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**AN IMPROVED PORTFOLIO OPTIMIZATION MODEL
FOR OIL AND GAS INVESTMENT SELECTION**

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Abstract: For oil company decision-makers, the principal concern is how to allocate their limited resources into the most valuable opportunities. Recently a new management philosophy, “Beyond NPV”, has received more and more international attention. Economists and senior executives are seeking effective alternative analysis approaches for traditional technical and economic evaluation methods. The improved portfolio optimization model presented in this article represents an applicable technique beyond NPV for doing capital budgeting. In this proposed model, not only can oil company executives achieve trade-offs between returns and risks to their risk tolerance, but they can also employ an “operational premium” to distinguish their ability to improve the performance of the underlying projects. A simulation study based on 19 overseas upstream assets owned by a large oil company in China is conducted to compare optimized utility with non-optimized utility. The simulation results show that the petroleum optimization model including “operational premium” is more in line with the rational investors’ demand.

The prominent question for decision-makers in petroleum companies is how to allocate their capital reasonably to the most valuable investment opportunities as to maximize their utility under a certain budget. Many companies employ Net Present Value (NPV) to evaluate Exploration and Production (E & P) projects to empower better investment decisions. But the optimal selection of one single project may not be the optimal allocation that can realize the maximum return with the minimum risk for the company as a whole. Despite NPV remaining a critical criterion for most capital allocating process, difficulties arise within NPV analysis when justifying projects with longer-term, huge hidden internal costs and investors’ various risk appetites. For investment decisions, risk and economic benefit are equally important. The volatilities of oil price, capital expense (Capex) and operating expense (Opex) would compound the complexity of upstream project selection. Therefore, petroleum company executives are moving on from deterministic NPV analysis to “beyond NPV” in their business planning analysis.

“Beyond NPV” was formally emphasized by petroleum economists from SPE in 2012. Within the concept of “Beyond NPV”, the integration of key performance indicators and uncertainties is strongly emphasized. Those uncertainties, rising from issues, and risk preferences of decision-makers, provide significant growth contribution to investment risks to meet sustainable development criteria, the industry need to adopt a broader range of valuation approaches besides NPV analysis. One of those alternative approaches is to employ the portfolio optimization method in terms of return to risk.

Portfolio theory was firstly put forward by Markowitz (1952). The portfolio theory proposes that a portfolio can be characterized by two indicators: the expected return of the portfolio and the variance of the expected return. The target of portfolio optimization is to minimize the variance for a given expected return or maximize the expected return for a given risk (Markowitz, 1952). This theory assumes a perfect market and that the investor's utility function of portfolio return is quadratic. Using variance as an indicator of risk can penalize both negative deviation and positive deviation from average. Markowitz revised the optimization model and proposed two new portfolio risk indicators: the below-mean semi variance and the below-target semi variance (Markowitz, 1959). Markowitz portfolio theory is supported by Fisher's separation theorem. The Fisher separation theorem proposes that the security portfolio optimization model doesn't need to include individual risk preference because of the underlying hypothesis of risk-free and identical borrowing-lending interest rates that investors can take advantage of frictionless transactions to achieve the optimal state (Fisher, 1906; Tobin, 2005). Thus, the target of "expected return maximization" becomes equivalent to the target of "expected utility maximization" if we ignore investors' risk preferences and the forms of their utility functions. Therefore, the portfolio optimization theory proposed by Markowitz (1952) uses "expected return maximization" instead of "expected utility maximization". Many industry sectors, such as aerospace, cogeneration and electricity generation, have employed the portfolio selection approach as an integral part of strategic planning to reduce exposure to fossil fuel price fluctuation. Since investments in the exploitation of hydrocarbons involve a high degree of risk as the value of candidate projects can be of very different nature and scope and fluctuate dramatically with the key value drivers, petroleum companies are constantly faced with investment decisions in multiple projects. Although literature has shown that the mean-variance method is the simplest and most effective approach available for asset selection.

The application of modern portfolio theory in petroleum industry stagnates in China, technically due to the lack of reliable and adequate data on comparable candidate projects. Another vital concern in the application of modern portfolio theory in the petroleum industry will be the difference between the oil industry and the securities market, manifesting market characteristics, time periods and the effect of budget.

Considering these differences mentioned above, there are two main challenges that call for further theoretical evidence for its practical use: The first notable challenge is that the market of O & G asset merger and acquisition is frictional. We the risk-free security.

Under the premise of no arbitrage and a ubiquitously risk-averse policy among oil and gas industry decision-makers, the principle of "Expected Utility-Variance" is more fitted in the petroleum market than the "Expected Return-Variance" principle.

Capital budgeters and operational premium.

Oil company executives who make investment and Project selection decisions are not like individual investors in the stock market. They are allocating capital to the best projects. Not only do executives care about the assessment and evaluation results

given by professional investment advisors, such as Goldman Sachs and Morgan Stanley, but they also want to develop insights into the most operational potential among these candidate E & P projects because projects with operational potential can provide significant growth contribution to the projects' underlying value. To distinguish oil company executives from security investors, we call the latter "professional investors", and the former "capital budgeters", who can create added value by using their own management and control systems. We name the added value part "operational premium". Based on research into operating behaviors of oil companies, we find that the degree of operational premium is mainly affected by two factors: one is the degree of investor's control ability on the project, namely, ownership interest. Measurement of operating efficiency can be considered from many aspects, including the input-output ratio, social status, staff development, social welfare contribution and R&D reserves. The most easily quantifiable factor is input-output ratio the return on investment ratio a project will get.

Ownership interest

In Markowitz's portfolio theory, return on investment is an exogenous variable and investors are all price takers, so the ownership proportion of each asset will not impact the underlying yields. This theory is reasonable for most professional investors. But in the case of capital budgeters, like international oil companies, the ownership interest Percentage will impact the operating efficiency to different degrees. Generally speaking, the greater proportion the investor's equity account for in an oil & gas asset, the closer the asset's output function will get to that under the investor's full control.

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ФІНАНСОВІ ТА ПОДАТКОВІ АСПЕКТИ УПРАВЛІННЯ РОЗВИТКОМ ГАЛУЗЕВИХ І РЕГІОНАЛЬНИХ СУСПІЛЬНИХ СИСТЕМ

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Розвиток галузевої і регіональної суспільної системи базується на ключових показниках розвитку економіки. В залежності від регіонального