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**Bridging Physical and Financial Business Water Risk:
waterVaR and waterBeta Metrics for Equity and Portfolio Risk Assessment**

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Abstract

The impact of water as a constrained resource for business operations is becoming part of the investor discourse on equity water risk. A key challenge is the absence of metrics that relate physical risk to financial risk, either at the company or at the portfolio level, resulting in the lack of asset risk pricing. Our research tests the hypothesis that water risk impacts revenue and the cost of doing business and, by inference stock volatility, unless the company manages its risk appropriately. We related stock volatility metrics and water risk exposures of four electric utilities during a two-year period (2007-2008) that captured multiple drought events, commodity (coal) price fluctuations, and systemic risk in the financial markets. Using waterBeta and waterVaR metrics, the impact of water risk on stock volatility (VaR) was highly dependent on the value chain position of the firm, the capital efficiency of water, and stock elasticity. The waterVaR values were calculated to range from \$5M for the Southern Company to \$167M for AES, accounting for 1-18% of VaR. This range was very similar to the risk management expenditures by the companies during the summer months (\$20-95M). Portfolio VaR and waterVaR analytics indicated a strong correlation between minimum VaR portfolio performance and lower waterVaR values, showing that financial risk metrics for water can improve decisions for asset allocation to reduce water risk exposure in portfolios, including stranded assets.

Keywords: risk management, portfolio volatility, value-at-risk

I. Introduction

The impact of corporate and investor exposures to physical, regulatory and reputational risks from water has been debated for the last five years, from both a supply-side and demand-side perspective. Indeed, both academics and policymakers discuss how water planners will need to adopt a variety of adaptation practices, designed to better conserve our water supplies, improve water recycling, and develop alternative strategies for water management to meet the needs of growing communities, sensitive

ecosystems, farmers, ranchers, energy producers, and manufacturers. The focus on local government practices for water planning has led to a one-sided argument on supply-side economics and water pricing, while ignoring demand-side opportunity cost, market risk impacts resulting from volatility in equity pricing, and the use of market signals to inform investment in (financial) risk management strategies (Larson et al., 2012).

Water scarcity, water quality, and thermal events are imposing financial risks to water-intensive companies and agricultural operations, and thus water constraints become liabilities unless they are properly managed and valued. Business organizations, NGOs, and the financial services industry have taken note of these risks as they impact economic development, job creation, and shareholder value. From food and beverage industries to manufacturing and oil & gas production, industry sector performance is dependent on freshwater access. The materiality of this risk is substantial. For example, a recent report on the value at risk ($VaR_{0.5}$) from stranded assets due to resource constraints (including water) estimated a potential increase from \$6.7 trn. to \$11.2 trn. (Caldecott et al., 2013). Stranded assets are environmentally unsustainable assets impacted by unanticipated or premature write-offs, downward revaluations or are converted to liabilities, as the result to exposure to environment-related risks.

Understanding the financial materiality of water risks facing watershed users cannot be understood from current industrial ecology frameworks or from water transfer econometrics alone. Rather, corporate approaches to water sustainability require an understanding of how financial risk management works, and of how risk mitigation strategies are valued by the market (public firms) or by private equity investors (private companies).

With the exception of recent academic research, and white papers from non-governmental (e.g. Ceres, Water Disclosure Project) and accounting organizations (e.g. Deloitte, PWC), corporate water risk assessment is still largely under the radar for equity analysts, even if it has risen to the level of the Chief Financial Officer in the corporate organization. Yet, given the material risk of water to revenue, stock prices, and asset valuation, the corporate and investor focus on water strategies is increasingly germane to

the sustainability discussion. A number of tools have been developed by the financial services industry and non-governmental organizations to take into account water risk to businesses.

For example, the World Wildlife Fund (WWF) and DEG (a German bank) have partnered to develop a ‘water risk filter’, based on a suite of basin- and company-related indicators that embed outputs from hydrological modeling. Company-related risk indicators include how much withdrawn freshwater is discharged with a certain type of pollution, the company’s exposure to regulatory changes, and its contingency planning around supply disruptions, price increases and more stringent regulations. Basin-related risk indicators include total annual renewable freshwater resources per capita and questions regarding enforcement of water-related regulations in the river basin in which the company is operating (WWF, 2011). The World Resources Institute (WRI), in partnership with industrial partners and academic advisors, has developed a navigable water risk map (Aqueduct), focused on comprehensive metrics for measuring geographic business water risks. The Aqueduct project consists of a global database and interactive tool that enable companies to quantify and map water risks at a local scale, worldwide.

II. Corporate Water Risk Management

1. Risk management approaches.

Corporations avail themselves of several tools to offset water risk exposure, including hedging strategies, real options, derivatives or insurance contracts, water trades, and infrastructure investment (Larson et al., 2012). Investments for water efficiency and reuse technologies, water supply enhancements (pipelines, desalinization plants, etc), and investments in real assets, are treated as long-term capital asset expenditures. Hedging strategies, risk transfer tools (insurance), and water trades tend to be short-term risk management tools that are more flexible.

