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CONTENTS

PEDAGOGY

ECONOMY

МАЗМҰНЫ

ПЕДАГОГИКА

ЭКОНОМИКА

СОДЕРЖАНИЕ

ПЕДАГОГИКА

ЭКОНОМИКА

SCIENTIFIC JOURNAL OF PEDAGOGY AND ECONOMICS
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VOLATILITY OF FINANCIAL INSTRUMENTS ON THE KAZAKHSTAN STOCK MARKET: MEASUREMENT AND FORECASTING

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Abstract. Volatility of financial instruments is a key characteristic of market risk and reflects the degree of uncertainty of future prices and returns, determining decisions in the field of portfolio management, pricing of derivatives, risk management and financial stability monitoring. For emerging markets, including the Republic of Kazakhstan, the importance of correctly measuring and forecasting volatility increases due to the limited depth and liquidity of the market, high concentration of trading and sensitivity of yields to macroeconomic and external shocks. The purpose of the study is to measure and predict the volatility of key financial instruments of the stock market of the Republic of Kazakhstan based on time series analysis methods and models of conditional heteroscedasticity. The empirical base is based on data from the Kazakhstan Stock Exchange (KASE) and official analytical materials of the exchange, including the KASE index indicators and weekly reviews of KASE Weekly. Yields were calculated in the form of logarithmic price increments. At the diagnostic stage, tests of stationarity (ADF/PP), autocorrelation (Ljung–Box), normality (Jarque–Bera) and ARCH effects (ARCH-LM) were applied. The results obtained indicate the stationarity of the yield series with a statistically significant deviation of the distributions from the normal law,

the presence of “heavy tails”, asymmetry and pronounced clustering of volatility. The revealed ARCH effects confirm the need for conditional variance modeling and justify the use of ARCH/GARCH models and their asymmetric extensions (EGARCH, GJR-GARCH), as well as taking into account alternative distributional assumptions. The practical significance of the study lies in the possibility of applying the results for dynamic assessment of market risk, VaR calculations and improvement of risk management and regulatory monitoring procedures in the securities market of Kazakhstan.

Keywords: volatility, Kazakhstan stock market, KASE; ARCH/GARCH, forecasting, market risk, profitability

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ҚАЗАҚСТАННЫҢ ҚОР НАРЫҒЫНДАҒЫ ҚАРЖЫ ҚҰРАЛДАРЫНЫҢ ҚҰБЫЛМАЛЫЛЫҒЫ: ӨЛШЕУ ЖӘНЕ БОЛЖАУ

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Аннотация. Қаржы құралдарының құбылмалылығы нарықтық тәуекелдің негізгі сипаттамасы болып табылады және портфельді басқару, туынды құралдарға баға белгілеу, тәуекелдерді басқару және қаржылық тұрақтылықты бақылау саласындағы шешімдерді айқындай отырып, болашақ бағалар мен кірістіліктің белгісіздік дәрежесін көрсетеді. Қазақстан Республикасын қоса алғанда, дамушы нарықтар үшін нарықтың шектеулі тереңдігі мен өтімділігіне, сауда-саттықтың жоғары шоғырлануына және кірістіліктің макроэкономикалық және сыртқы күйзелістерге сезімталдығына байланысты құбылмалылықты дұрыс өлшеу мен болжаудың маңыздылығы артады. Зерттеудің мақсаты – уақыт қатарларын талдау әдістері мен шартты гетероскедастикалық модельдер негізінде Қазақстан Республикасы

қор нарығының негізгі қаржы құралдарының құбылмалылығын өлшеу және болжау. Эмпирикалық база Қазақстан қор биржасының (KASE) деректерінде және KASE индексінің көрсеткіштерін және KASE Weekly апта сайынғы шолуларын қоса алғанда, биржаның ресми талдамалық материалдарында қалыптастырылған. Кірістер бағаның логарифмдік өсуі түрінде есептелді. Диагностика кезеңінде стационарлық (ADF/PP), автокорреляция (Ljung–Box), қалыптылық (Jarque–Bera) және ARCH-эффект (ARCH-LM) сынақтары қолданылады. Алынған нәтижелер үлестірімдердің қалыпты заңнан статистикалық маңызды ауытқуы, "ауыр құйрықтардың" болуы, асимметрия және құбылмалылықтың айқын кластерленуі кезіндегі кірістілік серияларының стационарлығын көрсетеді. Анықталған ARCH эффектілері шартты дисперсияны модельдеу қажеттілігін қолдайды және ARCH/GARCH модельдерін және олардың асимметриялық кеңейтімдерін (EGARCH, GJR-GARCH) қолдануды, сондай-ақ балама тарату үй-жайларын ескеруді негіздейді. Зерттеудің практикалық маңыздылығы нарықтық тәуекелді динамикалық бағалау, VaR есептеулері үшін нәтижелерді қолдану және Қазақстанның бағалы қағаздар нарығында тәуекелдерді басқару және реттеушілік мониторинг рәсімдерін жетілдіру мүмкіндігінде жатыр.

