Energy Consumption, Green-house Gases Emissions, Water Usage and Waste Practices: Evidence from Top Global 100 Firms in the Area of Sustainability

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Sustainability is a new imperative in the business world. However, there is scant research on factors that drive sustainability at firm-level. Our study examines the effects of gender diversity on Board of Directors, CEO pay levels and firm's R&D intensity on sustainability. Based on data from Global Top-100 Sustainable firms, our study shows that while gender diversity on Board of Directors and R&D intensity have positive correlation on sustainability, CEO pay level is uncorrelated to sustainability. Aggregate analyses in our study revealed a tenuous linkage between sustainability and firm-level determinants. We conclude with implications for managerial practice and future research.

INTRODUCTION

Across the world, we are facing crises of sustainability, resilience, and adaptation. Our living spaces have become sprawling, bloated, and traffic-burdened. Can we sustain the earth? From problems associated with climate change or sustainable water supply to those concerning increasing economic inequality or the break-up of communities, processes such as escalating resource use and cultural anomie that we once responded to as singular concerns are now bearing back upon us in a swirl of compounding pressures. In short, sustainability has become a concern for all. In a landmark report, the Brundtland Commission (World Commission, 1987, p.70) defined sustainable development as

> "*... development that meets the needs of the present without compromising the ability of future generations to meet their own needs*."

Note that the definition makes no mention of human well-being. In the Commission's view, sustainable development requires that future generations have no less of the means to meet their needs than we do currently. In their view, "sustainable development" requires that relative to their populations each generation should bequeath to its successor at least as large a quantity of what may be called an

economy's "productive base" as it had itself inherited from its predecessor. That raises another problem with the Commission's reasoning: it does not explain how the productive base should be measured. However, economists (Arrow, Dasgupta, Goulder, Mumford, and Oleson, 2010) contend that the "productive base" of an economy is directly correlated to a comprehensive measure of the economy's wealth, and go on to apply that method to assess sustainable development at the level of nations. In this paper we apply the same paradigm at the level of a firm to study sustainable development at the firm level. Specifically, we study firm-level investments to make assessments about sustainable development at enterprise level. Sustainability at the firm level is often understood as long term survival of the firm (De Geus, 1997). However, we define sustainability at firm level, in our study, in terms of green practices of the firm. Long term survival of the firm is much broader construct that may include such things as successful business strategies that may have nothing to do with green practices of the firm. Our study makes this conceptual distinction, and focuses on green practices of the firm.

SUSTAINABILITY AS A FIRM-LEVEL IMPERATIVE

Per Hilton (2003, p. 372), it is crucial for any company to focus on their customers' needs and desires during a companies' decision-making processes. Customers are becoming more demanding in their decision making, particularly due to the flow of information regarding the need to combat global warming, using recycled and renewable resources, among others. The majority of U.S. adults (82%) are knowledgeable about which companies and brands have a strong history of sustainability. Of those, a staggering 80% consider the history of the company's sustainability when purchasing from them (Marketing Weekly News, 2012).

Elkington (1999, p. 28) suggests that business have a moral responsibility to ensure that sustainability is on their growth agenda. Even if companies are created as profit-seeking entities, their long-term profits may not be achievable if their social and environmental issues are not managed properly. Some management leaders have been paying greater attention to the potential relationship between the way they run their businesses and the implications to the environment, society, and sustainable development.

Edwards (2005) suggests that efficient management of firm resources is also ethical and compassionate. *"The future belongs to those who understand that doing more with less is compassionate, prosperous and enduring and thus more intelligent, even competitive."* (Edwards 2005, p. 49). It is no wonder that the TQM (Total Quality Management) paradigm that has swept the corporate world in the past few decades dovetails very well with the current emphasis on sustainability. The big difference is that while TQM was predominantly focused on the continuous improvement of the business processes within a firm, the sustainability thrust of today is broader in scope and views the global supply chain as a business eco system within much larger time frames.

