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In This Issue: **Sustainability and Shareholder Value**

Tracking "Real-time" Corporate Sustainability Signals Using Cognitive Computing

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The last decade saw extraordinary growth in the number of companies and analysts measuring and reporting on corporate sustainability performance. Thanks to the efforts of large corporations such as MSCI, Bloomberg, Thompson-Reuters, and non-governmental organizations such as the Climate Disclosure Standards Board, sustainability reporting and measurement have responded to perceived needs of investors, consumers, and other stakeholders for ESG/sustainability indicators.

But, as one observer has commented, all this activity and growth has created considerable confusion:

There are a dizzying number and variety of external ratings, rankings, indices and awards that seek to measure corporate sustainability performance. Stakeholders of all kinds—investors, consumers, employees, etc.—are increasingly relying on these ratings to help inform their decisions (to invest, purchase, work, etc.). Companies also rely on such ratings to gauge and validate their own sustainability efforts, with some even linking management performance evaluation and compensation to external ratings. These ratings, therefore, must be robust, accurate and credible.[1]

To the words "robust, accurate and credible," the author of this statement might also have added "tracking changes in real-time." The reason it did not is that, until recently, no rating or ranking firm has tracked sustainability/ESG data in real-time using big data analytics, which is now widely used in other arenas such as marketing and consumer understanding, business informatics and analytics, and internet search and recommendations.

The aim of this article is to discuss the promise of big data sustainability analytics or, more specifically, the applications to ESG of a set of technologies known as "cognitive computing." More specifically, we present a model and initial data analysis of a computer-based application that we call *Sustainability Trend Analysis*, or STA. The main output of STA is real-time, big data-based *dynamic sustainability signals*, or DSS. DSS are forward-looking indicators of the quantity and quality of sustainability initiatives and investments by public companies and other large organizations. As discussed by a number of other articles in this issue, such corporate investment can be designed to address environmental, social, and governance problems while also furthering the goals of the organizations, including value maximization.

As we also suggest in this article, the DSS produced by cognitive computing can be viewed as analogous to the stock price "signals" provided by equity markets about future corporate financial performance. The volatility of such equity market signals reflects both differences, as well as continuous change, in market participants' views of the discounted value of future cash flows based on their perceived degree of risk. Using a similar process, DSS provides insight in the different and continuously changing views of all kinds of corporate stakeholders—investors as well as customers and employees, representatives of the general public, thought leaders and subject matter experts—about a company's reputation as a corporate citizen. As discussed in the pages that follow, the data gathered and analyzed by cognitive computing can serve both to measure and to shape future expectations about sustainability performance by corporations. And as we also suggest, the use of such data has the potential to improve equity analysis by identifying both risks and opportunities that tend to be overlooked by more conventional approaches.

We define sustainability in terms of environmental, social, and corporate governance (ESG) factors that companies and investors increasingly focus on as a core element of value creation. (And, indeed, "ESG" is used interchangeably with "sustainability" and "responsible investment."[2]) The goal of STA is to use the power of big data technologies and analytics, natural language processing (computational linguistics), and machine learning—known collectively as "cognitive computing"—to provide real-time trend analytics along a number of ESG dimensions without the need for human analysts—or, alternatively, to provide more frequent data to human analysts to facilitate an enhanced

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1. *http://www.sustainability.com/projects/rate-the-raters*, accessed 01/08/15
2. This is similar in usage by, for example, BlackRock (*http://www.blackrock.com/corporate/en-us/about-us/responsible-investment*); Context reporting (*http://www.contextreporting.com/top-global-1000-companies/methodology*); the Carbon Disclosure Project (*https://www.cdp.net/Documents/Guidance/2014/CDP-2014-Climate-Change-Scoring-Methodology.pdf*)

research process. Like other technological developments, cognitive computing is a scalable and disruptive technology that brings the ability to observe, measure, analyze, and compare sustainability signals producing real-time trends. Traditional, human-based analysis produces infrequent reports that are typically updated on a yearly or quarterly schedule (the ESG industry standard until recently), which is too infrequent to provide meaningful and actionable analytic (quantitative) results. STA offers a host of new avenues for evaluating corporate sustainable value creation (and risk detection and mitigation). The same is true on the investment side, where DSS and STA enable "extra financial value indicators" to be taken into account.[3] We argue that adoption of such technologies is a game changer: it can provide more comprehensive analysis of corporate risks and opportunities, and of projected growth prospects as well as returns on capital.[4] For this reason, DSS and STA are likely to prove useful to investors as well as to corporations wanting to monitor their ESG profiles and reputation.

