European Journal of Operational Research 234 (2014) 571–582

Contents lists available at ScienceDirect

European Journal of Operational Research

journal homepage: www.elsevier.com/locate/ejor

Performance replication of the Spot Energy Index with optimal equity portfolio selection: Evidence from the UK, US and Brazilian markets

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ARTICLE INFO

Article history:
Available online 19 September 2013

Keywords:
Energy markets
International equities
International investment
Index tracking
Evolutionary algorithms

ABSTRACT

This paper reproduces the performance of a geometric average Spot Energy Index by investing only in a subset of stocks from the Dow Jones Composite Average, the FTSE 100 and Bovespa Composite indexes, and in two pools that include only energy-sector stocks from the US and the UK respectively. Daily data are used and the index-tracking problem for passive investment is addressed with two evolutionary algorithms – the differential evolution algorithm and the genetic algorithm. The performance of the suggested investment strategy is tested under three different scenarios: buy-and-hold, quarterly and monthly rebalancing, accounting for transaction costs where necessary.

1. Introduction

Sixty years have passed since the pioneering publication of Harry Markowitz in the Journal of Finance (Markowitz, 1952), which laid the foundations of Modern Portfolio Theory (MPT). Until today, there is a plethora of financial models being developed which are based on the very same principles of the MPT for optimal portfolio construction, asset allocation, utility maximization, and investment diversification. As Fabozzi, Gupta, and Markowitz (2002) point out there have been numerous applications that have directly or indirectly resulted as an outcome of the MPT; among them tracking error budgeting, index and mutual funds, as well as diversification and asset allocation among different asset classes, the latter being the focus of this paper.

It is well-documented in the literature that investors can benefit from getting exposure in commodities as part of their long-term asset allocation plan. Over the past decade, impressive gains have been witnessed in commodity prices, with this pattern recently accelerating. The aforementioned trend, along with empirical evidence supporting the idea that passive strategies are better than active ones (see Barber & Odean, 2000; Konno & Hatagi, 2005; Malkiel, 1995; Sharpe, 1992; among others), especially in the longer term, have made passive strategies increasingly popular. One of the most popular forms of passive trading strategies is index tracking (Beasley, Meade, & Chang, 2003), a method that attempts to replicate/reproduce the performance of an index. This has attracted investors' attention and led to a considerable growth of index investing in the commodity markets. In general, there are three major ways of investing in a commodity index: first, by choosing an index and replicating it by following the related Rule Book; second, by investing in a fund that replicates the chosen index; and finally, in what is currently the most popular approach, by buying shares of an Exchange Traded Fund (ETF) whose strategy is to follow the respective commodity index. This trend has been recognized by investors, and prompted the set-up of the first commodity ETF in November 2004.[1]

Based on the principles of MPT, the aim of this paper is to replicate the unique price/return behavior of direct-energy commodity investment by selecting optimal equity portfolios. The proposed approach is based on previous research findings that discovered that, in the case of equally weighted long-only portfolios of commodity futures with a changing composition over the studied period, the statistically significant returns are similar to those of stocks (Bodie & Rosansky, 1980; Fama & French, 1987; Gorton & Rouwenhorst, 2006). In addition, it is documented in the literature that after the 2000s, commodities went through a financialization process, exposing them to wider financial shocks (Tang & Xiong, 2010).

Nonetheless, the question of whether returns on equity portfolios can be used to replicate the performance of physical-energy price returns, aggregated in a portfolio and proxied by a spot index, has received little attention in the existing literature. This paper is

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[1] The first listed commodity ETF was the streetTRACKS Gold Shares ETF, with its sole assets being gold bullion and, from time to time, cash. As of January 2010, the market capitalization of that first commodity ETF exceeded $39 billion US dollars, competing with numerous other commodity-related ETFs established since then, investing in physical commodities, futures, and commodity-related equities.

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http://dx.doi.org/10.1016/j.ejor.2013.09.006

Table 1
Parameters used as inputs in the algorithms.

GA	DEA
Solution representation: binary (10 digits) population size: $NP = 100$ Generations: 200 Crossover: arithmetic (80% probability) Selection: tournament (size = 4) Mutation: uniform (0.1% probability)	Solution representation: real valued population size: $NP = 10N$ Generations: 100 Crossover: exponential ($CR = 0.5$) Mutation: rand-to-best/1 ($F = 0.7$)

accomplishing the latter by proposing a new approach; that of reproducing the performance of a geometric average Spot Energy Index (SEI) by investing only in a subset of stocks from various equity pools. For the purposes of this study, the Dow Jones Composite Average, the FTSE 100 and Bovespa Composite indexes, and two pools that include only energy-sector stocks from the US and the UK respectively, are used. Daily data are analyzed and the index-tracking problem is addressed by two evolutionary algorithms – the differential evolution algorithm (DEA) and the genetic algorithm (GA). The performance of the resulting investment strategy is tested under three different scenarios: buy-and-hold, quarterly, and monthly rebalancing, after accounting for transaction costs in all cases.