Figure 1 about here

Depending on the industry sector under consideration (e.g. energy, mining, food and beverage, etc.), differences tend to exist in the mix of risk management approaches used by corporations. For example, electric utilities facing de-rating events (production of less than nameplate capacity power) have the option to lock in pricing on the open market or increase production at secondary plants. The reduction of water use through investment in cooling towers, or investment in make-up power through alternative energy production (e.g. wind or solar energy) represent major infrastructure investments that, while accomplishing the goal of reduced water use, can negatively impact operational costs and profits, and thus impact stock volatility. The rationale is that unless the investment can be passed on to the consumer, major investments in water risk management by companies operating in a regulated sector (e.g. electric utilities, water utilities) will be deferred unless rate structures are renegotiated. Apparel firms have been focusing on water efficiency processes in their operations, while food and beverage combine infrastructure investment with agricultural commodities hedging. Agricultural companies avail themselves of insurance, hedging positions, and investments in irrigation efficiency infrastructure.

2. Financial Risk Pricing of Water: Water Value-at-Risk (waterVaR).

With corporate water risks manifesting themselves both at the watershed and corporate governance level, investment decision-making has to be informed by a valuation of the opportunity cost of the impacted industry [e.g. Barth et al., 1997; Blacconiere and Northcut, 1997; McKinsey, 2009]. From a corporate perspective, the economic value of the risk management options is typically evaluated using net present value, discounted cash flow, or real options analysis to compare investments on a return-basis [e.g. Clarkson et al., 2004]. The term “real options” is commonly used in the context of strategic corporate planning when faced with decision-making under uncertainty [Heal, 2005]. The uncertainties associated with water risks, allocation policies, and water pricing present a challenge for investment decisions by the relevant industries (e.g. oil & gas, utilities, mining, beverage and apparel, e.g. [Bauer and Hann, 2010]). Hence, the decision of the firm to, for example, buy insurance vs. invest in water supply infrastructure, is one of capital efficiency in the face of uncertain future cash flows.

In the financial markets, risk ‘pricing’ of assets has long been an aspiration for equity analysts and portfolio managers to capture sensitivities of asset value to systematic (market) risk and residual (company-specific or idiosyncratic) risk. Water risk exposures, and the strategies employed to offset the risk impacts to business operations, are considered a systematic risk, while company-specific impacts represent idiosyncratic risks. The underlying premise is that there is a relationship between the risk driver and the return-on-equity (ROE) or return-on-assets (ROA). Similarly, the voluntary water risk disclosures under Sarbanes-Oxley are only ‘material’ if the water risk (and risk mitigation strategies can be tied to returns (and thus revenue targets or asset valuation). To date, specific risk-pricing strategies pertaining to water scarcity, climate change, or environmental, social and governance (ESG) risks have not been attempted. Rather, investors use simplifying assumptions such as the market risk measurement β (beta), a dimensionless ratio that captures deviations of a firm’s performance from the market performance in a given industry. The impact of ESG performance can then be integrated as a weighting factor influencing the β value.

The challenge with using a simplifying ‘beta’ is that this metric exhibits tenuous predictive capacity to securities returns. In other words, they need to be informed by robust understanding of underlying risk data. An approach that is widely used in the financial services industry is the value-at-risk (VaR) model [Jorion, 2007; Rockefeller and Uryasev, 2002]. At the conceptual level, the VaR model is a probabilistic metric that takes into account the likelihood of an event occurring that will impact the value of a given portfolio of companies (say, exposure to water risks such as drought, temperature, quality, etc) [Innovest, 2002; Webby et al., 2007]. The probabilistic element of VaR is that it quantifies the losses of a stock or portfolio performance at various levels of confidence (e.g. 0.1%, 1%, 5%). For example, suppose a \$1 MM. portfolio of stocks of companies is potentially exposed to water risk, and the probability of risk is normally distributed with an intra-day standard deviation of 100 base points (bp) on the stock value. For any normally distributed random variable, there is a 5 percent chance that an observation will be less than 1.645 standard deviations below the mean. Or, using the properties of the normal distribution, the 5 percent chance that the value will decline by more than $1.645 \times 100 \text{ bp} =$

1.645%. Based on the \$1 MM. equity portfolio in the example, this represents a minimum daily loss of \$16,450 ($0.01645 \times \1 MM.), which will be exceeded only 5 percent of the time. Thus, the equity $\text{VaR}_{5\%}$ on a \$1 MM. portfolio is \$16,450.

The ability to value water risk using financial metrics used in capital markets presumes that water risk has a material impact on (and thus is related to) revenue, production cost, and financial ROA or ROE. The ROA conveys what a company can do with what it has, *i.e.* how many dollars of earnings they derive from each dollar of assets they control. The ROE, on the other hand, shows how well a company uses investment funds to generate earnings growth and is shareholder-oriented. To demonstrate material impact, information is required on: (i) the impact of water quality and quantity on the company's operations; (ii) what the company does to mitigate this risk (hedge, insure, water banking, infrastructure investment); and (iii) whether the risk management strategy reduces financial risk (operational or as the result of asset valuation shifts) to the firm.

The probabilistic understanding of these relationships provides the theoretical backbone for the development of a financial water-based VaR metric. This VaR derivative, the $\text{waterVaR}^{\text{TM}}$, quantifies the water-based liability as part of this volatility. The premise is that this represents a market signal for water risk valuation (pricing) of companies and portfolios.

The focus of this paper is to demonstrate the application of $\text{waterVaR}^{\text{TM}}$ and $\text{waterBeta}^{\text{TM}}$ risk metrics for four electric utilities in the Southeastern US, and to start developing portfolio-based risk metrics for a simulated investment portfolio that holds these companies.