In their recently published book on global integrated reporting developments, Bob Eccles, Mike Krusz, and Sydney Ribot conclude with a call for greater use of information technology—more specifically, big data, analytics, cloud computing, and social media—in the sustainability space. They argue that "IT [can] dramatically improve the process and quality of integrated reporting to the benefit of both the company and its audience, it can improve both parties' integrated thinking."[5]

Eccles *et al.* identify four kinds of big data analytics: descriptive, diagnostic, predictive, and prescriptive.[6] At present ESG/sustainability research uses human labor-intensive work to cover descriptive tasks, while consultants do diagnostics and some elements of the prescriptive. In the way such tasks are now performed analysts have limited ability to identify meaningful descriptive trends because there are too few data points (that are generally too far apart) to discover either short-term or longer-term trends, or even to use past trends to predict how certain events might be perceived. But with the help of cognitive computing's probabilistic event analysis, functions such as description, diagnosis, prescription, and some elements of prediction become possible in the ESG arena. Indeed, they can be expected to operate according to much the same logic that produces the shopping or film suggestions offered by Amazon and Netflix.

Access to real-time sustainability information enables both investors and corporates to respond to the growing demand for sustainable processes, products, and investment vehicles. On the investment side, portfolio managers and analysts can stay on top of current information more easily, and can track, quantify, and report on larger amounts of information. Investment product creators can assemble investment indexes, ETFs, and other vehicles to take better account of DSS changes in the composition and weightings of those products. Long-term investors can both track portfolio sustainability movements, and scan the investment horizon for future sustainable investment prospects. Corporate governance monitors can similarly follow real-time events more easily, including both ongoing engagements and potential future engagement prospects. On the corporate side, individual firms can track both their own sustainability profiles and reputations, and those of their competitors, both within sectors and across sectors.

How to Meet the Growing Demand for ESG/Sustainability Information

As we noted at the outset, the last decade witnessed extraordinary growth in the number of companies and analysts measuring and reporting corporate sustainability performance. But the massive and steadily growing volume of such information presents a challenge for companies, investors, analysts, regulators, and other interested parties. Reading and analyzing these ever-growing sources is extremely costly when using primarily human analysts. Big data technologies and analytics offer a scalable complement or perhaps an alternative.[7] Additionally, human analysts inevitably bring a subjective point of view to their undertaking while the basis for and methodology of the analysis and recommendations typically lack transparency.[8]

This situation can be addressed by emerging technologies that are able to improve the quality, quantity, and timeliness of ESG data. These technologies, which are together referred to as cognitive computing, consist mainly of the following three:

• the ability to automatically data-mine all web-based material.

• the use of natural language processing (NLP, also called "computational linguistics") to summarize and analyze text ("unstructured data") in the way the human

3. What is "extra-financial" at one time period may well become "financial" in the next, as the valuation of corporate governance indicates. In the early 1990s the market did not perceive governance as material, yet by the turn of the century it was so valued and therefore 'financial'. Indeed, the larger issue is how the market values intangibles, which some have estimated currently to account for up to 80% of value of many if not most large firms.

4. Specifically these technologies can conform to what GISR (Global Initiative for Sustainability Ratings) lists as key process requirements for reporting and analysis: transparency, impartiality, continuous improvement, inclusiveness and assurability (http://ratesustainability.org/wp-content/uploads/2013/10/GISR-Principles-Map.pdf).

5. Robert G. Eccles, Michael P. Krzus and Syndey Bibot, *The Integrated Reporting Movement* (Workiva on-line, 2014, np. chapter 9). They add, "…paper based reports [which include pdf files] have severe inherent limitations [while] corporate reporting websites of the largest 500 companies in the world today only scratch the surface when it comes to using currently available IT."

6. Eccles et al, *Ibid*, 2014, chapter 9, np.

7. We define analytics as making meaning from patterns in data, a quantitative undertaking. Analysis is broader, usually defined as making meaning by disaggregating a larger problem into its component parts, which can be quantitative but also qualitative.

8. The recently formed organization, Global Initiative for Sustainability Ratings (*http://ratesustainability.org*), makes this abundantly clear. See especially their comparison mapping: *http://ratesustainability.org/wp-content/uploads/2013/10/GISR-Principles-Map.pdf* (accessed 04-03-15).

mind would. It can also assign consistent quantitative ratings from a text, making for consistency over time not subject to human subjectivity. In a more advanced form when combined with elements of artificial intelligence, the software can be trained to answer complex queries like the following: how does company x compare to company y on carbon emissions, water use efficiency or supply chain conditions and supply chain management?

• the use machine learning (ML) analytics (a form of artificial intelligence) to continuously enhance the above two technological functions.