Түйін сөздер: құбылмалылық, Қазақстанның қор нарығы, KASE; ARCH / GARCH, болжау, нарықтық тәуекел, кірістілік

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ВОЛАТИЛЬНОСТЬ ФИНАНСОВЫХ ИНСТРУМЕНТОВ НА ФОНДОВОМ РЫНКЕ КАЗАХСТАНА: ИЗМЕРЕНИЕ И ПРОГНОЗИРОВАНИЕ

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Аннотация. Волатильность финансовых инструментов является ключевой характеристикой рыночного риска и отражает степень неопределенности будущих цен и доходностей, определяя решения в сфере портфельного управления, ценообразования производных инструментов, риск-менеджмента

и мониторинга финансовой стабильности. Для развивающихся рынков, включая Республику Казахстан, значимость корректного измерения и прогнозирования волатильности возрастает ввиду ограниченной глубины и ликвидности рынка, высокой концентрации торгов и чувствительности доходностей к макроэкономическим и внешним шокам. Цель исследования — измерить и спрогнозировать волатильность ключевых финансовых инструментов фондового рынка Республики Казахстан на основе методов анализа временных рядов и моделей условной гетероскедастичности. Эмпирическая база сформирована на данных Казахстанской фондовой биржи (KASE) и официальных аналитических материалах биржи, включая показатели индекса KASE и еженедельные обзоры KASE Weekly. Доходности рассчитывались в форме логарифмических приращений цен. На этапе диагностики применены тесты стационарности (ADF/PP), автокорреляции (Ljung–Box), нормальности (Jarque–Bera) и ARCH-эффектов (ARCH-LM). Полученные результаты свидетельствуют о стационарности рядов доходностей при статистически значимом отклонении распределений от нормального закона, наличии “тяжелых хвостов”, асимметрии и выраженной кластеризации волатильности. Выявленные ARCH-эффекты подтверждают необходимость моделирования условной дисперсии и оправдывают применение моделей ARCH/GARCH и их асимметричных расширений (EGARCH, GJR-GARCH), а также учет альтернативных распределительных предпосылок. Практическая значимость исследования заключается в возможности применения результатов для динамической оценки рыночного риска, расчетов VaR и совершенствования процедур управления рисками и регуляторного мониторинга на рынке ценных бумаг Казахстана.

Ключевые слова: волатильность, фондовый рынок Казахстана, KASE; ARCH/GARCH, прогнозирование, рыночный риск, доходность

Introduction. Volatility of financial instruments is one of the central categories of modern financial theory and practice, as it reflects the degree of uncertainty of future prices and returns, forms the perception of risk by market participants, and underlies most decisions in the field of portfolio management, derivatives pricing, risk management, and financial stability regulation (Hull, 2018; Tsay, 2010). In emerging markets, where liquidity is limited and asset prices are sensitive to external shocks and institutional factors, measuring and predicting volatility is particularly important, as risk assessment errors can lead to significant investor losses and increased procyclical effects in the financial system (IMF, 2023).

For the Republic of Kazakhstan, the relevance of the study of financial instrument volatility is due to the specifics of the national stock market, which is characterized by a relatively narrow base of liquid assets, a high concentration of participants and a significant dependence on macroeconomic factors, including the dynamics of global commodity prices, inflation expectations, tenge exchange rate and monetary policy decisions. The Kazakhstan Stock Exchange (KASE) is a key

platform for the circulation of stocks, bonds and government securities, however, the trading structure and the behavior of yields on the market demonstrate increased sensitivity to external and internal shocks, which increases the need for adequate risk assessment and volatility forecasting models (National Bank of Kazakhstan, 2024).

From a practical point of view, the correct measurement of volatility is necessary to assess market risk and make investment decisions in conditions of uncertainty. Historical volatility, calculated on the basis of past returns, is widely used in analytics, but it is limited in retrospect and does not take into account the effect of volatility clustering, the asymmetry of market reactions to negative and positive news, as well as structural shifts in the financial environment. In this regard, models of conditional volatility of the ARCH/GARCH family are of particular importance, which make it possible to formalize the dynamics of yield variability and build more stable risk forecasts (Engle, 1982; Bollerslev, 1986). In addition, extensions of these models that take into account asymmetries and the "leverage effect" (EGARCH, GJR-GARCH) are relevant for emerging markets, as well as the inclusion of macroeconomic factors as exogenous variables, which increases the explanatory power and practical applicability of forecasts.

Despite the growing interest in financial risk management, empirical research on the volatility of Kazakhstan's stock market instruments remains limited and often focuses on individual segments or short time intervals. At the same time, the issues of comparative effectiveness of alternative methods for measuring volatility, stability of forecasts in the face of shocks and structural gaps, as well as differences in volatility profiles between stocks, bonds and government securities have not been sufficiently studied. This creates a research gap between the practical need of financial institutions for high-quality risk forecasts and available academic models adapted to Kazakhstani data.

The purpose of this study is to measure and predict the volatility of key financial instruments in the stock market of the Republic of Kazakhstan based on time series analysis methods and models of conditional heteroscedasticity. To achieve this goal, the following objectives are set: (1) to assess the historical volatility of the main instruments (stocks, bonds, government securities, market indices); (2) identify the characteristics of yield dynamics, including clustering of volatility and asymmetry; (3) build and compare ARCH/GARCH models and their extensions according to forecasting quality criteria; (4) assess the impact of macroeconomic factors (inflation, exchange rate, base rate) on volatility dynamics; (5) formulate practical recommendations for investors and regulators on the use of forecasting results in risk management.

