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A Major Qualifying Project Report
submitted to the Faculty of
WORCESTER POLYTECHNIC INSTITUTE

in partial fulfillment of the requirement for the
Degree of Bachelor of Science

by

Aristotelis Papadopoulos

Date: April 20, 2017
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Abstract

The clean energy sector is a unique asset class and is growing rapidly nowadays, since it provides alternatives for energy production and sustainability for the future. By gathering data, such as implied volatility, volume, and moving averages, we analyzed patterns in price movements and created trading strategies, which were then evaluated, based on performance. Although we expected trades to occur more often, the renewable energy sector is currently growing and therefore there aren’t a lot of opportunities for trading yet. However, profit can still be made, since energy asset pricing has increased substantially over the last decade.

Exordium

“We are like tenant farmers chopping down the fence around our house for fuel when we should be using Nature’s inexhaustible sources of energy -- sun, wind, and tide. I’d put my money on the sun and solar energy. What a source of power! I hope we don’t have to wait until oil and coal run out before we tackle that.”

-Thomas Alva Edison, 1931

The world is at a technological peak right now and is advancing very rapidly. Almost every day, barriers previously thought to be unbreakable are shattered. So, if that is the case, then why does Edison’s famous quote still stand true after so many years? Fossil fuel consumption is not dropping and scientists predict that the world will be out of oil and gas by 2060.¹ There is no question that humans live an unsustainable lifestyle nowadays, because it is heavily dependent on limited resources. If the world keeps using oil and gas at these excessive consumption rates, greenhouse gases in the atmosphere, along with other environmental hazards, would be too much

for the planet to take. Fossil fuels emit incredible amounts of carbon dioxide, especially coal, while global temperatures continue to rise at a slow, but steady, rate.

Renewable energy is the ongoing alternative source, which is defined as “any naturally occurring, theoretically inexhaustible source of energy, as biomass, solar, wind, tidal, and hydroelectric power that is not derived from fossil or nuclear fuel”\(^2\). These types of energy are considerably new in comparison to the non-renewable ones. Even though it can be a more expensive alternative, with every day that passes, more people latch on to the idea of switching to renewable energies. The market is evolving more, as environmental awareness grows and pollution becomes a more obvious threat in our lives. As a result, the stock market is also affected by these shifts, giving more space for renewable energy indices to expand their share.

**Background**

The renewable energy sector is becoming a very promising one, claiming more and more market share, and therefore it is important to pay attention to how these stocks have, and will perform in the coming years. Alternative energy continues to claim market share in the energy sector, and even though traditional energy companies are currently dominating it, clean stocks are prospering. A few companies combine alternative energy and conventional energy to survive, while others attempt to focus exclusively on renewable power generation.\(^3\) In order to have a spherical view of this growing sector, various clean energy equities have to be analyzed and tested, ranging from production, which is directly related, to new technologies and distribution, which are indirectly related to energy.

Initially, we looked at seven total renewable indices. These were picked with the purpose to represent the whole sector, so that the results are as accurate and specific as possible. This sample of companies is presented in the table below, along with their description and range.


Table 1: Sample Description (Initial)

<table>
<thead>
<tr>
<th>Ticker</th>
<th>Description</th>
<th>Sample Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>PEGI (NASDAQ)</td>
<td>Pattern Energy has a portfolio of 18 wind power facilities, in the US, Canada, and Chile.</td>
<td>03/01/14 – 11/11/16</td>
</tr>
<tr>
<td>RNW (TSE)</td>
<td>TransAlta Renewables has a portfolio of wind, hydro and gas power generation facilities, operating in Canada and the US.</td>
<td>03/01/14 – 11/11/16</td>
</tr>
<tr>
<td>EVA (NYSE)</td>
<td>Enviva Partners (limited partnership) aggregates wood fiber, and processes it into wood pellets. These are used by customers to replace coal in power generation, and they operate in the UK and Europe.</td>
<td>01/05/15 – 11/11/16</td>
</tr>
<tr>
<td>GPP (NASDAQ)</td>
<td>Green Plains Partners (limited partnership) provides ethanol and fuel storage, terminal and transportation services and the operation of these assets (US).</td>
<td>26/06/15 – 11/11/16</td>
</tr>
<tr>
<td>NYLD (NYSE)</td>
<td>NRG Yield owns a portfolio of contracted renewable and conventional generation and thermal infrastructure assets in the US.</td>
<td>15/05/15 – 11/11/16</td>
</tr>
<tr>
<td>HASI (NYSE)</td>
<td>Hannon Armstrong Sustainable Infrastructure provides debt and equity financing to energy efficiency and renewable energy markets.</td>
<td>03/01/14 – 11/11/16</td>
</tr>
<tr>
<td>REGI (NASDAQ)</td>
<td>Renewable Energy Group is a North American advanced biofuels producer and developer of renewable chemicals.</td>
<td>03/01/14 – 11/11/16</td>
</tr>
</tbody>
</table>