III. Methods

1. Companies.

The project focused on four electric utilities with operations predominantly in the South-Eastern and Mid-Western US. The companies, Duke Energy, AES, American Electric Power (AEP), and the Southern Company, were chosen based on water risk disclosures and availability of water intensity data through the

CDP database (CDP Water Disclosure program, London, UK), or imputed values from SEC disclosures and sustainability reports. Whereas Duke Energy and AEP are companies with regional operations, AES is a global corporation with operations in 27 countries, predominantly in the US and Latin America, and the Southern Company is structured as a holding company with assets across several regions. Each company's generation mix and total capacity are shown in Table 1.

The data indicate that AES is the only electric utility among the four companies that does not have nuclear energy in its mix, and has a predominant proportion of renewable energy in its portfolio (predominantly hydro). Southern Company has the highest proportion of natural gas in its mix, and Duke Energy has the highest proportion of nuclear energy.

Table 1 about here

2. Value at Risk (VaR) Calculations.

The VaR_{5%} metrics are industry- and company- specific as they reflect how capital markets view and reward risk management strategies. Two VaR metrics were calculated: (i) the three month moving VaR_{5%}, computed over a 90-day period, but adjusted on a daily basis over the two year time horizon studied in this report (2007-08); (ii) the VaR_{5%} calculated based on quarterly reporting periods. Inclusion of the longer time horizon allows for uncovering VaR trends as a function of seasonal impacts and to uncover systemic risk impacts. Briefly, daily stock returns were downloaded from Bloomberg terminals to calculate daily returns. These were then plotted on a quarterly basis, and over two years. The current paper focuses on the 2007-2009 period because of the availability of risk management strategy data, and the coverage of two major drought events. Both market capitalization-adjusted and absolute VaR metrics are reported. The calculated VaRs of the different companies can be compared by plotting the VaR_{5%} quantiles as a cumulative distribution function (cdf). This allows for groupings of companies in accordance with their VaR behavior: the flatter the cdf the less volatile the stock. Three month moving

VaR_{5%} data help with focusing on the specific time periods during which ‘drought events’ may have an impact on stock performance.

The quarterly VaR_{5%} calculations focused on the time periods selected based on the two-year VaR where the company was most volatile, and when specific weather, temperature or drought events were known to occur. The objective was to capture the financial reporting quarter with the largest VaR values ($VaR_{5\%,max}$) during these periods (systemic + idiosyncratic or company-specific risk) and correct them for systemic risk impacting this industry sector, based on average VaR data for the remaining three reporting quarters ($VaR_{5\%,ave}$). Hence,

$$\Delta VaR_{5\%} = VaR_{5\%,max} - VaR_{5\%,ave} \quad (1)$$

3. Revenue Sensitivity to Water (waterBeta™) Calculations.

The rationale for structuring a waterBeta is to allow for inter-sector and cross-sector comparisons of company revenue sensitivity when compared to a benchmark (e.g. companies operating on a specific watershed or basin, companies with similar industry classification codes, or the market as a whole). This metric is defined as a dimensionless sensitivity ratio. WaterBeta™ values are thus an indicator of sensitivity of revenue to water availability, and the ratio is based on a water exposure metric termed ‘capital efficiency of water’ (CEw; water withdrawal/revenue). Similar key water risk metrics of a company are currently in use: water intensity (WI, water use/unit produced), and financial intensity (FI, revenue/water use). Financial intensity can be either based on water withdrawals or water use in process. The CEw defined here is the inverse of financial intensity, and is specific to water withdrawals as a proxy of overall water availability. The denominator of CEw calculations is specific to revenue generation from energy production (to avoid inclusion of different lines of business unrelated to energy generation).

The CEw of the benchmark is based on the reference chosen. In the case of this paper, the reference is the aggregate value of all four companies in the portfolio.

$$waterBeta^{TM} = CEw (company)/CEw (benchmark) \quad (2)$$

The interpretation of the waterBetaTM is that a company can be less financially sensitive, similarly sensitive or more sensitive than the benchmark average. To correct for the relative share price movement of a given stock relative to the broader market in response to risk exposures, the waterBetaTM is corrected for the reported company Beta. The boundary condition is that the waterBeta values can't be greater than unity because in that case the waterVaRTM would exceed the overall equity VaR of that quarter, which is impossible. The waterVaRTM, defined as the opportunity cost from water risk exposures that may impact equity and portfolio volatility, is then calculated as a product of the waterBetaTM and the VaR differential (based on quarterly stock price volatility).

$$waterVaR_{5\%} = waterBeta \times [VaR_{5\%,max} - VaR_{5\%,ave}] \quad (3)$$

To validate the magnitude of waterVaR values, company-specific information is required on the investment in water risk management strategies, because they are a proxy for the company's opportunity cost due to water risk. Often, information at this level of specificity is not publicly disclosed in corporate financial disclosures, or is even not known, and thus has to be inferred. An example will be provided on an electric utility's investment in hedging strategies (open market positions and cost to increase production at a secondary plant) to offset water risks during the summer months. It should be noted that even though water risks and regional opportunity costs from water have been calculated or estimated (e.g. Hoekstra and Mekonnen, 2011; MSCI, 2013; Rice, 2010), the relationship of water risk exposures to financial risk volatility ('risk pricing') in the market has to date not been attempted.