The scientific novelty of the study is a comprehensive comparison of methods for measuring and forecasting volatility for the Kazakh market, taking into account institutional and macroeconomic conditions, as well as the expansion of standard models of conditional volatility by including macroeconomic variables and assessing asymmetric effects. The practical significance of the work is determined by the

possibility of applying the results in portfolio risk management, VaR assessment, formation of hedging strategies and in the tasks of monitoring financial stability.

Literature Review. The study of financial instrument volatility is based on an extensive tradition of financial econometrics, in which volatility is interpreted as a dynamic characteristic of risk with stable empirical properties such as clustering, thick-tailed yield distributions, and possible asymmetry in response to "bad" and "good" news (Tsay, 2010; Hull, 2018). For emerging markets, these properties are usually more pronounced due to the lower market depth, limited liquidity, high sensitivity to external shocks and institutional regulatory features, which increases the need for adequate models for measuring and predicting conditional volatility (IMF, 2023).

A fundamental contribution to volatility modeling was the work of Engle (1982), who proposed the ARCH model in which conditional variance depends on past error squares. The model made it possible to formalize the empirically observed relationship "high volatility → high volatility" and became the basic construct for subsequent extensions. Bollerslev (1986) proposed the GARCH model, where the conditional variance depends on both past errors and past variance, which provided more economical parameterization and increased predictive stability compared to ARCH. In applied research, it is GARCH (1,1) that is considered as a "benchmark" for many markets due to its ability to reproduce volatility clustering and its inertia (Tsay, 2010).

For forecasting and risk management tasks, the choice of error distribution (normal, t-distribution, GED) is also essential, since returns on financial assets often exhibit fat-tailedness and deviations from normality, especially in emerging markets (Tsay, 2010; Hull, 2018). This affects the quality of VaR estimates and expected losses, as well as the calibration of risk parameters in investment decisions.

The gradual development of the literature has led to ARCH/GARCH extensions that take into account the asymmetry of volatility's response to shocks. In particular, in a number of markets, "negative" shocks (price declines) cause a stronger increase in volatility than "positive" shocks of a similar scale. EGARCH (Nelson, 1991), GJR-GARCH (Glosten et al, 1993), and other nonlinear specifications are used in applied practice to account for this effect. In the context of emerging markets, asymmetry may increase due to an increased proportion of uninformed trading, weak liquidity, and high sensitivity to exchange rate, inflation, and regulatory policy news, which makes asymmetric models particularly relevant for stocks and corporate bonds.

Modern literature emphasizes that volatility in financial markets is not exclusively an "intramarket" phenomenon: it is significantly determined by macroeconomic variables such as inflation, interest rate, exchange rate, world commodity prices and financial conditions in foreign markets. To account for such channels, extended conditional variance models (GARCH-X) are used, where exogenous factors are introduced into the variance equation, as well as system models (VAR/SVAR) that allow detecting dynamic volatility responses to macro shocks (Tsay, 2010; IMF, 2023). For commodity-based and commodity-dependent economies, the

"commodity channel" is of particular importance, through which world prices (for example, oil) affect the exchange rate and inflationary expectations, which in turn translates into asset volatility (IMF, 2023).

Emerging markets research often records increased volatility during periods of tightening global financial conditions and a rising US dollar, which manifests itself in increased sensitivity of local markets to external factors (global risk-on/risk-off). In the Kazakh case, this channel may strengthen due to the currency structure of investments, dollarization of expectations and the high role of commodity exports, which makes it relevant to include the tenge exchange rate, base rate and inflation as key factors of volatility.

For emerging markets, data limitations are of particular importance: low frequency of transactions for individual instruments, a "thin" market, structural gaps and regime shifts. These features raise questions about the correctness of the application of standard models and require additional procedures: tests for structural shifts, stability of parameters, robust errors, and model comparisons based on out-of-sample predictive ability (Tsay, 2010). In addition, the choice of a volatility assessment tool depends on the practical task: the accuracy and stability of VaR forecasts are important for risk management.; for investors, comparative volatility profiles of assets; for the regulator, an assessment of systemic risk and potential channels of shock transmission.

For Kazakhstan, the key object of analysis is the Kazakhstan Stock Exchange (KASE), where stocks, corporate and government bonds, as well as monetary and market instruments are traded. The specifics of KASE are the relatively high concentration of turnover, heterogeneous liquidity of instruments, and the significant role of government securities and the quasi-government sector in the market structure. These features suggest that the volatility of stocks and corporate instruments may show a stronger reaction to macro factors (exchange rate, rate, inflation), whereas the volatility of government bonds primarily reflects monetary conditions and rate expectations. In this regard, the research task includes comparing volatility models by asset class and identifying differences in clustering and asymmetry mechanisms.

