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APPLICATION OF THE DCF MODEL IN CONDITIONS OF HIGHLY VOLATILITY OF COMMODITY MARKETS (ON THE EXAMPLE OF OIL AND GAS COMPANIES)

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A B S T R A C T	K E Y W O R D S
This article systematizes the practices of adapting DCF to commodity companies: constructing probabilistic scenarios and stochastic price trajectories (including taking into account mean reversion), Monte Carlo DCF, matching the discount rate to risks, specificity of terminal value for depletable assets, and integration of management flexibility through real Options. Using public reporting materials from oil and gas companies, this article demonstrates how scenario-based "price corridors" and stress tests are used in corporate practice.	DCF, oil and gas companies, volatility, scenario analysis, Monte Carlo Carlo, mean reversion, terminal value, real options, PV -10.

Introduction

The scientific novelty of the study lies in the development and substantiation of a comprehensive approach to adapting the classical DCF model for valuing oil and gas companies in conditions of highly volatile commodity markets, based on the integration of probabilistic price modeling, a modified calculation of the terminal value for depletable resources, and consideration of management flexibility.

Discounted Cash Flow Method (Discounted Cash DCF (direct cash flow) is a key tool for assessing company value in corporate finance and investment analysis. It is based on the fundamental principle of financial theory: a firm's value is determined by the present value of future free cash flows, taking into account a discount rate reflecting the cost of capital and business risk. In classical valuation methods, DCF is widely described in fundamental textbooks on financial management and corporate valuation. The main positions set forth in scientific papers emphasize the versatility of the method, but also note the difficulties of its application in conditions of high uncertainty of future flows and the discount rate [1].

Specifically, the DCF method was developed as a tool for valuing companies with relatively predictable cash flows, where operating and financial projections have a moderate level of risk and relatively low volatility. However, the classic formula:

$$V = \sum_{t=1}^{N} \frac{FCF_t}{(1+WACC)^t} + \frac{TV}{(1+WACC)^N}$$

Formula 1. Company valuation using the discounted cash flow method (DCF model)

Assumes a fairly stable expectation of future flows and low uncertainty of forecasts, which is not always realistic for the raw materials sectors of the economy.

The oil and gas sector is highly cyclical and heavily dependent on global oil and gas prices. Prices for these commodities exhibit high volatility due to external shocks (geopolitical conflicts, changes in supply and demand, OPEC+ policies, and financial turbulence), significantly complicating accurate forecasting of investment project cash flows and overall company value. Research on energy commodity market risk management demonstrates the difficulties of predicting price volatility, the occurrence of "fat tails", asymmetries, and structural changes in oil and gas market behavior, necessitating the use of complex econometric models (e.g., GARCH models) to describe price dynamics [2].

In the context of commodity cycles, traditional DCF valuation faces a number of methodological challenges:

1. Free cash flow forecasting becomes significantly more uncertain, as key operating parameters (revenue, margin, investments, etc.) directly depend on the future dynamics of oil and gas prices, which have high short-term and medium-term volatility.
2. Calculating terminal value raises methodological difficulties. The classical assumption of infinite growth in free flows is often inapplicable to exhaustible natural resources, as oil and gas production is limited by reserves and technological capabilities, as well as by changing economic conditions.
3. The value of the discount rate (WACC) under high price volatility should accurately reflect the systematic risks associated with the specificity of raw materials and include not only the market risk of capital, but also special components associated with fluctuations in raw material prices and structural risks of the industry.

As a result of these factors, modern scientific and practical literature highlights the need to adapt the classical DCF model to the conditions of highly volatile commodity markets. Key approaches include scenario price modeling, stochastic modeling of price trajectories (including mean reversion), Monte Carlo analysis and accounting of managerial flexibility using real These approaches are designed to improve the reliability of estimates in conditions where projections of future cash flows depend on complex, uncertain, and often unpredictable price formation mechanisms in global oil and gas markets.