4. Portfolio Simulations.

To assess the effect constituent companies have on the volatility of a hypothetical portfolio of these four stocks (DUKE, AES, AEP, SO), 100 simulated allocations were conducted to estimate minimum, maximum, and average portfolio VaR_{5%} values. To estimate portfolio VaR values, a covariance matrix is constructed using independent stock price returns for the four utility companies during the period under consideration (e.g. 2007 or 2008). The variance of a portfolio's return is a function of the variance of the component assets (the four utilities stock returns) as well as the covariance between each of them. Covariance is a measure of the degree to which returns on two assets move in tandem. A positive covariance means that asset returns move together. A negative covariance means returns move inversely. It should be noted that proper portfolio designs minimize covariance between the stocks to spread the risk. In this study, the objective was not to structure an investable portfolio, but rather to evaluate how individual company risk volatility impacts a grouping of these stocks.

Portfolio variance, the covariance or correlation coefficient for the stocks in the portfolio, was calculated in excel for each allocation (= allocation of stocks * covariance matrix in a portfolio * allocation of stocks). Portfolio returns were assumed normally distributed, and the maximum/minimum/average portfolio VaR (pVaR) was calculated for all 100 simulations over 2 years, on a quarterly basis. The pVaR_{5%,min} is represents a portfolio allocation with lowest possible VaR volatility, while, conversely, the pVaR_{5%,max} is based on a stock allocation with highest portfolio volatility. By bracketing the extreme values, it is possible to discern which stock influences the volatility most (least). The portfolio waterVaR was calculated based on the company allocations that led to the pVaR_{5%,max} and pVaR_{5%, min}, multiplied by their waterBeta™ values.

IV. Results

The water risk impact results are presented in the context of financial risk of the utilities in the market. Hence, the stock volatility trends will be presented first to understand the magnitude of long term and quarterly losses, and how these losses correspond to key events. The impact of stock volatility on portfolio variance and VaR_{5%} will be discussed from the perspective of identifying which companies have

a stabilizing or destabilizing effect on the volatility, and how this impacts stock allocations. The connection to the physical world of water is accomplished by way of understanding the sensitivities of revenue to water disruptions, and their impact on potential opportunity costs as reflected in waterVaR™ losses.

1. Electric Utility Stock Volatility Trends

The three-month VaR_{5%} was plotted for each company over the 2007-2008 timeframe to identify periods of significant volatility (loss) events. This is exemplified for Duke Energy (Figure 2, A), where the plot shows that these events coincide with summer months when drought and thermal events influence energy output. In addition, significant contributions to the losses were influenced by fuel (coal) price increases, affecting the cost of generation. This is not surprising given the dependency of these utilities on coal, being 37-71% of their energy mix. Similar plots and trends were apparent for the other three utilities (data not shown), with differences in the depth of the troughs in the data.

Given that equity VaR volatility encompasses the security's market pricing in response to financial performance, commodity price fluctuations, and externalities such as ESG issues, it is very challenging to tease out the specific contributions of each factor. However, the seasonality of extreme losses may be indicative of the contribution of weather and other environmental (water-related) events. Indeed, data from voluntary CDP disclosures (for Duke, AEP and Southern) and Global Reporting Initiative (GRI) reports, as well as a review of mandatory SEC disclosures (Adrio, 2012), lend credence to the impact water is starting to have these companies. For example, as will be shown later, the capital efficiency of water (CEw), which measures the sensitivity of revenue to water withdrawals, has been increasing since 2008 in the case of The Southern Company and AES, and fluctuating in the case of Duke and AEP. This occurring even as total water withdrawals are decreasing as the result of investments in water efficiency (e.g. cooling towers) and energy mix diversification, which comes at a cost to the company. Since these costs can't be easily recaptured in regulated markets (unless a change in ratepayer restructuring is approved), the markets perceive this investment as an increase in the cost of doing

business, resulting in a (temporary) down-valuation of the stock. In addition, NGOs have filed water risk management disclosure information from electric utilities in the South-Eastern US on behalf of shareholders, indicating that the impact of water on share price is perceived to be significant, and needs to be addressed.

Cumulative distribution functions (cdf) of the 3-month moving $\text{VaR}_{5\%}$ values allow for a comparison of the volatility losses among the four stocks (Figure 2, B). The figure, which plots percent occurrence of the loss against the magnitude of the loss, shows that, even if the VaR plots may indicate similar behavior in financial risk, the distribution of these losses is quite different. It should be noted that, to compare VaR losses for different companies, it is important to normalize the loss by market capitalization. Following this normalization, the Southern Company's financial performance is least volatile during this two-year period, followed by Duke, AEP and AES. The relative response of stock returns and 5% extreme losses in a period encompassing multiple drought periods is significant in the assessment of quarterly VAR evaluations, and the impact of revenue sensitivity to water.

Figure 2 about here

Quarterly (90 day) $\text{VaR}_{5\%}$ losses were calculated for the eight financial reporting periods (quarters) and for all four companies (Table 2). The objective was to isolate the impact of weather and temperature events on $\text{VaR}_{5\%}$ losses, by employing statistical metrics such as skewness and kurtosis on distribution of the 90-day returns. Operational VaR losses from weather or environmental events tend to exhibit the following characteristics: they are short-term, have high kurtosis ('sharp peaks'), and long tails in the distribution. Applying these criteria to the VaR distributions, the summer of 2007 noted VaR_{\max} values in the 2nd and 3rd quarter, corresponding to the March-June timeframe of the first dip in the 3-month $\text{VaR}_{5\%}$ (Figure 2, A). Similarly, in 2008, the $\text{VaR}_{5\%,\max}$ was predominant in the 4th quarter (except for AES), corresponding to an August-late November dip in the 3-month $\text{VaR}_{5\%}$ returns (Figure 2, A).

