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Research Article

Water exchange traded funds: A study on idiosyncratic risk using Markov switching analysis

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Abstract

We investigate the relationship between idiosyncratic risk and return among four water exchange traded funds—PowerShares Water Resources Portfolio, Power Shares Global Water, First Trust ISE Water Index Fund, and Guggenheim S&P Global Water Index ETF using the Markov switching model for the period 2007–2015. The generated transition probabilities in this paper show that there is a high and low probability of switching between Regimes 1 and 3, respectively. Moreover, we find that the idiosyncratic risk for most of the exchange traded funds move from low volatility (Regime 2) to very low volatility (Regime 1 and 3). Our study also identify that the beta coefficients are positive and entire values are less than 1. Thus, it seems that water investment has a lower systematic risk and a positive effect on the water exchange traded index funds

idiosyncratic risk

water investment

transition probabilities

Markov switching model

water exchange traded funds

Public Interest Statement

Water is essential for life and has been studied to some extent but not as much in terms of major investments and their associated risks. The issues related to climate change has increased the risk of even more people in the world living with lack of adequate water for drinking. To remove this crisis, water investments in a number of areas are urgently needed. This study provides impetus for further study of the financial aspects of the water industry and its related risks. In particular, this paper contributes by increasing the investor's understanding of the idiosyncratic risk of water investments. The results and findings will guide investors' in decision-making.

1. Introduction

Although water is essential for life, it is in severe shortage around the world (Tularam & Properjohn, [2011](#)). Water covers about two-thirds of the earth's surface (Roca & Tularam, [2012](#); Tularam & Marchisella, [2014](#)). Recent statistics suggest that more than 2.6 billion people of the world are living with lack of adequate water for drinking (Jin, Roca, Li, Wong, & Cheung, [2015a](#); Roca, Tularam, & Reza, [2015](#); Tularam & Marchisella, [2014](#)) and the number has been increasing daily in that 3.9 billion persons could be reached by 2030 (Jin, Li, Roca, & Wong, [2015b](#); Organisation for Economic Co-operation & Development, [2008](#); Roca et al., [2015](#)). Presently, more than one billion people are in acute drinking water availability problems in many developing countries including Bangladesh, Pakistan, and much of Africa (Jin et al., [2015b](#); Organisation for Economic Co-operation & Development, [2009](#); Roca et al., [2015](#); Tularam & Illahee, [2008](#); Tularam & Marchisella, [2014](#); Wild, Francke, Menzli, & Schon, [2007](#)).

As the global population increases, water demand will unavoidably increase and there

sanitation for regional populations (Tularam, [2014](#); Tularam & Illahee, [2010](#); Tularam & Keeler, [2006](#); Tularam & Krishna, [2009](#); Tularam & Singh, [2009](#)). The potential impacts of climate change on water availability and related impact on global agriculture will compound the existing problems of water availability. However, the urgently developing interfaces in many countries including much needed trade liberalizations together appear to present much important information on the values, benefits, and costs of investing in water (Roca et al., [2015](#); Tularam, [2014](#)).

Clearly, if the water shortages are to be addressed, the existing global water industry needs to examine the rapidly changing market (Jin et al., [2015b](#); Roca & Tularam, [2012](#); Roca et al., [2015](#)). There is a major drinking water crisis worldwide and therefore investments in water are urgently needed (Jin et al., [2015a](#); Roca et al., [2015](#)). The rapidly changing dynamics of the modern world suggest that water investing can be increasingly popular to investors (Roca & Tularam, [2012](#); Tularam, [2014](#)). Investing in water companies and water stocks has been the most commonly adopted approach as alternative to direct investment it seems (Jin et al., [2015a](#)). If the water sector expands and the market being rather economically resilient, investments in this industry should lead to fruitful financial returns. Investors could also gain better diversification benefits by involving investments in water within their portfolios (Roca et al., [2015](#)).