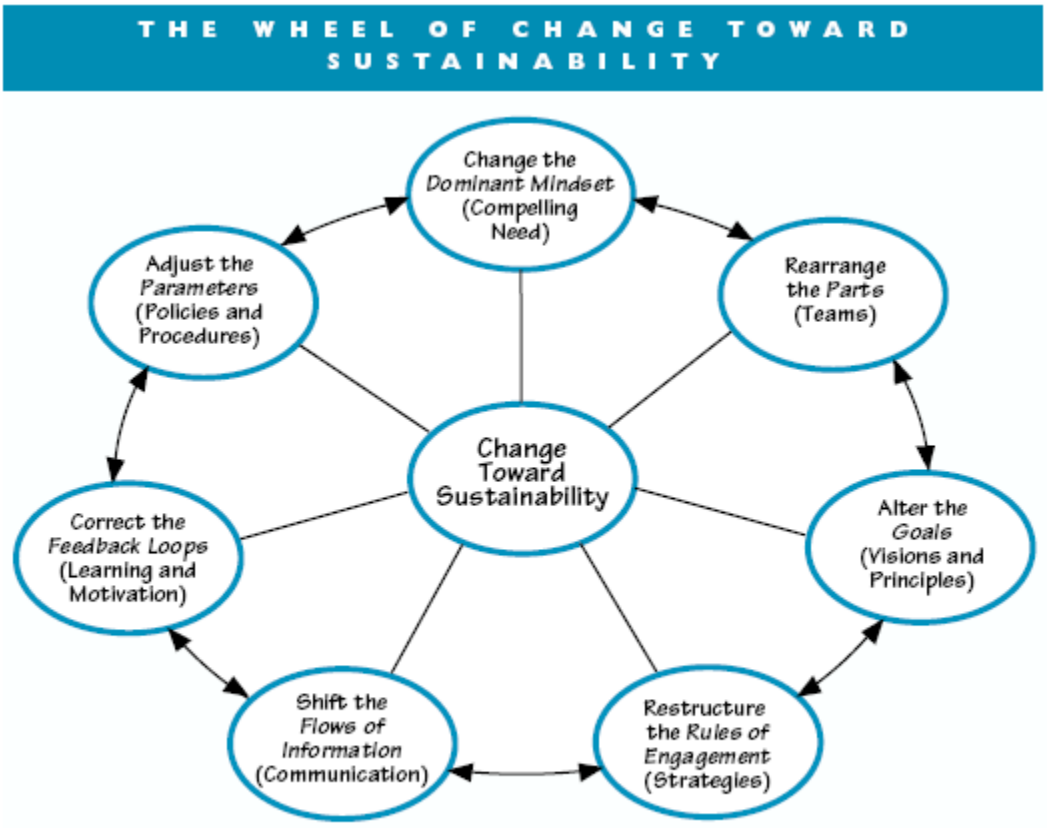
Globalization, ethics, technology and now sustainability have become powerful forces on businesses. In particular, the sustainability emphasis in a given company depends on its relationships with its stakeholders, suppliers, distributors, and clients. Hence, to address the concept of sustainability, the whole company – as well as all the parties in the value chain – should become involved in a new way of thinking and behaving (Hilton, 2003, p.376). Hart (as cited in Elkington, 1999, p.72) states that "the more we learn about the challenges of sustainability, the clearer it is that we are poised at the threshold of an historic moment in which many of the world's industries may be transformed." Companies should take into account the externalities, such as pollution and emission of toxic gases, generated by their activities in order to avoid complications – complaints or even lawsuits – that can diminish performance and lessen the value of their business. The environmental bottom line brings a new form of evaluating the influence of companies on environmental problems by relating their performance to the amount of emissions/waste produced per unit of a volume/value of production (Elkington, 1999, p. 82). Debora D. Anderson – vice president, Environmental Quality Worldwide, Procter and Gamble – lucidly states that sustainability is a new business imperative that "will be the price of entry that society will demand for business success in the 21st century" (as cited in Elkington, 1999, p. 1). The advantages of sustainability from a corporate perspective are manifold. First, cost reduction through increased efficiency. Second, reputational plaudits

from both the market and from customers. Third, the increased brand value can give the company a competitive edge. Fourth, improved risk management.

While sustainability appears to be a conceptually sound pursuit for all businesses, one key question that remains unanswered is: why aren't all firms pursuing sustainability as a primary strategy? What are the promoters and inhibitors of sustainability efforts at firm-level? Is it too expensive or resource-intensive to be an unaffordable venture for most firms? At one time quality initiatives were thought to be too costly and hence not pursued, but over time quality has become a minimum requirement to be in business as more and more competitors adopted quality as an integral part of what they do. Adoption of quality required a mindset or a strong belief system that challenged the existing paradigms that prevented its adoption. In a similar vein could sustainability be slow coming and gradually grow into a widespread phenomenon as more and more firms develop the mindset (a top management emphasis) to adopt it?

Understanding the factors that promote sustainability at firm-level is a question we want to focus on in this study. However, sustainability is a very broad area and is as multi-faceted as the scope of any business. A conceptual handle is required to study sustainability at firm-level. Fortunately, Doppelt (2003) and Hitchcock and Marsha (2007) provide a conceptual framework to help companies evaluate their errors, governance systems, and change initiatives in the sustainability area so as to anchor sustainability lastingly in their business processes, values and culture (see Figure 1 by Doppelt, 2003).

FIGURE 1



The "Wheel of Change Toward Sustainability" shows how the seven interventions interact to form a continuous reinforcing process of transformation toward sustainability.

Interestingly, the sustainability call of the Bundtland report, which is at the level of earth, can be applied with equal force to the corporate environment. Due to the fact that limited environmental resources are often overexploited, there is a need to integrate environmental and social decisions into the

economic decision-making processes of businesses (Dresner, 2002, p. 33). According to Doppelt (2003, p. 139), in business, sustainability means "managing human and natural capital with the same vigor we apply to the management of financial capital."

Businesses are expected to follow regulations as well as respond to society expectations. "Corporate behavior must not only ensure returns to shareholders, wages to employees, and products and services to customers, but it must also respond to societal and environmental concerns" (Organization for Economic Co-operations and Development [OCED], 2001, p. 158). Given these enhanced expectations from the stakeholders of a firm, the assessment of firm-level sustainability takes on the front stage. It is well recognized that multiple metrics will be required to assess firm-level sustainability, and that these different measures will be driven differently by the top management of firms.