Discounted Cash Flow Method (direct current flow function) is based on the fundamental principle of financial theory that an asset's value is determined by the present value of its expected future cash flows. This approach logically follows from the theory of the time value of money and the concept of a rational investor maximizing expected utility. In corporate finance, DCF is a central element of business and investment project valuation, which is reflected in detail in classical works on financial management and company valuation.

In its most common form, the value of a company (Enterprise Value) within the DCF approach is defined as the sum of discounted free cash flows to the firm (FCFF) for the forecast period and the discounted terminal value:

$$V = \sum_{t=1}^{N} \frac{FCF_t}{(1+WACC)^t} + \frac{TV}{(1+WACC)^N}$$

где FCF_t — свободный денежный поток в период t, $WACC$ — средневзвешенная стоимость капитала, TV — терминальная стоимость, N — горизонт прогнозирования.

Formula 2. Basic formula for the discounted cash flow (DCF) model for company valuation

This formula is the basic formula of the DCF model for assessing the value of a company and is widely used both in academic research and in investment practice [3].

The correct application of the DCF model requires the fulfillment of a number of theoretical conditions: relative predictability of future cash flows, stability of the business structure and investment cycle, correct reflection of systematic risk in the discount rate, and an economically justified terminal value. Classic textbooks emphasize that DCF works best for companies with a stable business model and moderate volatility in operating results. Thus, scholars note that with high uncertainty in forecast parameters, "the accuracy of the DCF valuation decreases sharply, and the result becomes extremely sensitive to input assumptions" [4].

Oil and gas companies operate in an environment of highly volatile commodity prices, which violates the fundamental assumptions of the traditional DCF model. Oil and gas prices exhibit sharp fluctuations influenced by macroeconomic factors, geopolitical risks, OPEC+ decisions, technological advances, and financial speculation. Empirical studies show that oil price dynamics are characterized by volatility clustering, distribution asymmetry, and the presence of structural breaks, which complicates the construction of deterministic forecasts [5].

Researchers emphasize that for cyclical and commodity companies, "price forecast errors lead to disproportionately large valuation errors", as prices directly impact revenue, operating margins, investment decisions, and the economic life of assets [6]. As a result, DCF valuations become extremely sensitive to price assumptions, especially when using standard scenarios and fixed long-term growth rates.

A particular methodological challenge in DCF valuation of oil and gas companies is calculating terminal value. The classic approach to determining TV is through the constant growth model (Gordon Growth Model) assumes the company's indefinite existence and a stable rate of cash flow growth. However, for extractive companies, this assumption often does not correspond to economic reality, since hydrocarbon reserves are finite, and production is subject to physical and technological limitations. The literature emphasizes that the use of the standard terminal formula can lead to a systematic overestimation of the value of raw materials companies. As an alternative, it is proposed to use a finite modeling horizon (life-of-asset), and to take into account the resource base and the economic limit of production when forming the residual value [3].

An additional theoretical problem is the confusion between the concepts of risk and uncertainty within the DCF framework. From a financial theory perspective, the discount rate should reflect systematic risk that cannot be diversified away, while uncertainty in future prices should not always be compensated for by increasing the WACC. Scholars within the framework of uncertainty investment theory demonstrate that high volatility can increase the value of expectations and managerial flexibility, but not necessarily reduce the present value of a project [7].

Thus, with high volatility in commodity markets, the classical deterministic DCF model loses some of its theoretical rigor and requires expansion through scenario analysis, stochastic price modeling, and the integration of elements of real options theory.

The specific nature of commodity companies, particularly those in the oil and gas sector, requires modifications to the classic discounted cash flow model. High volatility in oil and gas prices, the cyclical nature of investment programs, and the finite resource base necessitate the use of expanded DCF analysis tools aimed at more accurately reflecting uncertainty and industry-specific risks.

The most common and methodologically sound way to adapt DCF to high volatility conditions is scenario analysis. This approach involves generating several alternative oil and gas price trajectories (e.g., unfavorable, baseline, and favorable scenarios) and assigning probabilities to them. To improve the validity of scenarios, academic and applied literature recommends relying on external forecasts from international energy organizations (IEA, EIA), as well as taking into account macroeconomic and geopolitical factors.

