Financial waterBeta®: A Portfolio Approach to Value Corporate Water Risk Exposure

by

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Abstract

The scope of this study is to develop and test a novel approach to quantify and value the impact of water risk exposures on stock volatility, by using a combination of portfolio theory, water resource productivity and natural language processing approaches. Current physical, regulatory, and reputational risks due to water scarcity impact corporate financial performance, strategic corporate decisions, and asset allocation of portfolio investments on financial markets. Even though a diverse range of tools and methodologies exist to assist companies and investors in reducing the impact of water risk, there isn't currently a standard due to the challenge to translate risk into financial metrics. Therefore, this research tests the hypothesis that financial risk exposure from water depends on the type of activity in the watershed, the geographic distribution of a company's facilities and their economic output productivity. We used a sample of 25 companies in 5 different industries. Water risk was represented by waterBeta®, an extension of portfolio theory and a volatility signal that represents the excess water risk from extreme events uncorrelated to the general market trends. A model to estimate waterBeta® was developed prior and was tested to assess the water-impacted stock volatility profile of the companies. After filtering out the systemic market risk, waterBeta® is an idiosyncratic market risk metric with seasonal attributes that measures embedded water risk in stocks relative to the industry benchmark. The results show that utilities and semiconductors industries have higher stock volatility than the other sample industries due to exposure to water risk and that companies within each industry have a different volatility profile depending on the risk management response strategies to water related events. Such information can be used by investors to guide investment decisions, adjust the asset allocations in portfolios, or structure water-risk informed indexes to capture 'water alpha'.

Key words: waterBeta®, stock volatility, water scarcity, asset allocation, portfolio management

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1. Introduction

Society in the 21st century faces a wide range of environmental, social, and economic challenges on its sustainable development path, such as climate change, increasing energy demand, population growth and decrease in availability of natural resources, to name a few. Climate change has led to more extreme weather events, historic droughts, changes in the components of the freshwater systems, and decrease in the availability of water. [1] Population growth is directly correlated to the increase in global water withdrawals due to urbanization, and higher quantity of water demanded per capita. [2] Water is also important for economic growth since every industry relies on water to develop its businesses. The decrease in quantity and quality of water due to climate change and pollution from industrialization is exposing companies to a diverse range of challenges due to higher competition for resources with public water uses. Ultimately, this may lead to a reduction in water allocations for business operations, a growing community opposition for new licenses, increased scrutiny of corporate water management, more stringent water quality regulations, and an increase in the price of water to reflect the full cost of water. [3] Therefore, the World Economic Forum recently named water availability as the "top global risk." [4]

In recent years, these challenges have increased business engagement in corporate water management and response strategies to water risk. Even though a diverse range of tools and methodologies were created to help companies assess and reduce the risk of water scarcity exposure, companies are not reacting fast enough. There is a need for sustainable strategies for water stewardship, and for the development of a common understanding on how to evaluate the impact of water risk. Consequently, the financial impact of water risk on business operations in 2016 increased more than five-fold as compared to 2015 as the result of droughts, floods, pollution costs and increased environmental regulations. [5]

Such corporate financial risks have an impact on the broader capital markets resulting from operational risks, future growth limitations, and potentially the cost of business in a water-constrained world. [6] Therefore, to maximize the returns and reduce the risk on the portfolios, investors should incorporate water-related risks into their portfolio strategy. [4] But given the broad range of geographic and industry-specific water risk exposures, it is difficult for investors to create a comprehensive methodology to identify water risk signals in stock valuation and bond risk rating.

This creates an opportunity to research and develop novel methodologies to quantify the impact of water risk on company-specific stock volatility that can be used as decision tools for corporate water risk management and portfolio asset allocation.

2. Water Scarcity and Corporate Risk

2.1. Water-Related Challenges

According to the 2016 and 2017 Annual Reports of Corporate Water Disclosure from CDP (Carbon Disclosure Project), it is becoming increasingly difficult to provide a reliable supply of water in many parts of the world due to increase in water demand from population growth and economic expansion combined with a decrease in water supply due to climate change and polluted water sources. [7]

Research shows that the major current water-related challenges are:

- Increasing water demand from population growth and economic development, particularly agricultural and industrial use, out of which agriculture accounts for two-thirds of global water use, up to almost 90% in developing countries. [8] This leads to conflicts with local communities and other large-scale water users, regulatory caps on water use, growing demand for water efficient products and technologies and a general higher cost for water. [3]
- Water scarcity and unsustainable supply, which decreases the amount of water available for business activities, creating operational disruptions and financial losses and sometimes even impacting the license to operate. [3]
- Declining water quality due to agricultural and industrial production and inadequate wastewater treatment. This increases not only the cost for wastewater treatment to comply with regulations and obtain the necessary water for daily operations, but also the regulatory restrictions against specific industrial investments. [3]

Such water-related challenges create physical, regulatory, and reputational risks not only to the shareholders of companies in water-intensive industries, but also to owners of physical assets and holders of debt and equity positions in the capital markets. [4]

Risks	Supply Chain	Production Process	Product Use
Physical	Temporary non-availability of water disrupts supply chain	Temporary non-availability of water disrupts operations	Non-availability or scarcity of water required for using product or service limits growth
	Water scarcity drives up input prices	Increased capital expenditure on water treatment, water extraction, or alternative technologies to circumvent water problems raises costs	
	Intensifying competition for scarce water constrains growth	Intensifying competition for scarce water constrains growth	
Regulatory	Suspension or withdrawal of supplier's water license or discharge permits disrupts supply chain	Reallocation to more urgent needs during drought disrupts operations	Non-issuance of water license or restrictions on use of particular products or services due to water intensity raises costs or checks growth
		Suspension or withdrawal of supplier's water license or discharge permit disrupts operations and/or constrains growth	
Reputation	Competition with household water demand constrains suppliers' growth	Increased capital expenditure on wastewater treatment to meet or exceed standards	Public outcry regarding water intensity of product damages brand, reputation, hinders growth
	Responsibility "by association" for suppliers' water pollution damages brand or reputation, hinders growth	Competition with household demands, or pollution incidents, damages brand or reputation, hinders growth	

Source: World Resources Institute.

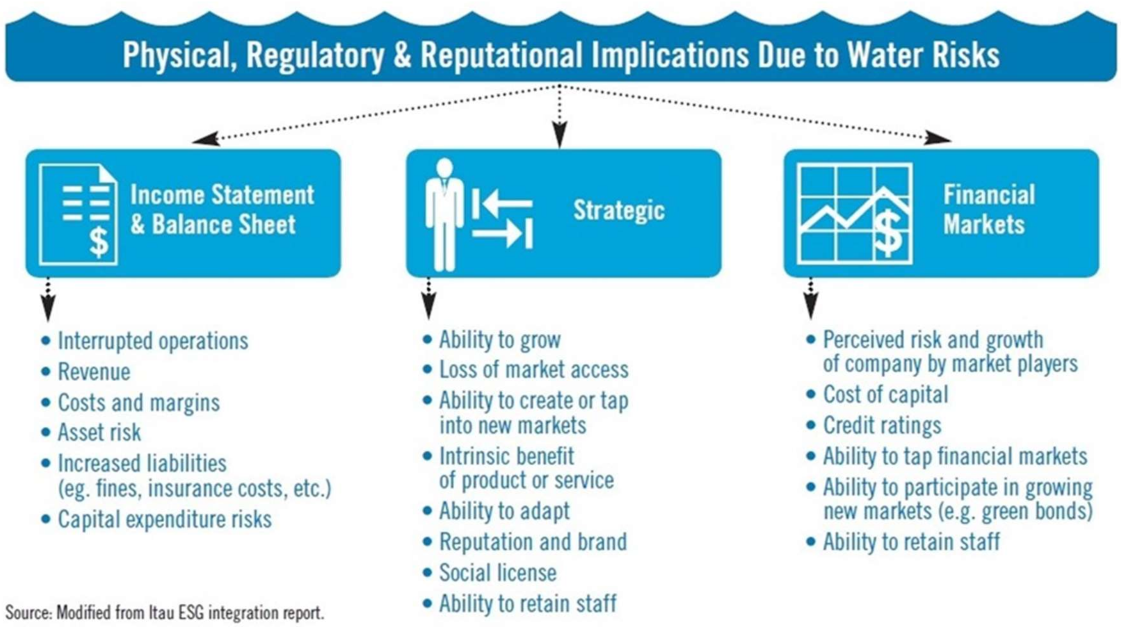
Source: JP Morgan, Watching Water, 2008

Figure 1. Water-Related Risks at the Company Level

An example of how these three risks impact the energy industry: physical risks are related to low and variable water flows and higher water temperatures above the required temperature threshold for water cooling (installing a less water-intensive cooling system can cost more than $1 billion), regulatory risks usually translate into requirements to minimize the impact on broader stakeholder withdrawals and allocations and impact on aquatic life, while reputational risks involve the increasing opposition from local communities against construction or expansion of power plants in water-stressed regions or loss of social license and brand value. [9]

Usually these risks appear in combination, whereby a physical risk (water scarcity) can trigger a regulatory risk (revocation of water license) or a reputational risk (a damage to the brand of the company). It is also important to mention that they may impact to variable degrees the different players in the value chain in a specific industry. Due to the backward (supply chain) and forward (product use) linkages, a company can have exposure to water risk outside its production operations or in countries where it doesn't have facilities altogether, and such risk may not be visible to investors. [2] For example, the food and beverage industries are exposed to water risk through irrigation, weather impacts on agricultural production, and their dependency on agricultural products as inputs in the production processes of the food processing plants.

These risks can have major impacts on corporate financial performance. A disruption in the production process will lead to financial losses due to forgone sales ('opportunity cost'). Disruptions in the supply chain, changes in the regulatory requirements, changes in production processes and increasing water prices will increase the operational costs and decrease gross margins. The risks of disruptions and potential constraints to regular operations may lead to a higher cost of capital for businesses in water-intensive industries. [4]



Source: Ceres, An Investor Handbook for Water Risk Integration, 2017

Figure 2. Modification of Financial Statements or Market Forecasts Due to Water

2.2. Value of Water

Even though there is an increasing interest from corporations to evaluate the impact of water risk on their operations, it is challenging to find a common perspective due to difficulty in quantifying the value of water as a scarce resource. The value of water tends to be higher than the price of water, which usually reflects only the costs to treat and transport water. Such price is heavily subsidized by the governments under the assumption that water is a basic human right and therefore, all citizens should have access to water. [9] The impact of undervaluing water is a decrease in shareholder value and overexploitation of aquifers and other water resources.

The private sector tends to value (access to) water in terms of a financial risk, either as a resource input (i.e., the cost to withdraw or consume water as determined by water prices) or as a liability (i.e., the cost to treat pollution or mitigate regulatory requirements).

Various stakeholders use price, cost and value of water interchangeably, despite the need for developing proper methodologies to quantify the value of water [9]. The price of water is the charge decided usually through government regulations via a local water service provider such as a public or private sector water utility. The cost of water is the total cost linked to water withdrawals and discharges, as well as other costs related to tertiary treatment, energy to move/heat water, numerous administrative costs and capital expenditures, typically on infrastructure. Since the costs to develop new technologies to mitigate the flood risk or increase the drought tolerance are seldom accounted for as a water-cost, water risks typically drive up the water-related capital expenditure costs. [9]

There are currently very few efforts to link the water value with water risk in order to assess the impact on operational performance, except for through extreme weather events. For example, in 2014, the National Flood Insurance Program (NFIP), which offers government-subsidized policies for households and businesses potentially affected by floods in the United States, will increase the rates 18 percent a year until it reaches levels that would reflect the actual risk from flooding. [10]

An increasing number of tools and methodologies are being developed to characterize water consumption, impacts, and risks. [11] While many of the tools address multiple objectives, in general they can be grouped into four major categories based on their primary elements:

- ***Water use accounting tools***, that compare performance and measure progress toward sustainability targets, but do not reflect the associated impact or risk because it does not consider the local watershed context. Tools like EcoLab and TruCost S&P Water Risk Monetizer can provide an estimated future water price extrapolated from various risk trends [11].
- ***Business risk assessment frameworks***, such as Aqueduct (WRI, 2012) that provides an interactive mapping tool to help companies quantify and map a range of water risks at a local scale worldwide, GEMI's Local Water Tool (GEMI, 2012), the Water Risk Filter (WWF and DEG, 2011) that help companies prioritize or select among water management actions at high-risk locations, the Ceres Aqua Gauge (Ceres, 2011) that defines leading

practices such as stakeholder engagement to reduce water risks and can be converted to a number scoring [11]

- ***Reporting and disclosure protocols***, such as Global Reporting Initiative and CDP Water Disclosure intended for information purposes for internal use or reporting to external stakeholders [11]
- ***Standards and certification frameworks,*** such as AWS Standard meant to drive social, environmental, and economic benefits at catchment level

In an effort to create a common understanding of how to evaluate water risk, different stakeholders introduced the notion of "value-at-risk", which has two interpretations: one related to the value at risk from water scarcity and another one which is a finance-based statistical methodology to evaluate the potential of losing a certain amount of money over a certain period. In this second case, value-at-risk or VaR calculates the maximum loss expected (or worst-case scenario) on an investment, over a given time period and given a specified degree of confidence. [12]

3. Investor Water Risk

3.1. Barriers to Water Risk Integration

The estimation of impact of water risk on financial performance of companies is challenging due to insufficient disclosure of water risk management strategies by companies. Corporate annual disclosures or sustainability reports typically focus either on financial data or on water use metrics, but it is usually not known what losses are incurred or what type of investments are made by companies to mitigate water risks [2]. The accounting disclosures such as fluctuations in revenue and cost, together with water management metrics such as water use targets, are necessary to be used by banks and institutional investors to adjust credit ratings, to include the water risk covenants in the loan and corporate bond portfolio, and to adjust financial asset allocations to fixed income and public or private equity investments. Since equity analysts don't have a standardized methodology to identify signals related to water risk on financial assets, the usefulness of disclosure of sustainability metrics to price assets on the stock market and diversify the risk is limited. [13]

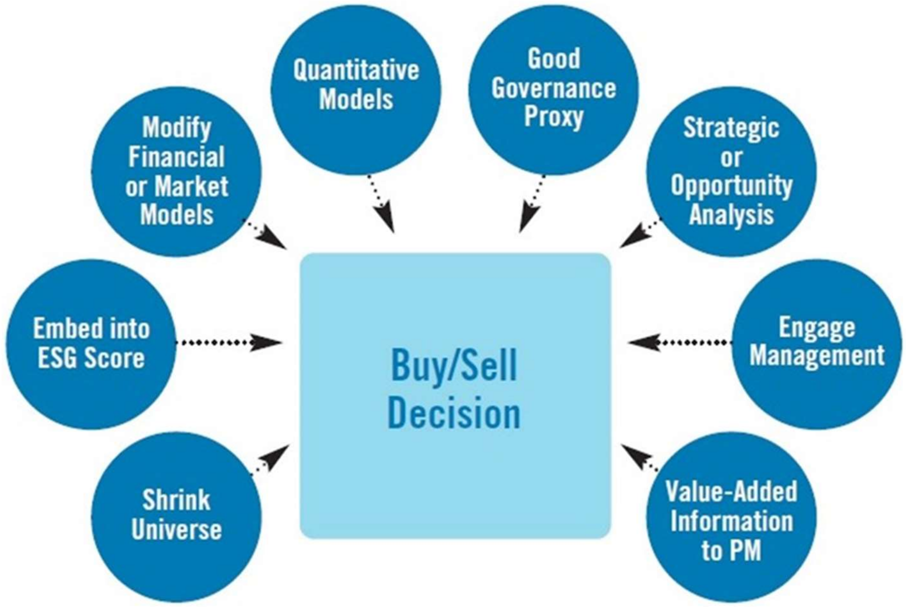
Major barriers to integrate water risk into portfolio management include the lack of clear mandates from clients for fund managers to prioritize water risks in investment decisions, lack of comparable data between companies on corporate water performance (a benchmark), lack of consistent disclosure of water metrics by companies, lack of an effective water risk analysis framework and insufficient consensus on which metrics or should make up a comprehensive water risk analysis. [4] As a result, there is no consistent or standardized approach to quantify business water risk. [14]

3.2. Practices to Analyze Water Risk

When analyzing corporate water risk, investors tend to assess sector- or company-specific risk or performance characteristics, such as water intensity, weather conditions in specific geographies and risk mitigation strategies at corporate level. Investors occasionally employ additional practices to analyze corporate water dependency, such as shadow pricing for water to account for environmental and social costs and benefits as a proxy for water risk analysis, or development of a network of experts to gain more information on the specific water-related reputational, legal or physical risk that may impede operations. [4]

Corporate water risk is rarely included by portfolio managers as a variable in their quantitative models or in portfolio tilting strategies towards companies with either less water-intensive operations or operations in regions with less water scarcity issues. The current approach is to include water risk information in the broader ESG scores, which can be further used in quantitative models and scenario analysis. [4] Financial analysis of the impact of water risk has the potential to help portfolio managers to better advise their customers, develop stronger client relationship and engage corporates.

An overview of how the corporate water risk can influence the investment decision is presented in the figure below.



Source: Ceres, An Investor Handbook for Water Risk Integration, 2017

Figure 3. Different Approaches in Applying Water & ESG Analysis to Buy & Sell Decisions

4. Impact of Water Risk on Company-Specific Stock Volatility

To further the objective of developing consensus on which metrics should be included in investor analysis of water risk, Ceres (an NGO focused on investor shareholder analytics) is working with the Investor Water Hub (asset managers comprising $1.85 trn AUM) to develop methodologies that assess corporate risk exposure influenced by the water intensity of the specific activity [4]. Generally, under this initiative, the tools are classified by investor utility: water dependency, water security, and water response (shown in the figure below).

Source: Ceres, An Investor Handbook for Water Risk Integration, 2017

Figure 4. Water Risk Analysis Dashboard

The results of the analysis of impact of water risk have not been comprehensively included in asset risk-pricing strategies. A potential consensus approach may involve adherence to portfolio theory and align water risk with financial asset performance. Equity analysts and portfolio managers broadly use the Capital Asset Pricing Model (CAPM) to describe and quantify the relationship between systematic risk and expected return for assets, particularly stocks. CAPM is widely used throughout finance for the pricing of risky securities, generating expected returns for assets given the risk of those assets and cost of capital. The general idea behind CAPM is that investors need to be compensated in two ways: time value of money and risk. The time value of money is represented by the risk-free rate and compensates the investors for placing money in any investment over a period of time. The risk-free rate is usually represented by the yield on government bonds such as U.S. Treasuries.