FIRM-LEVEL SUSTAINABILITY ASSESSMENT

The International Standards Organization (ISO) is a non-governmental organization that links the public and private sectors with the intention to promote the international commerce. It was launched in 1947 as the largest developer and publisher of International Standards in the world. Technical committees are responsible for developing the ISO standards (ISO, 2012).The ISO 14001, launched in 1993, is focused on the environmental dimension for which it proposes a set of requirements to be implemented in the operational processes of companies to emphasize the potential benefits of improving their environmental performance. According to the ISO 14001, the companies that get its certification are likely to have the following advantages:

(a) fortifying company's image and the participation in the market;
(b) preserving natural resources and energy;
(c) developing a well-structured production process capable of improving production efficiency and environmental performance;
(d) maximizing results of production;
(e) decreasing costs by promoting efficiency in energy and water consumption, discard of waste, recycling paper and energy, and insurance costs reduction;
(f) developing products and technologies that are more environmentally friendly;
(g) promoting better management of resources and dangerous substances;
(h) having better control of the environmental risks and reduction of associated costs through the monitoring that guarantees risk prevention and/or minimization;
(i) providing better communication with employers, stakeholders, distributors, suppliers, government, and society;
(j) improving work conditions;
(k) adding value in the relationship with internal and external interest parties, including employees, shareholders, customers, suppliers, organizations of environmental control and community;
(l) meeting the certification criteria of company's clients; and
(m) improving companies' and society's awareness about the importance of environmental friendly behavior.

FOCUS OF THE STUDY AND RESEARCH HYOTHESES

Recognizing that sustainability is a very broad subject area that spans multiple levels of analysis, we limited our research study to firm-level productivity measures in sustainability as proxy measures for a firm's sustainability performance. Furthermore, we were also interested in factors that promote the firm-level sustainability practices. Specifically, we were interested in the impact of gender diversity, i.e., female representation, on Board of Directors (BODs) and the level of disclosures by firms on sustainability practices within firms.

Gender diversity in BODs has been suggested to increase sustainability practices such as longer term strategic outlook of firms (Bear, Rahman, & Post, 2010; Bernardi, Bosco, & Columb, 2009; Terjesen, Sealy, & Singh, 2009), consider more business ethics (Nielsen and Huse, 2010; Williams, 2003), increased economic growth and social responsiveness (Galbraith, 2011). Recently, research results, based on 329 largest companies in the United Kingdom, reported that the higher percentage of women on BODs of a company the more likely that company will disclose its Green House Gas (GHG) information (Liao, 2014). These studies lead to the following hypothesis:

H_{01}: Greater gender diversity on Board of Directors, greater would be the firm's sustainability productivity measures.

As noted at the beginning of the paper, we recognize the reputational impact of a firm on its ethical behavior, in particular on its sustainability practices (Elkington, 1999; Hilton, 2003). In fact, voluntary disclosure and ethical behavior are positively correlated with firms that engage in extensive disclosure being less likely to engage in unethical activities (Jo and Kim, 2008). More interesting, in analyzing 191 firms from the most polluted industries in the U.S., Clarkson et al (2008) found positive relationship between voluntary environmental disclosure and environmental performance. Such self-enlightened interest by firms leads to the next hypothesis as follows:

H_{02}: Greater the voluntary disclosures by firms, greater would be the firm's sustainability productivity measures.

The impact of CEO on firm strategy is direct and unquestionable. However, excessive CEO pay is seen as an increasingly alienating factor that distances the CEO from the long term interests of a firm (Heineman, 2008; Rappaport, 1999). Recent empirical findings confirmed that CEO compensation and green management practices are negatively correlated (Goktan, 2014). In a finer grain analysis of 500 firms in the U.S., Cordeiro and Sarkis (2008) reported that even when there is a positive link between CEO compensation and environmental performance, the linkage is restricted to only Investor Responsibility Research Council (IRRC) compliances and spill indices but not include toxic emission indices. In a more nuanced and long-term perspective, Berrone and Gomez-Mejia (2009) found that firms' longer term environmental strategies merely function as a symbol since these strategies are not tied into CEO compensation. Based on these prior findings, we propose very high levels of CEO pay would lead to short term thinking. Thus, the next hypothesis is as follows:

H_{03}: Greater the CEO pay relative to the average worker, lesser would be the firm's sustainability productivity measures.

Sustainability requires firms to be innovative in bringing about improvement of existing processes and development of new processes (Seebode, Jearenaud and Bessant, 2012). At the same time, firms also manage innovative systems, by introducing incremental to disruptive innovations, to drive their sustainability in the marketplace (Adams, Bessant, Jearenaud, Overy and Denyer, 2012). This leads to our belief that high levels of R&D is positively related to higher levels of sustainability. Thus, the next hypothesis is as follows:

H_{04}: Greater the R&D intensity of a firm, greater would be the firm's sustainability productivity measures.

VARIABLES AND MEASURES

A global consulting firm called Corporate Knights surveys a large number of firms engaged in the sustainability of their business environments, specifically the conduct of the businesses in four specific areas, namely, energy consumption, green-house gases emissions, water usage and waste practices. Additionally, the consulting firm also collects data on five firm level attributes such as R&D intensity, CEO pay, tax burden, diversity of board, and disclosure practices. Corporate Knights also publishes the data for the top Global 100 firms in the area of sustainability. The data is publicly available with no charge.