In recent times, the development of the water market has led to the development of water exchange traded index funds (ETFs). Water EFTs, are baskets of water-related shares aimed at replicating the performance of the water market. They offer investors the flexibility of buying or selling in the whole water market with a single transaction (Roca et al., [2015](#)). For example, the American Stock Exchange (AMEX) introduced the Palisades Water Index (ZWI) in 2003, with a starting value of 1,000 points. And from August 2005, they started publishing this index on a regular basis. The ZWI is an equally weighted index comprised of companies engaging in the fundamental activities of the global water industry such as distribution, filtration, pumps and pipes, and treatment (Geman & Kanyinda, [2007](#); Jin et al., [2015b](#); Roca et al., [2015](#)). Following the publication of the ZWI, two exchange traded funds (ETFs), namely, Power Shares Water Resources (PHO) and Power Shares Global Water (PIO) were successively introduced to investors to assist them to keep track of companies included in the ZWI (Wong, Roca, & Tularam, [2007](#); Roca et al., [2015](#)).

Since March 2012 these two funds have been re-constructed to track the NASDAQ OMX

example, Guggenheim S&P Global Water Index ETF (GGW), which is based on the S&P Global Water Index; and First Trust ISE Water (FIW), which is based on the ISE Water Index (Atkinson, [2009](#)). However, often a number of companies included in these water indices generate only a small portion of their revenue from water-related products or services. Therefore, questions have been raised such as the need to examine whether these water ETFs can be defined as pure water funds (Kearney, [2008](#); Roca et al., [2015](#)).

To the best of our knowledge no study has investigated the relationship between idiosyncratic risk and return of ETFs in the water sector using Markov switching model. More importantly, in terms of the motivation of this study, none of studies reported appear to have investigated the changes of the idiosyncratic risk and risk-return relationship of the water ETF across different regimes. Therefore, this study contributes to investor's understanding of the idiosyncratic risk of water investments. The results will guide investors' in decision-making. Since the research on idiosyncratic risk of ETF is generally lacking, our study therefore aims to fill in this important gap. The main aim of this article was to investigate the relationship between idiosyncratic risk and return among four water exchange traded funds—PowerShares Water Resources Portfolio (PHO), PIO, First Trust ISE Water Index Fund (FIW), and Guggenheim S&P Global Water Index ETF using the Markov switching model for the period 2007–2015. In particular, we examine the effect of water exchange traded funds regimes on water investment using the Markov switching model.

The rest of this paper is organized as follows. In Section [2](#), we review the related literature. Section [3](#) outlines the data and methodologies employed in the study. Section [4](#) discusses the empirical results followed by the conclusion in Section [5](#).

2. Literature review

Much literature has focused on the issue of idiosyncratic risk. However, many researchers' performed studies identifying the stock market unsystematic risk premium. For example, Aaker and Jacobson ([1987](#)), Cox and Griepentrog ([1988](#)), Barber ([1994](#)), and Campbell, Lettau, Malkiel, and Xu ([2001](#)), Goyal and Santa-Clara ([2003](#)) find that unsystematic risk premium is positively related to return, whereas Cheung and Wong ([1992](#)), Bali and Cakici ([2009](#)), and Rollen, Skotnicki, and Veeraraghavan ([2000](#))

report no significant relationships between the idiosyncratic risk and returns in the US, Australia, and Hong Kong markets, respectively.

Goyal and Santa-Clara ([2003](#)) published a paper with the provocative title “Idiosyncratic risk matters!” They reported that there is a positive relation between market return and average idiosyncratic risk for the period of 1963–1999. Later, Bali, Cakici, Yan, and Zhang ([2005](#)) expand the Goyal and Santa-Clara’s sampling period using two more years of data to find the relation uncovered by Goyal and Santa-Clara is sample specific. They note that sample is driven by small stocks traded on NASDAQ. A dependence on the weighting scheme is partly attributed to liquidity premium. Wei and Zhang’s ([2005](#)) approach does not allow for the possibility that the relation between idiosyncratic risk and return may be different across high and low volatility states. Guo and Savickas ([2003](#)) state that Goyal and Santa-Clara’s ([2003](#)) did not find further co-movements of average stock volatility with stock market volatility.

