A Capital Markets-Based Water Risk Assessment of Key Industrial Water Users in the Great Lakes Region: Indicators for Portfolio Managers

University of Michigan Water Center
Project Report

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UNIVERSITY OF MICHIGAN

October 2019

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Executive Summary

This project explores capital markets risk exposure from water use in key industrial sectors in the Great Lakes region, represented by a subset of the region's largest companies and water users. The largest industrial water users in the Great Lakes region include (in decreasing order): thermoelectric, industrial, domestic/public supply, and commercial sectors. It is salient to make the distinction between water withdrawal and consumptive use, whereby the former is largely returned to the source reservoir after use in business operations, and the latter is removed from available supplies.

Industry-specific water risks can be viewed through several lenses: watershed stewardship, impact of water as a natural resource constraint on corporate operations, and risk pricing of water in the capital markets as a result of curtailed operations and growth. The approach taken here builds on portfolio theory by integrating share price trends, with corporate accounting and voluntary disclosure data to extract a share price volatility risk metric - *waterBeta*[1] - reflective of water and weather risk. The approach leverages signal processing waterBeta algorithms developed by Equarius Risk Analytics, a fintech firm, which prices water/weather risk directly into share price volatility, as a risk premium. The signal is derived from value-at-risk (VaR) models, which captures the short term 'tail' of extreme market volatility risks in share price behavior relative to industry and sector-specific benchmarks. Simply put, a higher waterBeta means a company is more prone to capital market volatility as a result of climate risks.

Our results indicate that, by comparing nine companies across four industry sectors, the waterBeta signal is lowest for utilities, followed by health care, consumer discretionary, and industrials. Companies with high waterBeta tend to exhibit a higher degree of tail risk volatility in their short-term share price, have a high percentage of facilities operating in water stressed regions, and exhibit low water intensities (WI). Interestingly, these same high waterBeta companies also tend to have high fixed asset turnover ratios, indicating high waterBeta companies are more dependent on fixed assets. Conversely, low waterBeta companies exhibit low VaR, high water intensities and a high percent of facilities in water stressed locations. However, these companies have low fixed asset turnover ratios, and are thus inefficient at generating revenue from fixed assets. Even though our subset of companies was too small for sector-wide generalizations, it appears that when an entity has higher fixed asset turnover ratios, even small changes in water intensity or exposure to high water risk areas can have a significant impact on waterBeta. This is the case with Archer Daniels Midland (ADM). However, the opposite trend can be observed, and is

[1] *waterBeta* is a registered trademark of Equarius Risk Analytics. All rights reserved. Used with permission.

exemplified by the thermoelectric companies, which are the most inefficient at generating revenue from fixed assets and have the highest WI but exhibit the lowest waterBeta values. This is largely due to the fact that thermoelectric plants/companies rely almost exclusively on surface water sources, such as the Great Lakes, and tend to have corporate/industry wide water risk management strategies in place, given their high dependency on water.

It should be noted that this capital markets risk at this time provides limited feedback to the companies on how to address this volatility, given that the model is multiparametric. Addressing water intensity (how much water a company uses to generate revenue) only has impact if its efficiency to generate revenue from its physical assets can be addressed. We are currently identifying factors that enable more targeted corporate risk management actions. As noted, the sample in this study was small and regionally focused. Broader universes of companies across multiple sectors such as represented in the '500' index will serve to develop imputation and learning models to scale capital markets-based water risk observations.

Glossary of Terms

Beta - a measure of a stock's volatility in relation to the market.

Catchment basin - the entire geographical area drained by a river and its tributaries; an area characterized by all runoff being conveyed to the same outlet;

Consumptive Water Use - is the portion of water withdrawn (for a particular use) that is evaporated, transpired, incorporated into products or crops, consumed by humans or livestock, or otherwise removed from the immediate water environment.

Cost of Goods Sold (COGS) - refers to the direct costs attributable to the production of the goods sold in a company. This amount includes the cost of the materials used in creating the good along with the direct labor costs used to produce the good. It excludes indirect expenses such as distribution costs and sales force costs.

Derating event - is a partial outage with an associated reduction in capacity that exists when a unit can generate but not at 100% capacity.

Fat-tail - is a probability distribution that exhibits a large skewness or kurtosis, relative to that of either a normal distribution or an exponential distribution.

Fixed Asset Turnover Ratios (FAT) - is, in general, used by analysts to measure operating performance. This efficiency ratio compares net sales (income statement) to fixed assets (balance sheet) and measures a company's ability to generate net sales from its fixed-asset investments, namely property, plant, and equipment (PP&E).

Fractional Asset Risk (FAR) - fraction of facilities an entity owns and operates in water-stressed regions.

Great Lakes Basin - consists of the Great Lakes and the surrounding lands of the states of Illinois, Indiana, Michigan, Minnesota, New York, Ohio, Pennsylvania, and Wisconsin in the United States, and the province of Ontario in Canada, whose direct surface runoff and watersheds form a large drainage basin that feeds into the lakes.

Great Lakes region - A bi-national Canadian–US economic region that includes portions of the eight U.S. states of Illinois, Indiana, Michigan, Minnesota, New York, Ohio, Pennsylvania and Wisconsin as well as the Canadian province of Ontario.

Idiosyncratic Risk - a risk impacting a specific entity as a result of its own internal actions.

Natural Resource Based View of the firm (NRBV) - is a model that sees resources as key to superior firm performance and is a strategic approach towards moving towards a more sustainable business practices that lead to increased profit.

Property, plant, and equipment (PP&E) - Long-term fixed assets vital to business operations and not easily converted into cash.

Revenue - is the income generated from normal business operations and includes discounts and deductions for returned merchandise.

Systematic Risk - is risk associated with fluctuations in the broader market that may impact an entity that is not necessarily the cause/source of the fluctuation.

Value at risk (VaR) is a statistic that measures and quantifies the level of financial risk within a firm, portfolio or position over a specific time frame.

Watershed - a land area that channels rainfall and snowmelt to creeks, streams, and rivers, and eventually to outflow points such as reservoirs, bays, and the ocean.

Water Asset Use Intensity (WAUI) - water withdrawals per total capital invested; plant, property and equipment or PP&E

Water Intensity (WI) - volume of water used per unit of value added in USD

Water Risk - the possibility of an entity experiencing a water-related challenge (e.g., water scarcity, water stress, flooding, infrastructure decay, drought).

Water Stress - a situation in which the water resources in a region or country are insufficient for its needs.

Water withdrawals - water that is withdrawn but returned to its source or recycled

1. Introduction

Globally, water resources play an essential role in the production and profitability of nearly every industry, in all sectors. However, climate change, population growth and an increasing demand for energy and water-intensive industrial products threatens the supply of water to industrial facilities and power plants. Climate change results in extreme weather events, including higher average temperatures and frequency of floods and droughts, which can lead to increased concentrations of some environmental pollutants from warming temperatures (Mogosanu, 2018). Population growth directly leads to an increase in water demand. Thus, access to water of desired quality and quantity exposes companies to a diverse range of risks, including opportunity cost and resiliency issues that may stunt growth and strand assets. For example, while growth in US electricity consumption has steadily decreased over the last 50 years, the US will still need an additional 26% installed capacity by 2030, primarily driven by population growth (Rice 2009). As water scarcity increases so does the probability of competition for water resources and the potential for business disruption.

As a result, in recent years, these challenges have increased corporate engagement in water management and response strategies, collectively referred to as water stewardship. Even though a diverse range of tools and methodologies has been created to help companies assess and reduce the risk of water scarcity and exposure, companies are not able to react fast enough. Therefore, there is a need for standardization on how to evaluate the business and capital markets impact of water risk, for benchmarking the risk across sectors and regions, and for climate transitioning approaches (Mogosanu, 2018). This need is exemplified by the observation that the financial impact of water risk on business operations in 2016 climbed more than five-fold as compared to 2015 as a result of increased droughts, floods, pollution costs and environmental regulations (Khalamayzer, 2016).

Such corporate financial risks have an impact on the broader capital markets resulting from operational risks, future growth limitations, and potentially the cost of doing business in a water-constrained world (Bernick, 2017). Therefore, to maximize the returns and reduce the risk on portfolios, investors should incorporate water-related risks into their portfolio investment strategies (Freyman, 2017). Given the broad range of geographic and industry-specific water risk exposures, it is difficult for investors to create a comprehensive predictive methodology that can identify water risk signals in stock valuation and bond risk ratings. This creates an opportunity to research and develop novel methodologies that 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 (Mogosanu, 2018).

At the corporate risk management level, the impact of highly variable weather conditions on geographic water quality and availability, regulatory risks, cost of operations, supply chain inefficiencies and return on assets has been amply demonstrated (e.g. Morgan and Orr, 2015). Corporate water risk management strategies require careful decision-making to balance long term operational risks and future opportunity costs with local community engagement and moral hazards. To navigate these decisions, novel tools have been developed to evaluate water use efficiencies, water footprints, economic costs, and regional asset risk exposures at granular catchment levels (Reig et al., 2013). Most of the attention has been focused on corporate engagement, disclosures and capital-efficient risk response measures including financial hedging, insurance and options contracts. Long-term capex outlay for technological or infrastructure investments related to recycling/re-use and supply extension tend to be a distant second (Larson et al., 2012).