This research is based on the compilation of two years data from Corporate Knights (http://www.corporateknights.com) for the years 2010 and 2011 for the following nine variables. Detailed descriptions of measurement of the nine variables are provided in Table 1.

1. Energy Productivity
2. Green-house gases (GHG) Productivity
3. Water Productivity
4. Waste Productivity
5. R&D-to-Sales ratio
6. CEO pay-to-Average worker pay ratio
7. %Taxes Paid
8. %Women on Board
9. %Voluntary Disclosure

TABLE 1
VARIABLE MEASUREMENT

Construct	Calculation Methodology	Rationale
#1. Energy productivity	The energy productivity score ranges from 0-100%. It is calculated by dividing an entity's total revenue in USD for a particular fiscal period by total direct and indirect energy (GRI: EN and EN4) consumed in GJ for the same period. An entity's energy productivity score is a function of two sub-scores: i) a group percentile score; and ii) an improvement factor score. The *group percentile score* is obtained by percentile ranking the entity's energy productivity score against that of industry group peers in the same equity index as the entity in question. The *improvement factor score* is determined by measuring the trailing two year improvement in the entity's group percentile score. An improvement factor score of 25% is awarded if energy productivity has increased by at least 12.5% over the preceding two years. If this condition is not met, an improvement factor score of 0 is given. The final equation for an entity's energy productivity score is represented below: **Energy productivity score = (.75 x the group percentile score) + the improvement factor score (0 or .25)**	Energy availability and costs are one of the greatest challenges facing global corporations in the 21st Century. Rising and increasingly volatile energy costs can lead to reduced profitability, particularly in energy intensive industries and in companies with unsophisticated energy management plans.
#2. Greenhouse gas (GHG) productivity.	The GHG productivity score ranges from 0-100%. It is calculated by dividing an entity's total revenue in USD for a particular fiscal period by total greenhouse gas emissions (GRI: EN 16) in metric tonnes of CO2e for the same period. Using the WRI/WBCSD GHG Protocol, only Scope 1 (Direct) and Scope 2 (indirect) emissions are included. An entity's GHG productivity score is a function of two sub-scores: i) a group percentile score; and ii) an improvement factor score. The group percentile score is obtained by percentile ranking the entity's GHG productivity score against that of industry group peers in the same equity index as the entity in question. The improvement factor score is determined by measuring the	Real and implicit carbon pricing (via cap-and-trade programs and carbon tax frameworks) is on a long-term upward trend, with established regimes in Europe, Canada and Australia. The regulation of carbon can have both positive and negative effects on company profitability, depending on individual company circumstances

	trailing two year improvement in the entity's group percentile score. An improvement factor score of 25% is awarded if GHG productivity has increased by at least 12.5% over the preceding two years. If this condition is not met, an improvement factor score of 0 is given. The final equation for an entity's GHG productivity score is represented below: **GHG productivity score = (.75 x the group percentile score) + the improvement factor score (0 or .25)**	(e.g. allocation of permits, management plan, marginal abatement cost, etc.)
#3. Water productivity	The water productivity score ranges from 0-100%. It is calculated by dividing an entity's total revenue in USD for a particular fiscal period by total water withdrawn (GRI: EN8) in cubic metres for the same period. An entity's water productivity score is a function of two sub-scores: i) a group percentile score; and ii) an improvement factor score. The group percentile score is obtained by percentile ranking the entity's water productivity score against that of industry group peers in the same equity index as the entity in question. The improvement factor score is determined by measuring the trailing two year improvement in the entity's group percentile score. An improvement factor score of 25% is awarded if water productivity has increased by at least 12.5% over the preceding two years. If this condition is not met, an improvement factor score of 0 is given. The final equation for an entity's water productivity score is represented below: **Water productivity score = (.75 x the group percentile score) + the improvement factor score (0 or .25)**	Water is a vital yet largely underappreciated input in many industrial sectors, including Oil & Gas and Mining. Global fresh water scarcity has been identified by several international bodies as a growing threat to peace and prosperity in certain regions. Interruption of water supply can lead to lowered production, with negative effects on long term competitiveness.
#4. Waste productivity	The waste productivity score ranges from 0-100%. It is calculated by dividing an entity's total revenue in USD for a particular fiscal period by total waste generated (GRI: EN22) in metric tons for the same period. An entity's waste productivity score is a function of two sub-scores: i) a group percentile score; and ii) an improvement factor score. The group percentile score is obtained by percentile ranking the entity's waste productivity score against that of industry group peers in the same equity index as the entity in question. The improvement factor score is determined by measuring the trailing two year improvement in the entity's group percentile score. An improvement factor score of 25% is awarded if waste productivity has increased by at least 12.5% over the preceding two years. If this condition is not met, an improvement factor score of 0 is given. The final equation for an entity's waste productivity score is represented below: **Waste productivity score = (.75 x the group percentile score) + the improvement factor score (0 or .25)**	Above average waste productivity indicates more efficient processes and lower disposal costs.
#5. R&D-to-	The Innovation Capacity score for a firm ranges from 0-	Companies at the forefront