Angelidis and Tessaromatis ([2009](#)) perform regressions analysis of the monthly value weighted excess market return on lagged value (equally) weighted idiosyncratic volatility. The absence of a relation using value weighted idiosyncratic volatility is consistent with Bali et al. ([2005](#)) and Wei and Zhang ([2005](#)) research. However, in the case of equally weighted idiosyncratic volatility, it is noted that there is strong evidence of a positive relation only when the stock market is in the low volatility state. While the relation between returns and risk is positive it is not statistically significant in the high volatility state. Huimin, Cheung, and Roca ([2010](#)) also find a positive relationship between the idiosyncratic risk and return during low and medium volatility states. Their results are consistent with that of Tang and Shum ([2007](#)) and Angelidis and Tessaromatis ([2009](#)); in the sense of the idiosyncratic risk premium under different market conditions.

Given the importance to water investment, the issue of idiosyncratic risk and returns has not received appropriate attention in the past literature. The water investment literature indicates that few studies have been done thus far (see Antoniou, Barr, & Priestley, [2000](#); Buckland & Fraser, [2000, 2001](#); Buckland & Williams, [2013](#); Geman & Kanyinda, [2007](#); Gilroy, Schreckenberg, & Seiler, [2013](#); Jin et al., [2015a,b](#); Morana & Sawkins, [2000](#); Roca & Tularam, [2012](#); Roca et al., [2015](#)). However, other studies on the systematic risk and return of investment in the water industry have been done in great depth (Wong et al., [2007](#)). Perhaps the study by Geman and Kanyinda ([2007](#)) is the

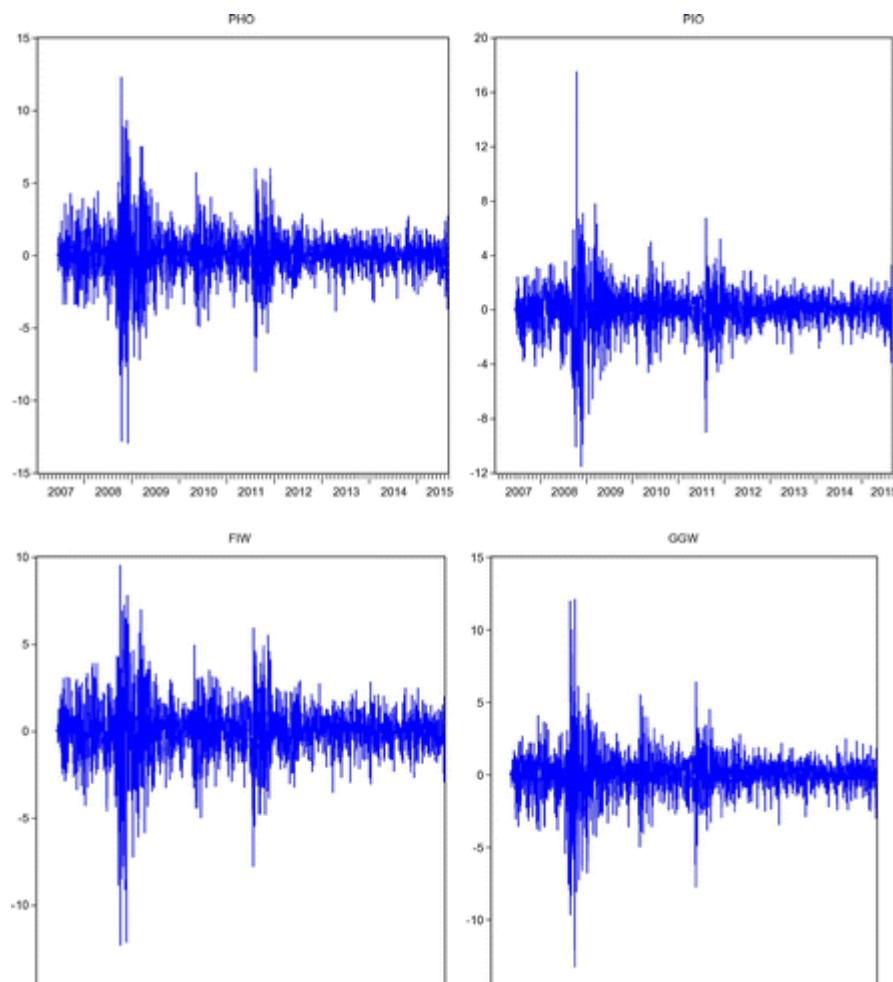
performance and volatility of the World Water Index (WOWAX) (December 2003–June 2006) and find that the index increased by more than 80% during this period (Jin et al., 2015a).