The ripple effect of corporate water risk exposures on capital markets signals, beyond credit warnings by ratings agencies and shareholder resolutions is less clear. In part, the argument is based on the assumption that equity analysts have no clear policy signals to help assess water risks on stocks or corporate bonds. Policy limitations notwithstanding, banks and institutional investors have started to focus on water risk exposures in their (loan and corporate bond) portfolios, and on integrating risk metrics for financial asset allocation across fixed income, public and private equities (Ceres, 2017). Most of these efforts are driven by accounting data such as revenue and cost impacts, as well as risk management metrics, i.e., water use targets, which are relevant to – but not directly correlated with – returns in the market. Hence, the guidance of these metrics to price volatility (risk) is limited.

It is important to make the distinction between water in the physical asset sense as opposed to its impact on liquidity, i.e., water risk propagated in the financial asset value context. Water risk can be thought of as ‘opportunity cost’, e.g., derating of Duke Energy’s power plants in North Carolina due to water shortages/increased temperatures up stream (Rice et al., 2009), reputational damage from overdrawing aquifer resources (e.g., Coca Cola in India, Nestle in N. Michigan). Hence, water/weather risks are not limited to ‘the cost of obtaining water for commercial and industrial purposes’. The question that arises then is how water as an externality can be reflected in the share price volatility, by considering both operational and long-term resiliency risk. The recent impact of the heat wave in Europe illustrates this challenge. The French utility EDF (Electricite de France) issued a warning to shareholders that because the water in its reservoirs is too warm for cooling, its electricity output would decrease (Bloomberg, 2019). As a result, the share price went down. Hence, the water use efficiency of EDF temporarily decreased, as illustrated in Chart 1.

Chart 1: Impact of heat wave in Europe on share price of EDF, a utility with a large portfolio of nuclear power plants, resulting from water temperature for cooling, which reduces output efficiency.

Approaches to quantify corporate and capital markets risks from water are limited because: (i) water is generally treated as a real asset, not a financial asset; (ii) water risk financials are still largely based on cost (which is often a 'rounding error' in accounting, if it is disclosed at all), rather than opportunity cost; (iii) corporate risk management tends to be treated homogeneously as an investment in technology or infrastructure, rather than as a spectrum ranging from short-term hedging to long term capital allocations; (iv) the overwhelming focus on water is based on drought (deficits) and largely ignores regulatory and quality risks; and (v) water is local, meaning that risk to a company with multiple and diverse plants or assets, and complex supply chains across geographies, is difficult to estimate. Companies are showing an increased awareness of the financial impacts of water risk on business operations, and are responding with diverse risk management strategies e.g., in the *Water Management and Stewardship: Benchmarking Corporate Practices* (Sustainalytics, 2019). Even though a diverse range of tools and methodologies have been developed to respond to water risks, it remains a challenge for investors to identify, measure and analyze water risk in their holdings for the purpose of portfolio risk management. A number of models and approaches are documented in the *Investor Water Handbook for Water Risk Integration* (2015).

By focusing on key companies operating in the Great Lakes basin, the motivation for this study is to assess a new approach to quantify and value the impact of water risk on stock volatility in the form of a novel data platform called *waterBeta* (Mogosanu et al., 2019). The waterBeta model was developed by

Equarius Risk Analytics, a Fintech company based in Ann Arbor, Michigan, in collaboration with the Center for Smart Infrastructure Finance at The University of Michigan. This model integrates portfolio theory, water resource productivity, and natural language processing (NLP) approaches by using empirical market pricing and corporate accounting data, water resource information, as well as voluntary and SEC disclosures. In this paper, the waterBeta model will be used to assess nine companies in four industry sectors (utilities, consumer, healthcare, and industrial) to assess the relationship between waterBeta, financial risk metrics, water intensity, and environmental, social and governance risk (ESG) rankings.

2. Methodology

The purpose of the study was to assess whether high water users in the Great Lakes region experience excess share price volatility as climate and weather events impact the region.

Company Selection

A universe of nine companies was identified as representative due to their corporate activities in the Great Lakes basin, and their reliance on local water resources for operations and revenue generation. The decision to use these companies was also informed by and framed in the historical context of key industrial water users in the Great Lakes (Shaffer and Runkle, 2007).

- Exelon Corporation (**EXC**) - a Fortune 100 energy company based in Chicago, Illinois and by revenue is the largest regulated utility in the US with more than 10 million customers. EXC is a utility services holding company that engages in energy generation and delivery businesses in the United States and Canada.
- DTE Energy (**DTE**) - Detroit based energy company with more than 2.2 Million customers, recognized as a national pioneer in energy management and energy related business including power generation, transmission and distribution.
- CMS Energy (**CMS**) - Jackson, MI based energy company with over six million customers in Michigan that operates in three segments: Electric Utility, Gas Utility, and Enterprises.
- Target Corporation (**TGT**) - Minneapolis, MN based, eighth largest retailer in the US, ranked 39th of Fortune 500 Companies by revenue in 2018. The company provides household and beauty essentials; food assortments, including perishables, dry grocery, dairy, and frozen items; and apparel, accessories, home décor products, electronics, toys, seasonal offerings, and other merchandise.
- Archer Daniels Midland (**ADM) -** Chicago Based, global food processor and commodities trading

corporation, ranks 49th in Fortune 500 Companies. ADM procures, transports, stores, processes, and merchandises agricultural commodities, products, and ingredients in the United States and internationally.

- General Motors Company (**GM**) - Based in Detroit, is the US's largest automobile manufacturer and ranks 10th in Fortune 500 Companies. GM designs, builds, and sells cars, trucks, crossovers, and automobile parts worldwide.
- Abbott Laboratories (**ABT**) - Lake Bluff, IL based health care company that has existed since 1888 and ranks 134th on the Fortune 500. ABT discovers, develops, manufactures, and sells health care products worldwide.
- Stryker Corporation (**SYK**) - Kalamazoo, MI based Fortune 500 medical technology corporation. The company operates through three segments: Orthopaedics, MedSurg, and Neurotechnology and Spine.
- 3M (**MMM**) - Maplewood, MN based industry, worker safety, health care, and consumer goods corporation that ranks 97th in Fortune 500 Companies and operates in more than 70 countries. 3M develops, manufactures, and markets various products worldwide. It operates through four business segments: Safety & Industrial, Transportation & Electronics, Health Care, and Consumer.

waterBeta model

The model is derived from empirical and theoretical observations and is structured in the context of portfolio theory and the capital asset pricing model (CAPM), based on the following assumptions outlined by Mogosanu (2018).

1. waterBeta is expressed as a probability loss because the exact correlation between water risk exposures and returns is not known;
2. waterBeta for each company has to be benchmarked relative to its industry sector classification (e.g. GICS, NAICS, NACE) measured via industry-specific indexes;
3. waterBeta is based on short term (quarter) value-at-risk (VaR) analytics, representing the 95th percentile of quarterly losses based on daily share prices (so-called "fat tails"), because water and weather impacts manifest themselves as high kurtosis (short term, extreme) events;
4. waterBeta is adjusted by direct or indirect exposure of the company's real assets to geographic risks at the watershed, catchment, or sub-catchment levels because corporate operations and growth are impacted by water (and weather) risk.

Based on these assumptions, the waterBeta factors comprise:

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

where VaR (asset)/VaR (index) represent the ratio of short term (3 months; approximately 63 trading days) value-at-risk losses (95th percentile of price volatility) of the company (asset) relative to its sector, represented by an index; fractional asset risk (F asset risk) is a factor-based equation that relates facility location, corporate accounting data, and water risk categories based on Bloomberg-Aqueduct information; the correction factor is based on water intensity and capital intensity of the asset and sector. The data were largely based on Bloomberg and FactSet data collected at the Tozzi Finance Center (Ross School of Business, The University of Michigan), and independent research of corporate disclosures. Ten years of financial market data (share price distributions) were gathered for each company. Corporate fundamentals (accounting data) were based on a review of ten years of income statements and balance sheets which provided the basis for determining earnings-to-price (E:P) ratios (earnings yield), historical and current market capitalization, cost of goods sold (COGS) and raw unlevered beta, a systematic market risk metric.

It was decided to include Fixed Asset Turnover Ratio (FAT) as well, to understand how efficiently a company generates net sales from its fixed assets. The connection to water is based on the natural resource based view (NRBV) of the firm (Hart, 1995), a theory which states that the interaction between an organization (company) and its natural environment can create serious constraints to a sustainable competitive advantage. The NRBV argues that there are three key strategic capabilities that a company needs to manage: pollution prevention, product stewardship, and sustainable development. Water use for product development, water recycling and efficiency for sustainable development, and emissions management for pollution prevention clearly fit in this context, and FAT was used as a proxy to compare companies across industries.