The main contribution of this paper to the literature is that investors are provided with the opportunity to select portfolios of equities, picked from their domestic equity market – that may appeal more to their investing criteria/preferences – which are able to track the spot energy markets. The latter is proxied by a stable benchmark, namely the Spot Energy Index (SEI). Hence, the proposed methodology allows investors to be more comfortable with their investment selection, which follows the minimization of a pre-determined risk-return trade-off, and also take into account any domestic stock market constraints. Second, this is the first time that a broad energy index incorporates electricity market prices in its calculation. This makes the SEI more suitable for replicating the energy sector price dynamics as it represents the full spectrum of energy commodities and their by-products, and not just the commonly used crude oil and its refined fuels. Finally, the price behavior of direct energy commodity investment is being replicated using equities, by applying both the DEA and GA in this specific index-tracking problem.

The structure of this paper is as follows. Section 2 presents a literature review on energy commodity investing and the relationship between commodities and equities. In Section 3, the problem formulation is described, and the two evolutionary algorithms (DEA and GA) are explained. Section 4 gives an explanation of the constructed SEI and the data used in the analysis. Section 5 offers the empirical results of the study and, finally, Section 6 concludes the paper.

2. Energy commodity investing

In recent years there have been an increasing number of direct-energy commodity-based products available to investors, such as the respective energy futures contracts that require constant active management, and the energy commodity indexes. There is a large number of mutual funds, hedge funds, Exchange Traded Funds (ETFs), Exchange Traded Notes (ETNs) and OTC return swaps that follow the energy sector through index investing; there are various types of these Energy Index Funds, based either on the construction type of the fund (single- or multi-contract, long-only or bearish[2]), or on the energy sector it tracks (broad energy or sector-specific).

2.1. The case for futures indexes

In the US alone, assets allocated to commodity index strategies via futures contracts have risen from \$13 billion in 2003 to \$260 billion as of March 2008, with an estimated 70% of these funds invested in the energy sector (Hamilton, 2009). Of the total commodity index investment in the US exchanges, about 42% is conducted by institutional investors (pension and endowment funds), 25% by retail investors (ETFs, ETNs and similar exchange-traded products), 24% by index funds (a client/counterparty with a fiduciary obligation to match or track the performance of a commodity index), and 9% by sovereign wealth funds (CFTC, 2008).

Nonetheless, there are several risks and disadvantages associated with futures-based commodity indexes. In the case of a futures index, unlike a passive equity portfolio which entitles the holder to a continuing stake in a company, contracts specify a certain date for the delivery of the physical commodity. In order to avoid the delivery process and maintain a long futures position, a passive futures portfolio requires regular transactions; nearby contracts must be sold and contracts with later deliveries must be purchased. This process is referred to as “rolling”. The difference between the prices of the two contracts – the nearby and the more distant-delivery one – is called the “roll yield”. Even though the term structure of commodity prices has historically been an important driver of realized commodity futures’ excess returns, there is no guarantee that the term structure will remain the same in the future. Also, there is a possibility that the futures term structure of an individual commodity may be, on average, in backwardation,[3] yet the particular contract that an index mechanically rolls into might be in contango. Commodity markets in contango could result in negative roll yields that would adversely affect the value of the futures index.

Furthermore, although most of the energy commodities have liquid futures contracts with monthly expiration, there are some that expire less-frequently; rolling forward can thus be more costly due to higher bid-ask spreads, and exposed to longer duration and smaller liquidity of the respective futures contracts. Moreover, Gorton and Rouwenhorst (2006) find that commodity futures contracts become illiquid in the delivery month, as most traders avoid delivery of the physical commodities. Another major disadvantage is the explicit rolling procedure that needs to be used when tracking a commodity futures index. Any transparent index publishes the specific rules of rebalancing, making them available to all market participants. This means that other traders and speculators can take advantage of the known future transactions mandated by those rules. Under the prevailing trend of these index funds constantly to grow in size, they will only become more vulnerable to

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[2] Bearish Energy Index Funds have the same structure as bullish (long-only) funds, with the major difference that investors are not only allowed to buy the fund, but also to put on a short position (sell the fund).

[3] When a futures contract’s price is at a discount (premium) to the spot price of the underlying, the resulting shape of the futures curve is in backwardation (contango). Towards the expiration of a futures contract, when futures markets are in backwardation, it converges or “rolls up” to the spot price. This price difference is the roll yield that investors can capture when commodities futures markets are in backwardation. However, when futures markets are in contango the reverse occurs, with investors making losses from the futures contracts that converge to a lower price. The levels of contango and backwardation can swing drastically both in terms of magnitude and sign, making the term structure of commodity futures contracts the main driver of the return differences among commodity futures.