3. Data and methodology

3.1. Data

This study utilizes the PHO, PIO, First Trust ISE FIW and Guggenheim S&P Global Water Index ETF (GGW), all obtained from the Thomson Reuters DataStream database. The particular water exchange traded funds have been selected based on the completeness of data starting from the same date, 15 June 2007. The sample period is from 15 June 2007 to 31 August 2015. Daily data utilized is in the form of returns on the price indices; as calculated by the following formula: $R_t = \ln(P_{t+1}/P_t) \times 100$; the returns are in US dollars (Figure 1).

Figure 1. PHO, PIO, FIW, and GGW water exchange traded funds movement, 2007–2015



3.2. Methodology

Quandt (1958), introduced a method of estimating the position of a single switching point for a linear regression system obeying two regimes. Goldfeld and Quandt (1973) presented a particularly useful version of these models which is called a Markov switching model. Hamilton (1989) proposed a multivariate generalization of the univariate Markov switching model. Particularly, we use Calice, Mio, Štěrba, and Vašíček (2015) and Calice, Ioannidis, and Miao (2012). According to them

$$\sigma_{12} = (1 - S_{1,t})\sigma_{1h2} + S_{1,t}\sigma_{1l2}, \sigma_{1h2} > \sigma_{1l2}$$

$$\sigma_{22} = (1 - S_{2,t})\sigma_{2h2} + S_{2,t}\sigma_{2l2}, \sigma_{2h2} > \sigma_{2l2}$$

When both $S_{1,t}$ and $S_{2,t}$ are zeros, the two components will be in the high volatility state as $\sigma_{12} = \sigma_{1h2}$ and $\sigma_{22} = \sigma_{2h2}$ similarly if $S_{1,t}$ and $S_{2,t}$ equal 1, the two components will be in the low volatility state since $\sigma_{12} = \sigma_{1l2}$ and $\sigma_{22} = \sigma_{2l2}$.

3.3. Transition probabilities

The regime generating process in Markov switching model is an ergodic Markov chain with a finite number of states which means that the current value of the process at time t depends only on its previous value at time $t - 1$ (Calice et al., 2012, 2015) and Garcia (1998). The transition probabilities from one state to the other are shown below

$$y_{1t} = \alpha_0 + \alpha_1 S_{1,t} + \omega_1 \varepsilon_{1t}$$

$$\phi_{1,00} = \Pr(S_{1,t} = 0 | S_{1,t-1} = 0)$$

$$\phi_{1,11} = \Pr(S_{1,t} = 1 | S_{1,t-1} = 1)$$

$$y_{2t} = \alpha_0 + \alpha_2 S_{2,t} + \omega_2 \varepsilon_{2t}$$

$$\phi_{2,00} = \Pr(S_{2,t} = 0 | S_{2,t-1} = 0)$$

The transition probability matrix P can be defined as follows:

$$P = \phi_{11} \phi_{12} \dots \phi_{1m} \phi_{21} \phi_{22} \dots \phi_{2m} \dots \phi_{m1} \phi_{m2} \dots \phi_{mm}$$