When used in combination, these three technologies open the possibility of not only making "intangibles" like ESG data "tangible," thereby making possible assessments of their materiality, but doing so on a broader, deeper, and more accurate basis than what currently exists. In sum, cognitive computing makes possible the detection of dynamic sustainability signals.[9]

Natural language processing (NLP) is a field of computer science in which large amounts of "unstructured" content are read by computers at extremely rapid speeds and transformed into "structured" data outputs. In addition to summarizing long documents, NLP can be used for topic segmentation and recognition—and also for a function called "relationship extraction," which uses algorithms to identify entities and relationships amongst entities within unstructured content. Finally, after the meaning of a text has been identified in this way, sentiment analysis can be used to determine the "polarity" of the topic and the "intensity" of language used about a specific object or subject within a body of text. Most modern NLP sentiment techniques use stochastic, probabilistic, and other statistical methods to derive actual meaning from text.

Machine learning (ML) is the use of computers to process new data in ways that reflect what it has learned from past processing of similar data. Because ML does not follow explicit programmed instructions, this learning can happen in different ways, in some cases "supervised," in others "unsupervised." An example of supervised learning involves the classification of content by a human analyst to aid the learning process. In unsupervised learning, the computer uses large amounts of input to start creating clusters of meaning and significance.

The following section presents analysis of early-stage dynamic sustainability data produced by NLP and ML processes.[10]

Initial Data Analysis

In this section we start by presenting DSS trends for twelve companies during the six-month period (July 4, 2014–January 7, 2015) with respect to the companies' initiatives to strengthen employee engagement. Then we present the results of a volatility analysis of that DSS data by NLP and ML technology operations (July 19, 2014–January 21, 2015).

The NLP and other programs parse tens of thousands of content pieces daily and automatically from a growing set of web and electronic sources available on the Internet. Most of that material is not germane to sustainability and is discarded. The remainder is sorted into six meta-categories of sustainability information.[11]

Figure 1 shows the trends regarding employee engagement (what is called compounded TruValue, which is defined in the technical appendix, exhibit 1) over about a six-month period for 12 companies. (Compounded TV is a sustainability-compounded score.) Costco and Exxon Mobil are, respectively, the best and worst cases in this period. With all companies beginning at a zero point, perceptions of Costco improve by 52% during the time period analyzed, while the standing of Exxon Mobil deteriorates by 44%. Costco's trend, for example, can be attributed to a number of dynamic sustainability signals (data points) that include the following: (1) recognition as best place to work without a college degree; (2) lower turnover than comparable firms, resulting in high service quality and customer satisfaction; (3) a higher level of employer paid health coverage and higher salaries than comparable firms. In addition, Costco also (4) hires the great majority of its managers from a group who began working behind the register, and (5) it even managed to raise (modestly) wages during the recession with no layoffs, striking a good balance among employees, shareowners, customers, and other stakeholders. NLP interprets these "stories" and their sentiments, assigning them a point-in-time rating for each piece of information, thereby creating the basis for establishing a trend.

9. Other financial sectors are beginning to use the new technology. For example, seekingalpha.com (08/21/14) points out that "…a performance-tracking dashboard includes tabs for creating/previewing ads, tracking ad impressions/reach, and monitoring user engagement. Facebook has been taking a go-it-slow approach to monetizing Instagram's 200M+ users, even as many top brands gain huge followings on the photo/video-sharing platform." Similar technology can be used to mine ESG related information.

10. From TruValue Labs data, July 19, 2014–January 19, 2015.

11. These are defined as follows:

Leadership/governance: relation with stockowners and stakeholders, integrity, strategy/vision and implementation, interaction with regulators, pending governmental actions, major lawsuit potential liabilities, executive compensation, supply chain monitoring (also in workplace as appropriate), political lobbying and contributions. *Product integrity and innovation:* services and products that are cutting edge, revolutionary, competitive; high safety and high quality, and delight customers; state-of-the-art minimal negative environmental impact; respect for privacy and data protection.

