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Fundamental indexation: An application to the Nordic wholesale electricity market

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ABSTRACT

In commodities futures trading, models are often applied to determine an optimal trading strategy. Traditional trading strategies employed include short (sell) and long (buy) positions, time, and locational spreads. Shorter-term power contracts, however, have relatively low correlations with financial markets because of fundamental supply-demand factors including a high correlation with weather effects. Based on the concept of fundamental indexation pioneered by Arnott et al. we investigate the application of a fundamental portfolio weighting indexation to power markets. We propose three fundamental indices, inverse inflow, inverse production and consumption, related to supply and demand, and which historically exhibit strong correlations with power prices. We benchmark the three indices to an equally weighted portfolio of the Nordic market's weekly futures prices (one to six weeks to delivery) from 1996 to 2006. The results show that the inverse inflow index obtains the highest returns. We conclude that the use of the indices combined with portfolio theory would benefit renewable energy plant operators and energy traders.

1. Introduction

The objective of this paper is to develop electricity futures portfolios with improved risk-return characteristics by using fundamental factors as a guide. In energy trading, portfolio-based techniques can be used to develop well-diversified trading or hedging portfolios. Depending on their time to maturity, futures contracts have different return and variability characteristics including market liquidity. Generally, an energy trader assembles a portfolio of contracts, which requires analyzing the portfolio's complete return, not the individual contracts. Using a volatility-adjusted, position-sizing analysis potentially smooths out the portfolio's returns and improves its risk characteristics. In this trading scenario, the higher volatility in an asset implies a smaller position size.

The objective of this paper is to construct an electricity futures portfolio with improved risk-return characteristics by using fundamental factors as a guide. Basically, fundamental indexing [1] weights a portfolio's components by fundamental factors rather than by market capitalization or equal weighting. In wholesale electricity markets characterized by a high share of renewables, there may be an inverse relationship between renewables output with low (or zero) marginal cost and price. Higher production (more supply) could lead to lower prices and thus a negative correlation. Hydropower production can be estimated proportionally to the inflows in the current period minus the changes in reservoir levels from the previous period (holds true from the reservoir balance equation). High reservoir levels and/or inflow levels (indicating excess supply) contribute to lower prices and vice versa. Likewise, there is a relationship between the consumption level (i.e. high in cold weather) and price. Everything else being equal, higher consumption leads to higher prices. To utilize these relationships in a trading strategy we need to create weights that express these relationships over time. The weights should reflect the relationship between reservoir levels, inflows, and consumption in order to capture the trading portfolio's future expected performance. Portfolio rebalancing is necessary if recalculating the weights indicates that they have changed materially. A low weight (high hydropower output or low consumption) indicates rebalancing sales, and a high weight (low hydropower output or high consumption) indicates rebalancing purchases. To apply the fundamental indexation concept to energy trading, we need a forecast of expected hydropower output as calculated by the inflow/reservoir levels and a forecast of consumption so that we can adjust the portfolio's weights in advance.

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In this paper, we propose three fundamental indices related to supply and consumption: inverse production, inverse inflow, and consumption. Historically, the three indices exhibit a strong correlation with power prices. We benchmark them to a portfolio with equal weights of the weekly futures prices (one to six weeks to delivery) in the Nordic wholesale electricity market from 1996 to 2006. A few earlier studies have applied the Markowitz portfolio approach [2] to power plant investments [3,4], but to our knowledge we are the first to apply the concept of fundamental indexation to power trading portfolios.

The remainder of this paper is organized as follows. Section 2 describes portfolio theory and fundamental indexing and briefly reviews the relevant literature. Section 3 describes the Nordic power market and its physical and financial markets including the important price drivers. Section 4 introduces the proposed fundamental indices and describes the possible approaches for creating their portfolio weights. Section 4 also discusses their application to the weekly futures prices in the Nordic market from 1996 to 2006. Section 5 highlights some of the issues involved in determining the index weights. Section 6 concludes.

2. Portfolio theory and fundamental indexing

Portfolio analysis guides investors in creating efficient portfolios that exhibit low variability to various outcomes. Portfolio returns are calculated by maximizing the expected return for any given level of risk (i.e. minimizing risk for every given level of expected return). Markowitz portfolio theory [1], which has been applied to financial markets and for asset allocation, does not prescribe a single optimal portfolio combination, but rather a range of efficient choices so that investors can select a risk-return combination based on their own preferences and risk attitude. Although standard deviation is the most commonly used risk measure, this measure is not robust; thus many investors instead use sortino ratio and conditional value at risk (CVar). Portfolio optimization frequently occurs in two stages: determining the optimal weights of portfolio assets and optimizing the weights of assets within the same asset class.