Ten years of daily share prices and market cap allowed us to determine VaR (Value at Risk) which we broke down into quarterly averages and benchmarked against relevant indexes, i.e., S&P 500 (SPX), MSCI World Index (MXWO), MSCI World Utilities (MXWO0UT) Index. Further, industry-specific indexes (four industries represented), i.e., MSCI World Utilities (MXWO0UT), S&P 500 Consumer Index (S5COND), S&P 500 Health Index (S5HLTH), and S&P 500 Industrial Index (S5INDU) were used to assess sector-specific Value at Risk data. Sector-specific ratios allow us to determine underlying systematic vs idiosyncratic (unsystematic) risks in the market. Certain characteristics of each sector are

indicative of stock performance, which underlies VaR (fat tail, share price volatility) risk relative to its benchmark:

- Consumer Staples: Since staples are considered to be essential, this sector tends to be non-cyclical, i.e. consumers will purchase goods regardless of the state of the economy. This report has two companies in this sector: Archer Daniels Midland (a food processor and agricultural trading company, and Target (a household, food and apparel company)
- Consumer Discretionary: This is a cyclical sector of the economy, because discretionary spending is related to the state of the economy and consumer confidence. This report has one companies in this sector: General Motors (an automotive company).
- Utilities: This sector, comprised of water, energy and sewerage services, typically offer investors stable and consistent dividends, coupled with less price volatility relative to the overall equity markets. It is heavily regulated. Because of these facts, utilities stocks tend to perform well during recessionary climates, and are fairly stable (low VaR risk). This report has three electric utilities companies: Consumers, Exelon and DTE, with varying portfolios of energy generation capacity.
- Health Care: This sector comprises companies engaged in the production and delivery of medicine and health care–related goods and services, including medical equipment. Stable demand for drugs can make the sector less sensitive to economic cycles, but the broad range of services and products introduces significant volatility in the sector performance. We have two companies representing this sector: Abbott (a medical devices, diagnostics, branded generic medicines and nutritional products company) and Stryker (a medical technologies firm focused on implants and surgical devices)
- Industrial Goods: This sector includes companies involved with aerospace and defense, industrial machinery, tools, lumber production, construction, waste management, manufactured housing and cement and metal fabrication. Performance is largely driven by supply and demand for building construction in the residential, commercial, and industrial real estate segments, as well as the demand for manufactured products, and thus can be quite volatile. We have one company representing this sector: MMM, a manufacturer of safety and industrial, transportation and electronics, health care, and consumer products.

The waterBeta signal was calculated by using the ratio of short term (4 month) company VaR over the VaR of the sector-specific index. This ratio is then multiplied by the correlation between the daily share prices of the index and the asset on a quarterly basis. Fractional Asset Risk (FAR) accounts for the exposure of the operational expense margin (COGS/revenue) relative to the fraction of facilities an entity owns and operates in water-stressed regions (as determined by Aqueduct data). Lastly, a proprietary correction factor is applied, derived from industry water intensity and capital intensity trends. It is widely

assumed that water use and capital asset intensity inform the risk of corporate assets becoming stranded and growth curtailed due to resource constraints.

Five years of Environmental, Social and Governance (ESG) scores were captured from Bloomberg based on data from the following ratings companies:

- **RobecoSAM** - is based in Switzerland and is one of the world's first investment specialists focused exclusively on Sustainability Investing.
- **Sustainalytics** - is a global leader in ESG and Corporate Governance research and ratings which supports hundreds of the world's foremost investors who incorporate ESG and corporate governance insights into their investment processes.
- **Bloomberg ESG Disclosure** provides ESG exposure and performance analysis via its terminals, leveraging portfolio-level ESG reporting and ESG news monitoring.
- **ISS Quality Score** Institutional Shareholder Services Inc. (ISS) is the world's leading provider of corporate governance and responsible investment (RI) solutions for asset owners, asset managers, hedge funds, and asset service providers. ISS analysts have unique expertise and insight on the governance and RI landscape, local market voting practices and regulatory requirements, along with expertise in varied fields such as law, M&A, compensation, and analytics.
- **CDP Climate Score** claims that by scoring companies and cities, CDP aims to incentivize and guide them on a journey through disclosure towards becoming a leader on environmental transparency and action.

In addition, we compared ten years of volumetric water usage data for each company (except CMS and SYK which don't report water use) to determine an entity's Water Intensity (WI) for production (volume of water used per $US of economic output generated) and Water Asset Use Intensity (WAUI) for capital asset intensity (water withdrawals per total capital invested; plant, property and equipment or PP&E). Facilities location data for each of the nine companies were obtained from Bloomberg, and water stress at each plant location was assessed using World Resources Institute Aqueduct Water Stress maps available on Bloomberg. This allowed us to determine the percent of facilities/plants each company has in water stressed regions. The COGS margin (COGS/Revenue) was divided by the number of facilities in water-stressed regions allowing us to determine a Fractional Asset Risk (FAR) based on geographic operations, as described in Mogosanu (2017). It is important to emphasize that the derivation of waterBeta is conducted on a corporate-wide basis, not at an individual facility level. Even though the proportion and location of facilities -asset specific risk - is considered in the estimation, waterBeta does not scale down to a target geographic location.

3. Results

3.1. Water-impacted volatility in the capital markets: waterBeta

The waterBeta calculations (Chart 2) indicate that companies in the Consumer Staples sector (TGT and ADM) exhibit higher waterBeta scores relative to other sectors. A Consumer Discretionary sector company, GM, has the lowest waterBeta of any company, relative to its sector, as the result of low short-term extreme price volatility (VaR) trends. One factor in waterBeta estimates is the correlation of company share price behavior to broader capital markets ('500' index) performance, and a sector-specific index. The VaR signal for GM, relative to its industry sector, indicates low beta (volatility) relative to the market much of the past 10 years (Chart 3). Consumer Staples companies TGT and ADM tended to be more volatile than the market, thus driving up VaR ratios and affecting waterBeta values.

When Consumer Discretionary and Consumer Staples companies are compared to Utility sector representatives (EXC, DTE and CMS), utilities have the lowest waterBeta values. This result would appear to be counterintuitive given the disproportionate volume of water usage among thermoelectric companies (Chart 9), relative to all sectors (Lotfipour et. al. 2013). However, waterBeta is not a measure of water use or consumption, but how water risk exposures impact share price volatility. A low waterBeta among utilities is likely a result of a low short term VaR signal observed among utilities, relative to the broader market, as well as within the industry sector itself. Thermoelectric companies tend to exhibit a lower extreme market volatility (low VaR) because of regulatory and other characteristics in the sector. In addition, historical industry standards have driven adoption and implementation of water reuse technology solutions, given the utility sectors disproportionate demand for water (WEF, 2012).

Health sector companies are split in terms of above and below average waterBeta. Abbott exhibited about twice the VaR of Stryker, which influences the higher waterBeta score for Abbott despite being in the same sector as Stryker (Chart 4). In addition, the geographic distribution of facilities and their water risk exposures need to be considered (see 3.2), in light of the differences in operations of each company (medical devices, drugs and nutritionals vs medical technology manufacturing). The actual water risk exposures will be discussed hereafter. The only company in the Industrials sector was 3M, which has the highest waterBeta of any asset analyzed. In addition, to the highest waterBeta, 3M also has the highest VaR signal of any company, relative to its sector benchmark, and nearly half of its facilities are in water-stressed regions.

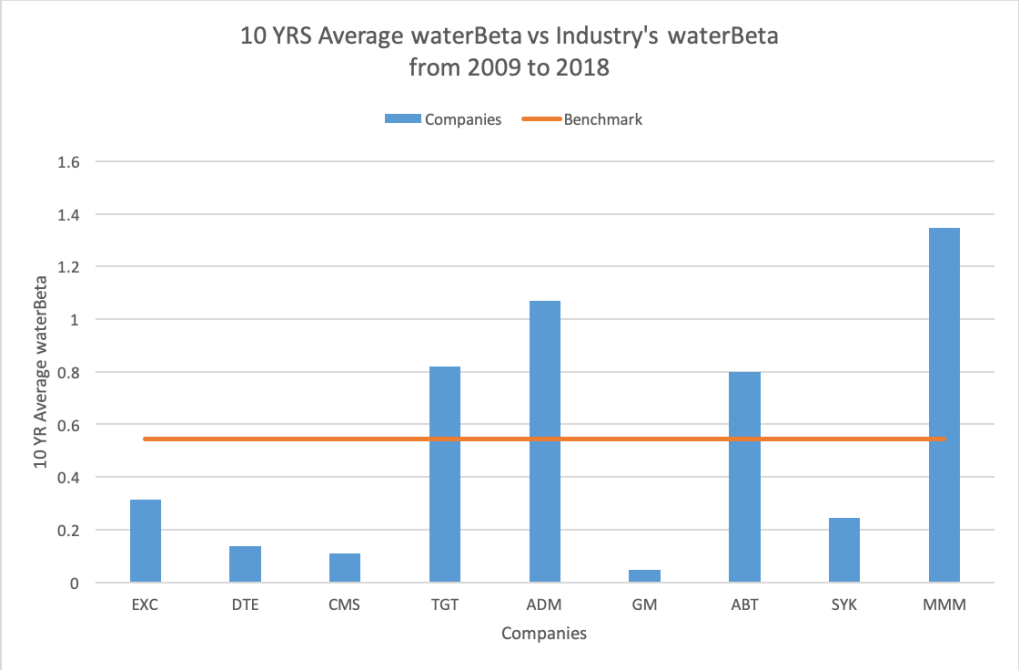

Chart 2: Trends of average waterBeta values for Great Lakes headquartered companies in the 2009 to 2018, benchmarked against industry average across the four sectors represented.