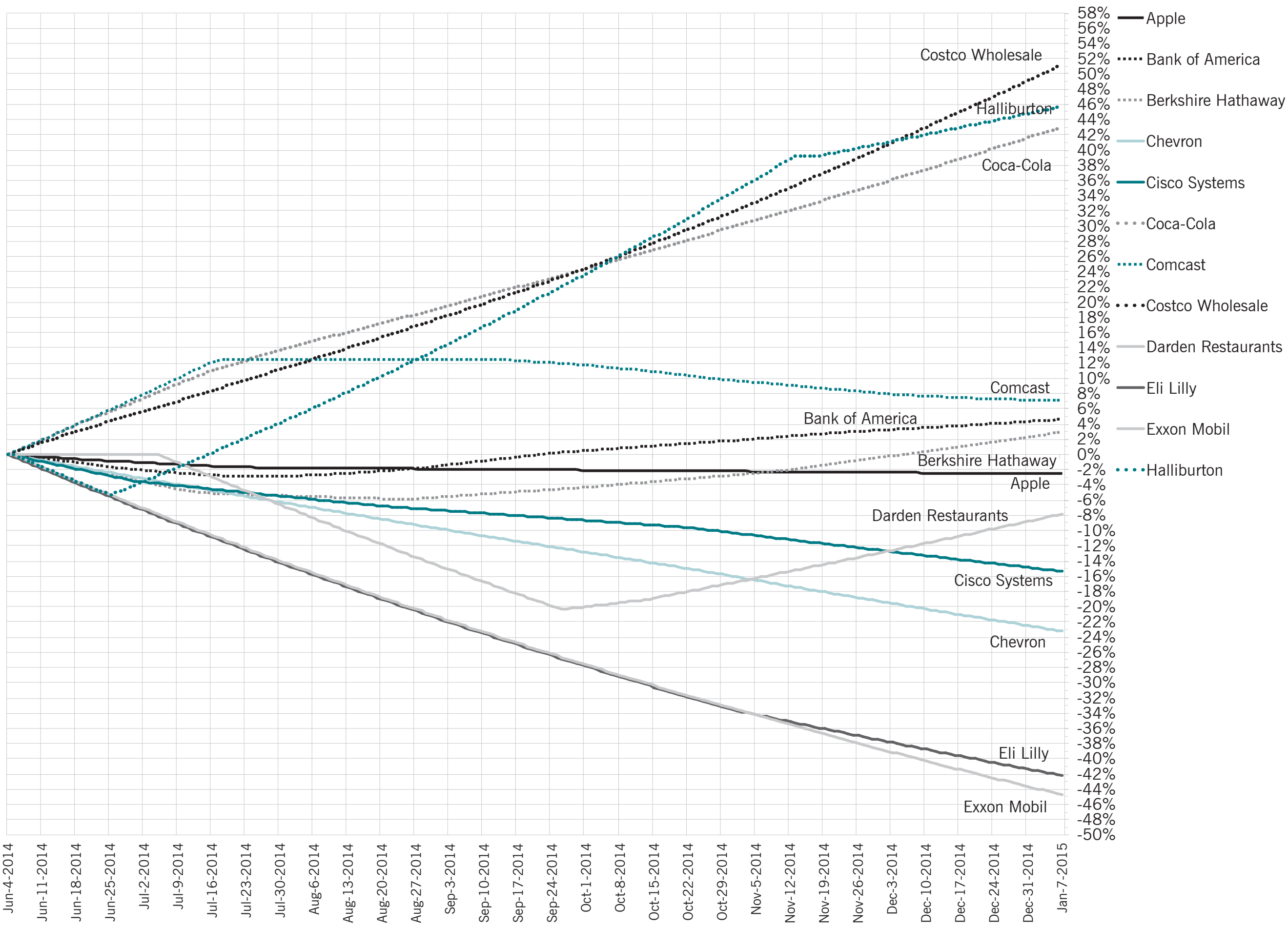
Environment: using clean state-of-the art technology; sustainable (including through full life cycle of product); accounting for negative externalities (e.g. on water, fuel consumption, biodiversity, clean up costs).

Workplace: properly motivate, compensate and respect employees; enhance diversity; focus on safety and health of employees; employee engagement; training and education opportunities; adequate benefits and retirement systems; monitoring supply chain for basic rights (e.g. health/safety, child and forced labor).

Social impact: attempts to benefit society; treat stakeholders fairly and ethically along with, stockowners, suppliers, vendors, contract workers; good community relations and, where relevant, meaningful philanthropy; customer satisfaction.

Economic sustainability: strong business/financial model and outlook; loyal customer base; positive return to shareowners (not necessarily short term); long-term focus.

Figure 1 **Compounded TruValue for Employee Engagement (7 month duration)**



Volatility

From this look at trends we move to a more detailed analysis that examines volatility within the trend (in aggregate and in each of the six meta categories listed above). We broadly define volatility as a measure of the dispersion of time series values over a particular interval. We analyze volatility for two reasons.

First is the widely held belief by ESG rating agencies and others that changes in the ESG performance occur slowly and only over the long term. We have found this not to be the case. For example, the case of Petrobras shown in Figure 2 is one of many examples in which short-term variability is clear. The kind of short-term variability revealed in Figure 2 is typically masked by most, if not all, conventional ESG measures that provide summary information spanning long time intervals.