The risk portion is represented by financial beta that compares the returns of the asset to the market over a period of time and to the market premium. Beta thus reflects how risky an asset is compared to overall (systemic) market risk and is a function of the volatility of the asset and the market as well as the correlation between the two. The risk is calculated as the covariance of the stock price of the company relative to the broader market over a specific number of trading days. Or, in other words, the standard deviation of the asset performance of that of the market (e.g.

S&P500 or MSCI World Index), multiplied by the correlation between the share and index price over a specified time period. Financial beta indicates if a company is similarly volatile (1), less volatile ($0 < ß < 1$), or more volatile (> 1) than the market or behaves opposite (negative values). [14]

The challenge with using a simplifying financial beta (resulting from a regression of the security and the market index) is that it is assumed that all information is available to the investor. However, due to information asymmetry in which corporations decide which information to publicly share with investors ('risk signaling'), the share price of a stock doesn't reflect certain events (e.g. water risk) that may affect short-term corporate financial performance. This information is geography- or industry- (and even plant-) specific and may not affect the short-term financial performance of the company nor be reflected in the share price of the company at that point in time. Financial beta relies on knowledge of systemic risk events, as well as company specific financial or other risks as known to the public equities analyst but may not reflect certain idiosyncratic risks that don't have a price, are subject to policy or regulation. For example, the analyst may incorporate carbon emissions information, because there is a carbon market and a carbon policy which may result in higher cost of operations or constrain future growth because of stranded assets.

No similar information is available regarding water risk exposures, unless the company is subject to legal or regulatory action or has been otherwise affected by climate and water risks that have affected or interrupted its operations. In addition to these limitations, water risk is location specific. There is no corporate or industry water use cap or policy.

5. waterBeta® Methodology

5.1. Background

The purpose of the current study is to test a novel approach to quantify and value the impact of water risk on stock volatility, by using a combination of portfolio theory, water resource productivity, and natural language processing approaches. This research uses empirical market and corporate data, supplemented with water resource information at watershed-level and voluntary and SEC disclosures to identify the capital markets impacts resulting from water and extreme events and corporate risk signaling based on portfolio theory. [14]

Portfolio theory states that the volatility (or standard deviation of returns from the benchmark, e.g. the broader market) for individual stock returns has two components: Systemic risk and unsystematic ("idiosyncratic" or "specific") risk. Systemic risks affect all stocks and are influence by variables such as interest rates, currency exchange, recessions etc. Unsystematic risk is specific to individual stocks or industry segments and represents the component of a stock's return that is not correlated with general market movement. [13]

Systemic risk of a security or a portfolio is represented by financial beta, a measure that relates the standard deviation of the asset returns, relative to the broader market benchmark. Water risk represents an idiosyncratic risk, because it is influenced by geographic components, such as the quality and quantity of the watershed and by industry-specific components, such as the level of water intensity of business activities or supply chain dependencies. Therefore, according to the portfolio theory, water risk can be diversified away if the risk can be independently assessed. [13]

The hypothesis for the proposed work is that water risk events impact share price volatility in the market and can be explained using portfolio theory. At the same time, the water risk is influenced by the type of corporate activity in the watershed, its economic output productivity from the water resource, and the geographic distribution of its fixed assets (plants, farms, utilities). [14]

5.2. Steps to Calculate waterBeta®

The first step in calculating waterBeta® is to quantify the value-at-risk (VaR) signal of the company stock relative to its relevant industry sector, to understand whether the risk is systemic (affecting the broader market) or idiosyncratic (industry- or company-specific). The second step is to aggregate and benchmark the productivity of the output of the company relative to the exposure of its assets to water resource risk by using Bloomberg-Aqueduct, an analytical tool developed by the World Resources Institute and available on the terminal, that relates economic output relative to water quality, quantity and regulatory risks in a specific region. The next step is to assess the ratio of net plant, property and equipment (PP&E from the corporate balance sheet) and enterprise value (EV), which represents the operational value generated from the real assets investments. Since the level of water risk depends on how water-intensive the respective operational activity is, the information gathered during the previous steps will be adjusted by a correction factor derived from the amount of water intensity and percentage of water withdrawal in that particular industry. The correction factor captures the intangible impacts of water risk. The last step is to integrate all the prior steps to structure a waterBeta®. The process is captured in the graph below:

Quantify the value-at-risk (VaR) signal of the company stock relative to its industry sector

- Is the risk systemic or idiosyncratic?

Aggregate and benchmark the output productivity of the firm relative to the water resource risk exposure of its assets

- Bloomberg-Aqueduct (analytical tool that relates economic output relative to water quality, quantity and regulatory risks)

Assess the operational value generated from real asset investments

- Ratio of net PP&E and enterprise value (EV)

Adjust by a correction factor

- What is the size of water intensity?
- What is the percentage of water withdrawal in the industry?
- Intangibles (disclosures and value chain exposure)?

The waterBeta® concept and algorithms were developed by Equarius Risk Analytics, a financial technology company (Ann Arbor, MI), and it is structured as an idiosyncratic volatility signal representing excess risk from water scarcity or extreme events, uncorrelated to general market trends. [13]

After aggregating the waterBeta®, a hierarchical cluster analysis can be used to aggregate waterBeta® values for sample companies over a specific timeframe to understand the impact of water on the market risk of the company and ultimately can be used by the asset managers to price premium or discount the financial asset.

5.3. Assumptions of waterBeta® Methodology

Since the waterBeta® methodology was derived based on empirical and theoretical observations, its structuring is based on the following assumptions:

i. It is expressed as a probability loss because the correlation between water risk exposures and returns is unknown;

ii. The benchmark used for calculating waterbeta® for each company is a relevant index for that specific industry;

iii. The risk metric is based on value-at-risk (VaR) analytics, which represents the 95th percentile of quarterly losses based on daily share price (so-called "fat tails"), because water and weather impacts tend to manifest themselves as extreme events over short periods of time;

iv. The risk needs to be adjusted by the direct or indirect exposure of the company's real assets to geographic risks at the watershed, catchment, or sub-catchment levels because corporate operations are impacted by water risk.

Consequently, the terms represented in the computation of waterBeta® are:

$$waterBeta® = f\left(\frac{VaR_{asset}}{VaR_{index}} * Correlation(Price_{asset}, Price_{index}),\ F_{AssetRisk},\ \frac{Net\ PPE}{EV}, Correction\ Factor\right)$$

where VaR represents the quarterly extreme losses (95th percentile) on asset return of a daily time series relative to those of the benchmark on a 10-year time frame; $Price_{asset}$ and $Price_{index}$ represent the daily stock price of the company and respective index traded on the stock exchange; $F_{AssetRisk}$ represents the fraction of economic output of the company in high risk watersheds derived from Bloomberg-Aqueduct maps; The ratio of net PP&E (value of net property, plant and equipment from corporate balance sheet) and enterprise value (EV) represents the operational value generated from real asset investments; The correction factor is derived from the amount of water intensity and percentage of water withdrawal in that particular industry, adjusted by the number of company facilities in water stressed regions and the type of facilities.

6. Application of the waterBeta® Methodology

6.1. Selection Process of Companies Universe

The research was developed in close cooperation with Dana Investment Advisors, an industry partner from the investment community and member of the Ceres Investor Water Hub. The company has a portfolio of holdings in sectors with significant exposures to water risk, including food and beverage, energy utilities, household products and semiconductors. As per the information provided by Lydia Miller, Senior Vice President, the company has a strong interest in integrating environmental, social and governance (ESG) principles in its asset allocation models.

Therefore, the initial list was selected in cooperation with the investors to include five industries (utilities, semiconductors, household products, food and beverages). Specific selection criteria were applied to select final universe of 25 companies (5 companies per industry) used to test the waterBeta® methodology. Even though all the companies are US-listed, they comprise both domestic and international assets. For the current pilot test, waterBeta® analysis was restricted to the US water risk information and output productivity in US water stressed regions. To the initial list of companies, the following specific criteria was applied to get the final sample of 25 companies.

The first step was to take out all the companies for which there is no information in Bloomberg-Aqueduct and companies without a focused line of business based on the NAICS code alignment from the information from FactSet and Mergent Horizon. The reasoning for considering companies with a more focused line of business is that it gives a better perspective on how the activities are tied to water risk and weather event impacts and it allows for a better isolation of the water risk from the diverse type of risks that can affect the daily operations. The second step was to focus on companies with a market capitalization higher than $10 bn (large caps) [15]. The next step was to filter out the companies based on the number of assets (facilities) in US according to information in Bloomberg-Aqueduct. The threshold was set at minimum 15 assets to get a better representation of different types of facilities and of percentage of water withdrawals from the watershed.

The list of the final 25 companies for the 5 industries (5 company per industry) is presented below.

Table 1. Selection of Companies for waterBeta® analysis

Utilities	Semiconductors	Household Products	Food	Beverages
Duke Energy	Intel Corporation	Procter & Gamble	General Mills	Coca-Cola
Southern Company	QUALCOMM	Colgate-Palmolive	Kellogg	Pepsico
Exelon	Texas Instruments	Kimberly-Clark	Tyson Foods	Constellation Brands
Consolidated Edison	Applied Materials	Clorox	Conagra Brands	Brown-Forman Corp.
DTE Energy	Lam Research Corporation	Church & Dwight	Ingredion	Molson Coors Brewing Company

6.2. Selection of Industry Specific Indexes

Since waterBeta® values are computed relative to specific industry indexes, the benchmark indexes for each industry are the following: Utilities: MSCI USA Utilities Index; Semiconductors: PHLX Semiconductor Index; Food and Beverages: S&P Food & Beverage Select Industry Index; Household products: S&P 500 Consumer Staples A major consideration for choosing the respective indexes was the availability of trading data for the 10-year window period, representative-ness of the companies included in the index relative to the companies included in the sample, and the size of the companies included in the index (percentage of large caps).

According to its prospectus, the MSCI USA Utilities Index captures the large and mid cap segments in the US utilities industries. The index includes 32 components, out of which the major 10 includes 4 of the utilities in the sample size of this research (The only utility not in top 10 constituents is DTE). The index gives a weight of 61.25% to electric utilities, which makes it a good fit as a benchmark for the sample electric utilities in this study.

The PHLX Semiconductor Index includes companies with a market capitalization of minimum $100 million classified under design, distribution, manufacture, and sale of semiconductors. The index includes 30 companies and top 10 allocations weight more than 60% in the structure of the index. All 5 sample companies of this research are included in the index.

The S&P Food & Beverage Select Industry Index includes 63 constituents and top 10 companies weight 20.5%. The proportion of the top 10 companies between food and beverages is almost half and half.

S&P 500 Consumer Staples includes companies with a market capitalization of $ 6.1 billion or higher and includes 34 constituents, all US-based companies. Top 10 constituents weight 69.4%.

6.3. VaR and Stock Volatility

In order to apply the described methodology, daily share prices at closing for all 25 US based companies from the 5 different industries were extracted from FactSet over a 10-year period (2007 to 2017). The daily share prices at closing were also extracted from FactSet for the 4 indexes used as benchmark for each industry for the same period. The final goal was to quantify water risk signals from the overall stock volatility data.

Based on the daily stock price, the quarterly correlation between the stock price of the company and the stock price of the index was computed using the correlation formula in Excel, together with the quarterly VaR of the company by using the percentile function in Excel (the 95th percentile of quarterly extreme losses) relative to the VaR of the index calculated the same way. The reason for calculating a quarterly VaR windows is based on the need to capture short-term events, and to be able to see the impact of daily volatility movements. [14] The quarterly correlation between the stock price of the company and the stock price of the index was then multiplied by the ratio of the quarterly VaR of the company and the quarterly VaR of the index to assess the VaR signal of the company relative to the index.

An example of such calculations is presented in Table 2 for Duke Energy, a security from the utilities group.

Table 2. Example computation of VaR outputs from company stock data

Date Quarterly	Quarterly Correlation Price Duke Price MXUSOUT Index	Quarterly VaR Duke	Quarterly VaR MXUSOUT Index	Duke VaR Signal
03/31/08	0.9508	-0.0291	-0.0281	0.9839
06/30/08	0.1261	-0.0222	-0.0152	0.1833
09/30/08	-0.4878	-0.0239	-0.0333	-0.3506
12/31/08	0.6144	-0.0571	-0.0608	0.5771
03/31/09	0.9564	-0.0334	-0.0358	0.8910
06/30/09	0.8534	-0.0198	-0.0198	0.8551
09/30/09	0.9417	-0.0156	-0.0140	1.0476
12/31/09	0.8851	-0.0117	-0.0158	0.6556
03/31/10	0.9069	-0.0148	-0.0110	1.2187
06/30/10	0.6876	-0.0167	-0.0241	0.4748
09/30/10	0.9393	-0.0123	-0.0142	0.8114
12/31/10	0.5469	-0.0087	-0.0083	0.5732
03/31/11	0.8617	-0.0137	-0.0130	0.9062
06/30/11	0.8950	-0.0097	-0.0106	0.8140
09/30/11	0.8379	-0.0160	-0.0204	0.6595
12/30/11	0.9324	-0.0139	-0.0154	0.8402
03/30/12	0.4024	-0.0129	-0.0085	0.6075
06/29/12	0.9498	-0.0113	-0.0082	1.3113
09/28/12	0.8262	-0.0151	-0.0084	1.4864
12/31/12	0.8601	-0.0135	-0.0098	1.1867
03/28/13	0.9338	-0.0073	-0.0066	1.0236
06/28/13	0.9811	-0.0167	-0.0157	1.0485
09/30/13	0.9789	-0.0125	-0.0128	0.9573
12/31/13	0.9343	-0.0111	-0.0106	0.9738
03/31/14	0.7550	-0.0120	-0.0097	0.9349
06/30/14	0.7326	-0.0125	-0.0123	0.7413
09/30/14	0.5804	-0.0159	-0.0156	0.5887
12/31/14	0.9379	-0.0195	-0.0175	1.0439
03/31/15	0.9843	-0.0248	-0.0222	1.1018
06/30/15	0.9719	-0.0179	-0.0135	1.2924
09/30/15	0.9572	-0.0199	-0.0169	1.1240
12/31/15	0.9128	-0.0198	-0.0182	0.9926
03/31/16	0.9287	-0.0169	-0.0098	1.6054
06/30/16	0.9587	-0.0178	-0.0186	0.9185
09/30/16	0.9666	-0.0214	-0.0152	1.3622
12/30/16	0.8665	-0.0255	-0.0215	1.0294
03/31/17	0.9931	-0.0113	-0.0108	1.0392
06/30/17	0.9769	-0.0085	-0.0086	0.9685
09/29/17	0.9666	-0.0102	-0.0092	1.0708
12/29/17	0.9673	-0.0135	-0.0120	1.0833

To estimate the potential expected losses (a worst-case scenario) from impact of extreme events over the 10 years period with a 5% degree of confidence, the 3-month (63 trading days) VaR for a company was multiplied by the company's daily market capitalization. An example of the monetary VaR (expressed in $ MM) is presented below for Duke Energy.

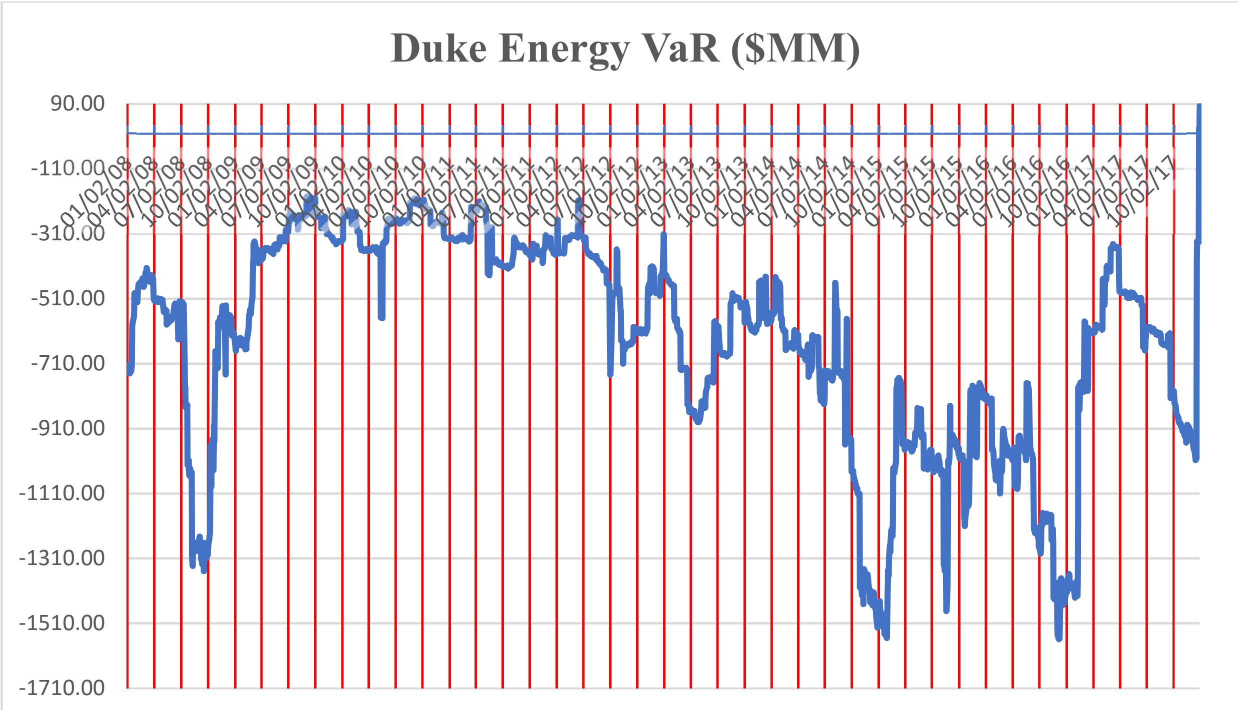


Figure 5. Value-at-Risk analysis for Duke Energy

From this graph we observe four major events (in Q3 2008, Q1 2015, Q3 2015 and in Q3 2016) that have to be further analyzed and compared to the broader utilities index to understand if they were affected by a systemic or by an idiosyncratic risk. An example for the other 4 industries except utilities is included below for Conagra Brands, randomly chosen as well.

