ARTICLE IN PRESS

Economic Modelling (xxxx) xxxx–xxxx

Contents lists available at ScienceDirect

Economic Modelling

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

The demand of energy from an optimal portfolio choice perspective

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ARTICLE INFO

JEL classification:
G11
G19

Keywords:
Strategic asset allocation
Energy sector
Intertemporal hedge demand
Myopic demand

ABSTRACT

This paper analyses the demand for energy sector by employing a model form strategic asset allocation literature and quantifying the welfare losses incurred by an investor due to sub-optimal asset allocation. Our sample group includes fifteen major oil producing and consuming countries. We analyze the short-run and long-run desirability of energy sector in the optimal portfolio of an investor with varying level of risk aversion; that is, risk averse and risk tolerant investors. Our results show that the portfolio demand for energy sector is myopic or short-run. For long-run investors, investing in a portfolio of equity market and government bonds is a better proposition. In addition, energy sector is more desirable for risk tolerant investors.

1. Introduction

Energy sector is one of the main pivots of capital and commodity markets around the world. It is an important portfolio component of both individual and institutional investors in the form of stocks, exchange traded funds or derivatives. Moreover, the price changes of energy sector have the ability to significantly impact the performance of various macroeconomic and financial variables (Lescaroux and Mignon, 2008). Most of the existing research in the area of financial economics of energy markets documents the risk return behavior or investment attributes of energy sector commodities (oil and gas, coal etcetera), factors explaining the risk return behavior of energy sector equities, effect of oil prices on equities and the associated derivatives. (Arouri and Nguyen, 2010; Hernandez, 2014; Bianconi and Yoshino, 2014; Reboredo, 2015; Kerste et al., 2015; Inchauspe et al., 2015; Sadorsky, 2001; Sardosky, 2012; Boyer and Filion, 2007; Oberndorfer, 2009; Henriques and Sardosky, 2008). However, the existing literature analyzing the portfolio attributes of energy sector equities is rather sparse. In particular, the demand for energy equities for investors with varying degree of risk aversion and different investment horizons has not been investigated in detail.

The purpose of this paper is to analyze the portfolio characteristics of energy sector stocks for investors with varying levels of risk aversion and different investment horizons. We employ a strategic asset allocation framework proposed by Campbell et al. (2003) to disentangle the short- run and long-run demand for energy sector stocks. The disentangling of the total demand allows us to analyze the short-run and long-run portfolio characteristics of energy sector equities. Thereafter, we quantify the welfare losses incurred by an investor by ignoring the short-run and long-run demand for energy sector equities. We employ energy sector equity indices for fifteen major oil producing and consuming countries. These include; Australia, Canada, France, Italy, Norway, Spain, UK, USA, Brazil, China, Colombia, India, South Korea, Russia and Singapore. Thus, our sample group encompasses both developed and developing countries. We employ time series data from 1999 to 2015, thereby covering the energy sector boom and bust. To the best of our knowledge, this is the first paper to quantify the welfare losses due to ignoring the short-run and long-run demand for energy sector equities for investors in each of these countries.

The strategic asset allocation framework of Campbell et al. (2003) renders certain unique advantages. Firstly, it takes into consideration the time varying nature of investment opportunities, thus overcoming one of the widely documented shortcomings of classic mean variance framework. The classic mean variance framework by Markowitz (1952) is often criticized because it's static in nature; that is, it does not take into consideration the time varying nature of investment opportunities and is based upon single-period rather than multi-period investment horizons. (Samuelson, 1969; Mossin, 1968; Merton, 1969, 1971, 1973, Campbell and Viceria, 1999, 2001). Motivated by the predictability of returns and the concept of intertemporal hedging demand introduced by Merton (1973), Campbell et al. (2003) decomposed the demand for an asset into myopic and intertemporal hedge demand. The myopic demand for an asset is the demand for an asset in the single period classical mean-variance setting, whereas, the intertemporal hedge demand is the component of total demand of an asset when the time varying investment opportunities are taken into consideration. The myopic demand may be attributed to the short-run desirability of an asset, whereas, intertemporal hedge demand for an asset may be attributed to the long-run desirability of an asset. Since investors hold

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http://dx.doi.org/10.1016/j.econmod.2016.12.027
Received 6 August 2016; Received in revised form 13 December 2016; Accepted 23 December 2016
0264-9993/

assets for both short-run and long-run investment horizons, therefore, the segregation of these two components of total demand have important implication for portfolio choice decisions of energy sector investors.