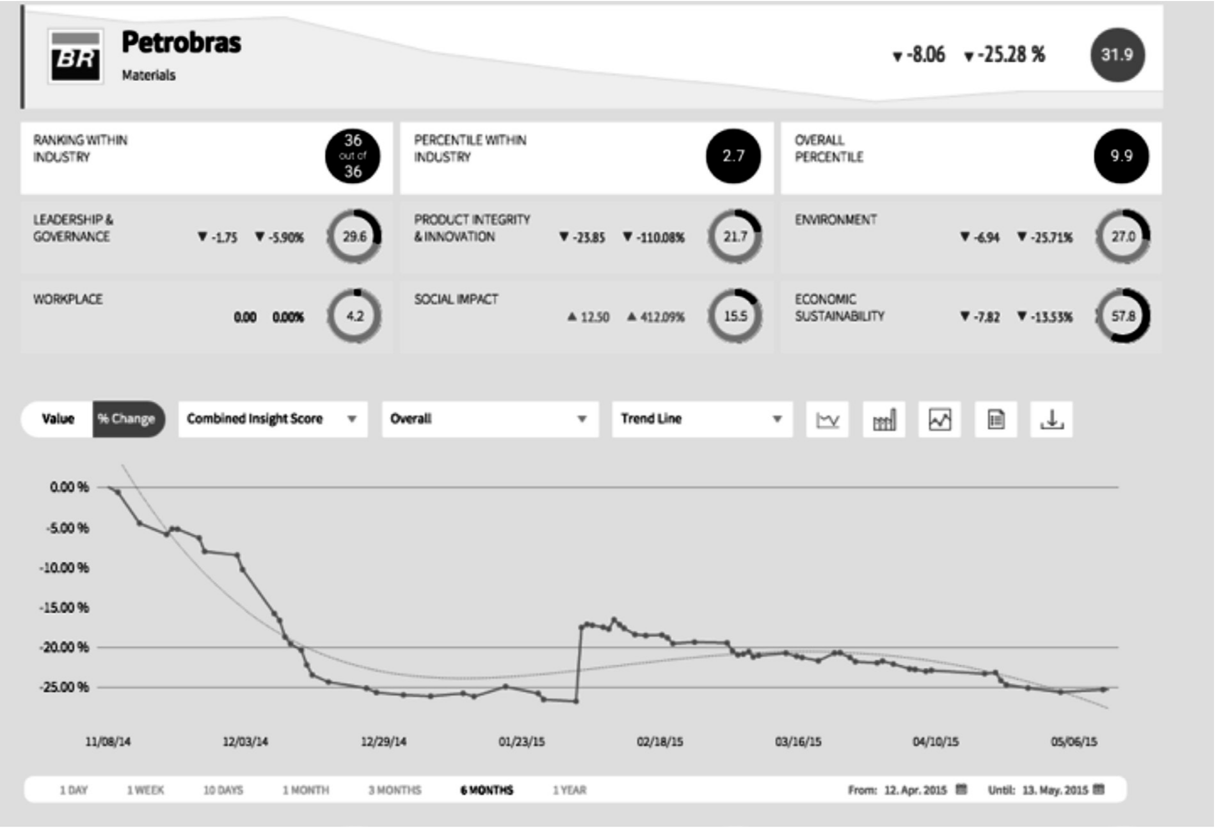
The second reason to examine volatility is that when it is significantly statistically correlated with a relevant variable, it can provide real-time indicators of investment risk or opportunity from DSS signals that can be used for portfolio construction and monitoring as well as for tracking corporate reputation. To our knowledge, no such analysis has been previously undertaken, since this level of granular ESG data has simply not been available. There is mounting evidence that markets are coming to realize and accept ESG factors as potentially material, and that at least some ESG factors will be seen as material not just in the long run, but also in the nearer term as well.

Our analysis of volatility proceeds as follows. From the database of the S&P 500, we found robust data across all six meta categories for 58 companies.[12] For those companies, we correlated volatility with compounded TruValue (CTV), as defined in Appendix 1. Such compounded value is the accumulation over time periods of ESG "value," as gathered

12. A more technical working paper detailing methods and data can be found at: *http://www.stmarys-ca.edu/sites/default/files/attachments/files/JACF%20paper%20ver%203.1%20SMC%20website%20submit%20version.pdf. Also at SSRN: http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2570616.*

Figure 2 **Petrobras**

The x-axis on the left is the aggregate metric, while the y-axis is the timeline, in this case a six-month period. The dotted line is the metric trend line over a 30-day period.



from dynamic sustainability signals. We found that the variability (defined as coefficient of variation) of CTV was statistically significant for the "E" and "S," and, to a lesser extent, the "G" categories.[13]

In addition to computing CTV for the aggregated six meta categories and each meta category separately, we also calculated the coefficient of variation (CV) over the real-time series of core ratings as a measure of their volatility.[14] We found that for two of the meta categories (environmental and social), there was statistical significance at lower than a 5% p-value level (0.02 and 0.01, respectively). In the meta category of leadership and governance, there was a potentially important, but not a statistically significant result (0.08).[15]

Our findings are graphically presented in Exhibit 2 in the appendix for "E" and "S" factors. Both such factors have a more dispersed distribution pattern than for the other meta categories, indicating greater volatility.[16]

What is the significance of volatility for ESG factors? We suggest that volatility has potential materiality and value implications, somewhat parallel to a company's beta as a measure of financial risk and associated return.