As you can see from Table 1, the sample range of the data goes up to two years. This happens because most clean energy companies just entered the market a couple of years ago, and therefore there isn’t a lot of data available. As we try to get an overview of their performance we had to graph them out, so that we can obtain a visual representation as well (see Figure 1).
As the research progressed, more renewable energy indices were added to the list, so as to broaden the spectrum of our focus. By gathering more data, five new stocks were included into the mix, increasing the sample. These are presented below (Table 2), together with their descriptions and sample ranges.
Table 2: Sample Description (New)

<table>
<thead>
<tr>
<th>Ticker</th>
<th>Description</th>
<th>Sample Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABY (NASDAQ)</td>
<td>Atlantica Yield PLC has a portfolio of contracted assets in the power and environment sectors.</td>
<td>13/06/14 – 01/02/17</td>
</tr>
<tr>
<td>FSLR (NASDAQ)</td>
<td>First Solar has developed, financed and currently operates many of the world’s largest grid-connected PV power plants.</td>
<td>17/11/06 – 01/02/17</td>
</tr>
<tr>
<td>CVA (NYSE)</td>
<td>Covanta is a leader in sustainable waste and energy management. They convert waste into renewable energy to power homes.</td>
<td>07/01/05 – 01/02/17</td>
</tr>
<tr>
<td>NEE (NYSE)</td>
<td>NextEra Energy, Inc. is a leading clean energy company and one of the largest wholesale generators of electric power in the US.</td>
<td>07/01/05 – 01/02/17</td>
</tr>
<tr>
<td>SCTY (NASDAQ)</td>
<td>SolarCity is a full-service solar provider, which makes clean energy available to homes, businesses, etc.</td>
<td>14/12/12 – 01/02/17</td>
</tr>
</tbody>
</table>

From this table, we can see a slight difference in the sample ranges, since there are two stocks which cover more than a decade in time. Below is the time-series plot for all the new indices.

Figure 2: Time-Series Plot B
Even though there is a small time frame to work with and generally slow asset pricing growth, considering oil and gas “giants” in the energy sector, it is possible to construct a performance evaluation and see if they can be profitable. In order to find out, we had to deploy market timing strategies and test each stock on different criteria.

Objectives

The project focuses on three main objectives:

➢ Test various market timing strategies using weekly data

➢ Test whether we can earn consistent profits
  ➢ Challenge the Efficient Market Hypothesis (EMH)

➢ Evaluate and rank the strategies based on performance

The first objective is to employ different strategies, which will help analyze patterns in price movements and allow us to create thresholds on which we can trade. The second objective is to test the thresholds that we have created in order to find out if we can earn consistent profits, by calculating the percentage change in the movements. This is an important indicator for challenging the EMH. The efficient market hypothesis states that it is impossible to “beat the market”, because stock market efficiency causes existing prices to reflect all relevant information. According to this theory stocks always trade at their fair value, and therefore it is impossible to outperform the overall market through expert stock selection or market timing. As such, the only way for an investor to have a chance at higher returns is to purchase riskier investments.  

4 Although the EMH is a highly controversial topic of discussion, there have been investors, like Warren Buffett, who have consistently beaten the market over long periods of time. With our analysis, we are aiming to disprove this theory, because we believe that our

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market timing strategies will return consistent results. Lastly, the final objective is to evaluate and rank the market timing strategies, based on their performance on the clean stocks and the cumulative percentage changes.