Sales	100%. It represents the ratio of 3-year average R&D expenditures to 3-year average total revenue.	of innovation are better positioned to capture emerging market opportunities and to control risk. This metric is a particularly revealing financial indicator in knowledge and science based industries, including Pharmaceuticals and Technology.
#6. CEO to Average Employee Pay	The CEO to Average Employee Pay score ranges from 0-100%. It is the ratio of CEO compensation[1] for a particular year in USD divided by the average employee compensation in USD over the same time period. Average employee compensation is calculated by dividing the company's total wage bill for a particular year divided by the total number of employees over the same period. The CEO to Average Employee Pay score is obtained by percentile ranking a company's ratio against that of every company in the equity index under consideration irrespective of industry group. The higher the ratio, the lower the pay equity score.	A disproportionate share of compensation expenditure going to one person can lead to lower overall workforce motivation, and can also be indicative of potential governance risks, or misalignments of interests.
#7. % Taxes Paid	The % Taxes Paid score ranges from 0-100%. It is the percentage of taxes paid in cash (trailing four year average) to the amount of taxes owed at statutory rates (trailing four year average) in USD. Companies score a 0% in the event that their statutory tax amount (trailing four year average) or taxes paid in cash (four year average) is zero or lower. Companies score a 100% in cases where the amount of taxes paid in cash is greater than the amount of tax owed at statutory rates.	In the current era of large government deficits and austerity measures, tax authorities are clamping down on legal tax loopholes and other vehicles that permit tax minimization. Against this backdrop, determining which companies pay substantially lower cash tax as a per cent of their reported statutory tax rate relative to their industry peers provides insight into a host of risk factors that could impact future cash flows.
#8. Women-in-BOD	The Board Diversity score for a firm ranges from 0-100%. It is calculated as the percentage of women on the entity's board of directors multiplied by two, up to a maximum of 100%.	An emerging body of research suggests that companies with more diverse boards, especially with respect to gender, have higher performance on key financial metrics such as Return on Equity, Return on Sales and Return on Invested Capital. CalPERS, the largest pension fund in

		the U.S., calls it the Diversity Return on Investment (DROI).
#9. Voluntary Disclosure	The Voluntary Disclosure score ranges from 0-100%. It is designed to award companies that have set up mechanisms to link the remuneration of senior executives with the achievement of clean capitalism goals or targets. A score of 100% is given to companies that describe such a mechanism in detail (e.g. the company specifies the proportion of a particular named executive's compensation that is linked to the achievement of certain clean capitalism performance targets). A score of 50% is given to companies that provide a high level description of such a mechanism (e.g. the company mentions the existence of a link between executive compensation and the achievement of certain clean-capitalism performance targets without specifying the proportion that is linked, the nature of the link, etc.). A score of 0% is given to companies that do not report any linking mechanisms.	Evidence of sustained management focus on clean capitalism business drivers can be found in mechanisms that link the remuneration of senior executives with the achievement of clean capitalism goals and targets.
Note: Total compensation excludes pension benefits. The compensation of the highest earning senior executive is used in cases where CEO compensation is unavailable. **Source for Table 1: http://www.corporateknights.com**		

Sustainability practices are measured by Corporate Knights by four productivity measures, namely, energy productivity, Green-house gases (GHG) productivity, Water productivity and Waste productivity. R&D-to-Sales ratio is used in this study as proxy measure for the innovativeness of a firm, with the expectation as stated in H_{04}: Greater the R&D intensity of a firm, greater would be the firm's sustainability productivity measures.

DATA ANALYSES AND FINDINGS

Table 2 shows the descriptive statistics of the nine variables in the study. The data yielded 146 independent observations of firms with no missing data.

TABLE 2
DESCRIPTIVE STATISTICS

	N	Minimum	Maximum	Mean	Std. Deviation
EnergyProductivity	146	$12	$263,867	$11,638.84	$30,864.749
CarbonProductivity	146	$123	$3,855,625	$173,136	$191,879
WaterProductivity	146	$16	$8,239,535	$77,525.36	$682,098
WasteProductivity	146	$3	$225,334	$87,625	$123,670
R&D-to-Sales	146	.1%	24.5%	6.07%	8.09%
CEO-AvgWorker-Pay	146	4.88	542.95	88.19	99.56
%TaxPaid	146	0%	100%	83.2%	25.6%
%Women-in-BOD	146	0%	50.0%	12.9%	10.3%
%VoluntaryDisclosure	146	2.4%	100%	66.8%	27.7%

Table 3 shows the Kendall's Tau which is a non-parametric correlation between pairs of variables. Spearman's rho which is another non-parametric correlation matrix showed similar results and is not shown here. Table 3 of bi-variate correlations reveals the following empirical results.