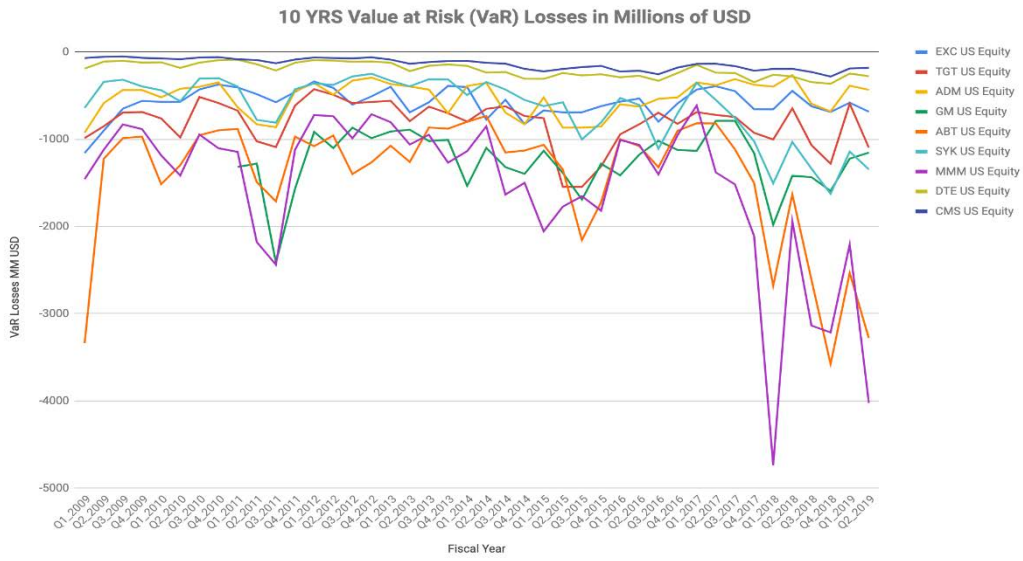

Chart 3: Value at Risk (VaR) trends for companies and sector indexes 2009-2019.

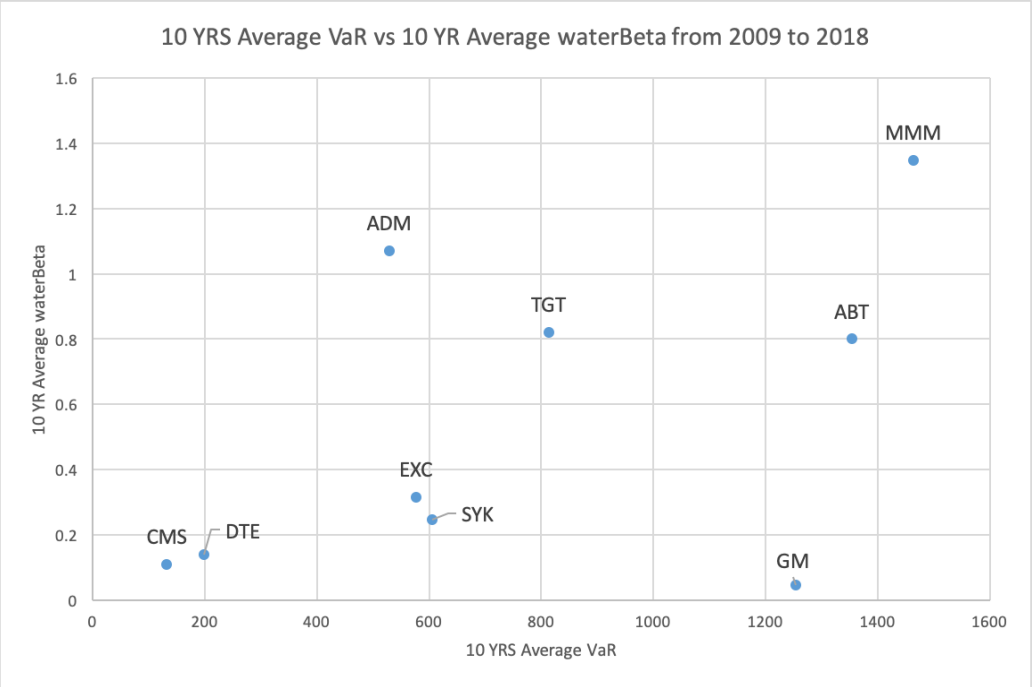

Chart 4: Value at Risk and waterBeta Trends for companies headquartered in the Great Lakes region (note: they don't have all their plants and facilities in the watershed).

As indicated earlier, a major factor contributing to waterBeta analysis is the VaR signal which measures extreme share price volatility ('fat tails') for each company over a 10-year period (Chart 2) relative to its sector benchmark (data not shown). Here we can see the share price-based market value in millions of dollars (USD) on a quarterly basis. Considerable volatility among company and sector VaR values can greatly influence the final waterBeta outcome but not in all cases. For example, 3M, ABT, GM and TGT had the highest VaR values over the 10-year period. But GM also exhibits the lowest waterBeta of any company analyzed, indicating the influence of other factors in the waterBeta estimates. In Chart 4, the average VaR and waterBeta values over 10 years are compared, and indicate a strong statistical significance linking these variables (T= 0.00169), indicating that VaR plays a central role in determining a company's waterBeta. Further correlation on a quarterly basis was not explored here given the small sample size.

3.2. Application of waterBeta: Adjusting asset allocation in portfolios

As mentioned earlier, waterBeta is an idiosyncratic risk, meaning that it is company and/or sector-specific, as opposed to systemic (market) specific. The importance of this distinction for portfolio managers is that they can diversify away from risk, i.e. decrease their allocations to high water risk companies, eliminate them from their portfolios, or bet against them (short). In that context, waterBeta has characteristics aligned with the capital assets pricing model (CAPM), which describes the relationship

between systematic risk and expected return for assets, particularly stocks. The model is widely used throughout finance to price securities and generate expected returns for assets given the risk of those assets and cost of capital (the weighted average of a firm's cost of debt and cost of equity blended together). The formula for expected returns includes a financial beta, a measure of how much risk the investment (a company's stock) will add to a portfolio that looks like the market. If a stock is riskier than the market, it will have a beta greater than one. If a stock has a beta of less than one, the formula assumes it will reduce the risk of a portfolio. This average stock volatility is relative to the broader market, instead of to the industry sector in waterBeta. It is typically measured over a 2-year time horizon, as opposed to waterBeta which is measured over 3 months). Hence, the investor can consider systemic (broader market; average) vs idiosyncratic (sector-specific; tail) risk to build a specific risk profile for portfolio holdings.

The interpretation of systematic vs idiosyncratic risk trends is illustrated for Exelon, a utility company (Chart 5) on a quarterly basis. Systemic risk (Beta) represents the average volatility relative to the broader market, which is set at 1, based on portfolio theory. When a company's beta is over 1, this means that on average the company is more volatile than the broader market (with potential higher returns). When beta is less than 1 (but above zero) the systemic risk (volatility) is less than the broader market. When beta is negative, the company's volatility runs counter to the market. In other words, when the market becomes volatile, the company's share performance is stable, and vice versa. This information can be used by portfolio managers to hedge risks within the portfolio. The unsystematic (idiosyncratic) risk imparted by water can be informed by voluntary SEC filings and analysis from third party information. For example, Exelon confirmed that its run-of-river hydro megawatt-hour production in 2018 was more than 43 percent higher than that in 2017 due to the higher rainfall in 2018 (Exelon, 2019). This resulted in higher water usage in its operational activities and revenue generation. However, the variability of rainfall impacts revenue and share price volatility, affecting high Q3 and Q4 tail risks, aligned with higher expected returns, relative to the industry. Additional analysis is necessary to understand any other causes of volatility in Q3 and Q4 of FY 2018 that were not disclosed by Exelon.

The market volatility across utilities is illustrated in Chart 6 for Exelon, DTE Energy, and CMS Energy on a quarterly basis (Q1). Financial beta spread is very tight for all companies, but waterBeta differentiates Exelon from DTE and CMS, in part due to the higher portfolio contribution of hydropower in the revenue and business model of Exelon. The variable volatility profiles, relative to the industry index reflect how water and weather risk has an impact on share price volatility. Further analysis is required to uncover and quantify individual contributions of specific risk factors to the extreme 'fat tail' risk.

