possibilities in analyzing stock price volatility. They serve as an important tool for modeling uncertainty in financial markets, assessing risk, and forecasting.

CONCLUSION

Analysis of stock price volatility is one of the most important issues in modern financial economics. In this process, GARCH models appear as an important theoretical and practical tool. They allow for accounting for heteroskedasticity in financial time series, forecasting volatility, and assessing risk.

The analysis shows that the GARCH model effectively reflects the internal dynamics of the market, in particular the impact of information flow on prices. At the same time, the values of the model parameters vary depending on the level of development and stability of the market. The use of GARCH models is especially important in emerging markets, where volatility is high and unstable.

However, the simple GARCH model cannot fully capture all the complexities. Therefore, it is advisable to use its various modifications, in particular asymmetric models. In the future, the integration of GARCH models with artificial intelligence and machine learning methods can further increase the accuracy of financial forecasting.

In general, GARCH models are an effective and reliable tool for analyzing stock market volatility, with the help of which investors and researchers will be able to better understand and effectively manage market risks.

REFERENCES

1. Bollerslev, T. (1986). Generalized autoregressive conditional heteroskedasticity. Journal of Econometrics, 31(3), 307–327. https://doi.org/10.1016/0304-4076(86)90063-1
2. Engle, R. F. (1982). Autoregressive conditional heteroskedasticity with estimates of the variance of United Kingdom inflation. Econometrica, 50(4), 987–1007. https://doi.org/10.2307/1912773
3. Tsay, R. S. (2010). Analysis of financial time series (3rd ed.). Wiley.
4. Brooks, C. (2019). Introductory econometrics for finance (4th ed.). Cambridge University Press.
5. Hull, J. C. (2021). Options, futures, and other derivatives (11th ed.). Pearson.
6. Alexander, C. (2008). Market risk analysis, volume II: Practical financial econometrics. Wiley.
7. Hamilton, J. D. (1994). Time series analysis. Princeton University Press.
8. Gujarati, D. N., & Porter, D. C. (2009). Basic econometrics (5th ed.). McGraw-Hill.
9. Nelson, D. B. (1991). Conditional heteroskedasticity in asset returns: A new approach. Econometrica, 59(2), 347–370. https://doi.org/10.2307/2938260
10. Glosten, L. R., Jagannathan, R., & Runkle, D. E. (1993). On the relation between the expected value and the volatility of the nominal excess return on stocks. The Journal of Finance, 48(5), 1779–1801. https://doi.org/10.1111/j.1540-6261.1993.tb05128.x
11. Poon, S. H., & Granger, C. W. J. (2003). Forecasting volatility in financial markets: A review. Journal of Economic Literature, 41(2), 478–539. https://doi.org/10.1257/002205103765762743
12. Shodmonov, Sh., & G‘afurov, U. (2018). Iqtisodiyot nazariyasi. Toshkent: O‘zbekiston.
13. Karimov, A., & Xolmatov, N. (2021). Moliyaviy bozorlar va risklarni boshqarish. Toshkent: Iqtisodiyot nashriyoti.
14. Mirzayev, B. (2022). O‘zbekiston fond bozorida volatilitetni baholash usullari. Iqtisodiyot va innovatsion texnologiyalar, 6(2), 45–56.