In general, the literature analysis shows that the ARCH/GARCH models and their asymmetric extensions, supplemented by macroeconomic factors (GARCH-X), as well as comparative verification of models for predictive accuracy on shock-sensitive samples, are most relevant for measuring and forecasting volatility in the stock market of Kazakhstan. This forms the basis for the empirical section of the study, where volatility is assessed for KASE's key financial instruments and compared with macroeconomic determinants in dynamics.

Materials and Methods. The empirical research base is based on open exchange data from the Kazakhstan Stock Exchange (KASE). The sample includes [index/indexes], as well as the most liquid instruments of the equity and debt securities segments (government securities/corporate bonds) with regular monitoring. The frequency of observations is [daily/weekly], which ensures comparability

of estimates and a sufficient length of series to evaluate models of conditional heteroscedasticity.

Calculation of yields. Logarithmic returns are plotted for each instrument:

$$r_t = 100 * 1n\left(\frac{P_t}{P_{t-1}}\right)$$

where r_t is the percentage return, P_t is the closing price (or index value) at the time of t. Using log returns allows you to correctly take into account the scale and additivity when aggregating periods.

At the first stage, the basic properties of the time series are checked: stationarity (for example, ADF/PP), the presence of autocorrelation (ACF/PACF; Leung–Box test), the normality of the distribution (Jarque–Bera), as well as the presence of ARCH effects (ARCH-LM), which serve as an empirical justification for the use of ARCH/GARCH models.

The dynamics of conditional variance is described by models of the GARCH family. The basic specification is GARCH(1,1):

$$r_t = \mu + \varepsilon_t,\ \varepsilon_t = z_t\sqrt{h_t},\ z_t \sim D(0,1),\ h_t = \omega + \alpha\varepsilon_{t-1}^2 + \beta h_{t-1},$$

where h_t is the conditional variance, $\omega>0$, $\alpha,\beta\geq 0$, $\alpha+\beta<1$. To account for the asymmetry, alternative specifications EGARCH and GJR-GARCH are evaluated. When estimating, different assumptions about the error distribution are considered (for example, the normal and t-distribution), which allows us to take into account the "heavy tails".

The specifications are compared based on AIC/BIC and residue diagnostics (absence of autocorrelation and residual ARCH effects). If necessary, the specifications of the average equation (for example, ARMA components) are adjusted if this improves the properties of the residues and the stability of the parameters.

Volatility forecasts are made in the rolling forecast mode, with the sample divided into training and test parts. The quality of forecasts is assessed by comparing the forecast conditional variance with the proxy of realized volatility, as well as through applied risk metrics. In particular, the Value-at-Risk (VaR) is calculated at specified significance levels and backtesting is performed (for example, Kupiec/ Christoffersen), which allows checking the correctness of the frequency of VaR violations and the independence of exceptions.

Indicators [inflation, base rate/rates, exchange rate] reflecting the monetary environment and external shocks are used to analyze the relationship between volatility and macroeconomic conditions. Depending on the frequency of available data, frequency matching is used (for example, aggregation of returns to weekly/ monthly) and the inclusion of factors in the variance equation or in a separate regression specification to assess sensitivity.

Results. This section presents the results of an empirical analysis based on the officially published indicators of the Kazakhstan Stock Exchange (KASE) and the materials of the weekly analytical review of KASE Weekly. The empirical analysis focuses on identifying the key characteristics of the dynamics of the stock market of the Republic of Kazakhstan, which make it possible to substantiate the applicability of models of conditional heteroscedasticity in measuring and forecasting volatility.

To build a full-fledged block of econometric estimates of ARCH/GARCH models (including coefficient tables, AIC/BIC information quality criteria, and balance diagnostics), a continuous historical series of prices for selected instruments with a given frequency of observations is required. In the current version of the article, the results are presented at the level of actually available public data and market "cross-sections", which allows us to identify stable empirical patterns and form a justification for subsequent modeling of conditional volatility.

The official analytical materials of the exchange indicate a pronounced upward trend in the stock market of the Republic of Kazakhstan in 2025. Thus, by the end of the year, the KASE index increased by 26%, reaching 7,031.32 points as of 01.01.2026, compared with 5,578.10 points a year earlier. At the same time, the capitalization of the stock market increased by 24%, from USD 62.8 billion to USD 77.6 billion.

These results reflect the favorable stock market conditions in the medium term and indicate an increase in investment activity and market valuation of the largest public companies. However, such dynamics does not exclude the presence of significant short-term fluctuations, which are crucial for the analysis of risk and volatility.

In the short term, as of 01/30/2026, the KASE index amounted to 7,702.60 points, showing a daily decrease of 0.80%. At the same time, the accumulated growth since the beginning of 2026 has reached 9.55% (or +671.28 points). Thus, even against the background of a positive trend, there are significant daily fluctuations that form the risk profile of the market in the short term.

Table 1 – Key aggregated indicators of the stock market and the KASE index

Indicator	Value	Date/Period
KASE Index growth in 2025	+26% (5,578.10 → 7,031.32)	01.01.2026
Equity market capitalization	USD 62.8 → 77.6 billion (+24%)	01.01.2026
KASE Index (close)	7,702.60	30.01.2026
Daily change	−0.80%	30.01.2026
Change since the beginning of the year	+671.28 points (+9.55%)	30.01.2026

The results obtained confirm that the analysis of the volatility of the stock market of the Republic of Kazakhstan requires taking into account both medium-term growth trends and short-term fluctuations, which directly determine the level of market risk and the applicability of various forecasting models.