**Methods**

**Market Timing Strategies**

As far as data gathering is concerned, we decided to create the different market timing strategies, based on three critical factors that affect price movement. In order to access all of the required financial data, we used Bloomberg Terminal to pull information on each renewable energy index, regarding their price, volatility (20 Day), volume, etc. for the according time period (weekly data). This information allowed us to complete the necessary calculations and derive the market timing strategies. The three strategies focus on volatility, trade volume, and moving averages, as presented below.

1. **Trading on Volatility Shocks** – shocks in the statistical measure of the dispersion of returns for a given security or market index.\(^5\)

2. **Trading on Trade Volume Shocks** – shocks in the total quantity of shares or contracts traded for a specified security.\(^6\)

3. **Trading on Moving Averages (MA)** – average price of a security over a defined number of periods\(^7\) (identifying crossovers for 4- and 12-week MA)

These three factors were chosen, because they play an important role during trading and therefore propose a concrete foundation for the analysis.

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Anatomy of Strategies

Volatility shocks

Volatility is basically a measurement of the amount of uncertainty or risk about the size of changes in a security’s value. A higher volatility suggests that a security’s price can potentially be spread out over a larger range of values. This means that the price can change dramatically over a short time period in either direction, which creates uneasiness in the market place. A lower volatility suggests changes in value at a steady pace over a period of time, and therefore means that investors are comfortable and the market place is calm.

When gathering data, we decided to include volatility, since it is an important parameter in most trading portfolios. More specifically, we chose the 20-Day volatility values, because there are 22 trading days on average in a month. To begin with we calculated the percentage change in volatility and performed a descriptive statistical analysis, in order to gain an overview of the data set. From there, we created trading thresholds, which are based on how much the volatility values deviate from their mean. These thresholds are meant to act as trading benchmarks for investors, which indicate when trades should be performed. The thresholds were tested three times, using a plus one, two, and three standard deviations from the mean respectively. As was expected, the smaller the deviation threshold, the more often trades happened, and vice versa. Over the time period that we had for each clean stock, trades that were performed when using the +2 S.D. had a greater cumulative percentage increase than the other two, making it the most profitable. Therefore, we decided to use this indicator for the volatility shocks strategy. Below is a graph of one of the renewable energy indices, showing price (white) and volatility (red) values.
As presented in Figure 3, there are a couple of volatility spikes that are easy to spot, and we can see that at these points there is a sudden and sizable price change. This shows how the thresholds that we created can be utilized to provide a safety net against dramatic changes in price, and to allow investors to make an attempt at profits.

**Trade volume shocks**

Trade volume represents the total quantity of shares and contracts traded, and also includes the total number of shares transacted between a buyer and seller during a transaction. When securities are more actively traded, their trade volume is high, and vice versa. Each market exchange tracks its trading volume and provides volume data. Investors use this data to check the market’s activity and liquidity. Higher trade volumes imply higher liquidity, better order execution and a more active market for connecting buyer and seller.

This is one of the simplest technical factors analyzed by traders when considering trade markets and also when deciding specified times for a transaction. Since it is an important factor in an investor’s decision making process, we decided to create a strategy that bases its trading thresholds on volume shocks. Like the volatility strategy, we tested three different standard deviation boundaries, and realized that the +1 S.D. was the most profitable one. Below is a visual representation of one of the renewable energy stock’s trade volume.
Moving average (MA)

The moving average is a widely used indicator in technical analysis, which helps smooth out price action by filtering out the “noise” from random price fluctuations. It is considered a trend-following or lagging indicator because it is based on past prices. The most common applications of MA’s are to identify the trend direction and to determine support and resistance levels. By comparing a pair of moving averages and finding their crossovers, investors know whether to expect an uptrend or a downtrend, and therefore can make the appropriate transactions. If a shorter-term moving average is above a longer-term average, an uptrend is to be expected. On the other hand, a long-term average above a shorter-term one signals for a downward movement in the trend.