Scenario DCF allows one to estimate the range of possible company values and reduce the risk of using a single deterministic forecast, but it retains the dependence of results on the subjective choice of scenarios and does not reflect the continuous nature of price uncertainty.

A more advanced tool for adapting DCF is stochastic modeling of commodity prices using Monte simulation techniques. Carlo). Unlike scenario analysis, this approach involves specifying a probabilistic process of price dynamics (for example, a mean-reverting model) . Monte Carlo DCF (also known as reversion), which allows for the generation of a distribution of possible cash flows and the final company value. The use of Monte Carlo DCF is particularly appropriate for oil and gas companies, as empirical studies show that oil and gas prices tend to return to a long-term equilibrium level. The result of the assessment is not a single value, but a set of probabilistic characteristics (P10, P50, P90), which significantly improves the analytical informativeness of the model and the quality of investment decisions.

In the context of the extraction of depletable natural resources, the standard approach to calculating terminal value based on the constant growth model often proves economically unjustified. Therefore, the literature suggests using alternative methods for forming terminal value, including modeling cash flows up to the economic limit of extraction (life-of-asset. approach) or calculating the residual value based on the resource base and the probabilities of commercial development of reserves. For oil and gas companies, the terminal value can also be interpreted as the value of a portfolio of future projects not included in the detailed forecast, which requires additional consideration of investment options and strategic management flexibility.

In an environment of high price volatility, management decisions in oil and gas companies take on an optional nature. The ability to defer investments, accelerate or slow field development, temporarily suspend production, or terminate a project early creates additional value that is not always accurately reflected in the traditional DCF model.

Integrating elements of real options theory into DCF analysis allows for a more comprehensive consideration of managerial flexibility and the asymmetric impact of price shocks on company value. In practical applications, this can be achieved through both separate option valuation and the incorporation of management decision rules into scenario and stochastic models.

Therefore, adapting the DCF to commodity companies requires the integrated use of scenario analysis, stochastic price modeling, modified approaches to calculating terminal value, and elements of real options theory. The combined use of these tools allows for increased valuation resilience to price volatility and brings the value model closer to the economic reality of oil and gas companies.

Corporate practice at major oil and gas companies shows that the impact of price uncertainty on financial results and valuations is a key topic of disclosure in financial reporting and strategic planning. Particular attention is paid to assumptions about future oil and gas prices, scenario analysis, stress tests , and asset impairment assessments taking these assumptions into account.

Many oil and gas companies, including international ones, disclose in their annual reports specific price assumptions that are used in calculating the recoverable value of assets, testing for impairment testing") and cash flow forecasting. For example, in Shell's financial statements plc publishes price forecasts for Brent oil and Henry gas Hub, which serve as the basis for estimating future cash flows and asset value recovery. The report includes annual supply and demand forecasts, as well as Brent and Henry prices. Hub for the nearest periods used in calculating the value of assets and future receipts [8].

plc demonstrates a similar practice in its annual Form 20-F: the company discloses the central price assumptions used to evaluate investment decisions and calculate asset values. Specifically, BP provides price forecasts for Brent and Henry. Hub provides multiple time horizons (2030, 2040, 2050) and indicates that these assumptions serve as the basis for analyzing the sustainability of investment projects and the sensitivity of forecasts to changes in the market environment [9]. This disclosure of price assumptions helps investors and analysts understand which oil price scenarios are incorporated into valuation models and how changes in these assumptions may affect financial performance and company value.

In addition to direct price assumptions, companies use scenario planning to incorporate oil and gas price uncertainty into strategic management and investment decisions. For example, ExxonMobil , one of the largest American oil and gas companies, publishes strategic development plans and oil price targets, which serve as the basis for financial forecasts and assessments of the future profitability of projects. In its public plans, ExxonMobil indicated that, with an average oil price of approximately $65 per barrel, the company expects significant growth in cash flow and profit in the medium term, reflecting the dependence of its long-term strategy on price assumptions [10]. This approach allows not only to formulate forecasts based on price expectations but also to analyze the sustainability of the investment strategy under various market conditions.