Application of Markowitz portfolio theory to energy markets has been demonstrated by Refs. [3] and [4]. The authors in Ref. [3] introduce mean-variance portfolio theory and evaluate its potential application to the development of efficient EU-15 generating portfolios that enhance energy security and diversification objectives as well as demonstrating the portfolio effects of various generating mixes. The authors in Ref. [4] apply portfolio theory to technology choices in electricity markets, study the effect on long term contracts, and demonstrate that power generation technologies have different risk and returns characteristics because of different exposures to market risks (electricity price, fuel price, and CO_2 price) and different degrees of capital intensity (ratio of investment to operating costs). The research in Ref. [5] examines the market efficiency of oil spot and futures prices by using both mean-variance (MV) and stochastic dominance (SD) approaches. Using crude oil data for the period 1989–2008, they find no evidence of any MV and SD relationships between oil spot and futures indices (i.e. there are no arbitrage opportunities between these two markets). The spot and futures oil markets are efficient and rational because neither can dominate the other.

Arnott el al [1]. introduced the concept of fundamental indexation. In equity markets most indices are market-capitalization weighted (i.e. number of outstanding shares times price per share). The more value a share gains, the more shares are purchased by an index manager. Conversely, the more value a share loses, the more shares are sold by the index manager. While these actions may result in the overvaluation or undervaluation of some companies, market-capitalization weighted indices do provide benefits such as a passive strategy that requires little trading, a convenient way to participate in the equity market, high correlation with liquidity, and high correlation with investment capacity. Arnott et al. [1] suggest using fundamental equity indices when stocks are portfolio-weighted by fundamental factors such as gross revenue, equity book value, gross sales, gross dividends, cash flows, and total employment. They demonstrate that fundamentals-weighted, non-capitalization-based indices provide higher returns and lower risk than traditional capitalization-weighted indices. For example, during a 43-year test period, the fundamental index outperformed the S&P 500 by an average 1.97 pps annually. They rebalance the fundamental index on the last trading day of the year. Possible explanations for the outperformance include superior market portfolio construction, price inefficiency, additional risk exposure to distress risk, or a mix of the three. Arnott el al [1]. conclude that the fundamental indices are materially more mean-variance efficient than standard capitalization-weighted indices. An index consists of several components and thus it is a portfolio. Moreover, by definition an index is less volatile than its individual components.

Perold (2007) [6], who describes the flaws associated with fundamental indexing, argues that capitalization weighting in fact does not underperform, i.e. it does not invest more in overvalued stocks than undervalued stocks but because it invests in the same proportions, the capital and equal weighted indices will have identical returns. Perold (2007) [6] also claims that fundamental indexing has a flavor of value investing by engaging in active security selection. Fundamental indexing, however, may be effective when value stocks are systematically mispriced, but investors should be well-skilled in value investing and active strategies.

In the commodity space, skilled investors can avail themselves of some fundamental indices. The SummerHaven Dynamic Commodity Index (SDCI) developed by SummerHaven Index Management provides an active commodity index benchmark [7]. The underlying concepts are that commodities with low inventories will tend to outperform commodities with high inventories, and that priced-based measures, such as futures basis and price momentum, will be used to guide the assessment of commodity inventories. The SDCI fund holds the commodities that should outperform over the next month according to their price histories. Specifically, the fund only holds 14 of 27 possible commodities based on two criteria:

- It owns the seven commodities with the greatest backwardation, and
- It owns the strongest seven commodities based on 12-month price change.

In other words, the SDCI fund profits by selecting futures contracts with the largest available backwardations accompanied by the strongest uptrends.

The Dow Jones RAFI Commodity Index [8] is a fundamental factor-weighted, broad-market commodity index with a modified roll mechanism. This approach yields an alternative beta (i.e. the general market risk) by generating alpha (i.e. the outperformance relative to a suitable market index). The Dow Jones RAFI Commodity Index utilizes momentum and modified dynamic roll methodology based on liquidity and implied roll yield to overweight or underweight the commodities within the equally weighted sectors of the Dow Jones Commodity Index.[1]

[1] It includes only contracts extending 24 months ahead and requires that each eligible contract must have open interest of at least 5% of the total open interest in the nearby most liquid contracts. The roll occurs over the five first business days with the monthly rebalancing.