TABLE 3
BIVARIATE CORRELATION MATRIX

		Energy Productivity	GHG-Productivity	Water Productivity	Waste Productivity	R&D-to-Sales	CEO-AvgWorker-Pay	%Tax Paid	%Women-in-BOD	%Voluntary Disclosure
Energy Productivity	Kendall's Tau	1.000	.435**	.541**	.424**	.117*	.026	-.002	.072	-.281**
	Sig. (2-tailed)		.000	.000	.000	.029	.340	.490	.110	.000
	N	146	146	146	146	146	146	146	146	146
GHG-Productivity	Kendall's Tau		1	.387**	.286**	.106*	-.008	.035	-.010	-0.073
	Sig. (2-tailed)			.000	.000	.041	.447	.277	.432	.106
	N		146	146	146	146	146	146	146	146
Water Productivity	Kendall's Tau			1	.504**	.039	-.032	.026	.112*	-.307**
	Sig. (2-tailed)				.000	.266	.306	.336	.030	.000
	N			146	146	146	146	146	146	146
Waste Productivity	Kendall's Tau				1	.074	.050	.018	.147**	-.368**
	Sig. (2-tailed)					.122	.216	.386	.007	.000
	N				146	146	146	146	146	146
R&D-to-Sales	Kendall's Tau					1	.084	.038	.006	-0.042
	Sig. (2-tailed)						.104	.279	.465	.253
	N					146	146	146	146	146
CEO-AvgWorker-Pay	Kendall's Tau						1	.008	-.099	-0.104
	Sig. (2-tailed)							.453	.058	.054
	N						146	146	146	146
%TaxPaid	Kendall's Tau							1	-.020	.119*
	Sig. (2-tailed)								.371	.029
	N							146	146	146
%Women-in-BOD	Kendall's Tau								1	-.101*
	Sig. (2-tailed)									.047
	N								146	146
%Voluntary Disclosure	Kendall's Tau									1
	Sig. (2-tailed)									
	N									146

**significant at 0.01 level
*significant at 0.05 level

The four sustainability productivity measures, namely, energy productivity, Green Houses Gases (GHG) productivity, Water productivity and Waste productivity are positively correlated with one another. Principal component analysis revealed a single factor for the four productivity measures (see Table 4). The four measured metrics of sustainability explain 99% of the variance in the single component that is extracted as can also be seen from the Scree Plot that immediately follows Table 4. Thus, it is comforting to note that the broader construct of firm-level sustainability can be measured by the four productivity measures used in this study.

Percent of women directors on corporate boards is not correlated with energy productivity or GHG productivity, but is positively correlated with water productivity and waste productivity. Thus, H_1 is supported for two of the four productivity measures.

Voluntary disclosures are correlated negatively with energy productivity, water productivity and waste productivity and is not correlated with GHG productivity. Thus, H_2 is not supported for three of the four productivity measures. We will have more to say about these negative correlations later in the discussion section.

CEO relative to average worker pay is not correlated with any of the four productivity measures. Thus, H_3 is not supported for any of the four productivity measures. Finally, R&D-to-sales ratio is

positively correlated only with energy productivity measure, and not with any of the other three productivity measures. Thus, H_4 is partially supported for the energy productivity measure only.

We also ran a Structural Equations Model (SEM) to empirically examine the variables in the study at an overall construct level, addressing the broader question of the strength of the linkages between sustainability practices (the four productivity measures) and the firm-level drivers of sustainability (% women on board; voluntary disclosures; CEO pay/Average worker pay and R&D-to-sales). We found a very weak link at the construct level as described in detail below. The SEM model is depicted in Figure 2.

TABLE 4
TOTAL VARIANCE EXPLANIED BY EXTRACTED COMPONENTS

	Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
		Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
Raw	1	2.607E+016	99.997%	99.997%	2.607E+016	99.997%	99.997%
	2	4.628E+011	0.002%	99.999%			
	3	2.434E+011	0.001%	100.000%			
	4	3.153E+008	0.000%	100.000%			

Extraction Method: Principal Component Analysis. The Scree Plot below shows the relative explanatory power of the four principal components that were extracted.

The model in Figure 2 above has chi-square of 13.84; moreover, the degree of freedom is 10, and the Chi-square/d.f. can be calculated as 1.38. Kelloway (1998) contended that Chi-square/d .f. is a measure of the validity of the structural model. A low value near 1 indicates a weak model whereas a high value greater than 5 suggests a strong model. This study reveals a very weak model linking the energy productivity, green-house gases productivity, water productivity and waste productivity to the firm-level attributes measured by Corporate Knights. The tenuous links may suggest that there may be several intervening variables that affect the sustainability metrics in organizations.

Besides the Chi-square test, this investigation employs two other indices for reporting: (1) the "root mean square error of approximation" (RMSEA); and (2) the comparative fit index (CFI). The RMSEA provides information regarding the model fit of the optimal parameter values used as the population covariance matrix if available. RMSEA values below 0.05 indicate a good fit; root mean square error of approximation (RMSEA) = 0.045 for our model in Figure 2. The rule of thumb is that the RMSEA value should be below 0.08 (Bentler and Bonett, 1980). Moreover, the CFI provides a measure of the complete co-variation of the data based on the independence model (also known as the null model). The proposed model has comparative fit index (CFI) of 0.98. Notably, CFI values exceeding 0.90 indicate acceptable fit to the data (Bollen, 1989). These two indices (RMSEA and CFI) show that the Structural Equations Model indicates only modestly weak linkages between the sustainability measures and firm-level determinants of sustainability (%women directors; R&D-to-sales; %disclosures).