Table 3. Example computation of VaR outputs from company stock data

Date Quarterly	Quarterly Correlation Price Conagra Price S&P 500-3020 Index	Quarterly VaR Conagra	Quarterly VaR S&P 500-3020 Index	Conagra VaR Signal
03/31/08	0.8274	-0.0228	-0.0167	1.1293
06/30/08	0.8203	-0.0329	-0.0130	2.0789
09/30/08	0.3851	-0.0201	-0.0158	0.4895
12/31/08	0.7515	-0.0405	-0.0420	0.7237
03/31/09	0.8363	-0.0315	-0.0272	0.9699
06/30/09	0.8385	-0.0228	-0.0135	1.4172
09/30/09	0.8941	-0.0150	-0.0095	1.4060
12/31/09	0.8774	-0.0183	-0.0115	1.4042
03/31/10	0.8759	-0.0120	-0.0086	1.2257
06/30/10	0.7050	-0.0172	-0.0194	0.6261
09/30/10	-0.6043	-0.0219	-0.0085	-1.5625
12/31/10	0.3759	-0.0128	-0.0069	0.6964
03/31/11	0.6490	-0.0136	-0.0084	1.0436
06/30/11	0.7331	-0.0152	-0.0118	0.9439
09/30/11	0.8279	-0.0252	-0.0245	0.8525
12/30/11	0.7234	-0.0137	-0.0137	0.7242
03/30/12	-0.7141	-0.0093	-0.0076	-0.8737
06/29/12	0.1692	-0.0145	-0.0107	0.2296
09/28/12	-0.1049	-0.0120	-0.0101	-0.1252
12/31/12	0.1876	-0.0119	-0.0110	0.2028
03/28/13	0.9593	-0.0084	-0.0054	1.4927
06/28/13	0.7038	-0.0191	-0.0172	0.7797
09/30/13	0.6193	-0.0164	-0.0092	1.1001
12/31/13	0.8855	-0.0123	-0.0092	1.1752
03/31/14	0.3023	-0.0185	-0.0122	0.4587
06/30/14	-0.0175	-0.0158	-0.0064	-0.0434
09/30/14	0.5516	-0.0119	-0.0123	0.5357
12/31/14	0.7068	-0.0137	-0.0109	0.8898
03/31/15	0.2822	-0.0172	-0.0123	0.3957
06/30/15	-0.0545	-0.0127	-0.0079	-0.0875
09/30/15	0.7236	-0.0260	-0.0172	1.0954
12/31/15	0.2698	-0.0228	-0.0132	0.4660
03/31/16	0.9660	-0.0267	-0.0143	1.8068
06/30/16	0.8224	-0.0129	-0.0153	0.6928
09/30/16	0.8979	-0.0151	-0.0119	1.1417
12/30/16	0.4070	-0.0168	-0.0112	0.6116
03/31/17	0.9347	-0.0107	-0.0056	1.7878
06/30/17	-0.0598	-0.0171	-0.0090	-0.1142
09/29/17	0.3885	-0.0204	-0.0101	0.7855
12/29/17	0.9316	-0.0173	-0.0099	1.6278

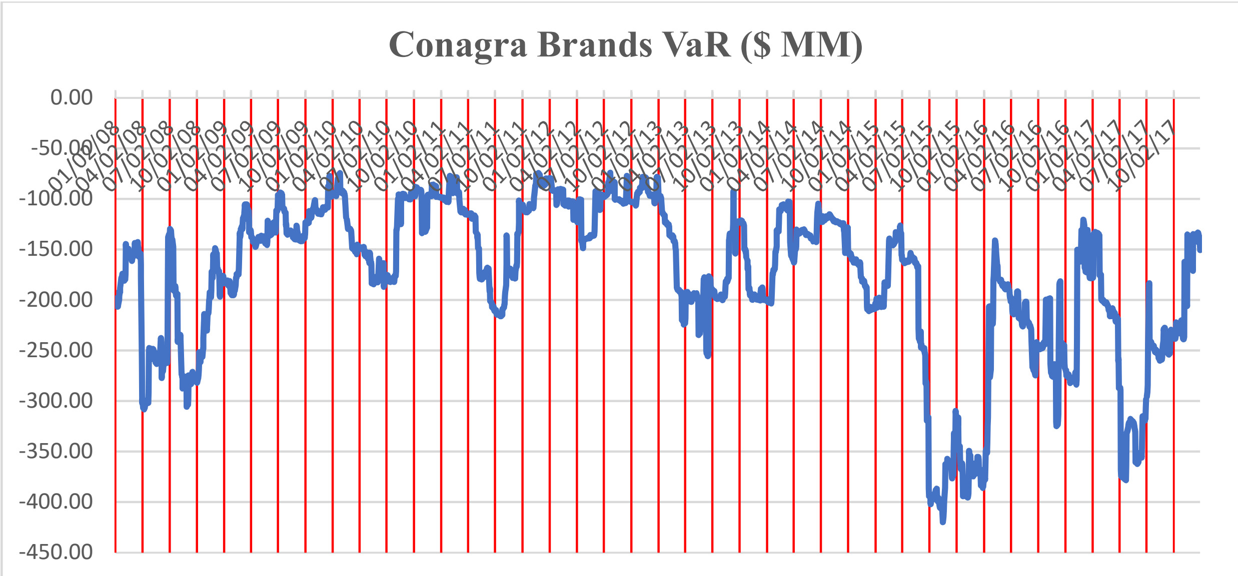


Figure 6. Value-at-Risk analysis for Conagra Brands

Compared to Duke Energy, Conagra Brands indicates a higher frequency in volatility, but their potential losses are lower than they are for Duke Energy because of the lower market capitalization of the company.

To illustrate the volatility of the Duke Energy stock relative to the industry benchmark (MSCI USA Utilities Index - MXUSOUT), the quarterly VaR was normalized to the start of the analytical period and averaged on a quarterly basis.

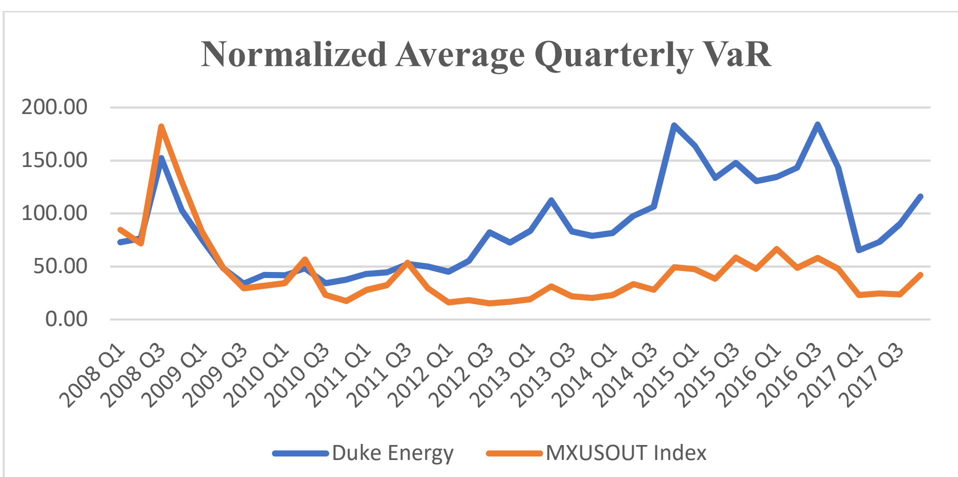


Figure 7. VaR Volatility Analysis for Duke Energy

It can be observed from the graph that the seasonal VaR for Duke Energy is more volatile than the industry, hence, the company is impacted by more extreme losses than the index as a whole. Since the index aggregates multiple companies, its volatility would be expected to be mitigated as a result of 'the law of averages'. However, when Conagra is compared to its index, the volatility losses appear to be less severe, indicating that VaR trends of individual companies are not always expected to exhibit excess volatility over the weighted index .

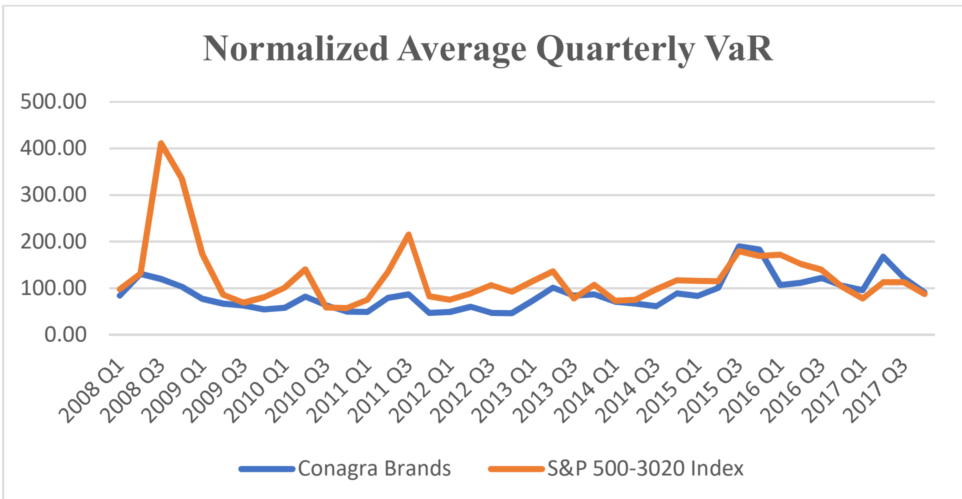


Figure 8. VaR Volatility Analysis for Conagra Brands

To further explore the use of VaR values to explain trends of company volatility relative to the index, the correlations between the 95th percentile of the security and that of the (utilities and food & beverage) index were computed. Whereas Figure 7 indicates that Duke Energy's normalized VaR indicates higher volatility than the utilities index, the correlation coefficient between the 95th percentile of stock price changes for the company and the index is 0.87 (Figure 9), showing a high degree of similarity in the volatility. On the other hand the correlation coefficient between the 95th percentile in stock changes of Conagra Brands and its industry index is only 0.61, indicating that the potential extreme losses on the share price are more different than for Duke Energy. Thus, based on statistical analysis, it is apparent that short-term VaR data have the inherent capacity to expose granular data features beyond what is possible using CAPM beta.

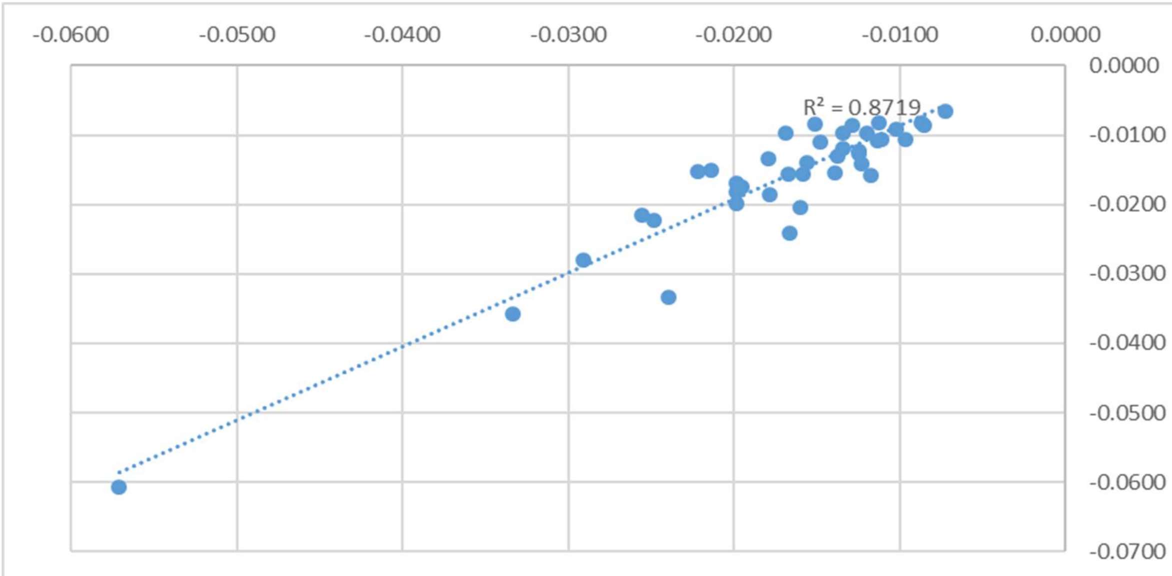


Figure 9. Correlation Analysis for Duke Energy

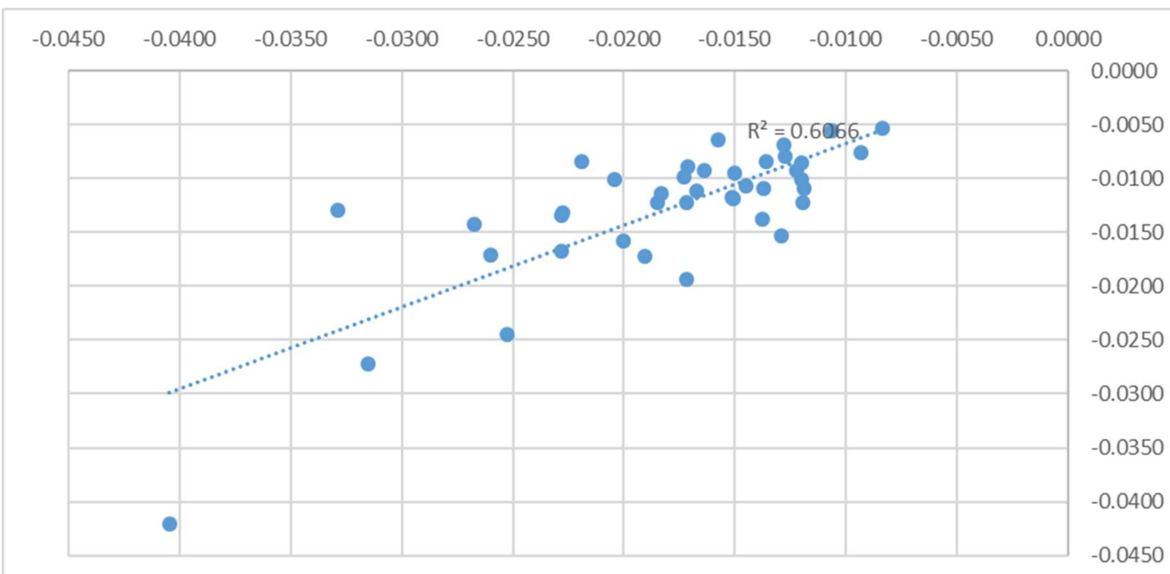


Figure 10. Correlation Analysis for Conagra Brands

All the quarterly VaR values for all companies were further analyzed to understand if those events are related to a systemic or idiosyncratic risk. The results of the analysis are presented below. (Table 4) and can be summarized as follows: The reporting quarters are impacted by both systemic and idiosyncratic risks. When idiosyncratic risks are reported, they relate to loss of operational performance due to regulatory or weather events (utilities), market demand and competition (semiconductors), investment in facilities and operations (household products), and competition or health concerns (food and beverage). Even though weather or water are not explicitly called out or priced in the securities, except for in the case of energy utilities, water-intensive business operations are impacted by access to supplies and management of their resources as they address sustainability issues. The waterBeta® analysis will develop the risk the company is exposed to in the case of an adverse event: *"What is the value of that risk?"*

Table 4. Sources of systemic vs idiosyncratic risk for Duke Energy and Conagra

Company Name	Period of extreme losses	Reasoning	Type of Risk	Sources
Duke Energy	Q3 2008	Global Financial crisis 2007-2008	Systemic risk	
	Q1 2015	Higher interest rates in US + decrease in gas price in US + significant losses from the hydro power plants in Brazil affected by droughts.	Systemic risk + Idiosyncratic risk	16, 17, 18
	Q3 2015	Sale of Midwest Renewable Generation and Gas Transmission to Dynegy. Renewable generation seen as volatile due to continuous changes in regulations	Systemic risk + Idiosyncratic risk	19
	Q3 2016	Loss on sale of the International Energy business (this division included mostly hydro power plants in regions affected by droughts) and the acquisition of Piedmont Natural Gas (followed by assuming its long-term debt). Acquisition performed to increase the focus on natural gas and reduce on a long-term generation from coal.	Idiosyncratic risk	20
Conagra	Q2 2008	Global Financial crisis 2007-2008	Systemic risk	
	Q3 2008	Global Financial crisis 2007-2008	Systemic risk	
	Q2 2013	Almost 60% decrease in profit due to the costs related to acquisition of Ralcorp	Idiosyncratic risk	21
	Q3 2015	Announcement of the sale of the private label division due to increased competition, because private labels have gone out of style and there is nothing proprietary about the business	Idiosyncratic risk	22
	Q4 2015	Delayed sale of Ralcorp to Treehouse Foods at a lower valuation than expected	Idiosyncratic risk	23
	Q3 2016	Lower sales volume due to increased competition + lower profits due to divestitures of Spicetec and JM Swank + accounting reorganization in anticipation of the Lamb Weston spinoff	Idiosyncratic risk	24
	Q2 2017	Decrease in sales due to decrease in demand as more consumers shift to fresh foods	Idiosyncratic risk	25

6.4. Calculation of Fractional Asset Risk ($F_{AssetRisk}$)

The next step was to assess the fraction of economic output of the company in water stressed US regions from Bloomberg-Aqueduct maps. This tool provides geographic information on where and how intense the water risk is from a watershed perspective. According to the information provided in the Bloomberg-Aqueduct screens, Aqueduct estimates the water stress as amount of withdrawals relative to the available flow in the watershed. Based on these estimates, the water stress is grouped in 5 categories, as seen below:

Table 5. Water Risk Exposure (as % of Water Removed, Relative to Available Flows)

Water risk	
Low	<10%
Low to medium	10-20%
Medium to high	20-40%
High	40-80%
Extremely high	>80%

Since our study focused on operations impacted by high risk localities, i.e. the percentage of economic output generated in US regions with high and extremely high water stress, only assets in regions above 40% were considered.

To calculate this percentage for the utilities industry, the power plants of each company in the US had to be overlaid in the Bloomberg-Aqueduct map. This map was further informed by visualizing the regions with high and extremely high water stress. By adding the two maps together, the specific company's facilities in the water stressed regions could be represented. For the four other industries, the methodology was the same, but instead of using the power plants maps, the geographic location of factories maps is shown.

By way of example, the maps of Duke Energy's facilities (Figure 9) and Conagra Brands plants (Figure 10) are shown in high and extremely high water stressed regions. The scale identifies the watersheds relative to the water risk from lowest to highest in high and extremely high water stress regions.