Table 2 about here

For demonstration purposes in this paper, the focus of the water risk impacts on stock returns and VaR was on the third quarter of 2007 and the fourth quarter of 2008 where drought events were known to occur (and impact volatility). As stated earlier, even though there was correspondence between the $VaR_{5\%, \max}$ and the extreme losses during drought and thermal event periods, there are many factors that influence the volatility of securities. Hence, an attempt was made to isolate idiosyncratic (company- or event-specific) volatility from systemic (broader market trends that impact stocks) volatility. This was accomplished by averaging the $VaR_{5\%}$ of all quarters, and subtracting this from the $VaR_{5\%, \max}$ with left skewed distributions. These values will be discussed as part of the waterVaR™ section.

2. Electric Utility waterBeta™ and waterVaR™ trends

Electric utilities, like many other public companies have started to disclose their water risk exposures and water risk management strategies via forums such as CDPs Water Disclosure Project and SEC filings. When compared on a water intensity (water use v. production) and financial intensity (revenue generated v. total water use) basis, Figure 3 indicates that Duke Energy has the highest dependency on water for its electrical output, nearly an order of magnitude higher than the Southern Company. Since water intensity includes water use, and not just withdrawals, Duke's energy mix driven by nuclear and coal is largely responsible for its differentiation from the other utilities. AEP is the most water-efficient company in terms of revenue generation (financial intensity), though all electric utilities are within a 20% range, indicating similar dependency on water to generate revenue. The waterBeta™ (unitless), which describes the ratio of the company CEw to the sector CEw, and thus indicates the influence of water constraints on revenue relative to the sector (Figure 4), shows that AES is most sensitive (highest waterBeta) and the Southern Company least sensitive (lowest waterBeta) to water risk exposure. The Beta and waterBeta move generally in the same direction, and trend similarly. However, AEPs waterBeta is higher than its

Beta, indicating exacerbated price sensitivity due to water risk exposures. On the other hand, the impact of water risk exposure on AES effects less stock price elasticity than that of overall market risk exposures.

Figure 3 about here

The waterVaR™ is the product of the $\Delta\text{VaR}_{5\%}$ and the waterBeta™, the fraction of equity volatility that could be ascribed to seasonal risk impacts ranges from about 4.6 (Southern) -167 (AES) MM\$ (Figure 4). Hence, <1% (Southern) up to 18.6% (AES) of the quarterly VaR differential during the drought months can be ascribed to water risk impacts. These are company-specific volatility losses, a market-based signal that may indicate propagation of water risk impacts on equity risk pricing. To verify whether this order of magnitude of risk pricing is plausible, company-specific opportunity cost analysis from water risk is required. This type of data is not always immediately available, or not known, even by the company. In the case of the electric utilities considered here, hour-step derating losses were available (Rice, 2009) which, when aggregated on a monthly time step, translated to \$300K-\$5M product losses per plant. These losses occurred predominantly during the months of July, August and September, and represent the closest known opportunity cost data.

Also available from disclosures was information on risk management expenditures. Data sources include open market energy price transactions, insurance contracts, SEC disclosures on infrastructure investment, etc. For example, one of the electric utilities (not named for confidentiality reasons) has expended risk management strategies between June and September 2007 and 2008 focused on open market positions and additional production at a more expensive plant. These strategies are common among electric utilities, and hence, the cost of risk management could be extrapolated to the other three companies using data on plant derating events, and energy production at drought- and temperature-impacted watersheds and reservoirs. The total costs of risk management strategies during the summer/drought months ranged from \$20M-95M. If one assumes that corporate expenditures for risk

management represent an ‘intrinsic valuation’ of business risk during water-critical months, the waterVaR (market signal; \$MM 4.6-167) estimates are close approximations of actual risk expenditures.

Figure 4 about here

3. Does Water Risk Drive Volatility Risk in Portfolios?

Portfolio managers use VaR risk data to inform allocation strategies that maximize returns and minimize risk or volatility. Whereas this is intuitive, it is important that portfolios tend to be managed against a volatility risk budget, which represents a percentage of the overall portfolio value that cannot be exceeded. For example, index portfolios have a lower risk budget (e.g. <0.5%) than a portfolio of growth companies (5-8%). To evaluate whether the water risk component of a portfolio VaR can be used to inform stock allocations, the impact of VaR losses of individual companies (during drought quarters) on the VaR of a portfolio (pVaR) of these stocks had to be assessed.

The hypothetical value of the simulated portfolio of these four stocks was set at \$1 bn., and the simulation was bounded by the stock price range in each quarter analyzed. One hundred portfolio simulations were conducted to find the pVaR_{5%,max}, the pVaR_{5%,min}, and the pVaR_{5%,ave} (Table 4), as well as the corresponding stock allocations that resulted in these volatility measures. The pVaRs are given as percentages of the value of the portfolio (\$1 bn.), hence, the minimum and maximum values of pVaR for the fourth quarter in 2008 range from \$50-110 MM., with an average of \$65 MM. The stock allocations resulting in the pVaR_{5%,max} were: Duke 3.84%; AES 75.73%; AEP 14.30%; and SO 6.12%. In other words, AES stock was the main contributor to portfolio volatility. In the case of pVaR_{5%,min}, the allocations shifted significantly: Duke 3.69%; AES 9.56%; AEP 13.31%; SO 73.44%. Hence, a majority allocation of Southern Company stock resulted in the lowest portfolio volatility.