As mentioned above, we employ a large sample set of energy sector equity indices from fifteen countries and analyze the welfare losses incurred by an investor due to ignoring the total, myopic or the hedge demand for energy sector equities. In addition, we also quantify the welfare losses for an energy sector investor who can invest in the aggregate equity market index in addition to the energy sector. This analysis helps us to shed light on portfolio implication of energy sector equities vis a vis the aggregate market. It also helps us to compare the portfolio attributes of energy sector equities with the aggregate equity market and analyze how energy sector is different from the equity market in a portfolio context.

Government bonds are known for their stable risk-return attributes and often referred to as a desirable portfolio component for long-run investors. Therefore, we expand the asset menu by including government bonds in the list of available assets for an investor. We calculate the welfare losses of an investor who ignores either the energy sector or the equity market and government bonds form the optimal portfolio. This analysis allows us to quantify the desirability of energy sector vis a vis the traditional financial asset classes.

Our results show that the desirability of energy sector is myopic or for short-run investment horizons only. However, for long-term investors energy sector is not a desirable portfolio choice. Similarly, energy sector is a desirable portfolio component for risk tolerant investors. However, investing in equity market and government bonds is a better proposition for risk averse investors.

The rest of the paper is organized as follow: Section 2 describes the methodology, Section 3 describes the data and sample statistics followed by the empirical results in Section 4. The conclusion of the study is presented in Section 5.

2. Methodology

As given in Campbell et al. (2003), we consider an investor with Epstein and Zin (1989, 1991) preferences given by[1]

$$U[C_t, E_t(U_{t+1})] = \{(1-\delta)C_t^{(1-\delta)/\theta} + \delta[E_t(U_{t+1}^{1-\gamma})]^{1/\theta}\}^{\theta/1-\gamma} \tag{2.1}$$

We consider a portfolio of 'n' assets. Let $R_{p,t+1}$, denote the real return of the portfolio. Similarly, let $R_{1,t+1}$ and $R_{i,t+1}$ be the real return on the benchmark asset (a money market asset with short-term maturity such as T-bills) and real return on the remaining "n-1" portfolio assets, respectively. Let $\alpha_{i,t}$ denote the weight for each asset i (i=2,3,...,n) in the portfolio. Given the above variables, the portfolio returns can be given as;

$$R_{p,t+1} = \sum_{i=2}^{n} \alpha_{i,t}(R_{i,t+1} - R_{1,t+1}) + R_{1,t+1} \tag{2.2}$$

Let x_{t+1} denote the vector of excess return; that is returns in excess of the benchmark. The vector of excess return is given by;

$$x_{t+1} = [r_{2,t+1} - r_{1,t+1}, \ldots, r_{n,t+1} - r_{1,t+1}]' \tag{2.3}$$

where $r_{i,t+1} = log(1 + R_{i,t+1})$ for all i.

Let z_{t+1} be the state vector containing the benchmark asset ($r_{1,t+1}$), the vector of excess returns.