Markov chain probability of P_{ij} is shown as follows:

$$\rho_{k,i,j} = \Pr(S_k, t=j | S_{k-1}=i) \text{ with } \sum_j \rho_{k,i,j} = 1, \forall i \text{ and } k = \{1, \dots, m\}$$

3.4. Regime probabilities

This procedure estimates the coefficient matrix, the variance-covariance matrix for each regime, the transition matrix, and the optimal inference for the regimes throughout the sample period. The latter is referred to as the regime probabilities ψ_{tt}^{\wedge}/T defined subsequently, where T denotes the end period for the estimation.

$$\psi_{tt}^{\wedge} = \Pr(S_t=i) \text{ for } i=1, \dots, m \text{ and } t=1, \dots, T$$

Three types of regime probabilities are involved. However the choice depends on the differences in the existing results. The three types of regime probabilities are written as follows:

$$\psi_{t/Tt}^{\wedge}, \zeta < t$$

$$\psi_{t/Tt}^{\wedge}, \zeta = t \text{ filtered regime probabilities}$$

$$\psi_{t/Tt}^{\wedge}, t < \zeta \leq T \text{ smoothed regime probabilities.}$$

3.5. The relationship between idiosyncratic risk and return

We test the following Markov switching model by following the studies of Krolzig (1997), Roca and Wong (2008), Guidolin and Hyde (2009), and Huimin et al. (2010). We can regress that model as follows:

$$Y_t = \mu_s t + \sum_k \beta_k s_t Y_{t-k} + \varepsilon_t$$

where Y_t is a multivariate regime switching process driven by a common discrete state variable, μ is a vector of intercepts in states, β is the coefficient of market risk premium at lag k , and $\varepsilon_t \sim N(0, \Sigma_s)$ is the vector of idiosyncratic return that is assumed to be joint

Recently, financial models on the relationship between idiosyncratic risk and returns have been developed by Bali et al. (2005), Roca and Wong (2008), Angelidis and Tessaromatis (2009), and Huimin et al. (2010). We have explored the relation between idiosyncratic risk and returns by regressing daily water ETFs stock returns by implementing of the CAPM with a time-varying coefficient.

$$R_t = \mu_0 + \beta_i PHO_t PHO + \beta_i PIO_t PIO + \beta_i FIW_t FIW + \beta_i GGW_t GGW + \varepsilon_t$$

where R_t represents the returns on an investment of water ETFs; $i=1,2,\dots,N$ $\beta_i PHO$, $\beta_i PIO$, $\beta_i FIW$, and $\beta_i GGW$ are the time series regression coefficients of R_t ; $i=1,2,\dots,N$ in the equation to emphasize age returns across assets; $ftPHO$, $ftPIO$, $ftFIW$, and $ftGGW$ are the returns on the CAPM. μ_0 is the intercept and ε_t is the error term.

Further, we test the following model to run a regression of the relationship between idiosyncratic risk and returns of water ETFs in regime t by following Angelidis and Tessaromatis (2009) and Huimin et al. (2010) by running OLS time-series regressions. According to them

$$R_t = \mu_0 + b X_t + \xi_t$$

where R_t represents the returns on an investment of water ETFs, μ_0 is the intercept, X_t is the idiosyncratic risk, and ξ_t is the error term.

4. Empirical results

4.1. Data preliminaries

From Table 1, it can be seen that stock returns are positive except PIO. The largest positive mean return (0.013%) is for FIW whereas the PIO has the lowest positive mean return (-0.009). The kurtosis values of all water stock exchange traded funds returns are higher than three, thus the returns distribution could be fat-tailed. As the skewness values are in general negative, the skewness values are the asymmetric tail. Since the Jacque-Bera results are statistically significant and reject the null hypothesis of a normal distribution for all stock returns. Nonetheless, our analysis is robust as models are usually robust as well in non-normal cases.