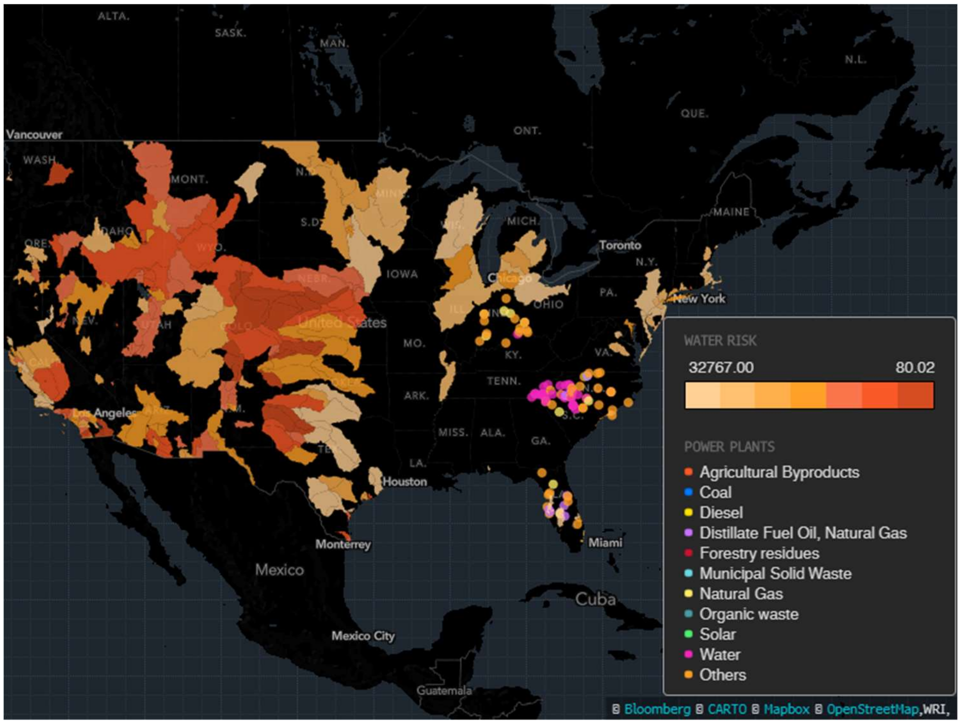


Figure 9. Bloomberg Aqueduct Water Risk Maps for Duke Energy plants

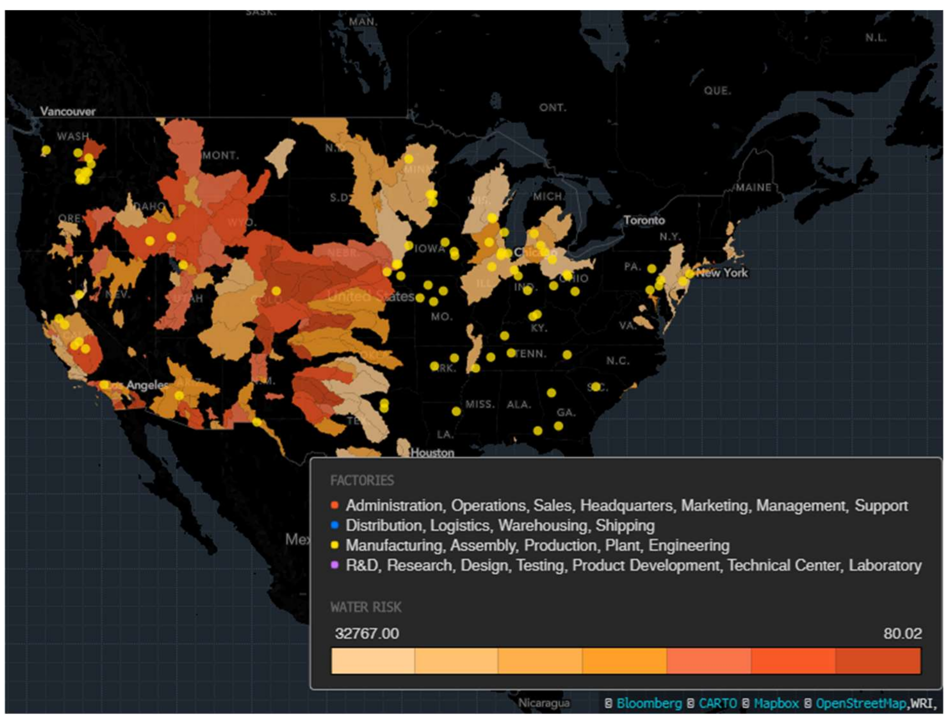


Figure 10. Bloomberg-Aqueduct Map for Conagra Brands locations

Bloomberg-Aqueduct contains detailed information about the utilities sector, but not as detailed for the other four industries. Therefore, for the utilities it was possible to extract the output capacity of each facility expressed in MegaWatts (MW), while for the other industries Bloomberg no operational output information was available. Therefore, for these industries it was necessary to develop a different methodology to estimate the percentage of output from high and extremely high water stressed regions, as detailed below.

For utilities, the $F_{AssetRisk}$ was calculated as the ratio of MW capacity in high and extremely high water stressed regions and the total MW capacity in the US. Any facilities that were already retired or decommissioned were excluded from the calculation. For all the other four industries, $F_{AssetRisk}$ was based on the corporate operational costs (COGS, cost of goods sold) as a percentage of total revenue, corrected by the number of relevant facilities in high and extremely high water stressed regions. This means that first the percentage of manufacturing or R&D facilities needed to be quantified in high and extremely high water stressed regions. Manufacturing facilities were considered to have a cost structure related to the sale of manufactured products (COGS) while R&D facilities generate costs related to the R&D activities. The final $F_{AssetRisk}$ in this case is the weighted average between the percentage of manufacturing facilities in total facilities in high and extremely high water stressed regions and their economic performance and the percentage of R&D facilities in total facilities in high and extremely high water stressed regions and their economic performance.

In other words: percent of manufacturing facilities in high and extremely high water stressed regions * (COGS/Total revenue) + percent of R&D facilities in high and extremely high water stressed regions * (R&D costs/Total revenue). If the company has additional types of facilities (for example, logistics and warehouse), those were included in the calculation as well based on the costs related to those specific activities as an additional component of the weighted average. The results of the $F_{AssetRisk}$ calculations for Duke Energy are presented in Table 6.

Table 6. Fractional asset risk exposure of Duke Energy facilities to high water risk

DUK (Duke Energy Corp.)

Nr	Ref ID	Capacity (MW)	Country Code	Fuel Type	Location	Name	Operator	Region Code	Status
1	47386	16.3	US	Distillate Fuel Oil	North Carolina	Morehead	Duke Energy Progress	SERC	Retired
2	48614	91.3	US	Bituminous Coal, Distillate Fuel Oil	North Carolina	L V Sutton	Duke Energy Progress	SERC	Operational
3	48653	2003.2	US	Nuclear	North Carolina	Brunswick	Duke Energy Progress	SERC	Operational
4	48726	508.4	US	Bituminous Coal, Distillate Fuel Oil	North Carolina	HF Lee Plant	Duke Energy Progress	SERC	Retired
5	48728	1068	US		North Carolina	Lee Combined Cycle	Duke Energy Progress		Operational
6	48736	1059	US	Distillate Fuel Oil, Natural Gas	North Carolina	Wayne County	Duke Energy Progress	SERC	Operational
7	49414	735.8	US	Bituminous Coal	North Carolina	Mayo	Duke Energy Progress	SERC	Operational
8	49474	342.1	US	Bituminous Coal, Distillate Fuel Oil	North Carolina	W H Weatherspoon	Duke Energy Progress	SERC	Operational
9	49585	30	US	Bituminous Coal, Distillate Fuel Oil	North Carolina	Cape Fear	Duke Energy Progress	SERC	Operational
10	49606	2558.2	US	Bituminous Coal	North Carolina	Roxboro	Duke Energy Progress	SERC	Operational
11	50120	1078.9	US	Bituminous Coal, Distillate Fuel Oil	North Carolina	Dan River	Duke Energy Carolinas	SERC	Operational
12	50164	2281.8	US	Natural Gas	North Carolina	Sherwood H Smith Jr Energy Company	Duke Energy Progress	SERC	Operational
13	50234	977.5	US	Distillate Fuel Oil, Natural Gas	North Carolina	Rockingham County CT Station	Duke Energy Carolinas	SERC	Stand By
14	50252	61.2	US	Solar	North Carolina	Duke Energy Capital Partners	Duke Energy Renewables		Operational
15	50264	184	US	Water	North Carolina	Blewett Falls Lake Dam	Duke Energy Progress	SERC	Operational
16	50267	94.6	US	Distillate Fuel Oil, Fuel Oil	North Carolina	Blewett	Duke Energy Progress	SERC	Operational
17	50419	2160.2	US	Bituminous Coal	North Carolina	Belews Creek	Duke Energy Carolinas	SERC	Operational
18	50501	784.9	US	Bituminous Coal, Distillate Fuel Oil	South Carolina	H B Robinson	Duke Energy Progress	SERC	Operational
19	50505	1045.8	US	Distillate Fuel Oil, Natural Gas	South Carolina	Darlington County	Duke Energy Progress	SERC	Operational
20	50666	1165.5	US	Bituminous Coal, Distillate Fuel Oil	North Carolina	Buck	Duke Energy Carolinas	SERC	Operational
21	50763	84	US	Water	North Carolina	Tillery	Duke Energy Progress	SERC	Operational
22	50800	3500	US	Distillate Fuel Oil, Fuel Oil	Florida	Martin Gas Storage Facility	Duke Energy Florida	FRCC	Operational
23	50896	56	US	Water	South Carolina	Wateree	Duke Energy Carolinas	SERC	Operational
24	51028	45	US	Water	South Carolina	Cedar Creek	Duke Energy Carolinas	SERC	Operational
25	51029	28	US	Water	South Carolina	Rocky Creek	Duke Energy Carolinas	SERC	Operational
26	51036	45	US	Water	South Carolina	Dearborn	Duke Energy Carolinas	SERC	Operational
27	51037	24	US	Water	South Carolina	Great Falls	Duke Energy Carolinas	SERC	Operational
28	51039	42.3	US	Water	South Carolina	Fishing Creek	Duke Energy Carolinas	SERC	Operational
29	51071	2440.6	US	Nuclear	North Carolina	McGuire	Duke Energy Carolinas	SERC	Operational
30	51074	350	US	Water	North Carolina	Cowans Ford	Duke Energy Carolinas	SERC	Operational
31	51080	1996	US	Bituminous Coal	North Carolina	Marshall	Duke Energy Carolinas	SERC	Operational
32	51085	601.2	US	Bituminous Coal, Distillate Fuel Oil	North Carolina	Riverbend	Duke Energy Carolinas	SERC	Operational
33	51089	60	US	Water	North Carolina	Mountain Island	Duke Energy Carolinas	SERC	Operational
34	51100	60	US	Water	South Carolina	Wylie	Duke Energy Carolinas	SERC	Operational
35	51106	1155	US	Bituminous Coal	North Carolina	G G Allen	Duke Energy Carolinas	SERC	Operational
36	51128	1753.6	US	Distillate Fuel Oil, Natural Gas	North Carolina	Lincoln Combustin	Duke Energy Carolinas	SERC	Operational
37	51144	2410.2	US	Nuclear	South Carolina	Catawba	Duke Energy Carolinas	SERC	Operational
38	51155	25.8	US	Water	North Carolina	Lookout Shoals	Duke Energy Carolinas	SERC	Operational
39	51233	36	US	Water	North Carolina	Oxford	Duke Energy Carolinas	SERC	Operational
40	51276	19.2	US	Distillate Fuel Oil	Florida	Rio Pinar	Duke Energy Florida	FRCC	Operational
41	51290	180.8	US	Distillate Fuel Oil	Florida	G E Turner	Duke Energy Florida	FRCC	Operational
42	51342	860.8	US	Distillate Fuel Oil, Natural Gas	Florida	DeBary	Duke Energy Florida	FRCC	Operational
43	51400	799.2	US	Distillate Fuel Oil, Natural Gas	South Carolina	Mill Creek	Duke Energy Carolinas	SERC	Operational
44	51402	25.5	US	Water	North Carolina	Rhodhiss	Duke Energy Carolinas	SERC	Operational
45	51427	67.4	US	Distillate Fuel Oil, Natural Gas	Florida	Avon Park	Duke Energy Florida	FRCC	Operational
46	51428	18	US	Water	South Carolina	99 Islands	Duke Energy Carolinas	SERC	Operational
47	51451	1310.2	US	Distillate Fuel Oil, Natural Gas	Florida	Intercession City	Duke Energy Florida	FRCC	Operational
48	51483	6.7	US	Water	South Carolina	Gaston Shoals	Duke Energy Carolinas	SERC	Operational
49	51600	2490.4	US	Bituminous Coal	North Carolina	Cliffside	Duke Energy Carolinas	SERC	Operational
50	51650	27.7	US	Water	North Carolina	Bridgewater	Duke Energy Carolinas	SERC	Operational
51	51655	278.1	US	Natural Gas	Florida	Tiger Bay	Duke Energy Florida	FRCC	Operational
52	51676	2262.5	US	Distillate Fuel Oil, Natural Gas	Florida	Hines Energy Complex	Duke Energy Florida	FRCC	Operational
53	51695	212.6	US	Natural Gas	South Carolina	Buzzard Roost	Duke Energy Carolinas	SERC	Operational
54	51899	43	US	Natural Gas	Florida	University of Florida	Duke Energy Florida	FRCC	Operational
55	51919	5	US	Water	North Carolina	Tuxedo	Duke Energy Carolinas	SERC	Operational
56	51960	463	US	Bituminous Coal, Distillate Fuel Oil	South Carolina	W S Lee	Duke Energy Carolinas	SERC	Operational
57	52027	837.1	US	Bituminous Coal, Distillate Fuel Oil	North Carolina	Asheville	Duke Energy Progress	SERC	Operational
58	52072	1970.1	US	Distillate Fuel Oil, Natural Gas	Florida	P L Bartow	Duke Energy Florida	FRCC	Operational
59	52087	2184	US	Nuclear	Florida	Levy Nuclear Plant	Duke Energy Florida	FRCC	Site approved

60	52096	226.8	US	Distillate Fuel Oil	Florida	Bayboro	Duke Energy Florida	FRCC	Operational
61	52110	153.2	US	Distillate Fuel Oil, Natural Gas	Florida	Higgins	Duke Energy Florida	FRCC	Operational
62	52137	3333.1	US	Bituminous Coal, Coal, Nuclear	Florida	Crystal River	Duke Energy Florida	FRCC	Operational
63	52158	5	US	Water	North Carolina	Marshall	Duke Energy Progress	SERC	Operational
64	52183	1112.4	US	Natural Gas, Residual Fuel Oil	Florida	Anclote	Duke Energy Florida	FRCC	Operational
65	52232	157.6	US	Water	South Carolina	Keowee	Duke Energy Carolinas	SERC	Operational
66	52245	2666.7	US	Nuclear	South Carolina	Oconee	Duke Energy Carolinas	SERC	Operational
67	52251	612	US	Water	South Carolina	Jocassee	Duke Energy Carolinas	SERC	Operational
68	52255	1065.2	US	Water	South Carolina	Bad Creek	Duke Energy Carolinas	SERC	Operational
69	52301	10.8	US	Water	North Carolina	Tennessee Creek	Duke Energy Carolinas	SERC	Operational
70	52321	108	US	Water	North Carolina	Walters	Duke Energy Progress	SERC	Operational
71	52341	9	US	Water	North Carolina	Bear Creek	Duke Energy Carolinas	SERC	Operational
72	52358	6.4	US	Water	North Carolina	Cedar Cliff	Duke Energy Carolinas	SERC	Operational
73	52374	21.6	US	Water	North Carolina	Thorpe	Duke Energy Carolinas	SERC	Operational
74	52376	3	US	Water	North Carolina	Tuckasegee	Duke Energy Carolinas	SERC	Operational
75	52390	330.6	US	Distillate Fuel Oil, Natural Gas	Florida	Suwannee River	Duke Energy Florida	FRCC	Operational
76	52487	1	US	Water	North Carolina	Franklin	Duke Energy Carolinas	SERC	Operational
77	52644	1.4	US	Water	North Carolina	Queens Creek	Duke Energy Carolinas	SERC	Operational
78	52646	43.2	US	Water	North Carolina	Nantahala	Duke Energy Carolinas	SERC	Operational
79	52746	1.8	US	Water	North Carolina	Mission	Duke Energy Carolinas	SERC	Operational
80	52893	1425.6	US	Bituminous Coal	Ohio	W H Zimmer	Duke Energy Ohio	RFC	Operational
81	52934	1317.9	US	Bituminous Coal, Distillate Fuel Oil	Ohio	Walter C Beckjord	Duke Energy Ohio	RFC	Operational
82	53039	489.6	US	Natural Gas, Propane Gas	Ohio	Woodsdale	Duke Energy Kentucky	RFC	Operational
83	53043	683.2	US	Natural Gas	Ohio	Madison	Duke Energy Indiana	RFC	Operational
84	53216	1344	US	Bituminous Coal, Distillate Fuel Oil	Ohio	Miami Fort	Duke Energy Ohio	RFC	Operational
85	53234	669.3	US	Bituminous Coal	Kentucky	East Bend	Duke Energy Kentucky	RFC	Operational
86	53302	64.8	US	Water	Indiana	Markland	Duke Energy Indiana	RFC	Operational
87	53397	83.6	US	Distillate Fuel Oil	Indiana	Connersville	Duke Energy Indiana	RFC	Operational
88	53523	135	US	Natural Gas	Indiana	Henry County	Duke Energy Indiana	RFC	Operational
89	53637	104.6	US	Distillate Fuel Oil	Indiana	Miai Wabash	Duke Energy Indiana	RFC	Operational
90	53646	600	US	Bituminous Coal	Indiana	R Gallagher	Duke Energy Indiana	RFC	Operational
91	53702	328	US	Natural Gas	Indiana	Noblesville	Duke Energy Indiana	RFC	Operational
92	54262	948.7	US	Bituminous Coal, Distillate Fuel Oil	Indiana	Edwardsport	Duke Energy Indiana	RFC	Operational
93	54285	540	US	Natural Gas	Indiana	Wheatland Generating Facility	Duke Energy Indiana	RFC	Operational
94	54337	1193.4	US	Bituminous Coal, Distillate Fuel Oil	Indiana	Cayuga	Duke Energy Indiana	RFC	Operational
95	54338	1477.3	US	Bituminous Coal, Distillate Fuel Oil	Indiana	Wabash Valley Power	Duke Energy Indiana	RFC	Operational
96	54345	683.2	US	Natural Gas	Indiana	Vermillion Energy Facility	Duke Energy Ohio	RFC	Operational
97	54522	3339.5	US	Bituminous Coal	Indiana	Gibson	Duke Energy Indiana	RFC	Operational
98	442	58.8	US	Wind	Texas	Ocotillo Wind Farm	Duke Energy Renewables	Onsite	Operational
99	643	51	US	Wind	Colorado	Kit Carson Wind Farm	Duke Energy Renewables	Onsite	Operational
100	779	62.25	US	Wind	Texas	Notrees Wind Farm Phase II	Duke Energy Renewables	Onsite	Operational
101	782	90.75	US	Wind	Texas	Notrees Wind Farm Phase I	Duke Energy Renewables	Onsite	Operational
102	1258	42	US	Wind	Wyoming	Silver Sage Wind Farm	Duke Energy Renewables	Onsite	Operational
103	1259	29.4	US	Wind	Wyoming	Happy Jack Wind Farm	Duke Energy Renewables	Onsite	Operational
104	1573	99	US	Wind	Wyoming	Campbell Hill Wind Farm	Duke Energy Renewables	Onsite	Operational
105	1593	16.8	US	Wind	Wyoming	Foote Creek Wind Farm Phase IV	Duke Energy Corporation	Onsite	Operational
106	1638	200.2	US	Wind	Wyoming	Top of the World Wind Farm	Duke Energy Renewables	Onsite	Operational
107	23096	69	US	Wind	Pennsylvania	Laurel Hill Wind Farm	Duke Energy Renewables	Onsite	Operational
108	24013	70	US	Wind	Pennsylvania	North Allegheny Wind Farm	Duke Energy Renewables	Onsite	Operational
109	28412	202	US	Wind	Texas	Los Vientos Wind Farm Phase II	Duke Energy Renewables	Onsite	Operational
110	28425	200.1	US	Wind	Texas	Los Vientos Wind Farm Phase I	Duke Energy Renewables	Onsite	Operational
	TOTAL	**72983.8**							