Table 4 about here

The portfolio-based waterVaR™ is the constituent waterVaR™ based on the stock allocations that are responsible for either the minimum or maximum volatility in the portfolio. The calculated portfolio waterVaR for the minimum and maximum pVaR_{5%} allocations was calculated to range from \$25-130 MM., a similar range as the actual risk management expenditures by the companies. A comparison of portfolio waterVaR values to the portfolio VaR_{max} or VaR_{min} values is challenging, given that the portfolio VaR scales as a function of the assumed value of the portfolio. When the calculated portfolio waterVaR is compared to a \$1bn portfolio value, the values represent 2.5-13% of the portfolio value.

Since portfolio waterVaR values are weighted based on stock allocations and individual waterBeta values, and not derived from deltaVaR values during drought/thermal event-impacted seasonal events, it is more appropriate to estimate the portfolio waterVaR percent of pVaR based on data from the individual companies. It was previously calculated that the waterVaR of individual companies explained 22.6 -36.5 % of the deltaVaR difference between the VaR_{max} quarter and the average systemic VaR. Compared to the total 4th quarter VaR in 2008 (Table 2), the waterVaR represents 8.5% (Duke), 8.9% (Southern), 8.0% (AEP), and 5.1% (AES). Using 5-9% as a benchmark for waterVaR contributions to VaR, financial water risk impacts constitute an appreciable volatility risk driver in this simulated portfolio, given that the estimated value of water risk volatility losses during summer are \$25-130MM.

Can these market signals be used to inform portfolio asset allocations? Risk-based asset allocations are feasible if there is a relationship between risk pricing and the underlying risk of the asset. Closer analysis of the portfolio results indicates that the pVaR and portfolio waterVaR are correlated: the high pVaR allocation exhibits \$130MM. in risk, while the low pVaR allocation results in \$25MM. waterVaR. Indeed, the majority stock in a pVaR_{min} portfolio is the Southern Company, which also has the lowest waterBeta and waterVaR. Similarly, the majority stock in the VaR_{max} portfolio is AES, which was calculated to have the highest waterBeta and waterVaR. Hence, an increased allocation of Southern or a decreased allocation of AES, aimed at reducing the water intensity of a portfolio, would also result in lowering the VaR of the portfolio.

V. Conclusions

This paper asked the question whether portfolio allocation decisions can serve as a market signal for corporate water sustainability. The premise is that business water risk has a measurable and material impact on equity and portfolio volatility. To prove this hypothesis, the research defined and employed two measures that leverage public corporate disclosure data: waterBeta and waterVaR. The application of these tools to electric utilities in the SouthEast indicates that financial volatility of individual companies and of simulated portfolios tracks risk management expenditures. The work further indicates that financial water risk represents a significant fraction of the total VaR during drought periods or thermal events. Given that equity analysts consider 3% of VaR a potential trigger for closer scrutiny, all but Southern's waterVaR are material. Given the caveat of this limited sample of companies, asset allocation decisions based on waterVaR should be carefully interpreted. Southern Company (low waterVaR) also has a dampening effect on portfolio risk volatility, whereas AES (high waterVaR) exacerbates pVaR risks. It should be noted that the use of VaR analytics alone is insufficient, because companies, investors and banks use different time horizons to assess financial risk (e.g. Osborn, 2013). Larger samples of companies and cross-industry sector applications will help to strengthen the case for waterBeta and waterVaR approaches to inducing investments in business water risk strategies.

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Collaborations with MSCI (NY) and extensive industry discussions with the financial services industry contributed to contextualizing this work.

VI. References

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Table 1. Energy Mix of Electric Utilities and Total Generation Capacity.

<i>Energy Mix (% , 2011)</i>	Duke Energy	AES	AEP	Southern
Natural Gas	1	32	17	45*
Coal	45	37	71	36
Nuclear	51	0	11	17
Renewables (hydro, solar, wind, energy efficiency)	1**	25	<1	2**
Other (oil, pet coke, diesel...)	NA	6	NA	NA
Total Capacity, MW (2012)	57,700	42,790	37,600	43,000
Total Revenue, \$ bn. (2012)	19.7	17.2	14.9	17.2

* Includes oil; **hydroelectric.

Table 2. Quarterly VaR_{5%} Values of Four Electric Utilities, Adjusted for market Capitalization (value at beginning of quarter)

		Duk	AES	AEP	SO
		VaR _{5%} , MM\$	VaR _{5%} , MM\$	VaR _{5%} , MM\$	VaR _{5%} , MM\$
2007	First	-393.03	-397.11	-312.53	-351.75
	Second	-610.40	-422.62	-431.58	-563.98
	Third	-603.35	-649.62	-492.28	-564.05
	Fourth	-485.34	-407.75	-358.21	-450.16
2008	First	-724.06	-594.63	-614.59	-567.67
	Second	-507.50	-305.06	-329.36	-445.29
	Third	-522.75	-1131.76	-443.30	-592.07
	Fourth	-1210.58	-765.77	-818.37	-1290.17

Table 4. Minimum, Maximum and Average pVaR_{5%} Values for Electric Utility Portfolio Simulations in 2007-2008.