4.2. Unit root test

The presence of a unit root in the water ETFs returns are tested using both the augmented Dicky-Fuller (ADF) and Phillips-Perron (PP). Table 2 shows that ADF and PP testing procedures of the data PHO, FIW, and GGW at 1%; and PIO at 5% level of significance. Hence, the ADF and PP tests consistently reject the null hypothesis. Both unit root tests suggest the funds' returns those of stocks are stationary. Consequently, the returns time series are used in the subsequent analysis without further differencing or testing for co-integration.

Table 2. Unit root tests results



4.3. Regime and transition probabilities

Table 3 presents the corresponding probabilities and characteristics for each of the three regimes in the PHO, PIO, FIW, and GGW models. Table 3 shows the funds stayed most of the time; and the longest time in Regime 2. The three numbers in a particular row show the probability of a regime shifting into Regime 1, 2, and 3, respectively. For example, in row 1, the first number 96.44%, which indicates the probability of Regime 1 shifting into Regime 1, this means Regime 1 staying in itself; while the second number 1.63% shows the probability of Regime 1 switching to Regime 2; 21.37% shows the probability of Regime 2 switching to Regime 3. 30.52% is the probability of Regime 3 staying in itself (and therefore, 13.95%, 41.33%, and 44.71% probability of shifting to Regimes 1, 2, and 3, respectively). Hence, 29.90%, 39.56%, and 30.52% are probabilities of shifting to Regime 1, 2, and 3, respectively.

Table 3. Transition probabilities and characteristics of Markov regime switching models



For the PIO, the probability of staying in Regime 1 is 50.78% (and consequently 27.83% is the probability of switching to Regime 2; and 21.37% probability of switching to regime 3). 33.42% is the probability of Regime 3 staying in itself and hence, 25.12% and 41.43% probability of shifting to Regime 2 and 1, respectively. Therefore, 43.46%, 2.75%, and 97.22% are probabilities of shifting to Regime 1, 2, and 3, respectively, as well.

Similarly, for the FIW, the probability of staying in Regime 1 is 35.87% (therefore 45.68% probability of switching to Regime 2; and 43.46% probability of switching to Regime 3); and 20.2345% probability of Regime 3 staying in itself (95.1025.12% and 2.13% probabilities of shifting to Regime 2 and 1, respectively). Consequently, 43.46%, 02.75%, and 36.30% are probabilities of shifting to Regime 1, 2, and 3, respectively, as well. Again the probability of staying in Regime 1 of GGW is 08.81% (and therefore 39.50% probability of switching to Regime 2; and 51.68% 21.37%) and 02.09% in Regime 3. Consequently, 96.29% and 01.6041.43 are probabilities of shifting to Regime 2 and 1, respectively). Hence, 61.30, 26.94, and 11.75% are probabilities of shifting to Regime 1, 2, and 3, respectively, as well.

Thus, these figures show that there is a high and low probability of switching between Regimes 1 and 3. This means that these regimes are highly and lowly volatile, which further confirms that the water exchange traded funds with the water sector is characterized by more regime stability compared to the funds relationship with the equity market (Roca, Tularam, & Wong, [2011](#)).

A graphical representation of the regime probabilities is presented in Figures 2-4.

[Figure 2. One-step ahead predicted regime probabilities.](#)