Facilities in regions with water stress high and extremely high:						
Name	**Operator**	**Capacity (MW)**	**Status**	**Fuel type**	**ater risk Catego**	**Water Risk Level**
LV Suttor	Duke Ene	91.30	Operational	Bituminous coal, Distillate Fuel Oil	Extremely high	1.023546849
Martin Ga	Duke Ene	3,500.00	Operational	Distillate Fuel Oil, Fuel Oil nr. 2, nat	Extremely high	1.610965349
Avon Par	Duke Ene	67.40	Operational	Distillate Fuel Oil, Natural gas	High	0.424667622
Hines En	Duke Ene	2,262.50	Operational	Distillate Fuel Oil, Natural gas	High	0.426676215
Intercessi	Duke Ene	1,310.20	Operational	Distillate Fuel Oil	High	0.426676215
Bayboro	Duke Ene	226.80	Operational	Distillate Fuel Oil, Natural gas	High	0.448731213
PL Bartov	Duke Ene	1,970.10	Operational	Distillate Fuel Oil, Natural gas	High	0.448731213
Higgins	Duke Ene	153.20	Operational	Distillate Fuel Oil, Natural gas	High	0.448731213
Anclote	Duke Ene	1,112.40	Operational	Natural gas, Residual Fuel oil	High	0.448731213
Crystal R	Duke Ene	3,333.10	Operational	Bituminous coal, Coal, Nuclear	High	0.448731213
Levy Nuc	Duke Ene	2,184.00	Site Approved	Nuclear	High	0.448731213
		16,211.00				
		22.21%				

Based on the percentage of capacity in high and extremely high water stressed regions, the $F_{AssetRisk}$ for Duke Energy is 22.2%. For comparison purposes, the same methodology applied to the industry sectors where no productivity output was available was also applied to utilities. The $F_{AssetRisk}$ based on the methodology for the other 4 industries is detailed in Table 7, and indicates that when applied to Duke Energy, the fractional asset risk is 7.6%. This is one third the risk exposure as compared to that based on economic output.

The comparison between F_{AR} based on economic output and COGS may indicate that the COGS methodology may underestimate exposed risk capacity in high and extremely high water stressed regions, and thus the impact of potential losses in case of extreme events. Therefore, considering that utilities are assets intensive industries, the best methodology to estimate the exposed asset risk in high and extremely high water stressed regions should be based on economic output.

Table 7. Fractional Asset Risk Exposure of Companies using COGS Proxy Values (when no economic output metrics are available)

Number of total facilities			108
Number of facilities in water stressed regions			11
% of facilities in water stressed regions			0.10
https://www.duke-energy.com/our-company/investors/financials/annual-reports			
As of December 31, 2017 (million $)			
Net Revenue USA		21,331	
COGS USA		15,840	
% of COGS in Net Revenue		0.74	
Far	**7.56%**		

The results of calculations for Conagra Brands are included below for comparison purposes and include the total number of facilities in the US (Table 8), the water risk exposed facilities (Table 9), and the fractional asset risk for Conagra Brands (Table 10). The calculations - using the COGS proxy methodology - approximate that the asset risk for Conagra Brands is 30.7%. Note that even though the COGS as a percent of revenue is similar between Duke Energy and Conagra Brands, the fraction of assets in water stressed regions is significantly higher (0.1 for Duke vs. 0.44 for Conagra).

Table 8. Total Assets of Conagra Brand in US

Conagra Brands						
Nr	**Ref ID**	**Address**	**City**	**Company**	**Facility Type**	**State**
1	1243		Boardman	Conagra	Manufacturing, Assembly, Prod	Oregon
2	1236		Oakdale	Conagra	Manufacturing, Assembly, Prod	California
3	1237		Helm	Conagra	Manufacturing, Assembly, Prod	California
4	1238		Azusa	Conagra	Manufacturing, Assembly, Prod	California
5	1239		Warden	Conagra	Manufacturing, Assembly, Prod	Washington
6	1240		Connell	Conagra	Manufacturing, Assembly, Prod	Washington
7	1241		Prosser	Conagra	Manufacturing, Assembly, Prod	Washington
8	1242		Paterson	Conagra	Manufacturing, Assembly, Prod	Washington
9	1244		American Falls	Conagra	Manufacturing, Assembly, Prod	Idaho
10	1245		Park Rapids	Conagra	Manufacturing, Assembly, Prod	Minnesota
11	1246		Fridley	Conagra	Manufacturing, Assembly, Prod	Minnesota
12	1247		Lake View	Conagra	Manufacturing, Assembly, Prod	Iowa
13	1248		North Liberty	Conagra	Manufacturing, Assembly, Prod	Iowa
14	1249		Trenton	Conagra	Manufacturing, Assembly, Prod	Missouri
15	1250		Macon	Conagra	Manufacturing, Assembly, Prod	Missouri
16	1251		Marshall	Conagra	Manufacturing, Assembly, Prod	Missouri
17	1252		Streator	Conagra	Manufacturing, Assembly, Prod	Illinois
18	1253		El Paso	Conagra	Manufacturing, Assembly, Prod	Texas
19	1254		Carrollton	Conagra	Manufacturing, Assembly, Prod	Texas
20	1255		Duncanville	Conagra	Manufacturing, Assembly, Prod	Texas
21	1256		Delhi	Conagra	Manufacturing, Assembly, Prod	Louisiana
22	1257		Brookston	Conagra	Manufacturing, Assembly, Prod	Indiana
23	1258		Humboldt	Conagra	Manufacturing, Assembly, Prod	Tennessee
24	1259		Newport	Conagra	Manufacturing, Assembly, Prod	Tennessee
25	1260		Sylvester	Conagra	Manufacturing, Assembly, Prod	Georgia
26	1261		Quincy	Conagra	Manufacturing, Assembly, Prod	Michigan
27	1263		Archbold	Conagra	Manufacturing, Assembly, Prod	Ohio
28	1264		Morral	Conagra	Manufacturing, Assembly, Prod	Ohio
29	1265		Milton	Conagra	Manufacturing, Assembly, Prod	Pennsylvania
30	1266		Womelsdorf	Conagra	Manufacturing, Assembly, Prod	Pennsylvania
31	1267		Hanover	Conagra	Manufacturing, Assembly, Prod	Pennsylvania
32	37814		Coucil Bluffs	Conagra	Manufacturing, Assembly, Prod	Iowa
33	69160		Hamburg	Conagra	Manufacturing, Assembly, Prod	Iowa
34	102253		Menomonie	Conagra	Manufacturing, Assembly, Prod	Wisconsin
35	102247		Richland	Conagra	Manufacturing, Assembly, Prod	Washington
36	102219		Columbia	Conagra	Manufacturing, Assembly, Prod	South Carolina
37	102221		Cedar Rapids	Conagra	Manufacturing, Assembly, Prod	Iowa
38	102222		Chicago	Conagra	Manufacturing, Assembly, Prod	Illinois
39	102223		Maple Grove	Conagra	Manufacturing, Assembly, Prod	Minnesota

40	102224		Russellville	Conagra	Manufacturing, Assembly, Prod	Arkansas
41	102225		Dothan	Conagra	Manufacturing, Assembly, Prod	Alabama
42	102226		Tolleson	Conagra	Manufacturing, Assembly, Prod	Arizona
43	102227		Forest Park	Conagra	Manufacturing, Assembly, Prod	Georgia
44	102228		Indianapolis	Conagra	Manufacturing, Assembly, Prod	Indiana
45	102229		Waterloo	Conagra	Manufacturing, Assembly, Prod	Iowa
46	102230		Louiville	Conagra	Manufacturing, Assembly, Prod	Kentucky
47	102231		Omaha	Conagra	Manufacturing, Assembly, Prod	Nebraska
48	102232		Marion	Conagra	Manufacturing, Assembly, Prod	Ohio
49	102233		Lancaster	Conagra	Manufacturing, Assembly, Prod	Pennsylvania
50	102234		Denver	Conagra	Manufacturing, Assembly, Prod	Colorado
51	102235		Memphis	Conagra	Manufacturing, Assembly, Prod	Tennessee
52	102236		Kent	Conagra	Manufacturing, Assembly, Prod	Washington
53	102237		Visalia	Conagra	Manufacturing, Assembly, Prod	California
54	102243		Lodi	Conagra	Manufacturing, Assembly, Prod	California
55	102244		Fresno	Conagra	Manufacturing, Assembly, Prod	California
56	102245		Quincy	Conagra	Manufacturing, Assembly, Prod	Washington
57	102246		Pasco	Conagra	Manufacturing, Assembly, Prod	Washington
58	102248		Hermiston	Conagra	Manufacturing, Assembly, Prod	Oregon
59	102249		Twin Falls	Conagra	Manufacturing, Assembly, Prod	Idaho
60	102250		Sparks	Conagra	Manufacturing, Assembly, Prod	Nevada
61	102251		Ogden	Conagra	Manufacturing, Assembly, Prod	Utah
62	102252		Lakeville	Conagra	Manufacturing, Assembly, Prod	Minnesota
63	102254		Ripon	Conagra	Manufacturing, Assembly, Prod	Wisconsin
64	102255		Lincoln	Conagra	Manufacturing, Assembly, Prod	Nebraska
65	102256		Excelsior Sprin	Conagra	Manufacturing, Assembly, Prod	Missouri
66	102257		South Beloit	Conagra	Manufacturing, Assembly, Prod	Illinois
67	102258		Carol Stream	Conagra	Manufacturing, Assembly, Prod	Illinois
68	102259		Naperville	Conagra	Manufacturing, Assembly, Prod	Illinois
69	102260		Batesville	Conagra	Manufacturing, Assembly, Prod	Arkansas
70	102261		Rensselaer	Conagra	Manufacturing, Assembly, Prod	Indiana
71	102262		Princeton	Conagra	Manufacturing, Assembly, Prod	Kentucky
72	102263		Buckner	Conagra	Manufacturing, Assembly, Prod	Kentucky
73	102264		Dickson	Conagra	Manufacturing, Assembly, Prod	Tennessee
74	102265		Grand Rapids	Conagra	Manufacturing, Assembly, Prod	Michigan
75	102266		Battle Creek	Conagra	Manufacturing, Assembly, Prod	Michigan
76	102270		Lancaster	Conagra	Manufacturing, Assembly, Prod	Ohio
77	102271		Troy	Conagra	Manufacturing, Assembly, Prod	Ohio
78	102272		Cranbury	Conagra	Manufacturing, Assembly, Prod	New Jersey
79	102273		Milwaukee	Conagra	Manufacturing, Assembly, Prod	Wisconsin
80	102274		New York	Conagra	Manufacturing, Assembly, Prod	New York

Table 9. Risk exposure of Conagra Brand facilities to water risk

Facilities in regions with water stress high and extremely high:				
Name	**Operator**	**Facility Type**	**Water risk Category**	**Water Risk Level**
Warden	Conagra	Manufacturing	Extremely high	6.147750878
Twin Falls	Conagra	Manufacturing	Extremely high	3.795290148
American Falls	Conagra	Manufacturing	Extremely high	3.795290148
Ogden	Conagra	Manufacturing	Extremely high	1.437630051
Sparks	Conagra	Manufacturing	High	0.51088552
Oakdale	Conagra	Manufacturing	Extremely high	1.114728272
Fresno	Conagra	Manufacturing	Extremely high	2.845079254
Visalia	Conagra	Manufacturing	Extremely high	2.845079254
Helm	Conagra	Manufacturing	Extremely high	2.845079254
Azusa	Conagra	Manufacturing	Extremely high	2.162405711
Tolleson	Conagra	Manufacturing	Extremely high	1.21634955
El Paso	Conagra	Manufacturing	Extremely high	1.474196574
Denver	Conagra	Manufacturing	Extremely high	13.13080624
Lincoln	Conagra	Manufacturing	Extremely high	1.951529436
Omaha	Conagra	Manufacturing	High	0.409230507
Council Bluffs	Conagra	Manufacturing	High	0.409230507
Lake View	Conagra	Manufacturing	High	0.409230507
Lakeville	Conagra	Manufacturing	high	0.797730568
Maple Grove	Conagra	Manufacturing	high	0.797730568
Fridley	Conagra	Manufacturing	high	0.797730568
Park Rapids	Conagra	Manufacturing	High	0.689226959
Cranbury	Conagra	Manufacturing	High	0.51971817
Archbold	Conagra	Manufacturing	high	0.516250492
Quincy	Conagra	Manufacturing	Extremely high	1.208263043
Battle Creek	Conagra	Manufacturing	High	0.582383213
Grand Rapids	Conagra	Manufacturing	Extremely high	1.040692824
Morral	Conagra	Manufacturing	High	0.516250492
Rensselaer	Conagra	Manufacturing	High	0.785905436
Streator	Conagra	Manufacturing	High	0.785905436
Chicago	Conagra	Manufacturing	High	0.785905436
Carol Stream	Conagra	Manufacturing	High	0.785905436
Napperville	Conagra	Manufacturing	High	0.785905436
South Beloit	Conagra	Manufacturing	Extremely high	1.499918125
Ripon	Conagra	Manufacturing	High	0.492578524
Menomonie	Conagra	Manufacturing	High	0.492578524

Table 10. Fractional Asset Risk of Conagra Brands

Nr of total facilities	80	
Nr of manufacturing facilities	80	
Nr of total facilities in water stressed regions	35	
Nr of manufacturing facilities in water stressed regions	35	0.44
http://www.conagrabrands.com/investor-relations/financial-reports/annual-reports		
As of May 28, 2017 (in millions $)		
Net Revenue Global	7,827	
COGS Global	5,485	
% of COGS in Net Revenue	0.70	
Far	**30.66%**	

6.5. Computation of waterBeta®

The next step was to calculate the quarterly ratio of net PP&E (property, plant and equipment – amount in $ MM from the company's balance sheet) to EV (enterprise value – amount in $ MM from FactSet) to assess the operational value generated from real assets investments. Net PP&E represents the investments the company makes in all of its assets worldwide (so not just US), to include all types of facilities and equipment. Enterprise value represents the operational value of the company to include debt, but net of cash and cash equivalents. The ratio represents an efficiency factor for the company in terms of generating market value from its assets. The underlying assumption built in this model is that underperforming assets would be depreciated or sold off, including those that are potentially 'stranded' due to limited access to water, drought, or other reasons.

The last step was to calculate an 'intangibles' correction factor which (in the current limiting case) represents a weighted average between the ranking of water intensity of the industry and the quantity of water withdrawal by each industry. Other intangibles include brand risk, supply chain risk, regulatory or local issues. The industry with the highest ranking of water intensity, respectively the one with the highest water withdrawal, represent the basis of 1. The other industries are ranked proportionally to 1. The data used for calculating the correction factor is provided by MSCI and included in the Appendix 1. The results of the calculations for the correction factors are the following:

Table 11. Estimation of Intangibles Correction Factor by Industry Sector (source of data: MSCI ESG, 2013)*

Based on MSCI ranking of water intensity:				Based on water withdrawals MSCI graph:		
Utilities	5.8	0.85		Utilities	160,000	1.00
Semiconductors	5.2	0.76		Semiconductors	20,000	0.13
Household products	4.7	0.69		Household products	5,000	0.03
Food	6.7	0.99		Food	5,000	0.03
Beverages	6.8	1.00		Beverages	5,000	0.03

Correction factor	0.93	Utilities
	0.44	Semiconductors
	0.36	Household
	0.51	Food
	0.52	Beverages

** ESG Issue Report: Water Upstream and Downstream Impacts from a Well Running Dry*

Quarterly waterBeta® was ultimately calculated from the results described earlier. The trend of quarterly waterBeta® for Duke Energy and Conagra is presented below. It can be seen from these graphs that Conagra is more volatile to water risk impact than Duke Energy.