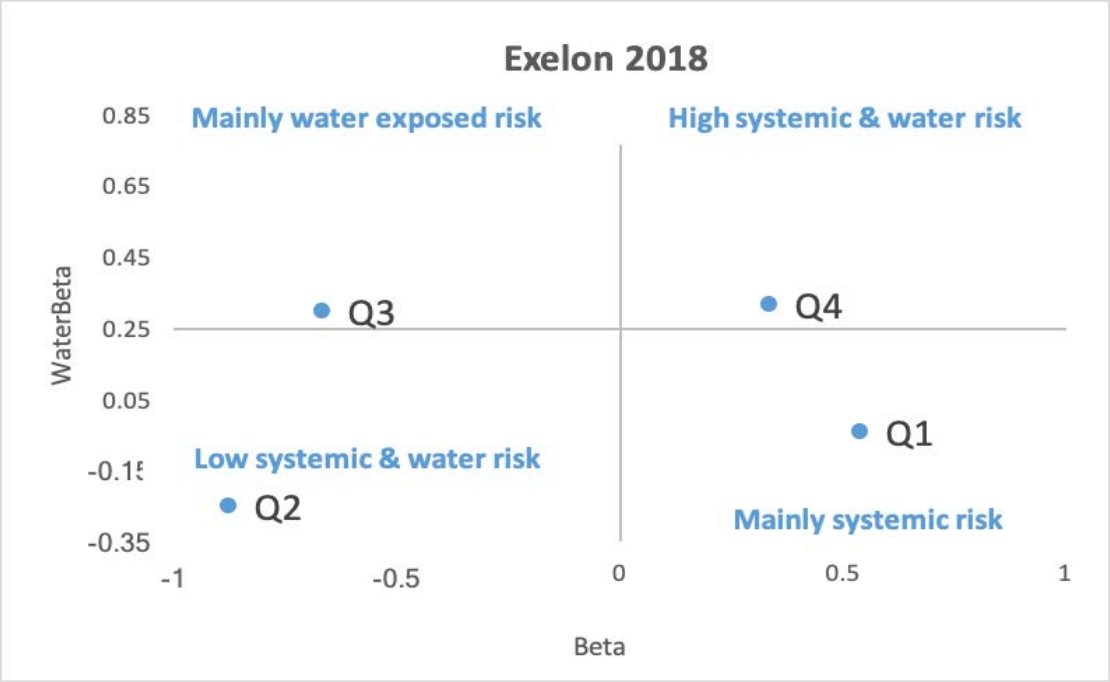

Chart 5: Systematic vs idiosyncratic risk example for Exelon in 2018.

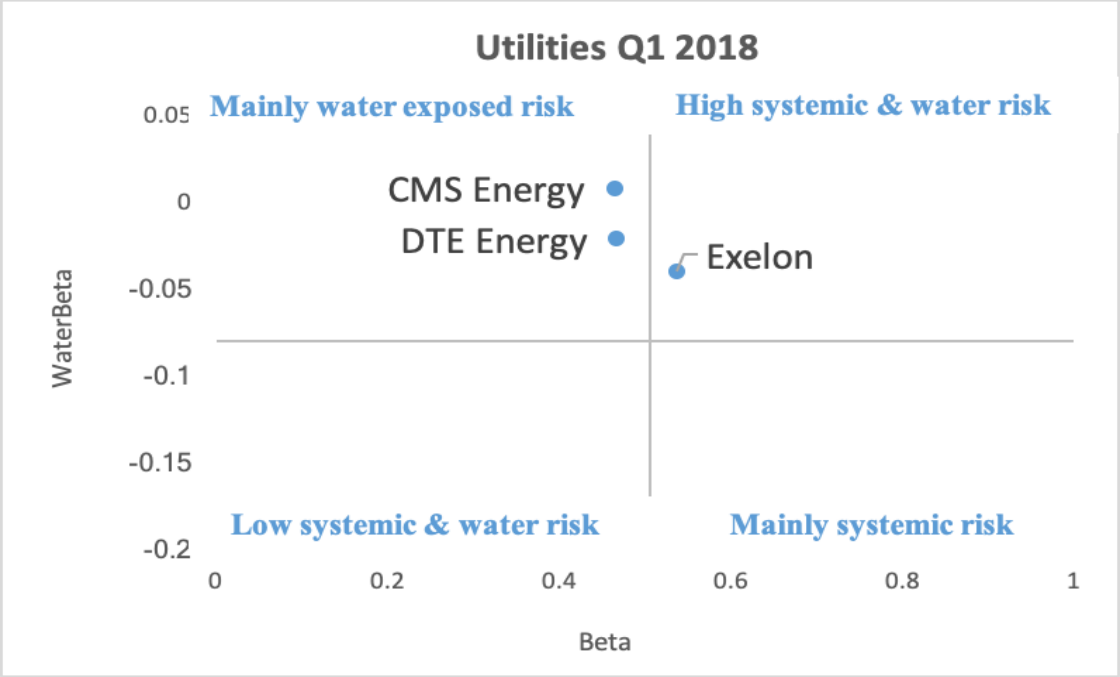

Chart 6: Systemic-idiosyncratic volatility risk map for multiple utilities in 2018.

3.2. Environmental and sustainability indicators

Based on previous work (Arnold, 2019) we were interested in investigating any linkages between a company's actual water usage, waterBeta, financial performance and ESG scores. Water usage is captured in cubic meters (m^3) but not all companies report this data, and some only disclose intermittent years of water use. Despite water use and water consumption data not being readily available this information is important in the context of financial performance, waterBeta and ESG given that company productivity is (in part) based on water use and individual facility risk (Gassert et al., 2014). Therefore, the effect of water use, which has geographic-, watershed- and sector-specific implications, is relevant for our analysis. We take our interpretation a step further and look at Water Intensity (WI), measured as m^3/revenue $MM USD generated and Water Asset Use Intensity (WAUI) (m^3/$MM USD PPE) which are measurements of productivity per volume of water used.

ESG rankings (Chart 7) capture the extent of disclosure in the various pillars of intangible risk among companies, are also compared to waterBeta (Chart 8). Socially responsible ESG investing is becoming a more mainstream investment strategy to address social values and material issues impacting long term resiliency and fiduciary risks. A t-test indicates strong statistical significance between waterBeta and ESG ratings, but caution needs to be exercised in its interpretation. First, ESG risk scores are an aggregate of many individual factors across environmental, social and governance pillars, and may have low relevance to company-specific water risk factors. Second, companies can attain high ESG scores based on frequency of disclosures, even if performance and corporate risk management on ESG indicators are sub-par (e.g. Massie, 2016).

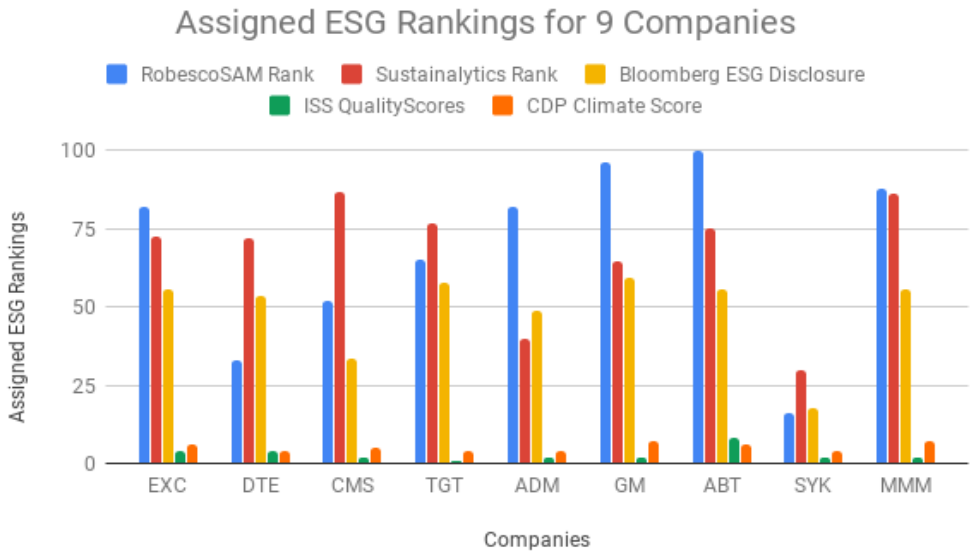

Chart 7: Average company ESG scores based on ten rating agencies for 2009-2018.

