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# Optimal commodity asset allocation with a coherent market risk modeling

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ABSTRACT

This paper fills a fundamental gap in commodity price risk management and optimal portfolio selection literatures by contributing a thorough reflection on trading risk modeling with a dynamic asset allocation process and under the supposition of illiquid and adverse market settings. This paper analyzes, from a portfolio managers' perspective, the performance of liquidity adjusted risk modeling in obtaining efficient and coherent investable commodity portfolios under normal and adverse market conditions. As such, the author argues that liquidity risk associated with the uncertainty of liquidating multiple commodity assets over given holding periods is a key factor in formalizing and measuring overall trading risk and is thus an important component to model, particularly in the wake of the repercussions of the recent 2008 financial crisis. To this end, this article proposes a practical technique for the quantification of liquidity trading risk for large portfolios that consist of multiple commodity assets and whereby the holding periods are adjusted according to the specific needs of each trading portfolio. Specifically, the paper proposes a robust technique to commodity optimal portfolio selection, in a liquidity-adjusted value-at-risk (L-VaR) framework, and particularly from the perspective of large portfolios that have both long and short positions or portfolios that consist of merely pure long trading positions. Moreover, in this paper, the author develops a portfolio selection model and an optimization-algorithm which allocates commodity assets by minimizing the L-VaR subject to applying credible operational and financial constraints based on fundamental asset management considerations. The empirical optimization results indicate that this alternate L-VaR technique can be regarded as a robust portfolio management tool and can have many uses and applications in real-world asset management practices and predominantly for fund managers with large commodity portfolios.



## 1. Introduction

The significance of assessing the market risk of a portfolio of financial securities has long been acknowledged by academics and practitioners. In recent years, the growth of trading activities and instances of financial market upheavals have prompted new research underlining the necessity for market participants to develop reliable risk assessment methods. In measuring market risk, one technique advanced in the literature involves the use of value-at-risk (VaR) models (Hull, 2009; Jorion, 2001) that ascertain how much the value of a trading portfolio would plunge, in monetary terms, over a given period of time with a given probability as a result of changes in market prices. Nowadays, VaR is by far the most popular and most accepted risk measure among financial institutions. Although VaR is a very popular measure of market risk of financial trading portfolios, it is not a panacea for all risk assessments (Sanders, 2002) and has several drawbacks, limitations and undesirable properties.

Conversely, commodity price risk management has received less attention from researchers and that is why it is still in its infancy compared to the more developed equity, interest rate and foreign exchange markets (Bartram, 2005; Weron, 2000). It is important to bear in mind, however, that commodity markets are not anywhere near as unambiguous as financial markets; hence few attempts have been made to measure price risk in commodity markets (Weron, 2000). Modeling market risk for commodity products thus presents an inherent complexity due to the strong interaction between the trading of products and the supply and demand imbalances that stem from the state of the economy (Al Janabi, 2009; Giot & Laurent, 2003). As a result, the increase in tradability of commodities in emerging markets necessitates a reexamination of current commodity risk management techniques (Satyanarayan & Varangis, 1994); specifically for investment funds with large trading portfolios—of either merely pure long positions or a combination of long/short trading positions—and within short-to-medium horizons of re-balancing and reporting focuses.

To address the above deficiencies, in this paper we characterize trading risk for diverse commodity products using a multivariate liquidity-adjusted value-at-risk (L-VaR) approach that focuses on the modeling of the optimum L-VaR under the notion of illiquid and adverse market conditions and by exercising different correlation factors and liquidation horizon periods. The overall objective of this paper is to construct a large commodity portfolio, which includes several crude oil/energy spot prices as well as other common commodities, and to evaluate the risk characteristics of such a

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portfolio besides examining an optimal process for assessing efficient and coherent[1] market portfolios. To this end, we propose a general trading risk model that accounts for the characteristics of the series of commodity price returns—for example, fat tails (leptokurtosis), skewness, correlation factors, and liquidity horizons—and adequately forecasts the market risk within a short-to-medium-term time horizon. As such, our focus on a short-to-medium-term time horizon is coherent with the use of a pure risk management method in which a more fundamental economic model would be of little aid vis-à-vis short-to-medium-term risk estimations (Giot & Laurent, 2003).