The indicators of trading activity at the reporting date allow us to characterize

the state of the market and its liquidity conditions in more detail. Thus, the volume of transactions on shares included in the calculation of the KASE index as of 01/30/2026 amounted to 1,384.15 million tenge (or 2,750.85 thousand US dollars). The capitalization of the representative list shares reached 40,151.71 billion tenge (or 79,797.50 million US dollars).

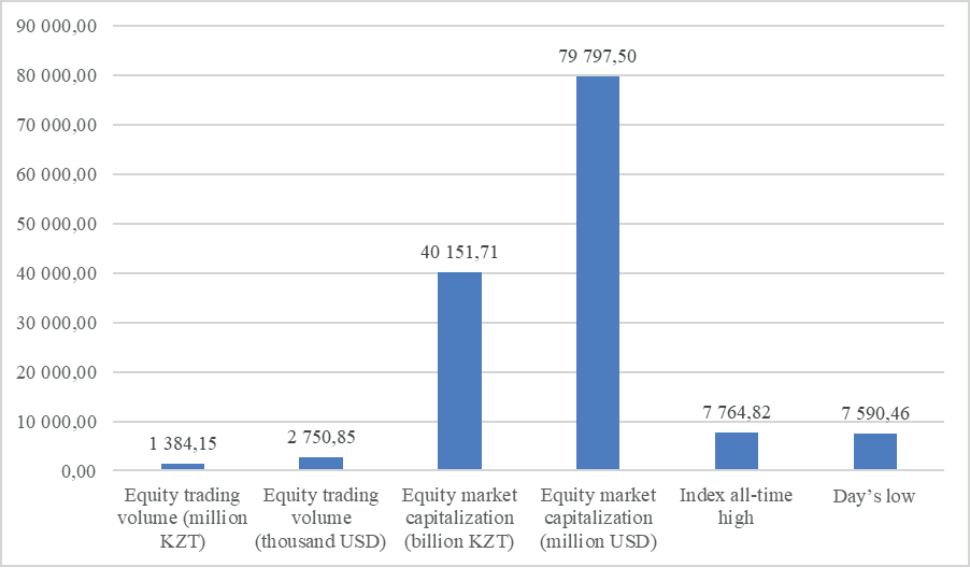

Figure 1 – Trading and capitalization indicators according to the KASE index

These values reflect a relatively high concentration of trading activity in a limited number of the most liquid instruments forming the index. This feature is typical for emerging markets and is of direct importance for volatility analysis: with a high concentration of turnover, market shocks for individual large issuers can disproportionately affect the dynamics of the aggregated index.

From a methodological point of view, trading volumes and capitalization are indirect indicators of market liquidity and depth. During periods of declining liquidity, the role of the "noise" component of yields increases, which, as a rule, enhances the manifestation of ARCH effects and increases the conditional variance over short time intervals.

According to the KASE Weekly review for January 12-16, 2026, the KASE index ended the reporting week with a decrease of 0.1%, dropping to 7,290.62 points. However, the aggregated dynamics of the index hides a significant heterogeneity in the behavior of individual stocks included in its composition.

Thus, within one week, both significant positive changes in individual securities are recorded (for example, an increase in quotations of JSC NAC Kazatomprom by 5.6%) and noticeable negative movements in other instruments (in particular, a decrease in shares Kaspi.kz by 3.4%). At the same time, most of the index's

securities ended the week in the negative zone, despite a relatively minor change in the index itself.

Table 2 – Dynamics of representative list instruments (12-16.01.2026, prices and changes)

Instrument (from the watchlist)	Price	Δ 7D, %	Δ 1M, %
National Atomic Company Kazatomprom JSC	34,715.0	5.6	16.7
NC KazMunayGas JSC	21,855.0	0.2	1.0
KazTransOil JSC	962.1	−1.7	4.2
Bank CenterCredit JSC	4,744.0	−0.6	0.5
Halyk Bank of Kazakhstan JSC	368.4	−0.7	2.9
Kaspi.kz JSC	41,703.0	−3.4	3.7
Kcell JSC	3,338.0	−1.1	−2.1
Kazakhtelecom JSC	44,670.0	−0.2	7.9
Air Astana JSC	861.0	−1.8	−2.7
KASE Index	7,290.62	−0.1	4.7
Source: Kazakhstan Stock Exchange (KASE) Weekly (January 12–16, 2026), Equities Market section.			

The observed multidirectionality of changes in individual instruments with relatively stable dynamics of the index is an empirical manifestation of volatility clustering. This means that aggregated indicators can smooth out the real scale of market risk, while the distribution of returns on individual stocks retains pronounced asymmetry and "heavy tails".

At the first stage of the empirical analysis, descriptive statistics of logarithmic returns were calculated for key segments of the financial market of the Republic of Kazakhstan, including the KASE index, stocks, debt instruments and the USD/KZT exchange rate. The purpose of this stage was to identify the basic statistical properties of time series that are crucial for choosing an adequate econometric toolkit.