From the samples studied, we found statistically significant evidence, in the social and environment meta categories, that compound TV increases as TV volatility decreases.[17] In other words, the more positively the ESG/sustainability values accumulate, the lesser the degree of volatility.

13. The coefficient of variation volatility is calculated by dividing standard deviation of the time series by the average of time series over a chosen time period.

14. The coefficient of variation was selected as a primary measure of volatility because, unlike standard deviation, it is calculated by dividing standard deviation of index by the average of TV index over a time period, and it is a relative measure. For example, CV of 0 means no variation relative to the mean and 1 means standard deviation is equal to the mean. The findings (graphs 3 and 4) are displayed graphically for economic and social categories in exhibition 3 in the Appendix, along with the correlation, R squared and p values.

15. We hypothesize that this is due to the as yet developing data sources which feed the governance metric. Thus, in the future we expect this will also be statistically significant. A fuller, more definitive examination of these initial correlations awaits additional study with more data as well as focusing on event analysis among other approaches.

16. We believe this is, as stated, an artifact of news feed inputs and generally reflects that 'good news' tends to impact firms more and more intensely in product and economic stability areas. Why workplace also fits this pattern is not clear and will be investigated in a future study.

17. It is worthwhile to note that the more volatile the time series, the less it contributes to the ongoing accumulation because volatility usually involves both upward and downward movements.

What is likely happening with the E and S meta categories is that they show a reasonable relationship across the companies selected. The consistent effect of volatility was to erode companies' ratings. In other words, the more a signal bounces around, the less it will sustain a value, thus compounding less. Recall that a high compound value shows greater ESG value. (Alternatively, such volatility could be interpreted as the direct effect of negative E and S, which in turn reduces ESG compounded value.) In either case, there are clear indicators of short-term variation. From these short-term movements we establish trends and can evaluate their statistical significance.

Conclusion and Future Analysis

We have presented an overview of the potential for cognitive computing in the ESG arena using NLP, machine learning, and other artificial intelligence techniques. These technologies can draw on and analyze real-time developments that were previously a limiting factor in ESG analysis. Together they produce not merely "data," but data analytics. The output of these technologies is what we call dynamic sustainability signals, or DSS.

At the moment, we do not have strong evidence that DSS is a significant explanatory variable in predicting corporate stock price performance. But we expect that with the use of these new technological and analytical tools, DSS may over time affect various measures of corporate performance (not only stock price, but measures of operating performance such as ROA, ROIC, and EVA). We see promising indications that markets increasingly take into account ESG/sustainability factors. Our analysis implies that DSS volatility measures provide another way that markets can react to ESG factors that investors or other important corporate stakeholders see as material.

Our initial analysis suggests that there are statistically significant short term volatility variations when correlated against compounded sustainability signals, to a large degree in the E and S meta categories, and somewhat less so in the leadership/G meta category. And although we are reluctant to identify a causal relationship between such volatility and corporate market values, stock returns or other performance measures, our findings indicate that changes in ESG can be observed in the short term—which in turn suggests the potential materiality and value of ESG data.

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18. We compute CTV as a time series by applying a compounding rate in the compounding expression P(new) = P(old) x (1 + q x r) ^ (Dt), where Dt is the number of time ticks between events, and r is the compounding rate per time tick. The prevailing compounding rate r is based on a maximum metric goal M, and in our case we stipulate that if a company sustains a TruValue rating of 100 for an entire year, then it is rewarded with a 2x multiple at the end of the year. Anything below that diminishes the return rate by a factor q, and it is diminished negatively if the rating falls below a neutral value N, which is 50 in our case. Our particular time tick is in minutes so our parameters are set thusly:

```
maxReturnRatioPerYear = 2,
returnIntervalInMinutes = 365 * 24 * 60,
r = Math.Pow(maxReturnRatioPerYear, (1 / returnIntervalInMinutes)) - 1
M = maxValue = 100,
N = neutralYvalue = 50,
q = (TV(new) - N)/(M - N),
```

TV(new) is the latest TruValue rating that triggered the scoring event. The very last value in the series spread over a particular interval, such as the six months here in our sample set, is the Compounded TruValue for that interval that can then be compared with that of other companies.