Companies also regularly conduct stress testing and sensitivity analysis of financial models to changes in energy prices. These tests include modeling negative scenarios with low oil and gas prices, as well as assessing the impact of price fluctuations on key financial metrics, such as operating cash flow, capital expenditures, dividend payments, and other corporate strategies. Although such exercises are not always fully disclosed in the text of annual reports, individual elements of the stress tests and sensitivity assessments are often cited in notes to the financial statements or investor presentations.

Corporate practices of major oil and gas companies, particularly in the US and internationally, include: transparent disclosure of price assumptions used to estimate future cash flows and test for asset impairment; scenario planning, including strategic oil and gas price targets; and sensitivity analysis, reflecting the impact of commodity market volatility on key financial metrics.
Such approaches facilitate more realistic and adaptive valuation of assets and projects in the face of high uncertainty in commodity markets.
Despite the limitations of the classic discounted cash flow model, DCF remains a fundamental tool for valuing oil and gas companies, provided it is properly adapted to the high price volatility of commodity markets. Methodologically sound application of DCF in the oil and gas sector requires the consistent implementation of the following steps. The assessment is based on the classic formula of the discounted cash flow (DCF) model:

$$V = \sum_{t=1}^{N} \frac{FCF_t}{(1+WACC)^t} + \frac{TV}{(1+WACC)^N}$$

(1) Базовая формула DCF-модели оценки стоимости компании

где FCF_t — свободный денежный поток, $WACC$ — средневзвешенная стоимость капитала, TV — терминальная стоимость, N — горизонт прогнозирования. Для нефтегазовых компаний предпочтительно использовать свободный денежный поток к фирме (FCFF), поскольку он позволяет абстрагироваться от текущей структуры финансирования.

Formula 1. Basic formula for the DCF model for assessing the value of a company
The next step is to decompose cash flows into price and non-price components. For oil and gas companies, the key factor is the price of oil and gas, which directly impacts revenue, operating margins, investment decisions, and the economic life of assets. This approach allows us to clearly identify the impact of price volatility on a company's bottom line. In conditions of high volatility, it is recommended to replace deterministic price assumptions with probabilistic ones. In practice, this can be implemented through scenario analysis assigning probabilities to alternative price trajectories; stochastic price modeling (including mean-reverting processes) using Monte Carlo simulations.
The result is a distribution of possible values of the company's value, rather than a single point value, which increases the analytical stability of the assessment.
For oil and gas companies, the standard approach to terminal value based on infinite growth requires modification. A more reasonable approach is to use a finite modeling horizon (life-of-asset) or calculate residual value based on the resource base and probabilities of commercial development of reserves. This avoids methodological pitfalls associated with the finite nature of natural resources.
The final step is to account for the managerial flexibility that arises in a volatile price environment. The ability to defer investments, change production rates, or temporarily suspend projects has option value and can be accounted for either through elements of real options theory or through decision rules embedded in scenario and stochastic models.
Thus, the methodological "recipe" for applying DCF to oil and gas companies in highly volatile environments involves maintaining the classical structure of the model while simultaneously expanding it through probabilistic price modeling, terminal value modification, and accounting for

managerial flexibility. This approach improves the theoretical validity and practical applicability of DCF valuation in the raw materials sector.

Therefore, we examined the theoretical and practical limitations of applying the classical DCF model to the valuation of oil and gas companies in the context of highly volatile commodity markets. We demonstrated that the traditional deterministic approach to cash flow forecasting and terminal value calculation requires methodological adaptation to account for price uncertainty, finite resource base, and managerial flexibility. We substantiated the feasibility of using scenario and stochastic price modeling, as well as modified approaches to terminal value calculation, to improve the sustainability and economic feasibility of DCF valuations of oil and gas companies.

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