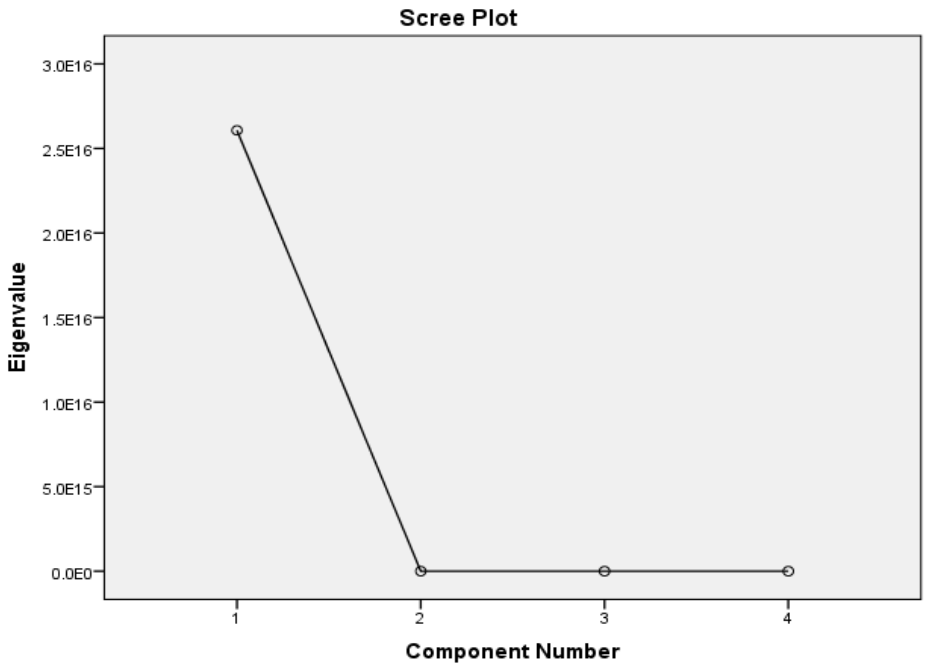
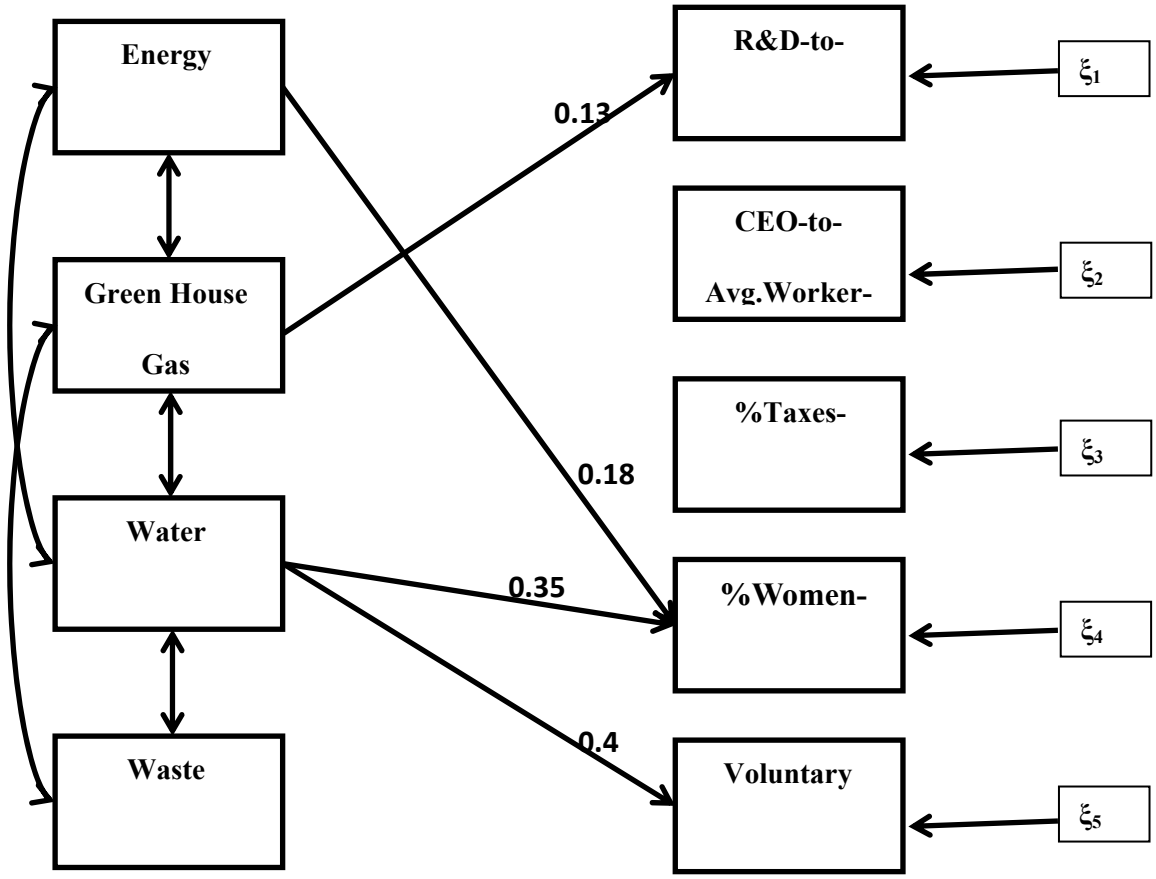