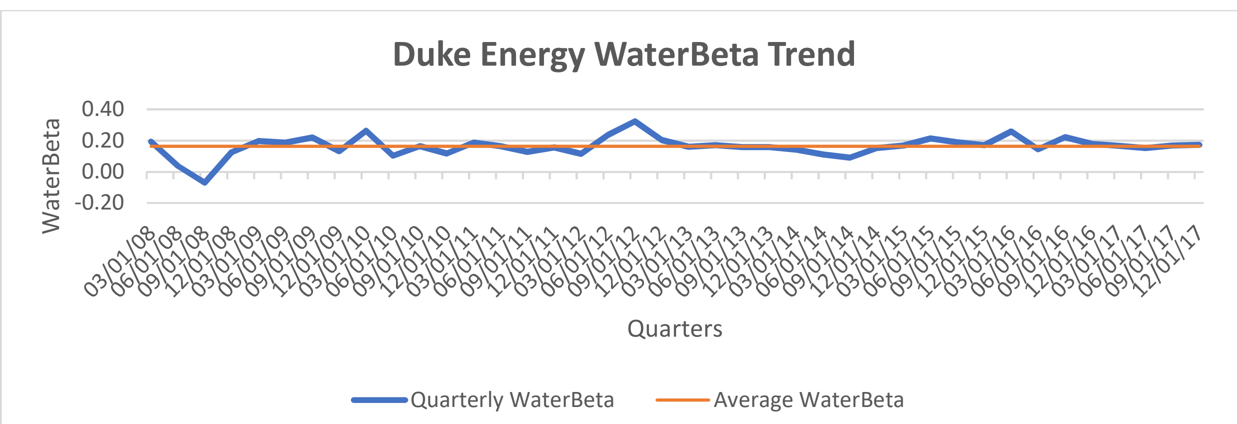


Figure 11. waterBeta® Trends of Duke Energy

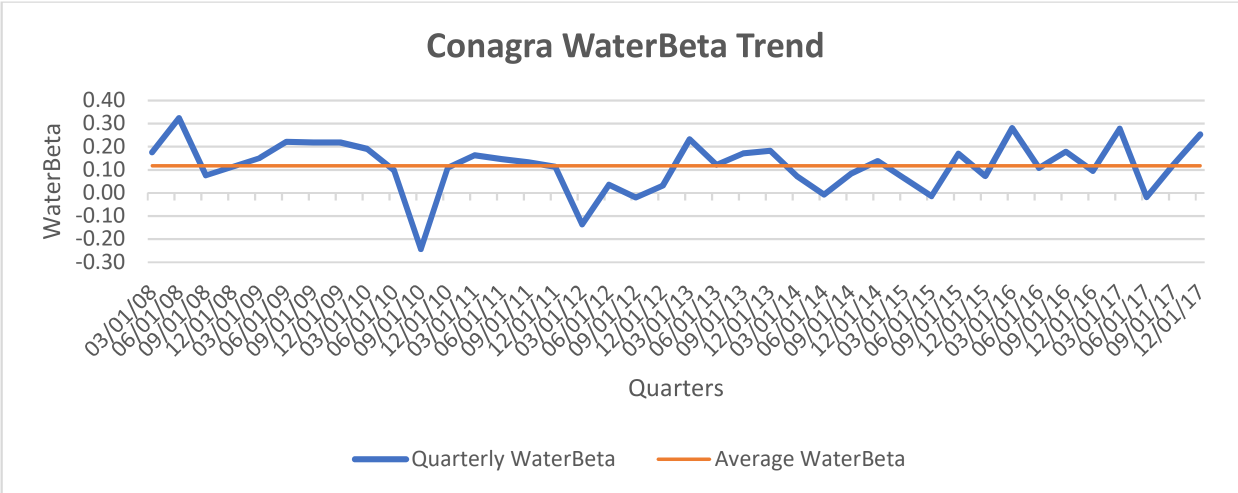


Figure 12. waterBeta® Trends of Conagra Brands

In terms of waterBeta® trends for utility industry, it can be seen from the graph below that Duke Energy has a waterBeta® below that of the utilities industry average over the past ten years, while Conagra Brands has a higher waterBeta® than the food industry average. Averaging over shorter time periods provides some insights in the trends as well, as DTE is below the industry average in the 2013-2017-time period, and above average before.

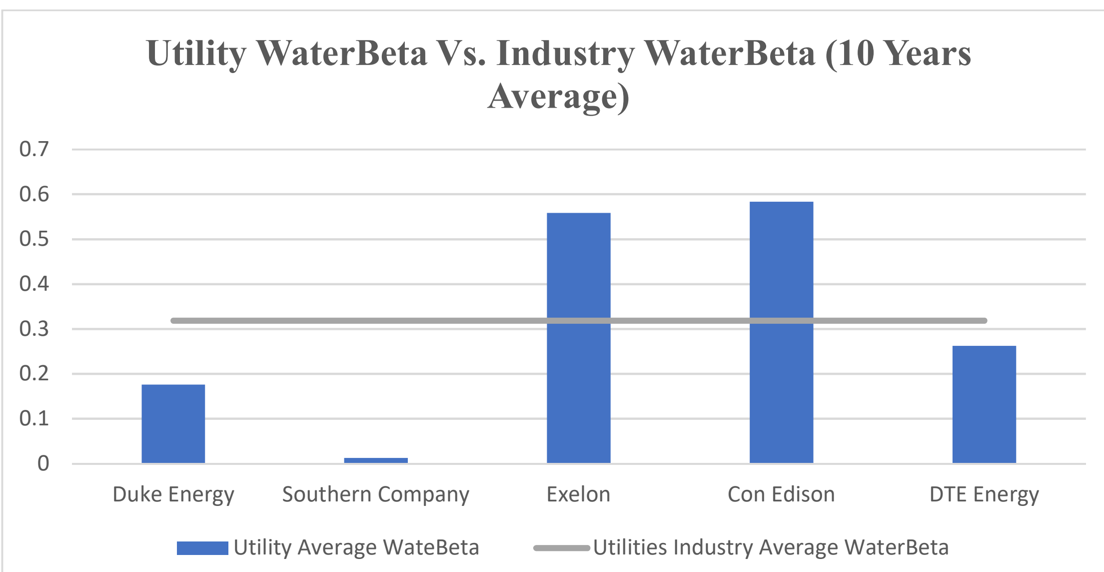


Figure 13. waterBeta Comparison across Energy Utilities for 2007-2017

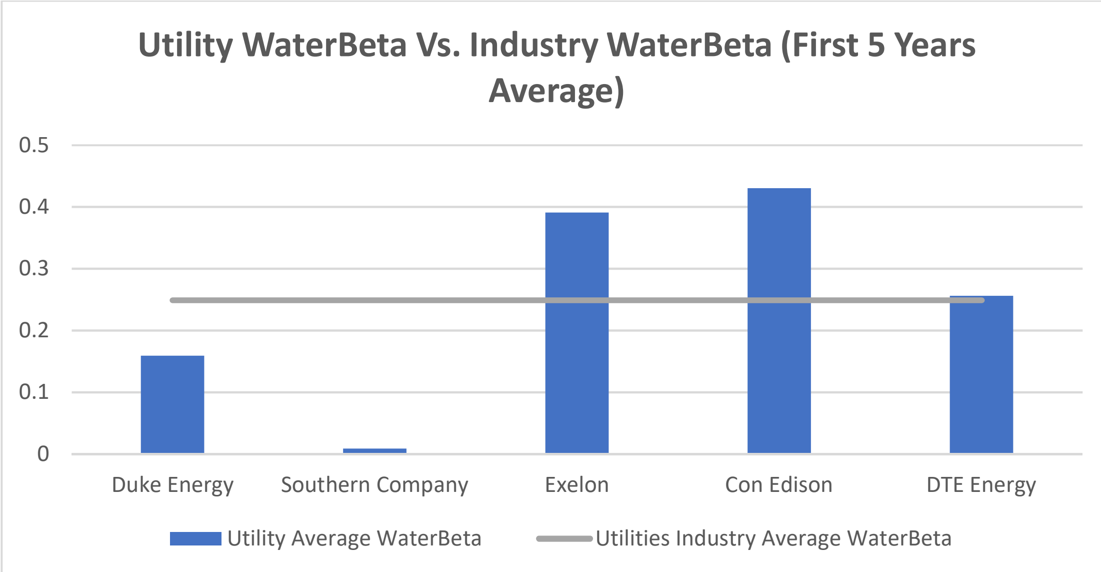


Figure 14. waterBeta across utilities industry 2007-2012

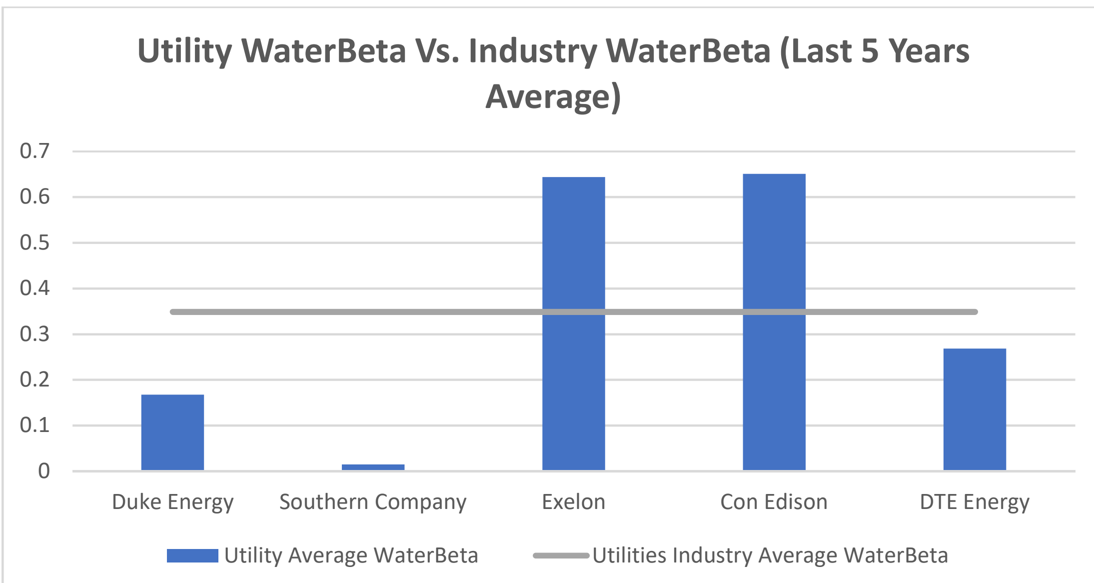


Figure 15. waterBeta across utilities industry 2013-2017

When considering the food industry, there are significant differences between companies, whereby Tyson, for example, which has a larger number of facilities in the US, has most of them located in lower water risk areas. Conagra and Ingredion on the other hand tend to be over-exposed to water risk. Temporal trends are evident as well, with General Mills having larger exposures in the 2013-2017-time frame.

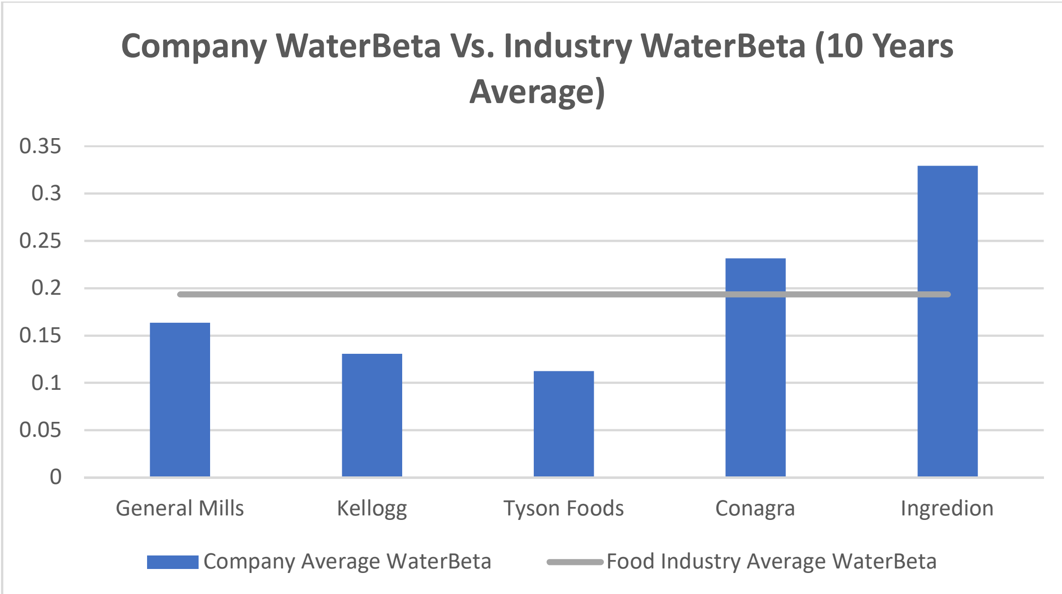


Figure 16. waterBeta across food industry 2007-2017

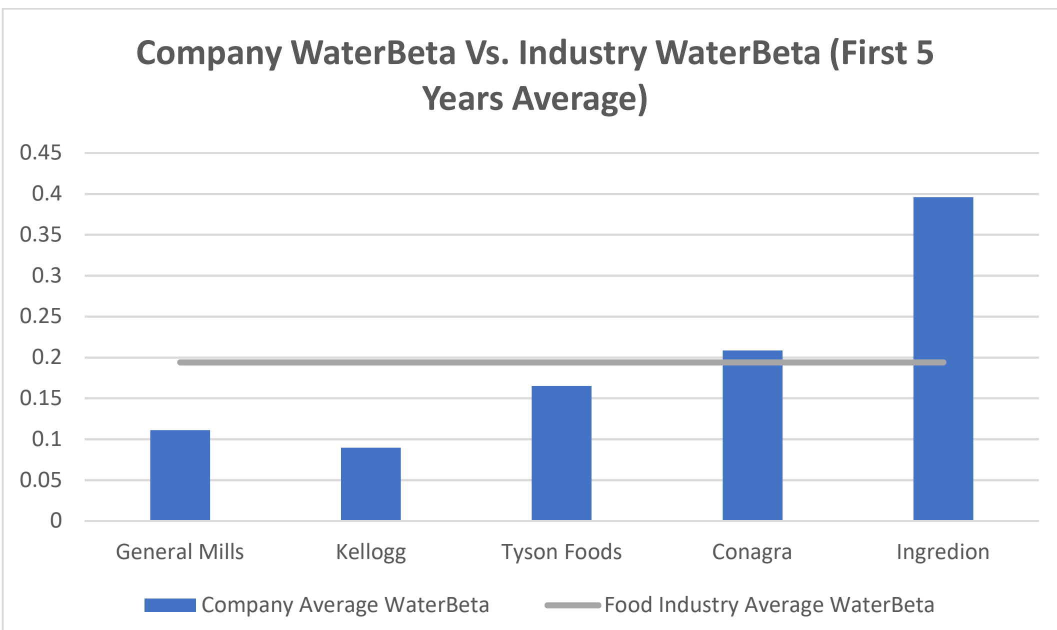


Figure 17. waterBeta across food industry 2007-2012

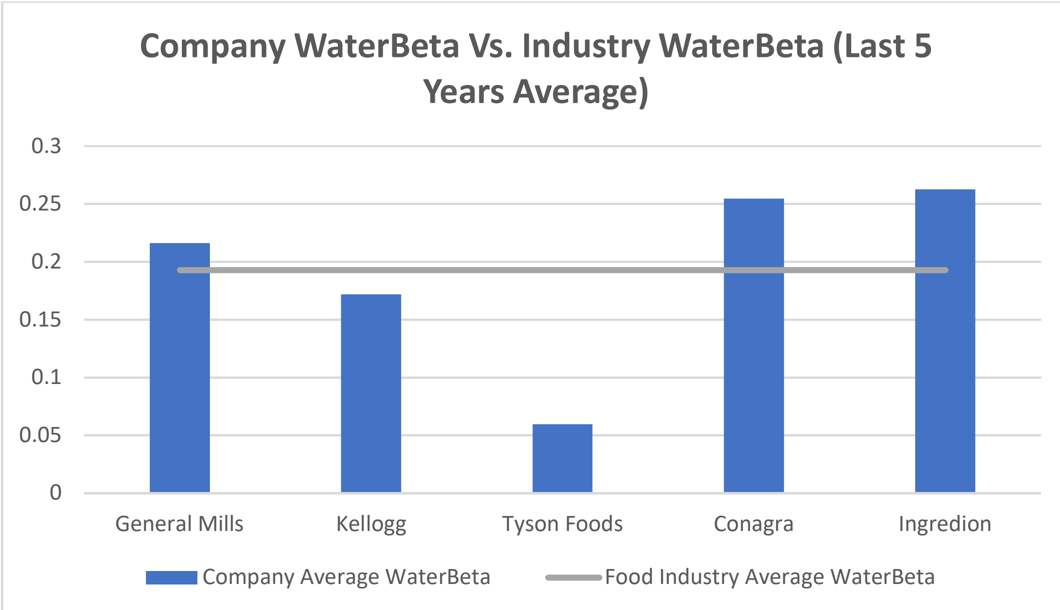


Figure 18. waterBeta across food industry 2013-2017

Similar graphs for semiconductors, household products and beverages industries are included in Appendix 2. A cross-comparison across industry sectors proves to yield industry-specific results, whereby energy utilities and semiconductor companies are more highly exposed.