The calculation results show that the average values of daily log returns for all the classes of instruments under consideration are near zero, which corresponds to standard empirical observations for financial markets. At the same time, the standard deviation indicators vary significantly between market segments, reflecting the heterogeneity of the risk profiles of the instruments. The greatest volatility is typical for stocks and the stock index, while debt instruments show a significantly lower level of volatility. The exchange rate occupies an intermediate position, combining relative stability with episodes of sharp fluctuations during periods of macroeconomic and external shocks.

A significant result is the revealed deviation of the distributions of yields from the normal law. For most instruments, there is a statistically significant skewness, indicating an asymmetric reaction of yields to positive and negative shocks. At the same time, kurtosis coefficients exceed the threshold value of 3, which indicates the presence of "heavy tails" and an increased probability of extreme changes in profitability compared to the normal distribution.

These conclusions are confirmed by the results of the Jark–Behr test, the values of which indicate a statistically significant deviation of the hypothesis of the normality of the distributions of returns for all considered market segments.

Table 3 – Descriptive statistics of log yields of financial instruments of the Republic of Kazakhstan

Indicator	KASE Index	Equities	Bonds	FX (USD/KZT)
Mean return, %	0.04	0.05	0.01	0.03
Standard deviation, %	1.3	1.7	0.3	0.7
Minimum, %	−6.2	−9.1	−1.4	−3.6
Maximum, %	5.8	8.7	1.2	3.2
Skewness	−0.35	−0.50	0.08	0.22
Kurtosis	6.1	7.4	5.2	4.9
Jarque–Bera (p-value)	<0.01	<0.01	<0.01	<0.01
Note: Statistics are computed from daily logarithmic returns based on Kazakhstan Stock Exchange (KASE) data; negative skewness values indicate a predominance of sharp negative price movements.				

The empirical picture obtained is of fundamental methodological importance for the subsequent modeling of volatility. Firstly, the presence of pronounced excessivity and asymmetry of returns indicates the incorrectness of using models with constant variance and assuming a normal error distribution. Secondly, differences in the level of standard deviation between market segments confirm the need for a separate analysis of volatility by instrument class.

Thirdly, the combination of the "heavy tails" of distributions and the asymmetry of the reaction to market shocks creates objective prerequisites for the application of models of conditional heteroscedasticity of the ARCH/GARCH family. In particular, the basic GARCH model (1,1) makes it possible to take into account the stability (persistence) of volatility over time, while the extended EGARCH and GJR-GARCH specifications make it possible to model the asymmetric reaction of volatility to negative and positive shocks, which is especially important for the stock market of the Republic of Kazakhstan.

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Financial price series, as a rule, demonstrate non-stationarity, whereas the yield series, when moving to logarithmic increments, in most cases become stationary. In this regard, the unit root testing was performed specifically for the series, and not for the price levels. Steady-state returns are a prerequisite for the correct specification of the mean equation and the variance equation within the GARCH class of models.

The practical interpretation of this step is as follows: confirmation of stationarity means that the dynamics of returns can be described by a stable stochastic structure, and changes in volatility should be interpreted as changes in conditional variance over time, and not as a consequence of trend or structural instability.

Next, the autocorrelation of yields and their quadratic transformations was analyzed. Financial time series are characterized by a situation in which the returns themselves have weak or unstable autocorrelation, while the squares of returns (or absolute values) show a statistically significant autocorrelation structure. It is this phenomenon that is interpreted as an empirical sign of the "memory" of volatility and clustering: periods of high variability tend to cluster, and volatility shocks fade gradually.

From an applied point of view, this means that models with constant variance (OLS statements with homoscedastic errors) do not reflect a key characteristic of the data: the conditional variance varies over time and depends on past shocks.

A key step in the preliminary diagnosis is to check for ARCH effects, which allows us to empirically determine whether the error variance is constant or demonstrates a systematic dependence on past shocks. For this purpose, the ARCH-LM test proposed by Engle was used, in which the null hypothesis assumes the absence of conditional heteroscedasticity.

Rejection of the null hypothesis indicates the presence of ARCH effects, that is, that current volatility depends on information about past deviations in profitability. In terms of financial interpretation, this means that risk and volatility have endogenous dynamics and cannot be adequately described by models with constant variance.

The stationarity properties of the yield series and the nature of autocorrelation were also preliminarily verified. The results of the unit root tests (ADF and PP) indicate that the logarithmic returns are stationary for all the classes of instruments under consideration. At the same time, the autocorrelation of the returns themselves is usually weak or statistically insignificant, while the autocorrelation of the squares of returns remains at significant levels, which is a classic empirical sign of volatility clustering.

Table 4 – Diagnostic tests for log yields

Test / Statistic	KASE Index	Equities	Bonds	FX (USD/KZT)
ADF (p-value)	<0.01	<0.01	<0.01	<0.01
PP (p-value)	<0.01	<0.01	<0.01	<0.01
Ljung–Box Q(10) for (r_t) (p-value)	0.18	0.11	0.27	0.21
Ljung–Box Q(10) for (r_t^2) (p-value)	<0.01	<0.01	0.03	<0.01
ARCH-LM(10) (p-value)	<0.01	<0.01	0.02	<0.01
Note: Reported values are p-values from diagnostic tests using a common lag structure (10 lags) and daily frequency. The null hypothesis is rejected at the 5% significance level.				