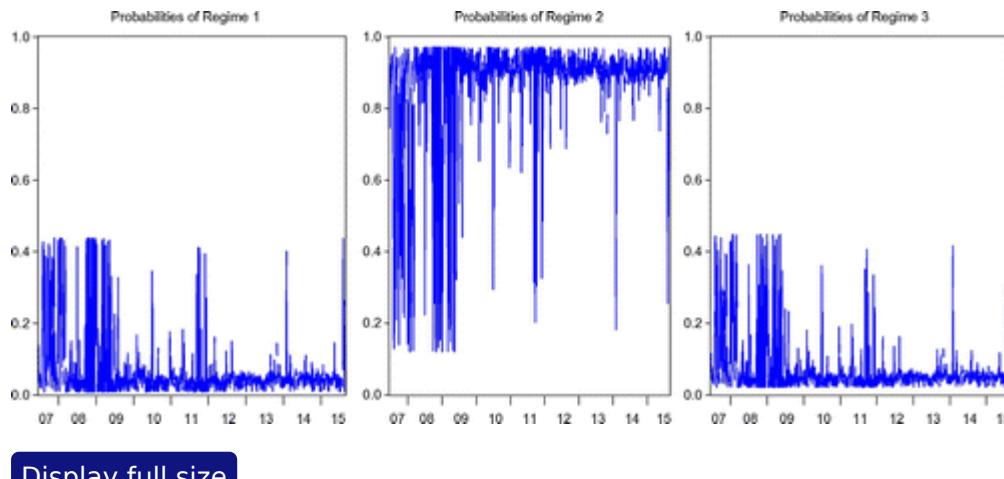
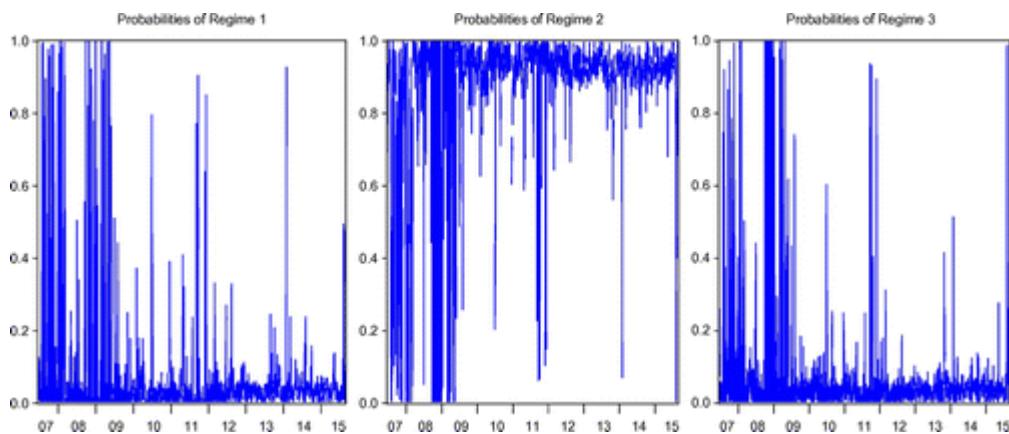
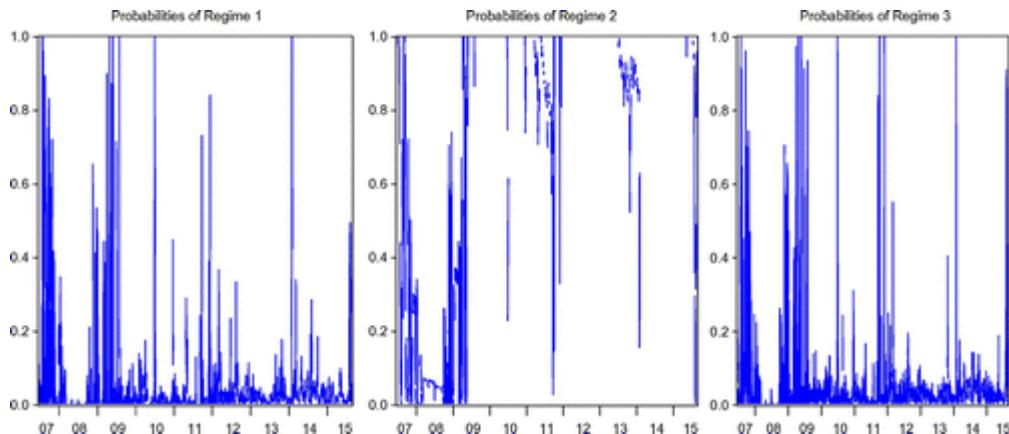


Figure 3. Filtered regime probabilities.



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Figure 4. Smoothed regime probabilities.