As it is considered one of the simplest, yet holding crucial information, we decided to include moving averages into the strategy. This market timing strategy is slightly different than the previous ones, as it bases its trading thresholds on MA crossovers. We chose a 4-week and a 12-week MA (one month and three months interval) to compare. Figure 5 below shows the two moving averages and their movement on the price line graph of the CVA renewable stock (see Appendix 1 for the rest of the indices and their graphical representations).
Whenever the 4-week MA crosses the 12-week one from below going up, a trade command is given to buy, since we expect an increase in price. On the opposite side, when the 4-week MA crosses the 12-week one from top to bottom, a trade command is given to sell, because we expect a decrease in price. By using this strategy on the renewable energy indices, we calculated the cumulative percentage change in price, in order to test its profitability.

Evaluation

Once the trading thresholds were established for each market timing strategy, the results were clear, regarding the performance of each stock. By looking at the cumulative returns, we were able to determine whether each index was profitable or not, after each strategy. From our findings, a big majority of the renewable energy securities indicated substantial profits with all three strategies (see Table 3). This was a positive first impression, as it starts to prove how promising this sector is. Although most indices performed well, there were some exceptions, such as the PEGI ticker, which resulted in losses for all three strategies used. Even though this has a negative connotation, the upside is that in combination with the successful results, they allow us to challenge the Efficient Market Hypothesis, by showing consistency in returns. This means that the market timing strategies are indeed effective for trading, since they will not provide random outcomes.
Table 3: Performance Evaluation A (%)

<table>
<thead>
<tr>
<th>Rank</th>
<th>Ticker</th>
<th>Volatility Shocks ≥ (μ+2σ)</th>
<th>Trade Volume Shocks ≥ (μ+1σ)</th>
<th>Moving Average {MA (4) = MA (12)}</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>EVA (NYSE)</td>
<td>79.52</td>
<td>47.24</td>
<td>64.51</td>
</tr>
<tr>
<td>2</td>
<td>HASI (NYSE)</td>
<td>50.58</td>
<td>47.81</td>
<td>57.27</td>
</tr>
<tr>
<td>3</td>
<td>GPP (NASDAQ)</td>
<td>22.74</td>
<td>18.86</td>
<td>37.78</td>
</tr>
<tr>
<td>4</td>
<td>RNW (TSE)</td>
<td>18.81</td>
<td>31.55</td>
<td>29.96</td>
</tr>
<tr>
<td>5</td>
<td>NYLD (NYSE)</td>
<td>-2.87</td>
<td>-27.23</td>
<td>11.04</td>
</tr>
<tr>
<td>6</td>
<td>PEGI (NASDAQ)</td>
<td>-27.43</td>
<td>-33.03</td>
<td>-18.22</td>
</tr>
</tbody>
</table>

From the table, we can see that performance varies for each stock and strategy. The indices are ranked in order of profitability from top to bottom. EVA is showing top performance in all three strategies, yielding the highest returns. In the case of NYLD and PEGI, the market timing strategies do not seem to be a strong trading approach, since we got negative results from the thresholds that were used.

As far as ranking the strategies is concerned, the moving average one came first in terms of performance. By using this strategy investors have the potential to gain more profit, than with the other two. The volatility shocks strategy yielded a lot of profits as well, coming really close to the MA’s. However, it had some negative returns, for a few the renewable energy stocks, which were the reason for its lower rank. Lastly the trade volume shocks came in third, because this strategy, even though it was profitable overall, resulted in the most losses. When comparing its results to the other two, we can deduce that the transaction thresholds were not as accurately positioned. Therefore, trade volume is not as strong a factor/indicator in trading decisions, as volatility and moving averages.
Similar values were obtained from the second set of renewable energy indices that were tested against the three market timing strategies. The table below presents the rest of the stocks along with their rank, based on the total profits which were accumulated.

Table 4: Performance Evaluation B (%)

<table>
<thead>
<tr>
<th>Rank</th>
<th>Ticker</th>
<th>Volatility Shocks ${\geq (\mu+2\sigma)}$</th>
<th>Trade Volume Shocks ${\geq (\mu+1\sigma)}$</th>
<th>Moving Average ${\text{MA (4)} = \text{MA (12)}}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>CVA (NYSE)</td>
<td>92.03</td>
<td>53.42</td>
<td>70.35</td>
</tr>
<tr>
<td>2</td>
<td>FSLR (NASDAQ)</td>
<td>65.40</td>
<td>45.39</td>
<td>57.27</td>
</tr>
<tr>
<td>3</td>
<td>NEE (NYSE)</td>
<td>40.75</td>
<td>25.67</td>
<td>48.23</td>
</tr>
<tr>
<td>4</td>
<td>ABY (NASDAQ)</td>
<td>13.93</td>
<td>28.20</td>
<td>39.10</td>
</tr>
<tr>
<td>5</td>
<td>SCTY (NASDAQ)</td>
<td>-4.06</td>
<td>-14.51</td>
<td>19.64</td>
</tr>
</tbody>
</table>