FIGURE 2STRUCTURAL EQUATIONS MODEL WITH STANDARDIZED COEFFICIENTS



Chi-squared = 13.84, d.f.=10, p>0.18; RMSEA = 0.045; CFI = 0.98; IFI = 0.99

DISCUSSION

First, our study found that energy productivity, green-house gases (GHG) productivity, water productivity and waste productivity, when taken together, constitute the broader sustainability construct. That is the measurement methods followed by Corporate Knights, a global consulting firm in the area of sustainability, are empirically valid. The implication of this finding is that future research on firm-level green practices can be confidently based upon these four specific measures. The composite scores of sustainability and the resultant rankings of Global Top-100 Sustainability firms can be used as "sustainability" scores in future studies. On possible future study would be correlate the sustainability score from Corporate Knights with other sustainable indices such as the Dow Jones Sustainability Index World (http://www.sustainability-indices.com/).

Second, the weak linkage, at the aggregate construct level, between sustainability construct and firm-level determinants of sustainability as revealed from the structural equation modeling suggests that there may be several intervening variables that might weaken this relationship. It is also possible that sustainability as a broad construct is still a peripheral issue that has not taken root at the core of corporate mindset. Sustainability movement today may therefore be similar to the quality movement in its incipient days in early 1980s.

Third, it is interesting to note that percent of women directors on corporate boards is positively correlated with water and waste productivity but not correlated with energy and green-house gases (GHG) productivity. Our explanation of this perplexing finding is that energy and GHG productivity may be a more function of the nature of the production function of the firms (some firms are in energy intensive industries and others are not). This is also a limitation of our study in that we did not account for industry effects in our study. One implication of our findings is that having more women directors on corporate boards would push the firms toward greener practices at the firm-level.

Fourth, voluntary disclosures had a statistically significant negative correlation with all productivity measures except GHG productivity with which there was no statistically significant correlation. This empirical finding is harder to explain on an *a-priori* basis, but makes sense upon further reflection when one notes that voluntary disclosures often occur *post-hoc*, i.e., after extreme negative events take place in order to thwart legal or public onslaught. In any case we recognize we only have a weak explanation for this anomalous finding with respect to voluntary disclosures.

Fifth, R&D-to-sales ratio is correlated only with energy productivity and with none of the other three measures of productivity. Our explanation of this finding is that energy productivity requires substantial R&D outlays whereas water and waste productivity could go through several incremental continuous improvement strategies. Again, we recognize that we lack a more granular view of R&D projects in the sustainability area to fully account for our findings.

Lastly, it is gratifying to note from our study that "*CEO pay/Average worker pay*" is not correlated to any of the productivity measures in our study. The implication of this finding is that CEOs of all stripes are equally interested or apathetic about sustainability. While future research can be more specific in ascertaining whether it is genuine interest or apathy in sustainability issues, manipulating the "*CEO pay/Average worker pay*" as a design variable to make firms greener is not a recommended strategy.

LIMITATIONS AND FUTURE RESEARCH

There are several limitations of our study we would like to highlight in the spirit of self-critique and also for identifying areas for future research. Industry effects are not included in our study, and we recommend future studies to replicate our study by including industry effects as part of the predictor variables. Likewise, the imperatives for each of the four productivity measures in our study may be very contextual, that is, determined by factors such as the location of the plant (near a water source), the type production function (manufacturing or service), the regulatory environment (EPA regulations), the resource availability (firm profitability and competition), etc. Our study did not examine the factors that contribute to each of the four productivity measures. Future research may expand the scope of the study

by including some of these variables. "*Women directors on corporate boards*" is an intriguing variable, especially when seen as a contributing factor to firm-level sustainability. Our study did not examine the professional backgrounds of the women directors, and future research should focus on that characteristic of women directors since those with engineering and other professional backgrounds would have significantly greater impact on firm-level sustainability practices. Future research could also develop specific sustainability levels of performance in each of the four productivity measures in our study. For example, following Tol (2009), one can assume that the damage from global emissions is $50 per ton carbon. Based on this simple quantification, future research studies could develop benchmarks for GHG productivity for various groups of firms. Another example is on country-level comparisons that are empirically based on sustainability studies such as ours. Viscusi and Aldy (2003) performed a cross-country meta-analysis and concluded that the value of a statistical life in other countries is approximately proportional to the 0.6 power of per capita GDP. This implies a value of a statistical life for US of $6.3 million, Brazil of $2.4 million, for Venezuela of $2.1 million, for China of $1.7 million, and for India of $1.3million (Arrow, et al., 2010, p.27).

CONCLUSION

Proponents of sustainable development advocate that economic development is intimately tied to environmental integrity and social equity. Increasingly we see that many firms are now subject to intense public scrutiny with the increasing environmental consciousness in society. In response, management research and conceptual thinking on ecological sustainability has expanded from a narrow focus on the concept of pollution control to a broader concept of being socially responsible that combines environmental issues into functional considerations. The potential links between firm-level energy productivity, green-house gases productivity, water productivity and waste elimination work as motivators to examine the determinants of corporate social responsibility (CSR). Our research findings provide specific guidelines for strategic innovation in the area of sustainability in terms of firm-level determinants of sustainability practices.

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