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4.5. Idiosyncratic risk

From Table 4, it can be seen that idiosyncratic risk for the four ETFs through the three regimes; i.e. SIGMA (σ) for regressions across regimes from the Markov switching model output. The SIGMA (σ) of these ETFs indicates that the movements of ETFs' returns are in a same direction to their benchmarks over one day. The idiosyncratic risk for most of the exchange traded funds move from low volatility (Regime 2) to very low volatility (Regime 1 and 3). In other words, SIGMA (σ) seems to be assessed in low volatility water exchange traded funds. This result shows that as idiosyncratic risk is not constant during the three regimes for Markov switching heteroscedasticity (MSH), and

same way affect the total risk. Now this question arises: why water ETFs' idiosyncratic risk is so lowly regime dependent. However, it is noted that Water ETFs with decreasing competitive stress have to shift some of their attention to investors. Further studies are needed to investigate the systematic risk for the financial performance of ETFs and their corresponding benchmark indices during different regimes because of the low volatility of four ETFs.

Table 4. Estimated idiosyncratic risk

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4.6. The relationship between idiosyncratic risk and return

From Table 5 it can be seen that during Regime 1, the beta coefficients of four water ETFs are found to be positive. The Three ETFs (PHO, PIO, and FIW) are significant at the 1% level of significance. The beta coefficients are all positive for the four water ETFs at Regime 2 and Regime 3, respectively. All ETFs are significant at the 1% level of significance during Regime 2. However, three ETFs (PHO, FIW, and GGW) are significant at the 1% level of significance during Regime 3. Overall, the results show that water ETFs' beta coefficients' entire values are less than 1, which implies that water investment has a lower idiosyncratic risk which coincide with Angelidis and Tessaromatis (2009) and most of the beta coefficients are positive and significant at Regime 1, Regime 2, and Regime 3, respectively. The results indicate that idiosyncratic risk has a positive effect on the water ETFs returns during different regimes. Based on the time series data, as the beta coefficients are significant at the 1% level of significance, the results indicate that idiosyncratic risk has foretelling influence for the forthcoming returns. It is noted that the results of idiosyncratic risk and return are not constant during different regimes. Thus, Markov switching model involving time series analysis was suitable for this study.

Table 5. Empirical coefficients of unsystematic risk

[Display Table](#)



5. Conclusion

The objective of this article was to investigate the idiosyncratic risk and return of the water investment. In particular, we examine the time-varying transition probabilities using the Markov switching model. The study utilizes daily returns of four water ETFs from the data-stream database based on the time series data (period 15 June 2004–31 August 2015). In so doing, the study has taken into account of the regime effects.

In this paper, the ADF and PP testing results show that PHO, FIW, and GGW at 1%; and PIO at 5% level of significance. Both unit root tests confirm that the ADF and PP tests consistently reject the null hypothesis and the funds' returns those of stocks are stationary.

The transition probabilities show that there is a high and low probability of switching between Regimes 1 and 3, respectively. The transition probabilities show that three regimes are both highly and lowly volatile. The Markov switching model results show that the idiosyncratic risk of the exchange traded funds (ETFs) are not constant across the three regimes and that the water ETFs appear to have little influence on the idiosyncratic risk. Moreover, the “standard error” terms for regressions across regimes outputs are rather low. In a similar manner, water ETFs affect the total risk. We also identify that the beta coefficients are positive and entire values are less than 1 at Regime 1, Regime 2, and Regime 3, respectively. It seems that water investment has a lower systematic risk and a positive effect on the water ETFs returns during different regimes. Thus, as the Markov switching model is changing when the regime either falls or rises, higher idiosyncratic risk of different regimes illuminating greater returns of water ETFs accordingly.

Due to the under diversification of the water investment form, the idiosyncratic risk of the water investment can play an important role in terms of the total risk and it can allow changes across three regimes. This study has important implication for the water investors and international institutions in decision-making need to include water investment in portfolio. Further, this research study can be extended along with a complementary investigation on the financial performance of the water ETFs' and their corresponding benchmark indices during different stock market regimes.

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