Technical Appendix

We developed a metric called Compounded TruValue (CTV) and applied it over the approximate six-month period during which the data was generated.[18] The CTV metric is a derivative quantity based upon the real-time TruValue time series that is intended to be accretive in nature (either positive or negative, depending of course on sustained sentiment performance of the firm). CTV is designed to show steady growth, or lack thereof, of a more rapidly varying, underlying sentiment function of time. The general intent is the important recognition of value over longer terms in these extra-financial areas, yet in a way that is different from conventional summary ratings. These longer-term indicators are based on underlying real-time series and are much more precise and consistent than other methods. For example, if we look at the accumulation of "value" over time (i.e. sustained better than neutral scores), we can accumulate them into this "integral"-like index, called CTV, showing what is analogous to compounded annual growth on the financial side.

Figure 3 **Distribution of CTV in the Environmental Meta Category**

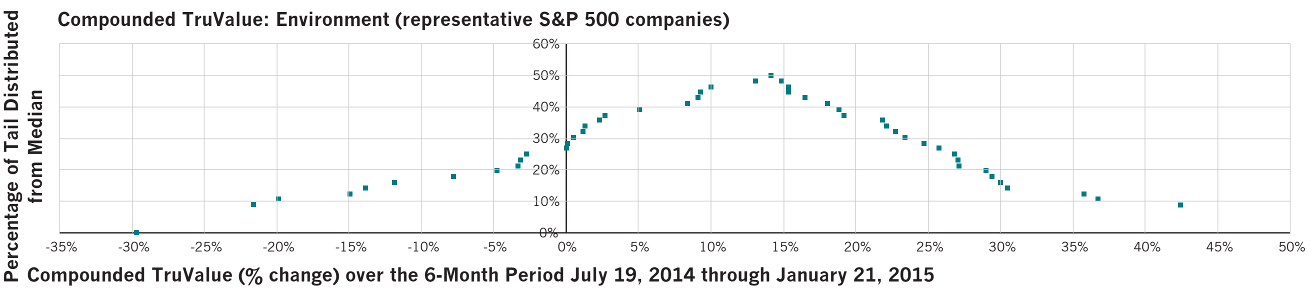


Figure 4 **Distribution of CTV for the Social Meta Category**

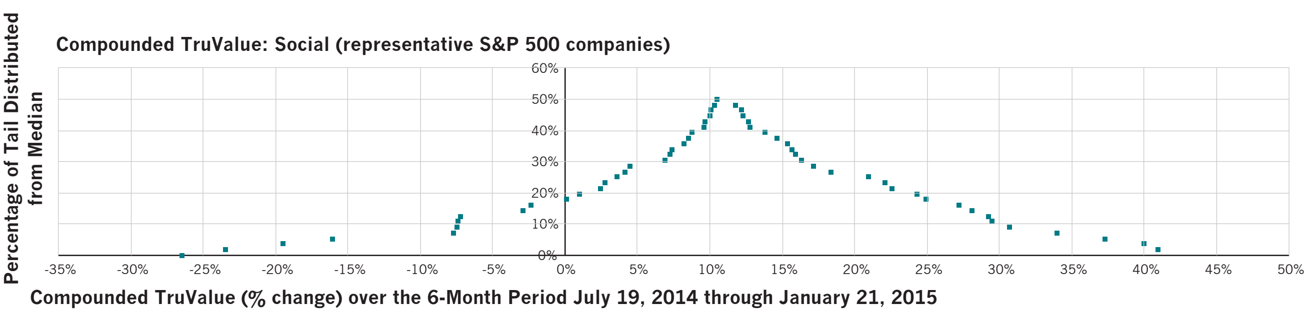


Figure 5 **Compounded TruValue vs. Coefficient of Variation Volatility: Social**

(representative S&P 500 companies) [correlation = -0.54824, RSQ = 0.30057, p-value = 0.00001]