(x_{t+1}) and other state (predictor) variables (s_{t+1}). Then, z_{t+1} is given as

$$z_{t+1} = [r_{1,t+1}, x_{t+1}, s_{t+1}]' \tag{2.4}$$

Following Campbell et al. (2003), we employ the following vector auto-regression model for z_{t+1},

$$z_{t+1} = \varphi_o + \varphi_1 z_t + \upsilon_{t+1} \tag{2.5}$$

where φ_o and φ_1 denote the vector of intercept and the matrix of slope coefficients, respectively. υ_{t+1} denotes the vector of i.i.d normally distributed shocks with mean 0 and covariance matrix Σ_υ given by;

$$\Sigma_\upsilon = Var_t(\upsilon_{t+1}) = \begin{pmatrix} \sigma_1^2 & \sigma_{1x}' & \sigma_{1s}' \\ \sigma_{1x} & \Sigma_{xx} & \Sigma_{xs}' \\ \sigma_{1s} & \Sigma_{xs} & \Sigma_{ss} \end{pmatrix} \tag{2.6}$$

σ_1^2 is the variance of the shocks to return on the benchmark asset. σ_{1x} and σ_{1s} denotes the covariance vectors of the shocks of the return on the benchmark asset to other assets and the other state variables, respectively. Σ_{xx} and Σ_{ss} represent the covariance matrices of shocks to excess returns on assets and shocks to other state variables, respectively. Σ_{xs} is the covariance matrix between shocks to excess returns and other state variables.

Campbell et al. (2003) derive the portfolio weights α for the system defined in Eq. (2.5)[2]:

$$\alpha_t = A_0 + A_1 z_t \tag{2.7}$$

where:

$$A_0 = (1/\gamma) \sum\nolimits_{xx}^{-1} (H_x\phi_0 + 0.5\sigma_x^2 + (1-\gamma)\sigma_{1x}) + (1-(1/\gamma)) \sum\nolimits_{xx}^{-1} (-\wedge_0 /(1-\psi)) \tag{2.8}$$

And

$$A_1 = (1/\gamma) \sum\nolimits_{xx}^{-1} H_x\phi_1 + (1-(1/\gamma)) \sum\nolimits_{xx}^{-1} (-\wedge_1 /(1-\psi)) \tag{2.9}$$

where $\gamma > 0$ represents the coefficient of risk aversion (CRRA);H_x represents the selection matrix for selecting the vector of excess returns (x_t) from z_t;   represents the elasticity of intertemporal substitution, $\bigwedge_0$ and $\bigwedge_1$ represents matrices whose values depend upon γ, , δ, ϕ_0, ϕ_1 and $\sum_v$. The sum of the first two terms of Eqs. (2.8) and (2.9) represents the myopic demand ofan asset; thatis,

$$\text{Myopic Demand} = (1/\gamma)\left(\sum\nolimits_{xx}^{-1} (H_x\phi_0 + 0.5\sigma_x^2 + (1-\gamma)\sigma_{1x}) + \sum\nolimits_{xx}^{-1} H_x\phi_1 z_t\right) \tag{2.10}$$

The sum of the other two terms of Eqs. (2.8) and (2.9) equates to the total hedge demand; that is,

$$\text{Hedge Demand} = (1-(1/\gamma))\left(\sum\nolimits_{xx}^{-1} (-\wedge_0 /(1-\psi)) + \sum\nolimits_{xx}^{-1} (-\wedge_1 /(1-\psi))z_t\right) \tag{2.11}$$

Rapach and Wohar (2009) document that the estimated asset demand under the Campbell et al. (2003) framework can be interpreted in either a normative or a positive manner. As per the normative interpretation, for a given asset return process, the optimal asset demand boils down to the demand of an investor with the same investment preferences as assumed by Campbell et al. (2003). The positive interpretation of estimated demand is similar to that of Lynch (2001). According to this interpretation, optimal asset demand can be seen as either the investment behavior of a individual investor or a small group of investors. This unique investor or small group of investor exploits the return predictability created by a large number of other investors with different preferences. For instance, the habit-formation preferences documented by Campbell and Cochrane (1999).

In addition to portfolio weights, we also calculate welfare losses associated with the sub-optimal asset allocation. We consider the following value function, expressed as power function of the optimal consumption-wealth ratio (Epstein and Zin, 1989,1991).

[1] The methodology is largely based on Campbell et al. (2003).

[2] For a detailed description and derivation, please refer to Campbell et al. (2003).