This study makes the following contributions to the literature in this specific commodity risk management field. First, it represents one of the limited numbers of academic/practitioner papers that empirically examines commodity trading risk management using actual data of different commodity markets. Second, unlike most empirical studies in this field, this study employs a comprehensive and real-world trading risk management model that considers risk analysis under normal, severe (crisis) and illiquid market conditions. The principal advantage of employing such a model is the ability to capture a full picture of possible loss scenarios of actual commodity trading portfolios. Third, given the fact that the classical (Markowitz, 1959) mean-variance optimizers have serious financial shortcomings, which could often lead to financially meaningless *optimal* portfolios (see for instance, Michaud, 1989), this paper proposes a new approach to optimal and coherent portfolio selection and within an L-VaR framework. The rationality behind introducing L-VaR as an effective portfolio management tool is because it complies with real-life trading situations, where traders can liquidate (or re-balance) small portions of their commodity trading portfolios on a daily basis according to prevailing market liquidity conditions. To this end, an L-VaR approach is introduced to allocate commodity assets by minimizing L-VaR subject to enforcing meaningful operational and financial constraints that are based on fundamental asset management considerations and practices, such as: a) the target expected return of the investable commodity portfolio; b) total trading volume of the investable portfolio; c) monetary asset allocation of each commodity asset class; d) portfolio managers' choices of pure long positions or a combination of long/short commodity trading positions; e) the unwinding or close-out liquidity horizons of each commodity asset-class. The focus on L-VaR as the appropriate measure of portfolio risk allows risk managers and portfolio managers to assign the desired liquidity horizon and to allocate pure long and/or a combination of long/short commodity assets according to realistic market trading conditions.[2] Another contribution of the paper is to provide a new approach in estimating portfolio managers' risk parameters. Accordingly, a robust optimization process is introduced to calculate risk tolerance in the L-VaR asset allocation model. Finally, the results of empirical testing are interesting in terms of theory as well as practical applications and provide an incentive for further research in the area of L-VaR and commodity price risk management, particularly in light of the aftermath of the latest 2008 financial crisis. Moreover, the different robust optimization studies and discussions are widely applicable to any commodity end-user, providing potential applications to practitioners and research ideas to academic scholars and researchers. In a nutshell, the proposed L-VaR risk-engine and optimization-algorithm have the potential of producing realistic risk-return profiles and could be a useful tool, for portfolio managers in many ways and applications, in developing enterprise-wide portfolio management models in the wake of the pshots of the most-recent financial crisis. This ultimately may improve *real-world* understanding of embedded risks and asymmetric market-microstructure patterns and could potentially create better investable coherent portfolios for fund managers.

## 2. Related literatures and objective of current research

Despite many criticisms and limitations of the VaR method, it has proven to be a very useful measure of market risk, and is widely used in financial and non-financial markets. Evidently, the overwhelming emphasis on VaR techniques has come from the finance literature, mostly as it pertains to the need of entities to satisfy regulatory requirements (Manfredo & Leuthold, 2001). Based on studies to date, there is little agreement as to the best method for developing VaR risk measures. However, literature related to VaR is continually growing as researchers attempt to reconcile several pending issues. The prior literature on VaR and portfolio risk management has been focused on two distinct lines of research. The first category focuses mainly on the development of liquidity risk as an integral part of market risk and, therefore, leads to several approaches for the estimation of L-VaR, whereas the second category emphasizes the use of different VaR models for market and credit risk management and discusses the use of VaR for other assets, such as commodities. Below we concisely discuss some of the relevant literature classified according to the above two categories.

### 2.1. Literatures related to liquidity-adjusted value-at-risk (L-VaR) modeling

The conventional VaR approach, employed by previous researches (e.g. Giot & Laurent, 2003; Manfredo & Leuthold, 1999, 2001), in computing the market (or trading) risk of a portfolio does not explicitly consider liquidity risk. Typical VaR models assess the worst change in mark-to-market portfolio value over a given time horizon but do not account for the actual trading risk of liquidation. Customary fine-tunings are made on an ad hoc basis. At most, the holding periods (or liquidation horizons) over which the VaR number is calculated is adjusted to ensure the inclusion of liquidity risk. As a result, liquidity trading risk can be imprecisely factored into VaR assessments by assuring that the liquidation horizon is a minimum larger than an orderly liquidation interval (Al Janabi, 2010, 2011). Moreover, the same liquidation horizon is employed to all trading asset classes, albeit some assets may be more liquid than others. Neglecting liquidity risk can lead to an underestimation of the overall market risk and misapplication of capital cushion for the safety and soundness of commodity dealers.

Within the VaR framework, Bangia, Diebold, Schuermann, and Stroughair (1999) approach liquidity risk from another angle and provide a model of VaR adjusted for what they call exogenous liquidity—defined as common to all market players and unaffected by the actions of any one participant. It comprises such execution costs as order processing costs and adverse selection costs resulting in a given bid-ask spread faced by investors in the market. On the contrary, endogenous liquidity is specific to one's position in the market and depends on one's actions and varies across market participants. They propose splitting the uncertainty in market value of an asset into two parts: a pure market risk component that arises from asset returns and uncertainty due to liquidity risk. In a similar vein, Angelidis and Benos (2006) apply L-VaR measures to the Athens Stock Exchange by incorporating bid-ask variation and the price effect of position liquidation. Their study focuses on the use of high frequency transaction level data of stocks besides sorting out each stock according to their average transaction prices and capitalization.

On the other hand, Berkowitz (2000) argues that unless the likely loss arising from liquidity risk is quantified, the models of VaR would

[1] In this paper, the concept of coherent market portfolios refers to rational portfolios that are contingent on meaningful real-world financial and operational constraints. In this sense, coherent market portfolios are not located on the efficient frontiers as defined by Markowitz (1959), and instead have logical and well-structured long/short asset allocation proportions.

[2] It is, hence, important to recognize assets liquidity risk and its close relationship with market risk for trading position because it can add significant losses to the overall market risk exposure. Furthermore, if liquidity risk is not included in the risk measurement, it can give incentive to traders to buy illiquid assets. This is because illiquid assets offer a higher expected return to compensate for their higher liquidity risk.