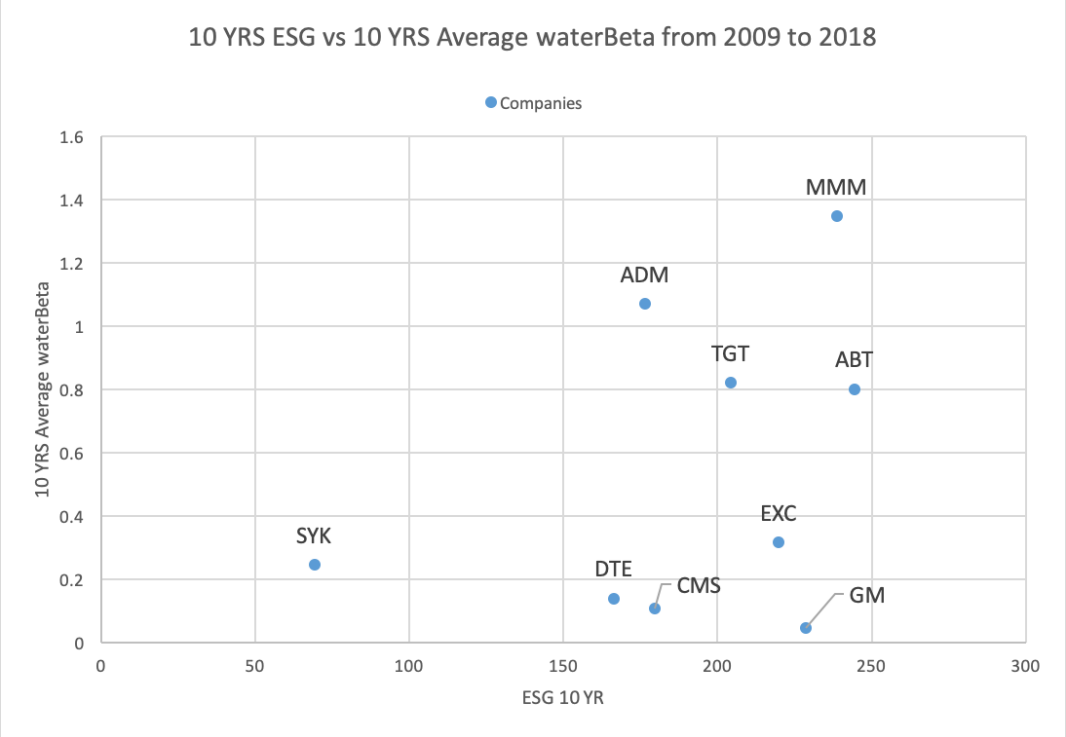

Chart 8: Average 10-year ESG Risk Scores vs. average 10-year waterBeta outcomes.

Despite these limitations in the interpretation, it is of interest to note that EXC, DTW, CMS and GM have high ESG scores and low waterBeta values, both indicators of good corporate responsibility and financial performance by those metrics. However, utilities, EXC and DTW (and likely CMS) report significantly higher raw water usage and water intensity than all other companies (Chart 9), even if this use is not consumptive (not removed from the watershed resources). This as opposed to Target, ADM, Abbott, and 3M, which exhibit high ESG scores and high associated waterBeta values, indicating poor correlation between disclosure indicators and water risk volatility. This is not surprising given the interpretation of ESG risk factors across three pillars (E, S, and G), high ESG values reflect disclosure transparency, low exposure risks and good performance on actual operational risk management. Hence, the contribution of water risk and water use efficiency measures in the disclosure cannot be interpreted. It may be feasible to explore the information value in year-on-year ESG improvement and waterBeta changes on a quarterly basis. However, since waterBeta responds to market pricing of shares relative to an industry index, and ESG scores represent a sentiment based on disclosures, spurious correlations may result that are not causative in nature.

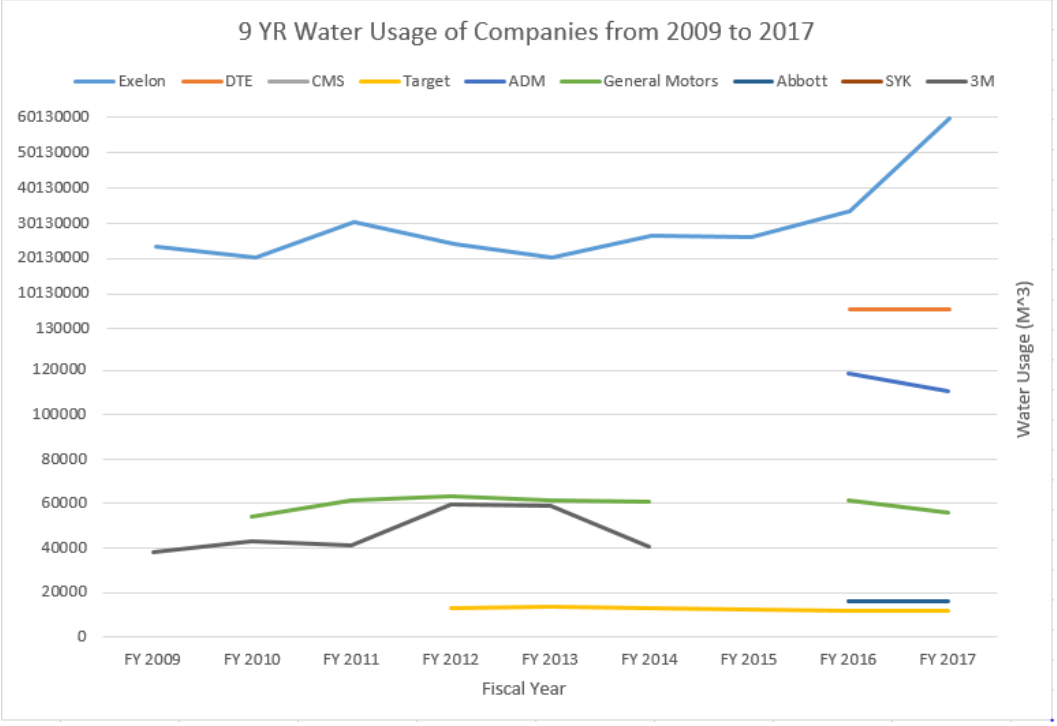

Chart 9: Reported water usage of nine companies from 2009 to 2017.

Water use volumes (Chart 9) show that ADM, GM and 3M are leaders among all sectors, except for utilities. Disclosure of water usage among these companies is limited and therefore we were only able to glean a relative water usage pattern among the companies that report. The values are aggregated across the company, and not facility-specific. The temporal shifts are, except for in the case of 3M, insignificant, and hard to interpret given the small dataset. But a temporal increase of 50% water use by 3M in 2012 and 2013 was not recorded in sustainability reports, and hence interpretation would amount to speculation as to which plants and operations were responsible for this change.

Water use appears to not have any statistical relationship to waterBeta (Chart 10). This is not surprising given how waterBeta is a volatility risk correlation impacted by many other factors, such as regulation and geographic location of the company's facilities. The water use of Exelon and DTE reflects the overall known trend of electric utilities dependency on water. Interestingly, ADM and 3M both exhibit high waterBeta as well as relatively high water usage among all surveyed companies. Given the small universe of companies and other factors impacting waterBeta, sector-wide conclusions should not be invoked for Industrials or Consumer Staples companies. Current efforts are underway to apply machine learning and artificial intelligence approaches to understand the contributions of these factors in a much larger universe of companies and sectors. Two companies, CMS and SYK do not report water use data.

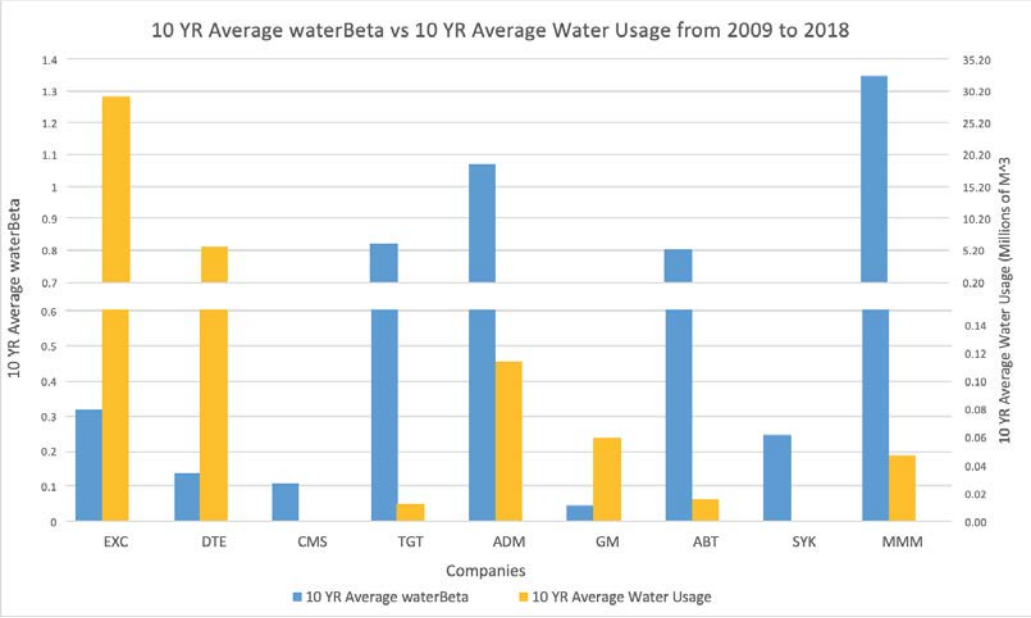

Chart 10: 10-year average corporate water use vs. 10-year average waterBeta.

Even though the selected companies have headquarters in the Great Lakes region, the geographic distribution of their facilities is an important characteristic of water risk exposure overall, if not necessarily in the capital markets. Most companies in our sample (6 out of 9) have more than half of their facilities in water stressed areas, defined in Aqueduct as '*locations where withdrawal of water from the resource exceeds replenishment, where regulatory constraints may impact operations, and/or where water quality may be impaired*'. Companies in utility, consumer, and healthcare sectors have most of their facilities in water-stressed regions. Over 50% of health care sector facilities are located in water-scarce regions . The only company we choose in the Industrials sector, MMM, has a relatively low percentage in high risk areas compared to others (Chart 11). While percent of facilities is not a proxy for revenue exposed to water risk, it does present a potential indicator for PP&E exposed, and thus may be a proxy for capital use efficiency and opportunity cost (Mogosanu, 2017).