Year	2007-08	2007		2008	
<i>Quarter</i>		<i>Jun-Sept (Q3)</i>	<i>Oct-Dec (Q4)</i>	<i>Jun-Sept (Q3)</i>	<i>Oct-Dec (Q4)</i>
pVaR _{min} (%)	2.70	2.40	1.60	2.20	5.00
pVaR _{max} (%)	4.50	2.95	2.35	4.45	11.39
pVaR _{ave} (%)	3.30	2.70	1.80	3.00	6.50



Figure 1. Spectrum of Corporate Water Risk Management Strategies

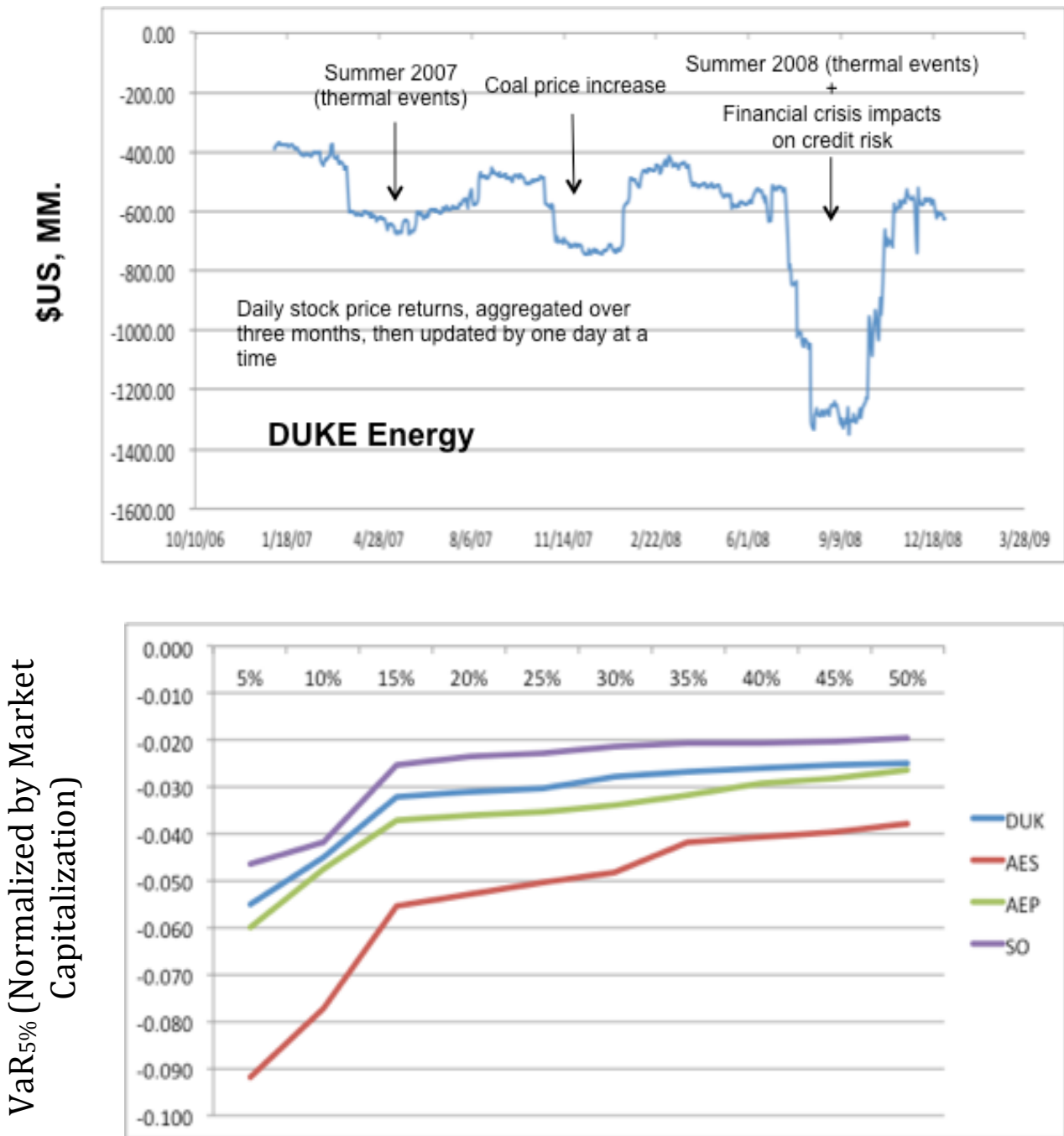


Figure 2. Three month moving VaR_{0.5%} graph for Duke Energy (2007-08) (A) and Quantile comparison of all four utilities (B)