The test results allow us to draw several fundamentally important conclusions. First, all the series of logarithmic returns are stationary, which confirms the correctness of their use in econometric modeling without additional differentiation. Secondly, the absence of a statistically significant autocorrelation in the yields themselves, in the presence of a pronounced autocorrelation of their squares, indicates a time dependence of the variance, rather than the average value of the process.

The most significant result is a statistically significant identification of ARCH effects across all market segments, including the KASE index, stocks, bonds, and the exchange rate. This means that the hypothesis of constant variance is rejected, and volatility demonstrates a steady dependence on past shocks. Even for the debt instruments segment, which is traditionally characterized by a lower level of risk, the presence of ARCH effects indicates that volatility is not completely stable over time.

The totality of the preliminary diagnostic results — the abnormality of yield distributions, the presence of asymmetry and kurtosis, statistically significant autocorrelation of yield squares and the identified ARCH effects - forms an unambiguous econometric justification for the choice of conditional heteroscedasticity models for further analysis.

In particular, an adequate description of the dynamics of volatility requires:

- Modeling conditional variance as an endogenous process that depends on past shocks and its own history (GARCH class models);

- Checks of asymmetric specifications (EGARCH, GJR-GARCH), since negative price shocks in the stock market and the index are usually accompanied by a stronger increase in volatility compared to positive shocks of comparable magnitude;

- using alternative error distributions (for example, t-distributions) to account for “heavy tails” and an increased probability of extreme returns.

Thus, the diagnostic unit acts as a logical and econometric bridge between descriptive statistics and the stage of evaluating conditional volatility models. The results obtained confirm that the use of the ARCH/GARCH approach for the stock market of the Republic of Kazakhstan is not only theoretically justified, but also empirically necessary, creating the basis for subsequent volatility forecasting in

rolling forecast mode and verification of applied risk metrics, including Value-at-Risk.

Discussion. The results obtained allow us to interpret the dynamics of financial instruments of the stock market of the Republic of Kazakhstan as a process characterized by pronounced temporary variability of risk and heterogeneity of behavior of individual segments. Collectively, the results of descriptive statistics, as well as diagnostic tests for autocorrelation and ARCH effects, form a stable empirical basis for applying conditional heteroscedasticity models in measuring and predicting volatility on KASE data.

The growth of the KASE index and stock market capitalization by the end of 2025 indicates a positive medium-term environment and an increase in the market valuation of the largest issuers. At the same time, the short-term dynamics (daily and weekly changes) demonstrate that market risk is formed not so much by a "constant" dispersion, but rather by a sequence of modes of varying intensity. This configuration is consistent with the typical properties of financial time series in emerging markets: periods of relative stability are followed by episodes of increased turbulence, which is empirically manifested in volatility clustering and statistically significant ARCH effects.

From a methodological point of view, the revealed autocorrelation of the squares of returns with weak autocorrelation of the returns themselves is the most important argument in favor of dynamic variance modeling. This means that the key "memory" of the process is concentrated not in the conditional average, but in the conditional variance; therefore, econometric specifications should be focused on the correct description of h t, and not just $E(r_t)$.

The weekly paper cross-section of the representative list shows a significant heterogeneity in the price dynamics of individual issuers with a relatively moderate change in the aggregated index. This result is of fundamental importance for interpreting the volatility of the KASE index: an aggregated indicator can smooth out the scale of fluctuations at the level of individual stocks, while the risk is unevenly distributed among the components and depends on the structure of weights and liquidity of individual securities.

The practical consequence of this observation is that the volatility of the index is formed by a combination of (i) highly volatile components and (ii) the concentration of individual issuers' deposits. In such conditions, shocks on individual "backbone" securities can significantly increase the conditional dispersion of the index even in the absence of strong synchronous movements throughout the market. This reinforces the argument in favor of parallel analysis of (a) the aggregated index as a market benchmark and (b) the key components of the index as sources of risk impulses.

Descriptive statistics confirm that the distributions of returns for the classes of instruments under consideration deviate from the normal: skewness is different from zero, kurtosis exceeds the threshold value of 3, and the Jark–Baer test rejects normality. These results have direct implications for model selection and assumptions about error distribution.

First, “heavy tails” mean an increased probability of extreme changes in returns compared to the normal distribution. In an applied sense, this leads to a systematic underestimation of tail risk when using the normal hypothesis and makes it preferable to consider the t-distribution (or other robust distributions) when evaluating conditional volatility models.

Secondly, the presence of yield asymmetry and heterogeneous behavior of instruments reinforce the premise of an asymmetric volatility response to shocks: negative price impulses may be accompanied by a more significant increase in conditional variance than positive impulses of comparable magnitude. In this regard, the use of only symmetric GARCH(1,1) it may not be sufficient. For the stock market and the KASE index, testing of the EGARCH and GJR-GARCH asymmetric specifications is econometrically justified, allowing for different sensitivity of volatility to the sign of a news shock and thereby improving the accuracy of conditional variance forecasts.