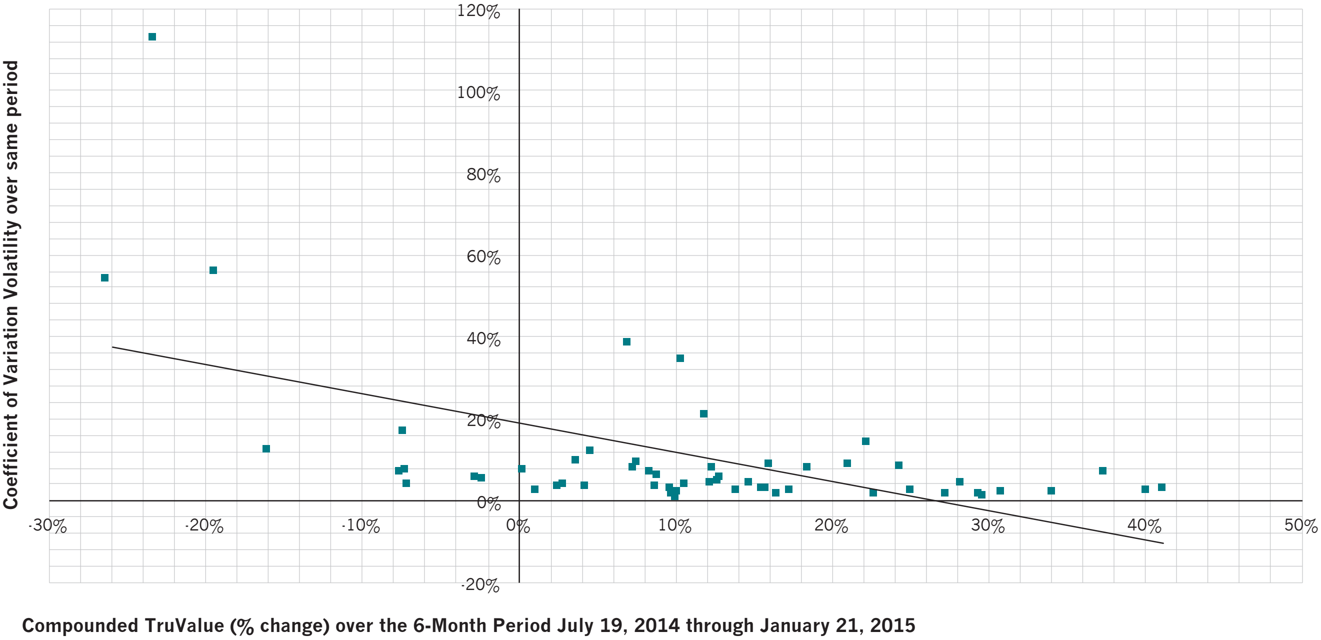
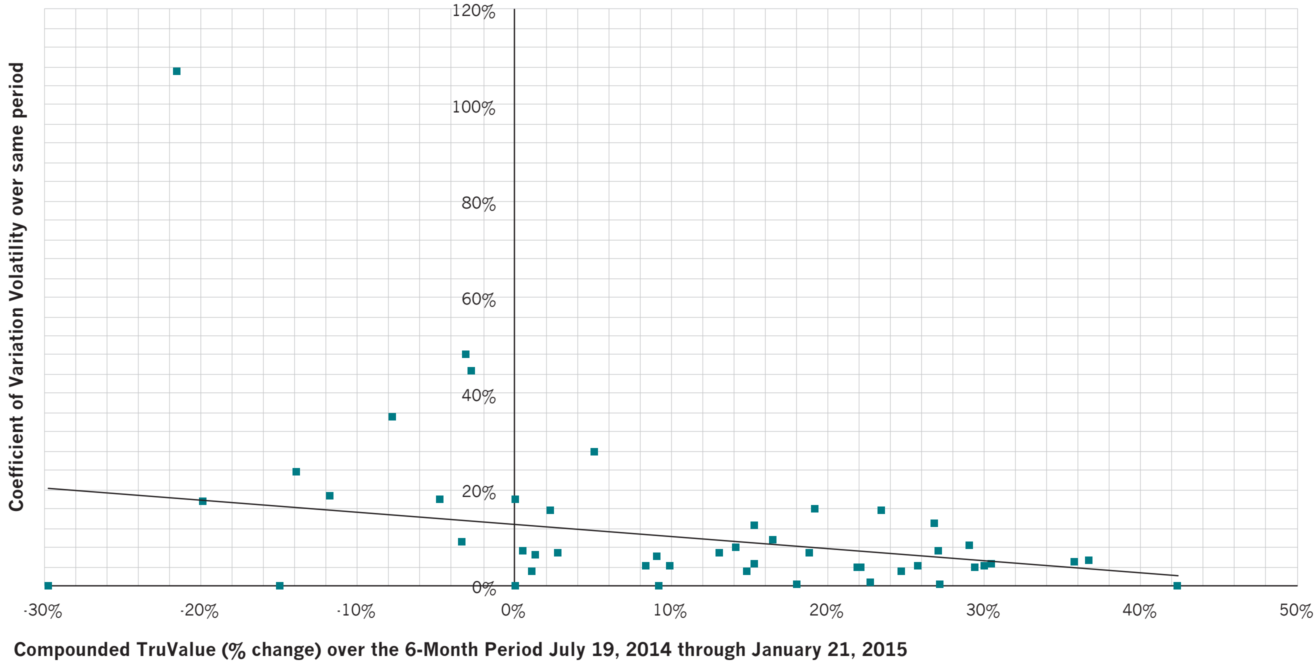


Figure 6 **Compounded TruValue vs. Coefficient of Variation Volatility: Environment (representative S&P 500 companies)**

[correlation = -0.30823, RSQ = 0.09501, p-value = 0.02083]



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