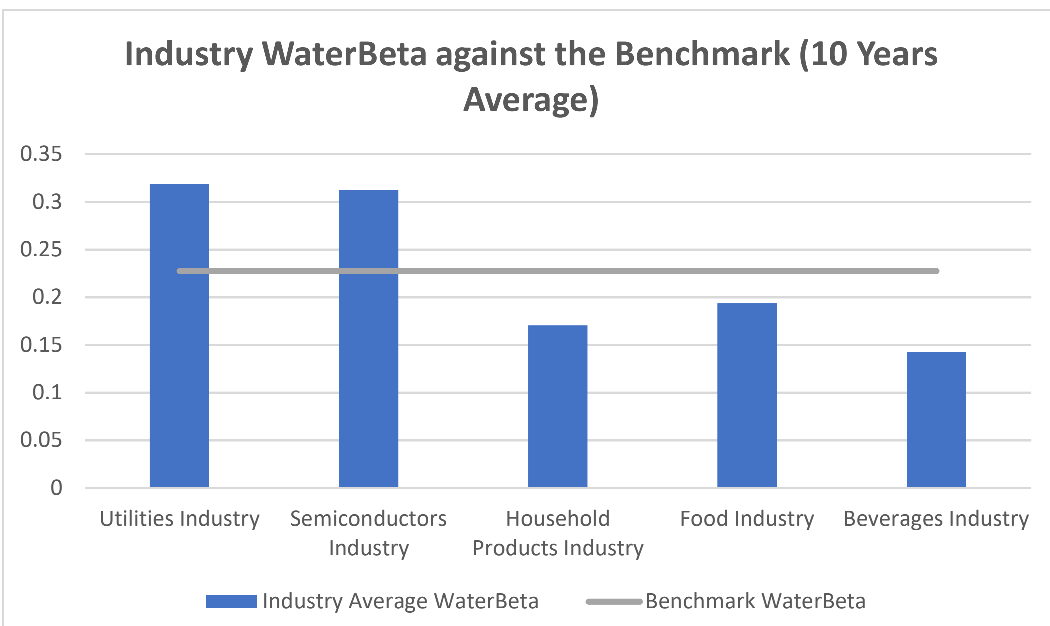


Figure 19. waterBeta across industry sectors 2007-2017

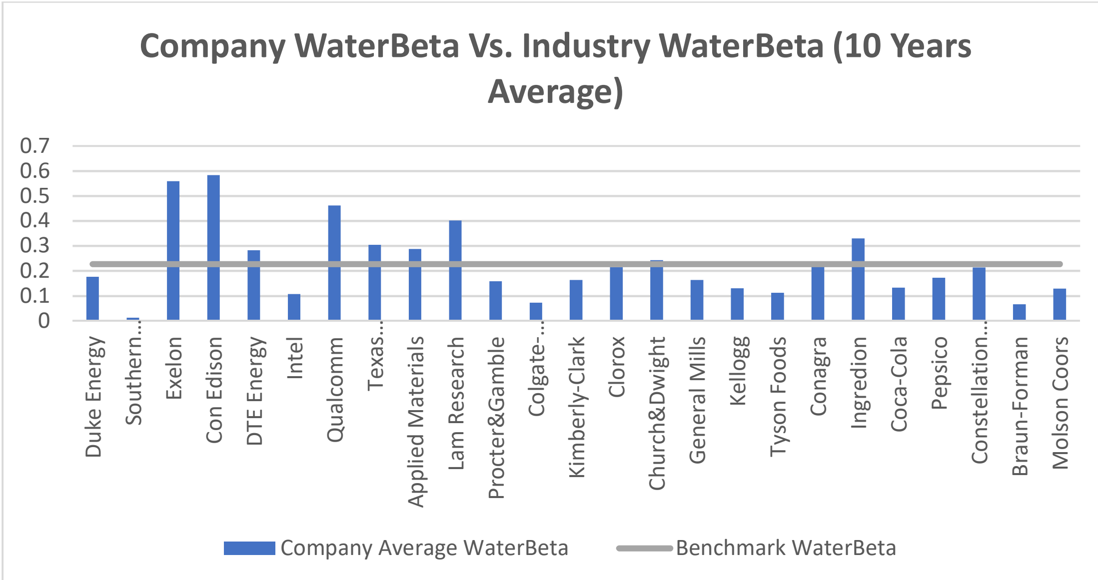


Figure 20. waterBeta across companies 2007-2017

Utilities and semiconductors industries have waterBeta® higher than the other industries, while Exelon and Con Edison have the highest waterBeta® among all the sampled companies. A potentially counter-intuitive trend that food and beverage companies have lower waterBeta® values than for example semiconductors given their high-water intensity needs to be considered in the context that these are food processing companies, not agricultural companies. Hence, where they may have supply chain risks, the food/beverage processing operations themselves are not as much at risk. Second, the only facilities considered here are US-based, not international, however, any risks that the company may have been exposed to in commodities (e.g. sugar) would have been captured in the stock/VaR computations and in the PP&E/EV metric. Third, the waterBeta® is not based on water use, but how water risk impacts the company from a financial performance perspective.

Since both financial beta and waterBeta® are calculated quarterly, we can build quadrants to track for each company the type of risk that may impact every quarter the operational and financial performance and its intensity. The same quadrants can be built to track quarterly for each industry the main types of risk that affect the companies in each industry. An example of such quadrants is presented below.

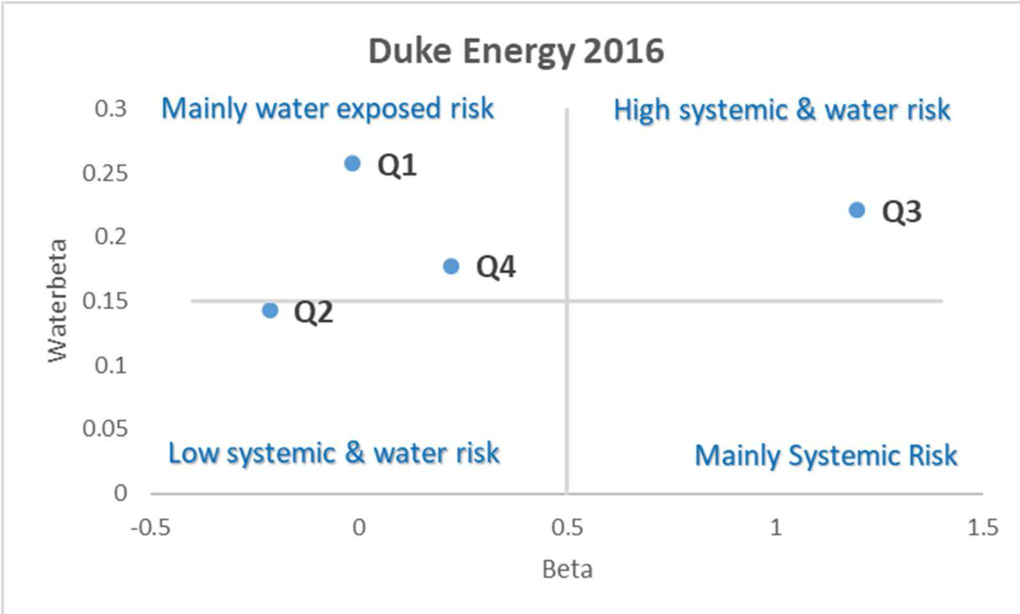


Figure 21. Systemic-idiosyncratic financial risk map for Duke Energy (2016)

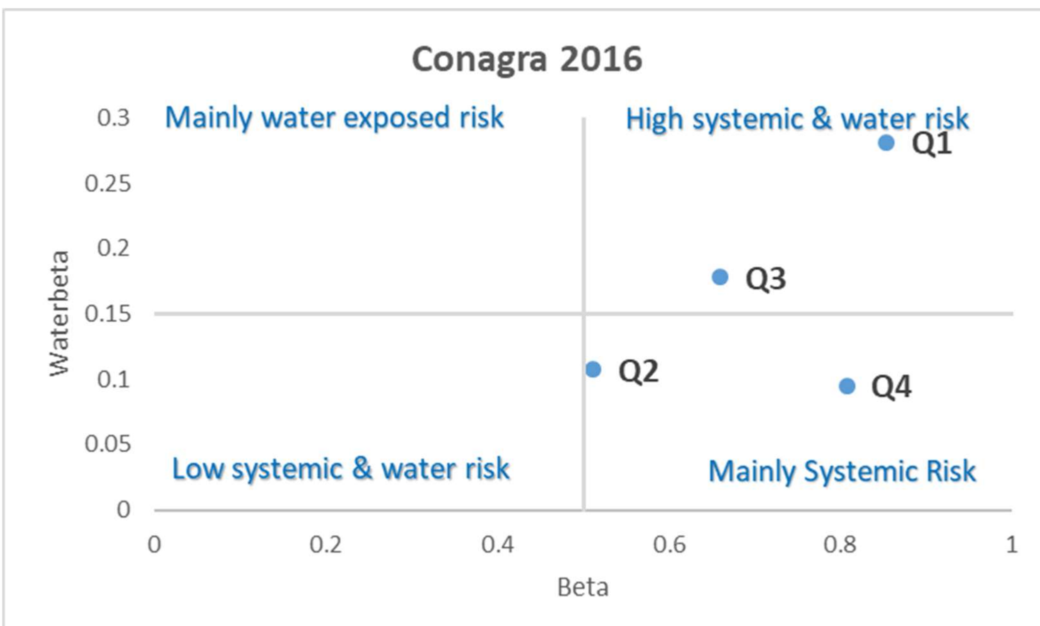


Figure 22. Systemic-idiosyncratic financial risk map for Conagra (2016)

In the case of Duke Energy, the volatility risk cannot be explained only by the general market conditions, because it is impacted by water-driven volatility in the first, third and fourth quarter of 2016. According to the voluntary disclosures, SEC filings, and analysis from third party information already included in this write-up, Duke Energy confirmed that the financial performance in Q3 was impacted by the losses from the hydro power plants affected by severe droughts. Additional analysis is necessary to deeper understand the causes of volatility for Q1 and Q4 2016 that were not disclosed by Duke Energy and which may be due to other factors besides the water issues at some of its power plants.

Conagra is impacted by water-driven volatility in the first and third quarter of 2016. According to voluntary disclosures, SEC filings, and analysis from third party information, Conagra's operational and financial performance was strongly influenced by competition, without disclosing the impact of water-related events and which financial metrics strongly influenced the performance.

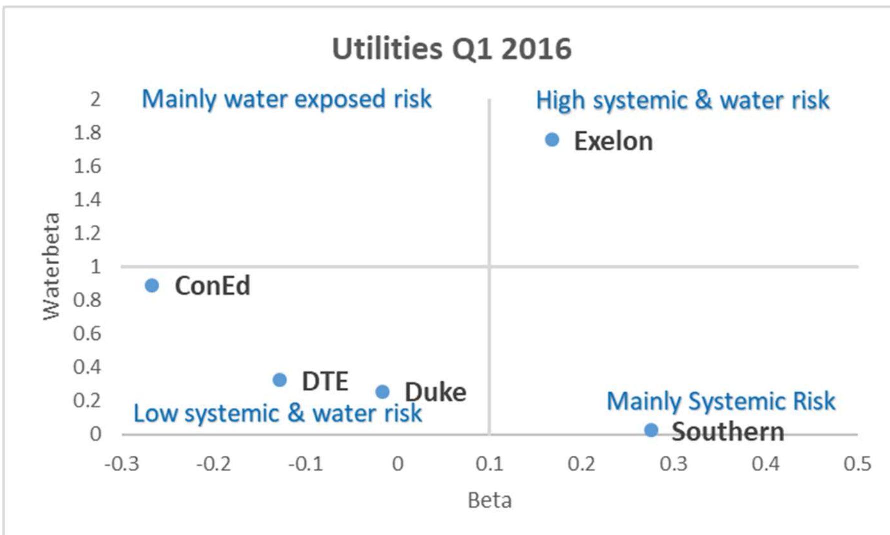


Figure 23. Systemic-idiosyncratic financial risk map across utilities

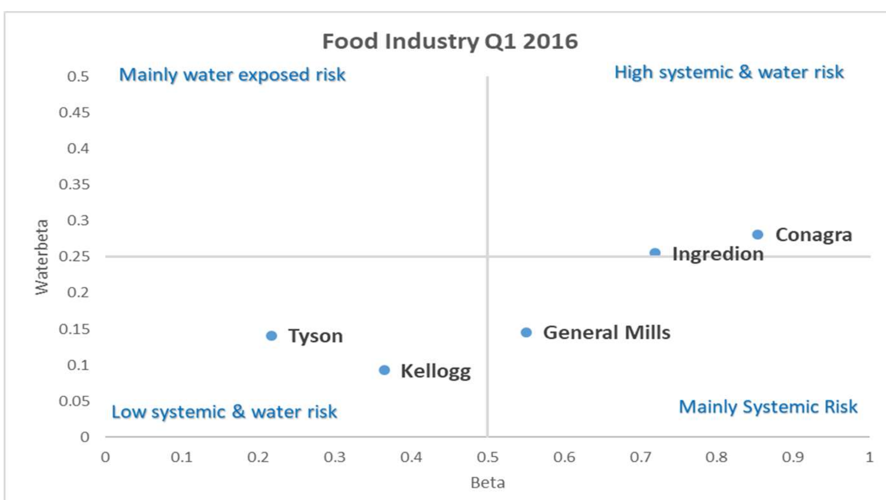


Figure 24. Systemic-idiosyncratic financial risk map across food companies

When waterBeta® is assessed for multiple utilities over the same timeframe, the volatility profiles differ considerably between companies (Figure 23). This indicates that corporate exposure to water risk and any risk management response strategies, influence the market value of companies, and ultimately the investment strategies from a portfolio risk management perspective. Consequently, this information can be used by investors to assess their asset allocation strategies in portfolio management and initiate a dialogue with companies in the portfolio on water strategies and water stewardship.

7. Conclusions

This proposal tested a quantitative theoretical framework for the impact of corporate water risk signaling on price volatility. After filtering out systemic risk, waterBeta® becomes an idiosyncratic metric with seasonal effectiveness to measure embedded water risk in stocks relative to the industry benchmark during a specific time period.

WaterBeta® is an extension of portfolio theory with applicability to portfolio management across industry verticals. The waterBeta® correlates to MSCI Key Issue Scores on Water, a leading metric used in Environmental, Social & Governance (ESG) – based investment models. Asset managers can include WaterBeta® in the cost of equity, which drives some key investment activities, including the selection of securities to invest in and the allocation of the assets in the portfolio to reduce volatility and increase the returns.

By understanding the magnitude and frequency of the signal in response to water-related events (voluntary and SEC-mandated disclosures) and quantifying them using financial metrics that are well-understood in the financial services industry, capital market signals could be used to design policies that value industry specific water impacts and incentivize corporate investment in - and sustainable management of – water resources.

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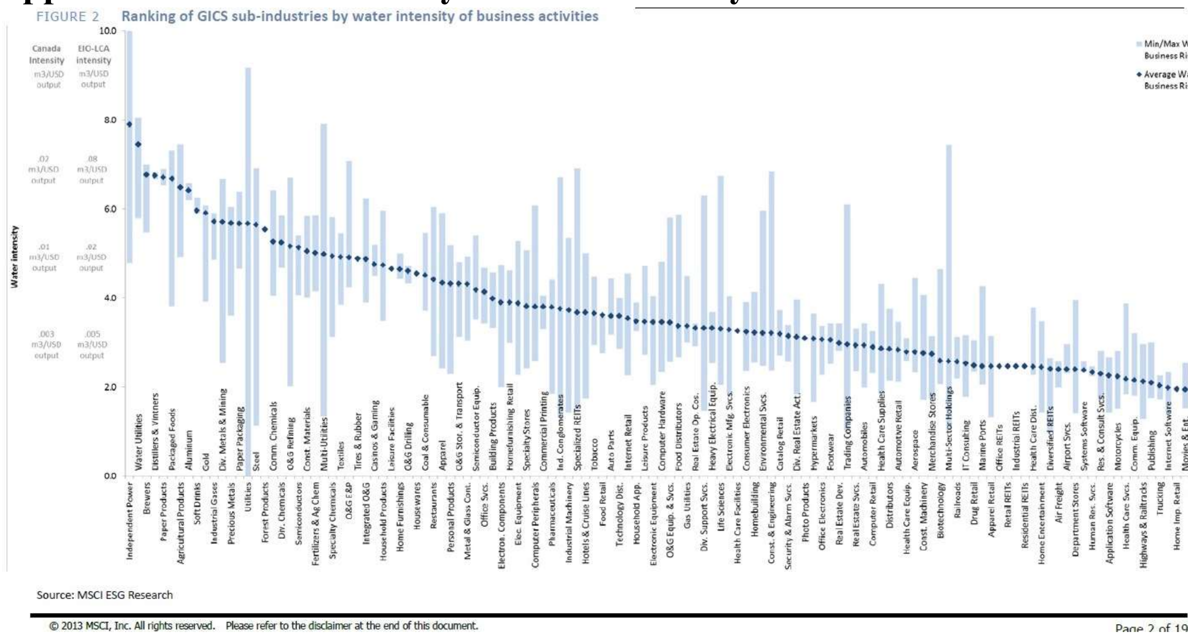
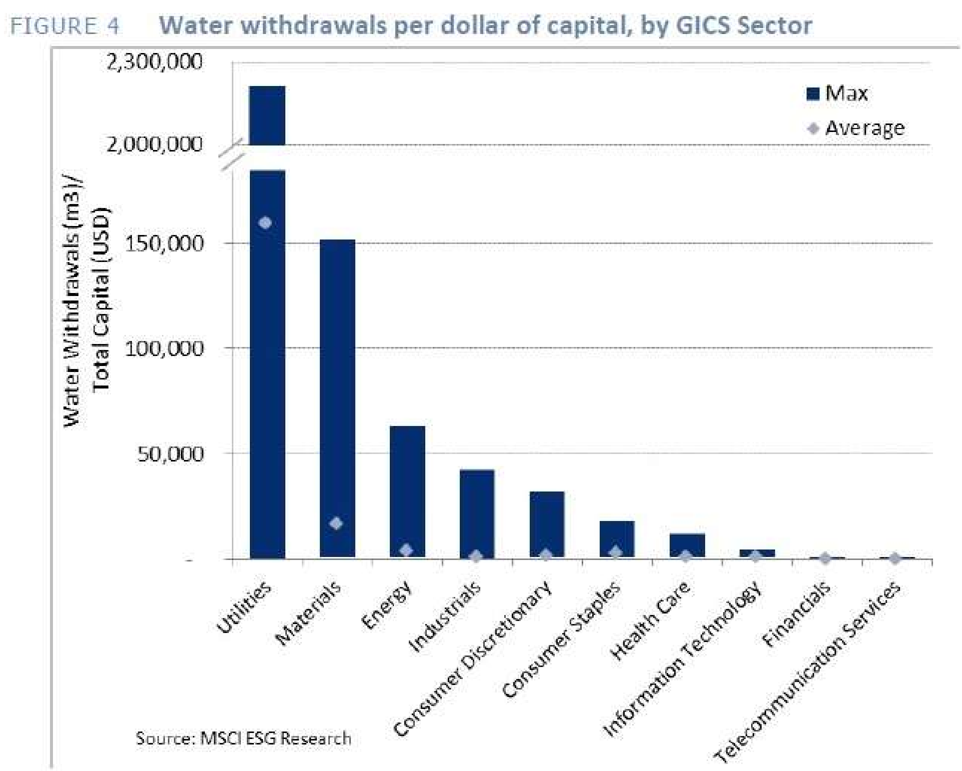
Appendix 1. Water Intensity of GICS Industry Sectors



Source: MSCI ESG Issue Report: Water Upstream and Downstream Impacts from a Well Running Dry, 2013

Figure 1. Ranking of GICS sub-industries by water intensity of business activities



Source: MSCI ESG Issue Report: Water Upstream and Downstream Impacts from a Well Running Dry, 2013