There is some variation in profit, as we can see from the table above, however there is still consistency in results, just like in table 3. Again, there seems to be an exception, for example SCTY, which produced losses for the two first strategies, but was profitable when using the third one (MA). After the second set of results, it became more obvious which strategy was more dominant in terms of returns. The MA’s come in first place, since they continue to outperform and yield the highest profits, with volatility shocks coming second, and trade volume third.
Interdisciplinary Relevance and Future Application

This analysis is directly related to other disciplines than finance, and with their help, investors can improve their efficiency while trading. For example, basic knowledge of statistics and psychology are required to analyze data and react to volatility, which describes the overall sentiment of the market. Furthermore, with the use of computer science knowledge, investors can create trade algorithms that will transact based on the thresholds provided, by employing programming languages. The different disciplines which are related to this project, along with some future applications of the analysis, are the following:

➢ **Computer Programming (trade algorithm)**

➢ Where you need to program an algorithm to trade on given thresholds. In other words, when to buy and when to sell. If you want to trade in real time and you are away from your computer, the algorithm will do it for you. Thus, C programming or Python will be useful in carrying out the task.

➢ **Psychology (volatility → risk)**

➢ You need to understand psychology when examining the movements of the VIX. When the VIX is high, it means there is fear and negative emotions in the market place. This leads to declining stock prices. This is when you would buy. On the flip side, when the VIX is low, it is a sign of complacency and investors are perhaps too comfortable. That would be a time to sell. However, you cannot appreciate this strategy completely, unless you understand basic concepts of psychology.

➢ From the perspective of retirement plans and personal finance, the VIX can play a key role in affecting future price movements. In today's market, the VIX is at historic lows. Which means that we as investors may be too comfortable. Usually when the VIX is so low for a prolonged period of time, it means that a market
correction is in the horizon. If a correction does happen, retirement accounts linked to equities will lose money.

➢ **Economics (Renewable Energy Sector)**

➢ It is important to know why this industry is growing so fast and what risks does it face. Unlike other companies, renewable energy companies may not have the liquidity that big monopoly-type oil companies have. Thus, they rely even more on their shareholder wealth. This means that they must be acutely aware of what can affect shareholder wealth in order to be proactive and take the appropriate decisions.

**Conclusion**

To conclude, the market timing strategies proved to retrieve consistent profits for most of the renewable energy indices that we tested, even though a few were losses. After getting the results from the analysis, it was obvious which strategy performed better, judging by profitability. The renewable energy sector has a promising future, as scarcity of resources is becoming a bigger problem with every day that goes by. This is proved by the successful results from the stock evaluation, which shows that investors can make profits by trading on the thresholds of the market timing strategies.

Furthermore, this analysis can be utilized by investors, who can trade efficiently in the sector, and even make improvements to it for maximized profits. With the assistance of computer science and psychology, the strategy performance can be greatly improved, since the transaction thresholds will be more accurate. Trade algorithms can also provide an alternative to active trading, for those who are not able to trade at certain times.

The results from the market timing strategies allowed us to easily rank them, in terms of cumulative percentage change for each stock, and also rank the stocks according to their profitability using the same criteria. Moreover, we were able to identify consistent returns for the majority of the renewable energy indices, regardless of whether they were positive or negative.
This consistency means that we can disprove the Efficient Market Hypothesis, which dictates that in theory every trading strategy produces random returns. Therefore, we come to the conclusion that this sector is currently growing at a steady rate and it would be beneficial for investors to include renewable energy stocks in their portfolios. There are many techniques and strategies that traders can employ for their transactions, but if they chose to use some of our market timing strategies, they have high chances of earning substantial profits.
Appendix

1. Moving Averages Graphs (+ Trade Volume)

NEE

SCTY

ABY
References

12. Bloomberg Terminal