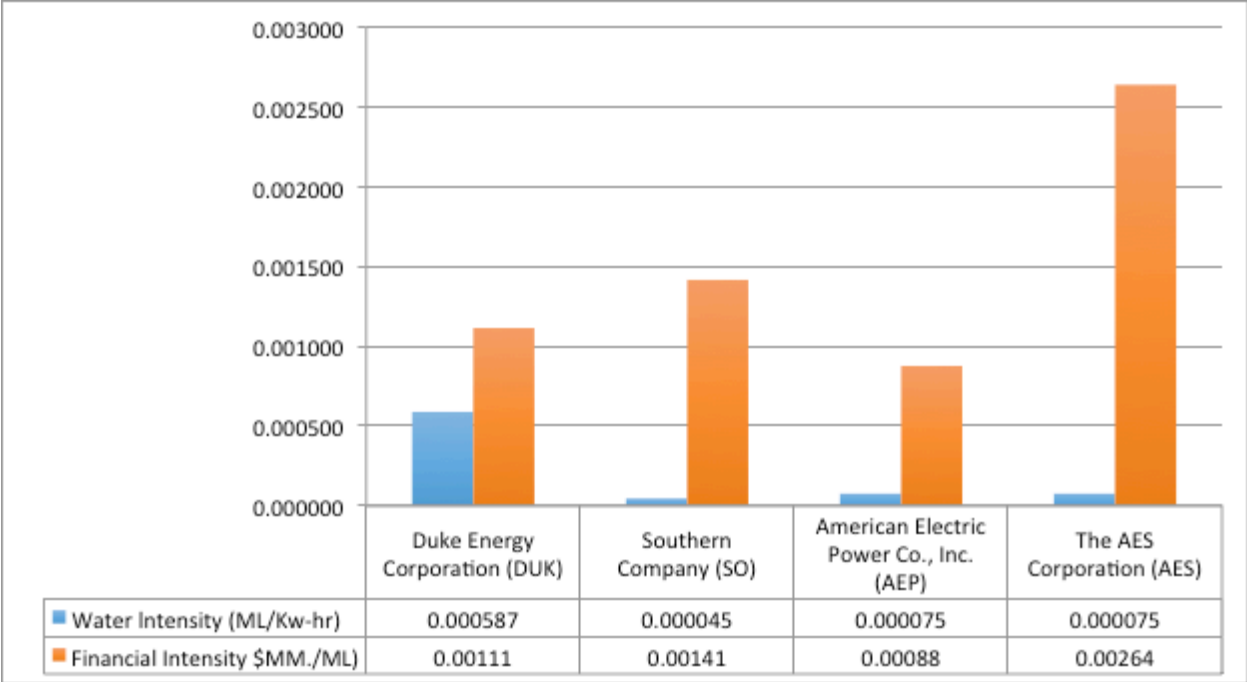


Figure 3. Water Intensity and Financial Intensity of the Four Electric Utilities

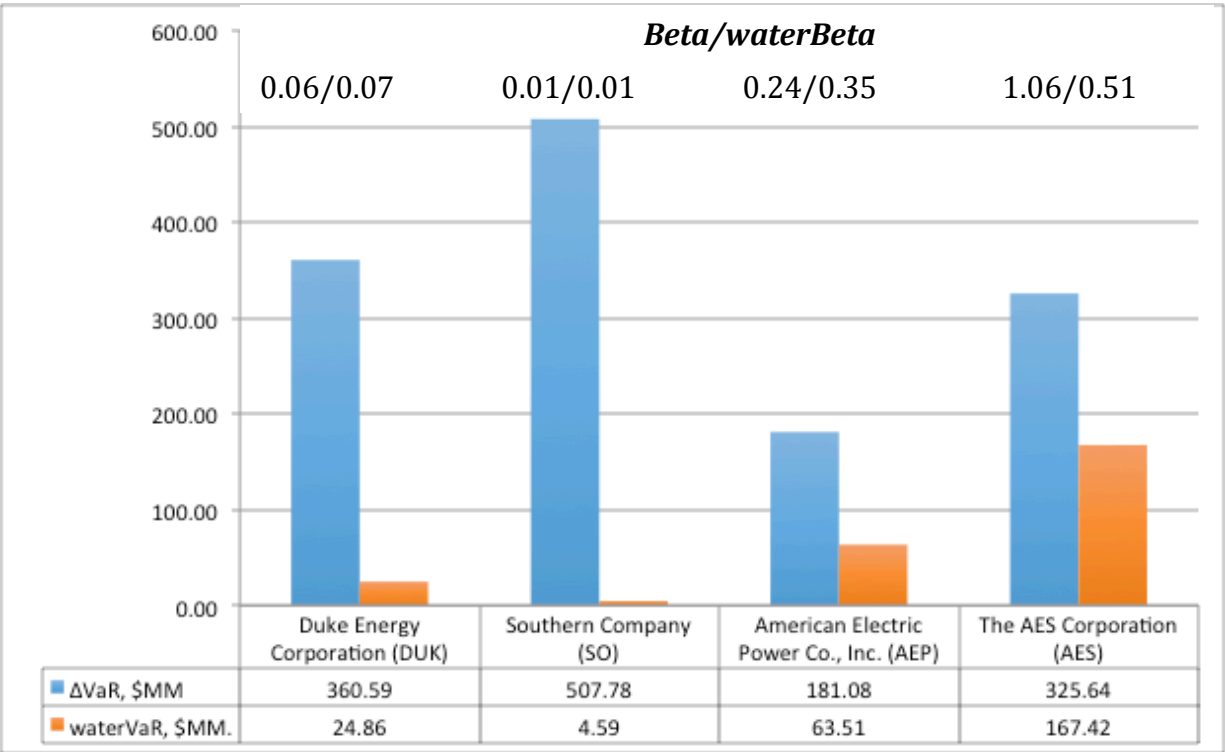


Figure 4. waterBeta and waterVaR values for four electric utilities