Figure 2. Water withdrawals per dollar of capital, by GICS Sector

Appendix 2. Comparisons of waterBeta® values across industries

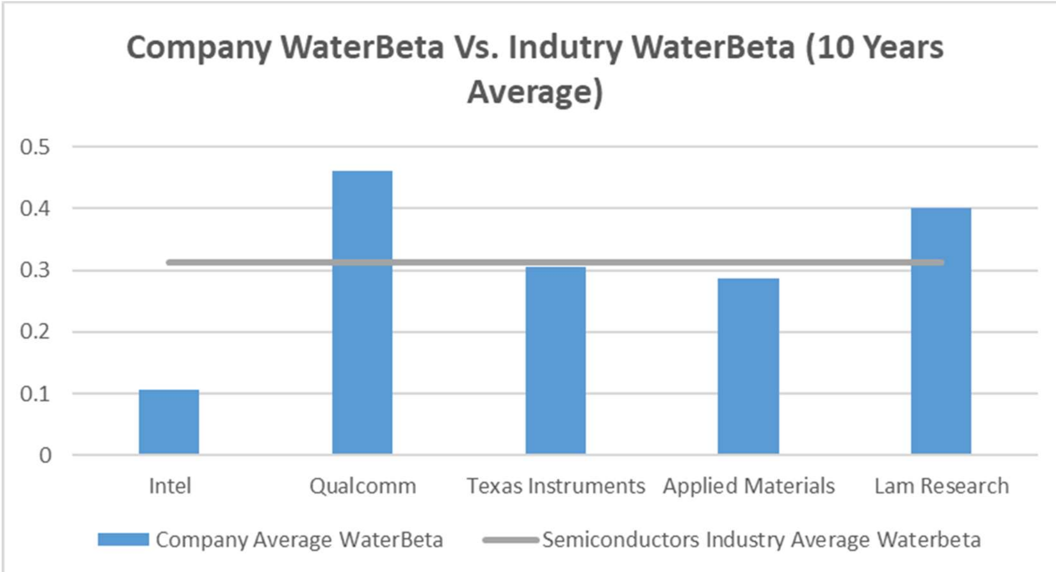


Figure 3. waterBeta® Comparison across Semiconductors Industry for 2007-2017

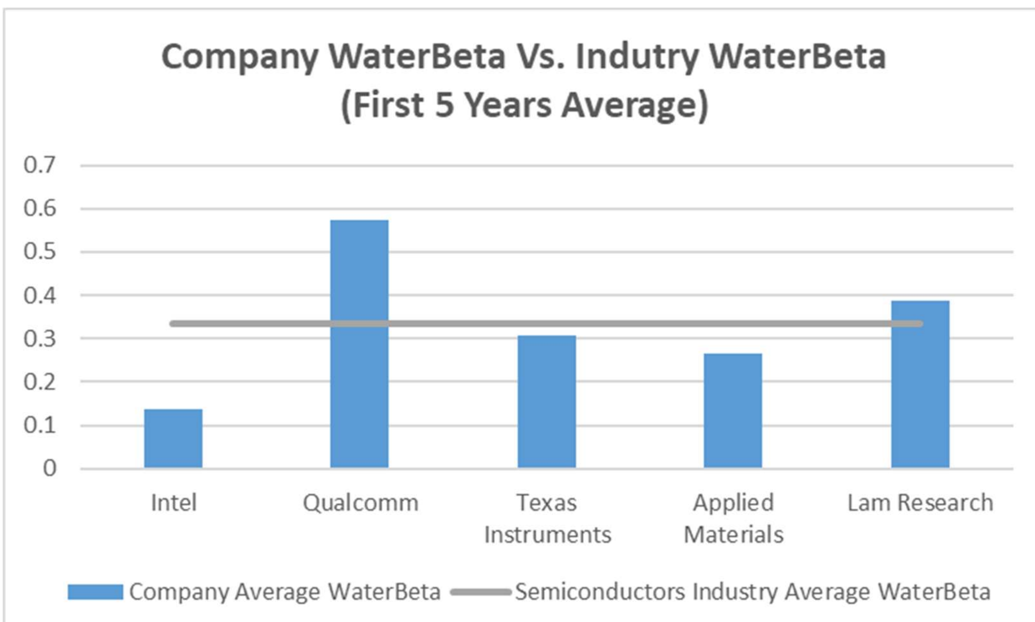


Figure 4. waterBeta® Comparison across Semiconductors Industry for 2007-2012

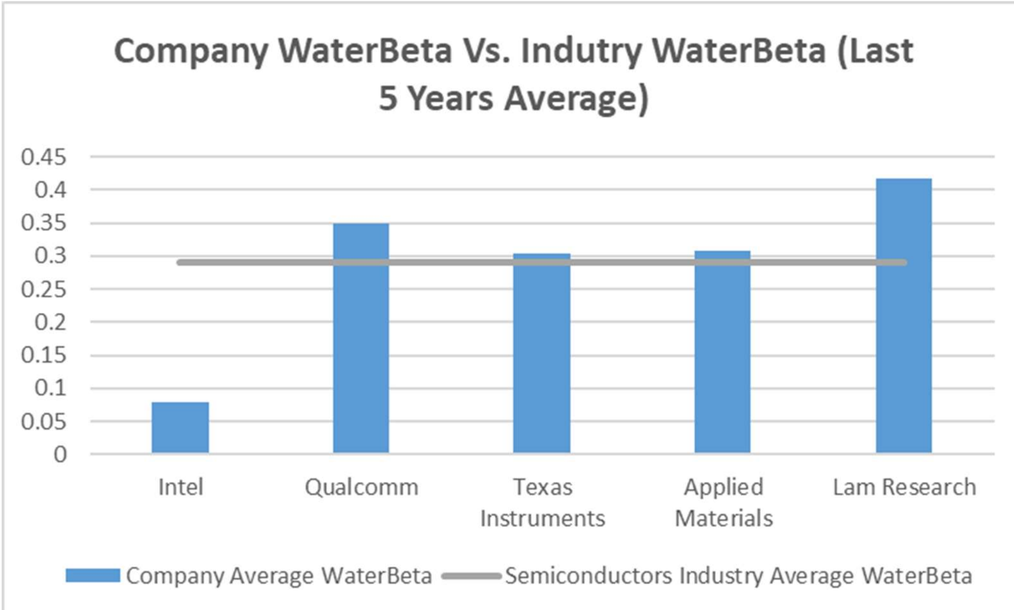


Figure 5. waterBeta® Comparison across Semiconductors Industry for 2013-2017

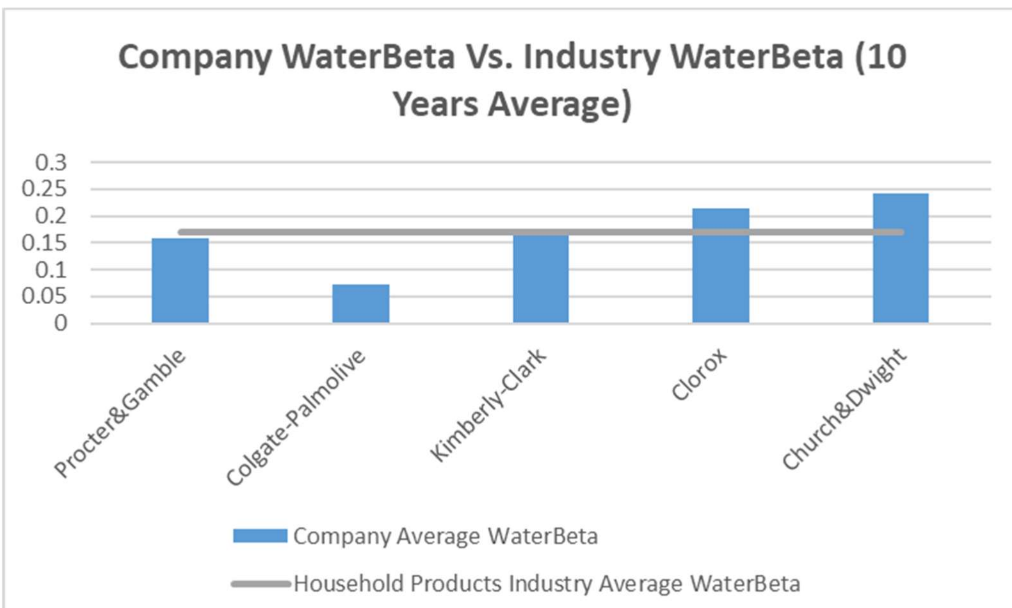


Figure 6. waterBeta® Comparison across Household Products Industry for 2007-2017

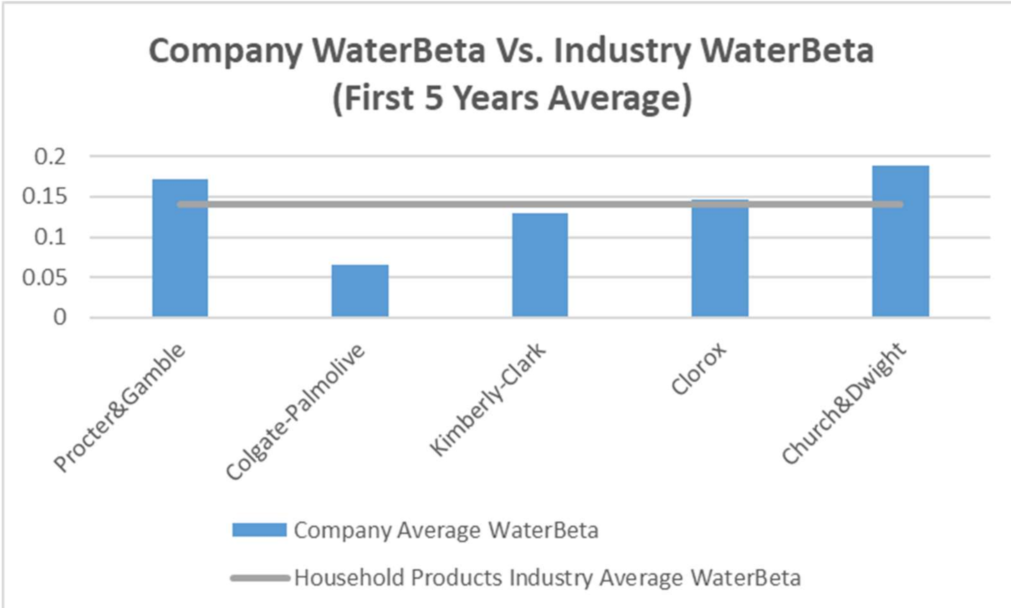


Figure 7. waterBeta® Comparison across Household Products Industry for 2007-2012

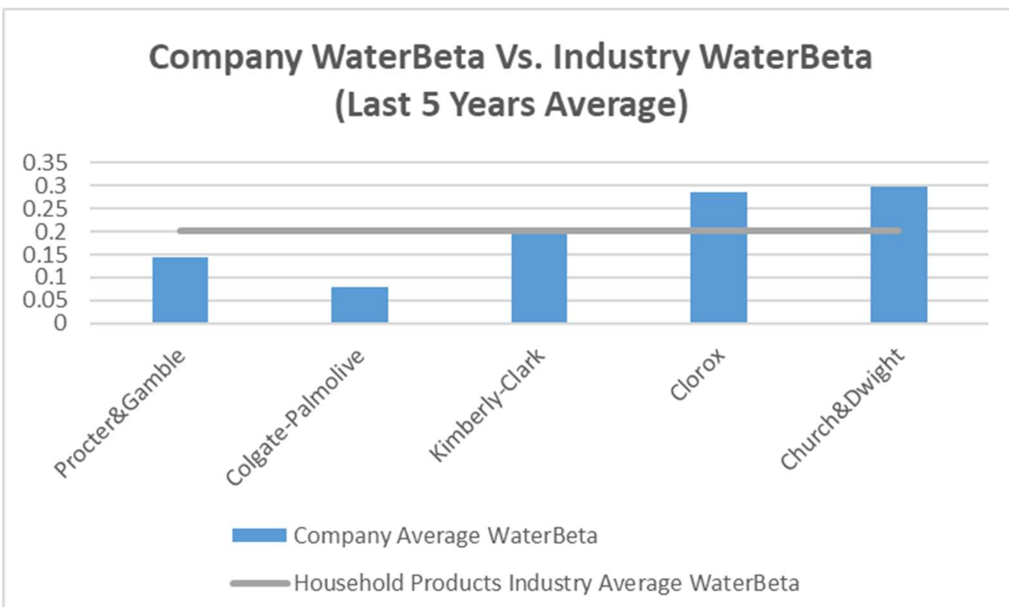


Figure 8. waterBeta® Comparison across Household Products Industry for 2013-2017

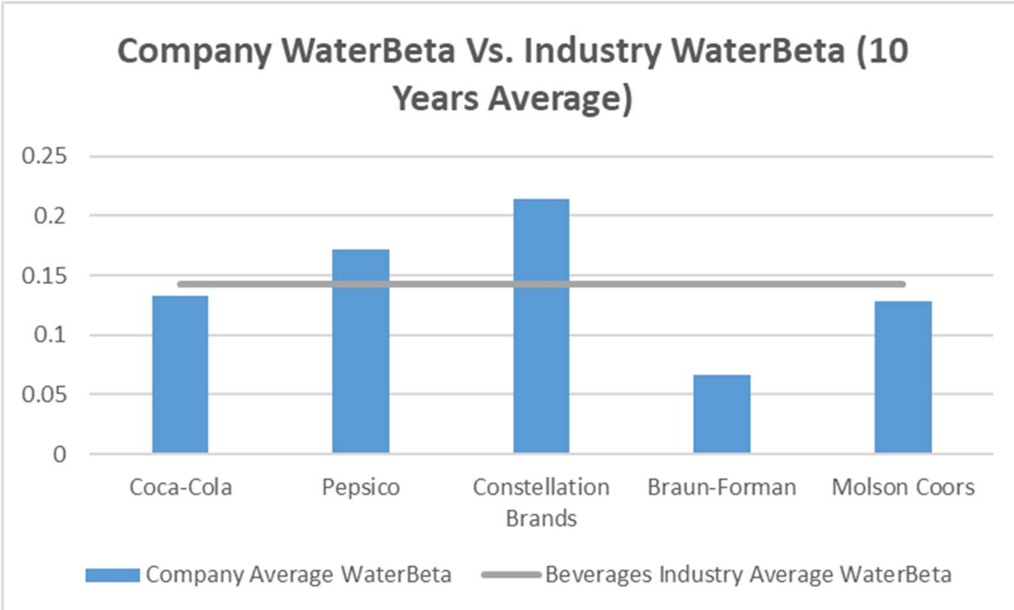


Figure 9. waterBeta® Comparison across Beverage Industry for 2007-2017

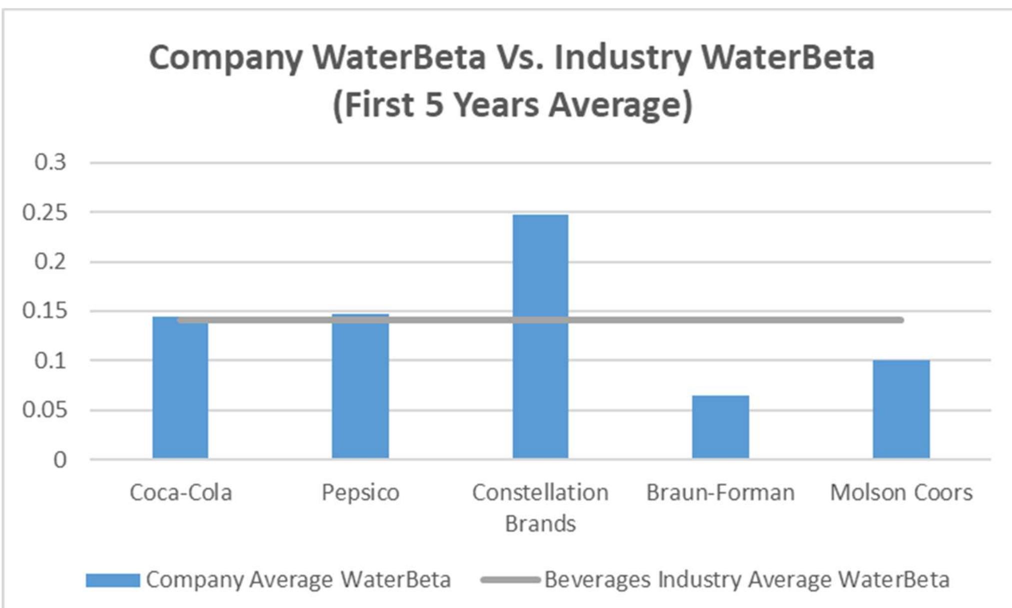


Figure 10. waterBeta® Comparison across Beverage Industry for 2007-2012

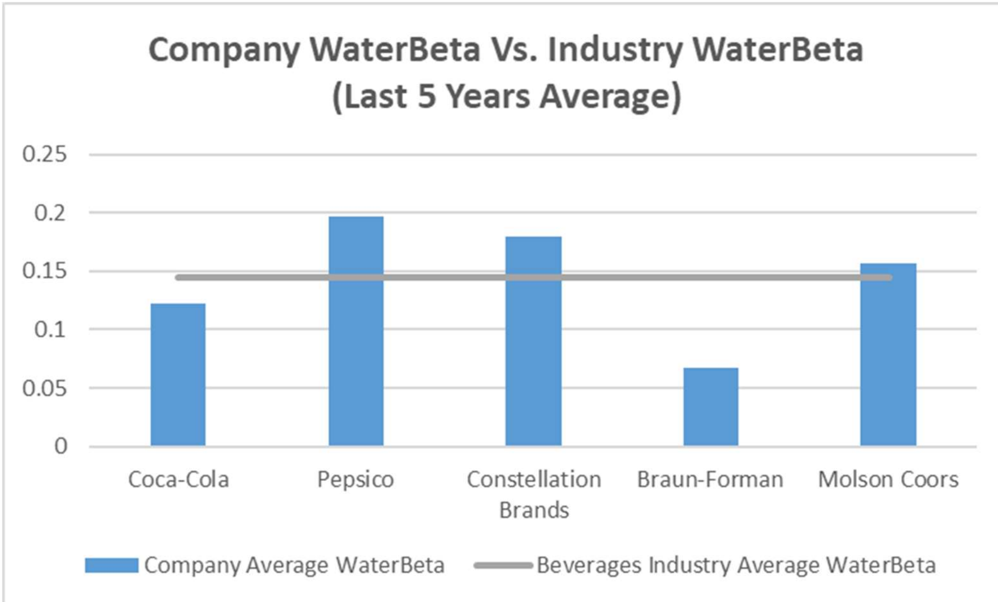


Figure 11. waterBeta® Comparison across Beverage Industry for 2013-2017