When we compared the percent of facilities in water-stressed areas to waterBeta, most companies with higher percentages tend to have a lower waterBeta. This appeared to indicate that asset use efficiency and water do not have a significant impact on corporate growth, earnings per share or share price volatility. On the other hand, ADM (a consumer staples company) and ABT (healthcare company) have both high percentages of facilities in water scarce regions and high waterBeta, contradicting the former. The first observation appears to be counterintuitive, unless one hypothesizes that the companies from this first

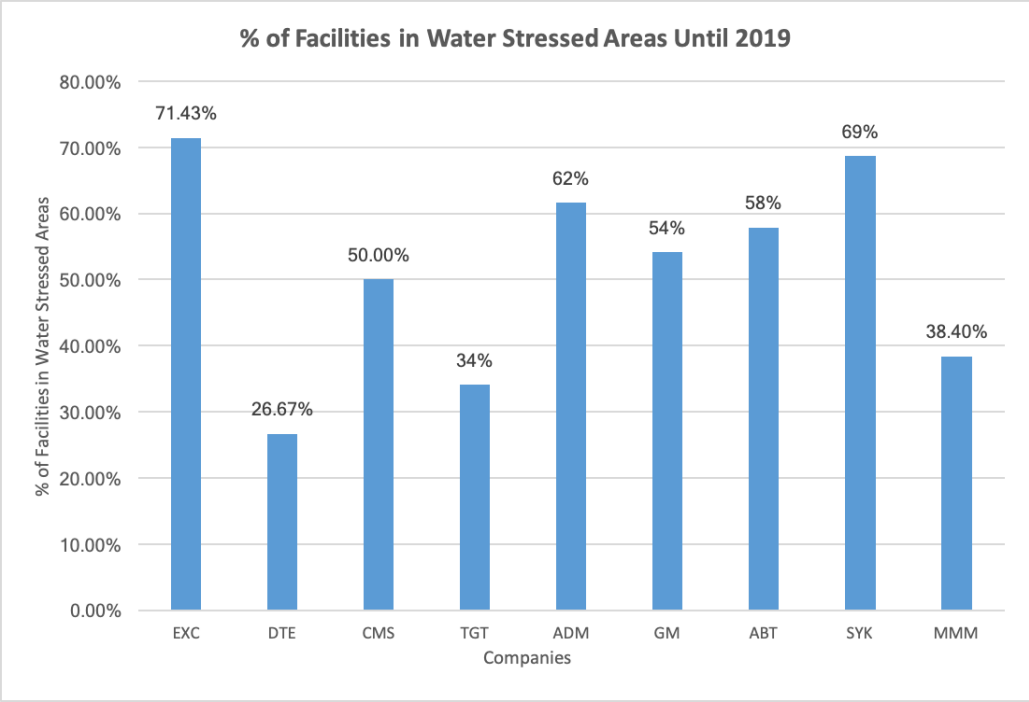

Chart 11: Percentage of exposed facilities to water stressed areas.

group may have better water risk management strategies in place (and fewer water dependencies, either direct or in their supply chains) than ADM or ABT. This finding warrants further investigation in corporate operations and may require the inclusion of additional factors in waterBeta estimates. Since waterBeta has correlative significance to the VaR signal (relative to its sector), and the percent of facilities exposed has an ambiguous relation with waterBeta, a new hypothesis was explored to further query the relationship between water and the volatility in pricing.

3.3. A new framework for interpretation of water risk and its ripple effect in the capital markets

Water risk exposures and the corporation fit the context of the natural resource-based view of the firm (NRBV), which argued that natural resources are a key strategic asset of the form impacting product development, pollution and profitability. Hart (1995) proposed that the existing resource-based theory (RBT) had a serious omission. Namely, while it considered a variety of potential resources and had a logic that was compelling and more complete than prior attempts to explain competitive advantage, it ignored the interaction between an organization and its natural environment. Increasingly, data indicate that the natural environment can create a serious constraint on a company's attempt to create sustainable advantage, as reflected in the new climate transitioning strategies embraced by companies.

We argue that water is a key component of the firm's sustainable advantage by creating long term value and profitability, while limiting volatility on the market. Indeed, earlier studies have shown that the integration of ESG in corporate practice and portfolio allocation strategies resulted in lower share price volatility. Let's break down the argument for waterBeta reflecting an efficiency not only of water use, but of capturing value from physical assets, as tied into fixed asset turnover ratios. In other words, the interpretation of waterBeta, as estimated from VaR signals and water/weather risk exposures will need to be considered in the context of how efficiently a company is generating revenue from its assets.

The Fixed Asset Turnover ratio, a corporate finance measure of a company's ability to generate revenue from its fixed assets, is a widely reported metric. Fixed assets are reported as plant, property and equipment in the balance sheet of a company. The higher the ratio, the more efficient the company is in generating sales from its fixed assets (infrastructure). The ratios (Chart 12) indicate that utilities are much less efficient than consumer discretionary companies, with Stryker (a Health Care company) and ADM (a consumer staples company) showing the highest capacity to generate sales from their assets.

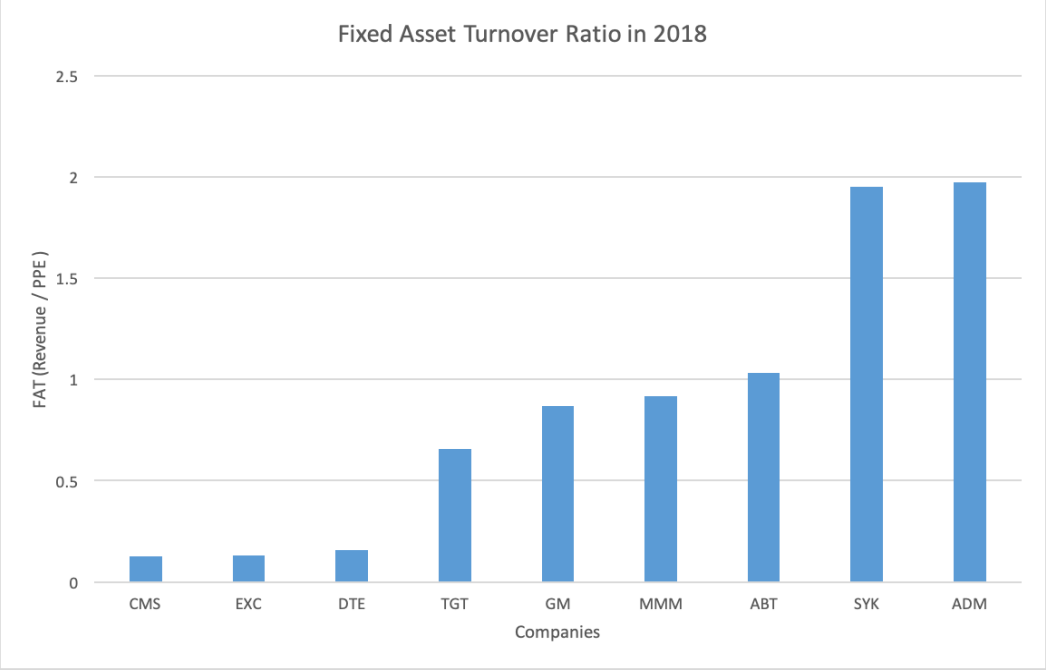

Chart 12: Fixed Assets Turnover Ratio (FAT) for surveyed companies.

The hypothesis advanced here is that water is a natural resource input in either the product or operations, and thus can be considered to have an embedded risk captured in fixed asset turnover ratios. Since Water Intensity (WI; how much water does a company consume to produce revenue) and Water Asset Use Intensity (WAUI; how much water does the corporation use/consume to run its infrastructure measured as

capital outlay, plant property and equipment, PPE) are key inputs in the waterBeta model, we proposed that these metrics should be benchmarked against the Fixed Asset Turnover ratio. The water intensity of the companies analyzed tends to be the highest for utilities with consumer staples (agricultural commodities; ADM) and Industrials (MMM) a close second (Chart 13). Water asset use intensity (water used per unit PP&E) indicates similar trends across the sector representatives (Chart 14).

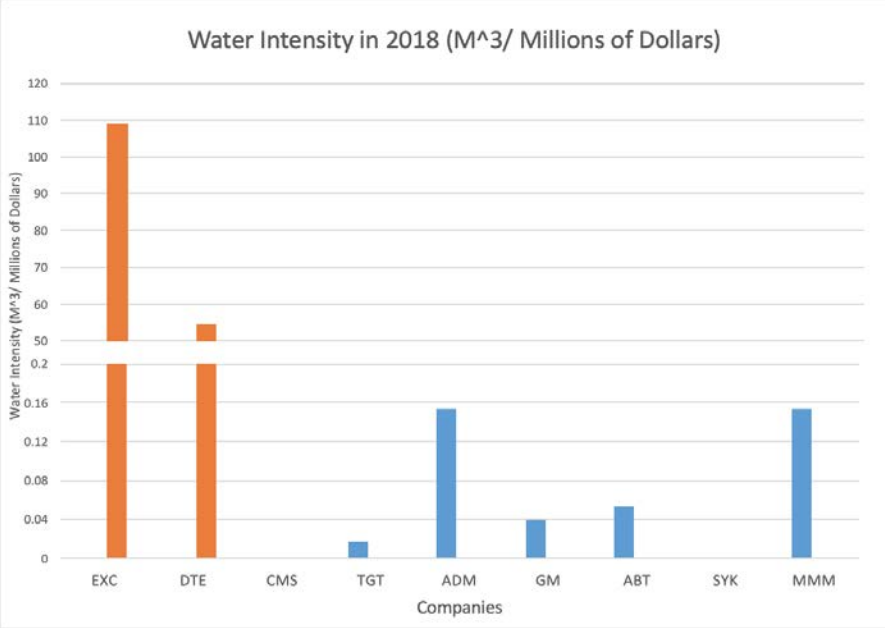

Chart 13: Water intensity (m^3/MM USD revenue) of each company.