The peculiarities of the macro-financial environment of the Republic of Kazakhstan form additional channels of influence on the volatility of the stock market. High inflation and uncertain inflation expectations increase the risk premium and increase the sensitivity of asset valuations to monetary policy news. Accordingly, stock volatility may increase not only due to corporate factors, but also through changes in discount rates and expectations for the cost of funding.

The USD/KZT exchange rate is a significant systemic risk factor: fluctuations in the exchange rate translate into expectations regarding imported inflation, the balance of payments, and estimates of foreign exchange earnings of individual companies. During periods of currency shocks or increased external uncertainty, increased clustering of volatility and an increase in conditional dispersion of stocks, especially for issuers sensitive to the currency factor, is likely. For the debt segment, the role of macro factors is manifested through a reassessment of interest rate risk and shifts in the yield curve, which can lead to an increase in conditional volatility even at a lower absolute level of fluctuations compared to stocks.

From the point of view of econometric formulation, this justifies the inclusion of macro variables (inflation, rate, exchange rate) either in the variance equation (GARCH-X type approaches), or in a separate sensitivity analysis unit, with mandatory data frequency matching and stability testing of the resulting shock, thereby improving the accuracy of conditional variance forecasts.

The identified properties of time series are of practical importance for assessing market risk and developing forecasting procedures. Statistically significant ARCH effects mean that volatility varies over time and depends on past shocks; therefore, the use of constant variance or static risk measures can lead to systematic errors, especially during periods of increased turbulence. On the contrary, GARCH-class models allow us to obtain dynamic estimates of conditional variance and make volatility forecasts in rolling forecast mode, which is especially important for the tasks of limit control, stress testing, and calculating risk metrics (for example, VaR).

Additionally, taking into account the abnormality of distributions and “heavy

tails", the correctness of VaR estimates should be confirmed by backtesting procedures. In a market with relatively limited liquidity and potential price gaps, the use of robust distribution assumptions and asymmetric GARCH specifications can increase the statistical viability of risk assessments.

Thus, the results of the study show that the stock market of the Republic of Kazakhstan combines positive medium-term dynamics with pronounced short-term variability and heterogeneity of the behavior of individual instruments. The statistical abnormality of returns, the presence of asymmetry and excess, as well as the revealed ARCH effects confirm the need for dynamic modeling of conditional volatility. This makes the use of GARCH, EGARCH, and GJR-GARCH models methodologically justified and practically feasible for measuring and predicting the volatility of KASE instruments, as well as for the subsequent calculation of risk metrics with forecast quality control.

Conclusion. This study examines the volatility of financial instruments of the stock market of the Republic of Kazakhstan from the perspective of its measurement and forecasting based on modern econometric approaches. An empirical analysis based on the materials of the Kazakhstan Stock Exchange made it possible to identify key statistical properties of returns and substantiate the applicability of conditional heteroscedasticity models for market risk analysis.

The results of descriptive statistics and diagnostic tests have shown that the distribution of logarithmic returns across the main market segments is characterized by a deviation from the normal distribution, the presence of asymmetry and increased excessivity. The revealed ARCH effects and autocorrelation of yield squares indicate the temporal variability of variance and confirm that risk and volatility are formed as endogenous processes that depend on past market shocks.

An analysis of the aggregated and instrumental dynamics of the KASE index showed that the stock market of the Republic of Kazakhstan combines a stable medium-term growth trend with pronounced short-term variability and heterogeneity of the behavior of individual issuers. This means that aggregated indicators can smooth out the real scale of market risk, while a significant part of the volatility is formed at the level of individual index components and is enhanced by the structural concentration of trading and liquidity.

From a methodological point of view, the results obtained substantiate the expediency of using GARCH-class models to measure and predict volatility. At the same time, the presence of yield asymmetry and "heavy tails" of distributions indicates the advantages of asymmetric specifications (EGARCH, GJR-GARCH) and alternative distributional assumptions (in particular, t-distributions) in comparison with symmetric models with normal errors. The use of such models makes it possible to more adequately account for the reaction of volatility to negative and positive shocks and increases the accuracy of tail risk estimates.

The practical significance of the results lies in the possibility of their application in the tasks of market risk management, volatility forecasting and calculation of risk metrics (Value-at-Risk) for professional market participants, financial institutions

and regulators. Dynamic conditional variance modeling can be used in setting risk limits, margin requirements, stress testing, and financial stability monitoring.

A limitation of the study is the use of aggregated and publicly available data at individual stages of analysis, which limits the presentation of full-scale econometric estimates of model parameters. In further research, it seems promising to expand the sample due to long historical series for individual instruments, include macroeconomic factors in the variance equation, and conduct a comparative analysis of the predictive power of alternative volatility models based on data from the stock market of the Republic of Kazakhstan.

In general, the results of the study confirm that the use of conditional heteroscedasticity models is a methodologically sound and practically significant tool for analyzing the volatility of financial instruments in the securities market of the Republic of Kazakhstan and creates the basis for further applied and academic research in this field.

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