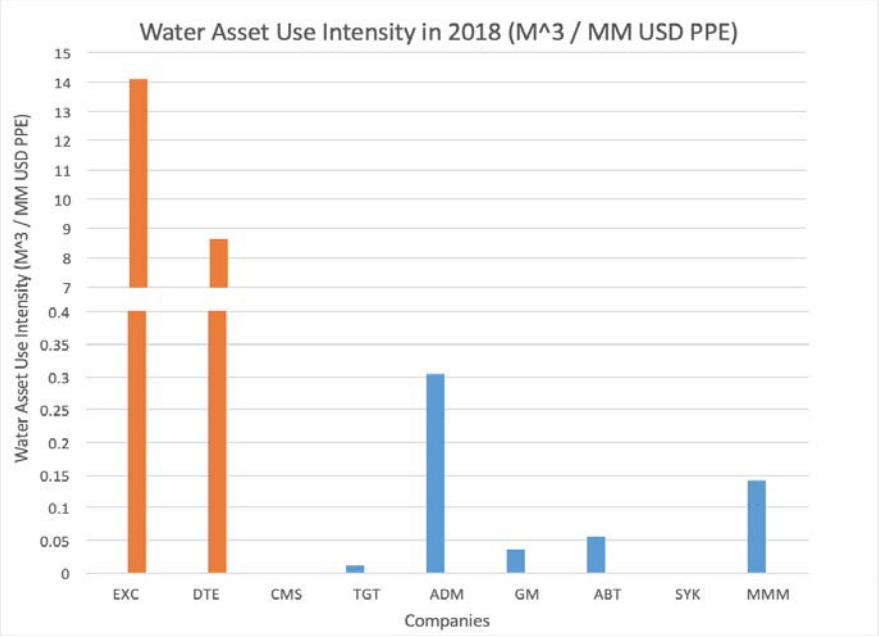

Chart 14: Water asset use intensity (m^3/MM USD PPE), indicating how efficient a company uses water to operate its fixed assets.

Taken together, it appears that there are some early signs that fixed asset turnover may play a significant role in understanding water risk in the physical sense vis a vis waterBeta in the capital market pricing context. It is always risky to make generalizations from small sample sets when a multitude of variables are involved in assessing the performance of an individual company. Hence, outcomes will be presented based on the exemplars tested and the benchmarks used in the analysis, but no broader inference should be made beyond the available data.

- Utilities tended to have the lowest waterBeta, lowest VaR signal and lowest fixed asset turnover, but have the highest water use, water intensity and capital intensity. Because of their high percent of facilities in regions that are water stressed, and low VaR signal, the water-driven volatility is low. Taken together with their strong exposure to regulation (and thus a measure of stability), utilities tend to have lower waterBeta signals despite excessive water usage, low fixed asset turnover efficiencies, and a high percentage of facilities in water stressed regions.
- The Health Care sector tend to have lower waterBeta's, as well as lower water intensities. The companies analyzed here have a low fixed asset turnover, and a high percentage of facilities in water stressed regions. This may indicate that - in the context of the natural resource view of the firm - operating efficiency in water stressed regions impacts fixed asset turnover ratios, despite high water use efficiency indicators.
- Consumer Discretionary company performance did not exhibit encouraging VaR financial or water use performance but did have high fixed asset turnover results indicating efficient use of fixed assets, even with a high percentage of facilities in water stressed regions. Given these results, inherent financial volatility within the Consumer Discretionary sector is due to other business environment and market factors beyond the scope of this report.
- Consumer Staples companies (Target and ADM) varied widely. ADM exhibited the second highest waterBeta and had high water intensities as well as inefficient water use in its assets, but it fixed asset turnover ratio was the highest of all companies. This again may indicate that very efficient companies, measured by fixed asset turnover, are exposed to significant waterBeta if tthey are inefficient water users. The company also had the 3rd highest percent of facilities in high water risk areas.
- Industrials is the most difficult sector for us to compare and assess given only one company (3M) represented from this sector. 3M scores worst for waterBeta with water intensities on par with ADM and in the lower third of facilities in water stressed regions. Industrial as a sector may inherently derive less revenue per facility as indicated by a relatively low FAT. Given the inverse relationship between water intensity and waterBeta, its high excess volatility is likely mainly driven by its VaR signal resulting from factors other than total water use or intensity.

Based on the previous analysis of the relation between waterBeta and other financial performance indicators, and also the relation between waterBeta and water-related risk factors, we're able to illustrate the meaning of waterBeta when considering a company's risk and making a further investment. In addition, we are able to look at historical and current water use literature specific to the Great Lakes and see how various sectors for this analysis stand today and have changed over time.

The framework of the waterBeta model demonstrates two kinds of risk: systematic risk and idiosyncratic water-related risk. Systematic risk is the risk that impacts the broader financial market, such as interest rates, currency exchange rates and trade wars. We use VaR signals in this report to measure short term tail risk within a company. As we can see from Chart 15, a positive correlation exists between waterBeta and VaR signal. This implies that a company with lower waterBeta tend to have lower tail risk. The challenge then is to assess what comprises that tail risk.

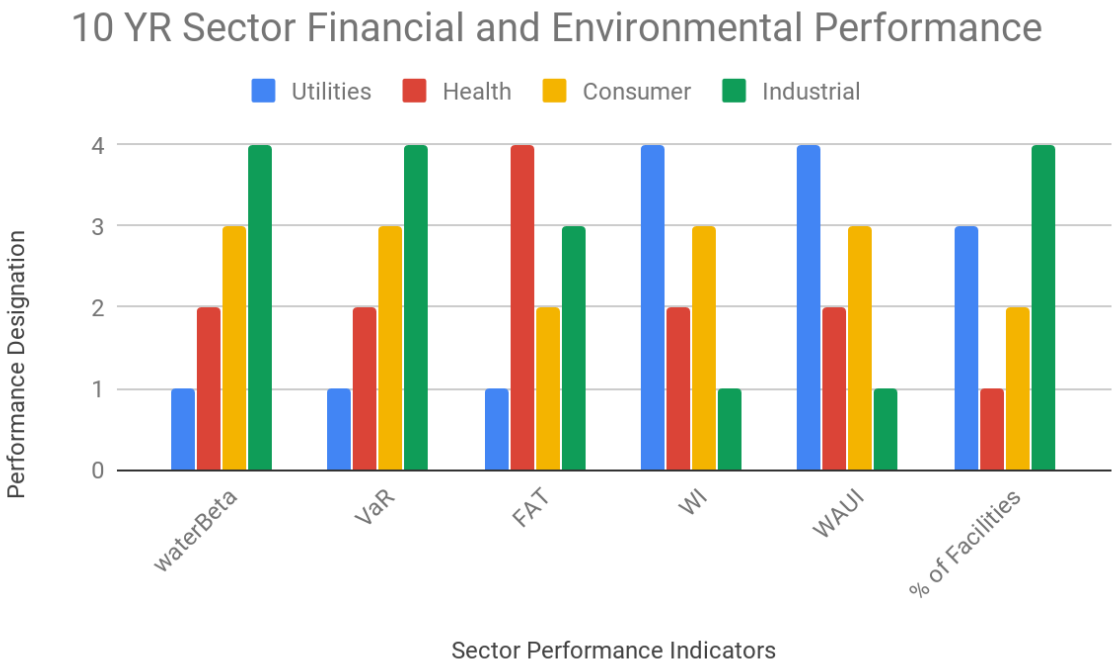

Chart 15: Industry sector performance ranking based on six financial and environmental variables (waterBeta, VaR, FAT, WI, WAUI, and the percentage of facilities in water stressed areas).

Much of the data used in the financial analysis of this report is publicly available, hence it is possible for anyone to perform a similar fiscal analysis of companies headquartered in the Great Lakes Region. Since these companies have facilities in a much broader geographic realm and waterBeta analysis is conducted at the corporate, not the facility level, there is no direct guidance as to Great Lakes water use specifically. Leveraging big data feeds and AI/ML models in concert with ground truthing company- and plant-

specific operations is imperative to predicting real time environmental and financial trends displayed by individual entities. Further refinement and finer scale waterBeta analysis will provide more impactful company specific recommendations and adaptations by synthesizing market sentiment as well as *in situ* data.

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