

Using the Technology-Organization-Environment Framework for Analyzing Nike's "Considered Index" Green Initiative, a Decision Support System-Driven System

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Abstract

This study explains the implementation of an environmental management information system that supports the sustainability goals of Nike using the technology-organization-environment (TOE) framework of Tornatzky and Fleischer. Literature review is applied to a single firm in using the TOE framework, with particular emphasis on the technological context of the framework. The use of Nike's firm level decision support systems is highlighted in this study. Suggestions are made about improving Nike's Material Sustainability Index (MSI), its key sustainability tool, which is at the heart of the firm's group decision support system tool.

Keywords: sustainability, technology-organization-environment framework, decision support system, environmental management information systems

1. Introduction

Recently, global firms have recognized the importance of environmental sustainability as a key part of their strategy and are pursuing initiatives way beyond "green washing" efforts (Siegel, 2009). Within the supply chain context, "green" initiatives are far more encompassing and include raw material/component selection, materials sourcing, production, packaging, distribution, recycling, and reverse logistics business processes (Closs et al., 2011). Environmental sustainability is also a multi-stakeholder issue that has captured the attention and continuing lobbying efforts of government agencies, nongovernmental organizations, social activists, consumers, firms, sustainability special interest groups, etc. Regulatory, political, and commercial actions driving environmental sustainability now have a more compelling force in the marketplace and increasingly, firms are responding to them. More proactive firms, though, have risen beyond the compliance stage and are using sustainability as a platform for creating more innovative products and services that bring competitive advantage.

Information technology (IT) has a key role to play in supporting firms' sustainability initiatives. While there are many possible avenues for using IT in supporting a firm's environmental management information system (EMIS), this study will pay particular attention to the implementation of a decision support system (DSS) to enable sustainability. An EMIS is an "...organizational-technical system for systematically obtaining, processing, and making available relevant environmental information available in companies...." (El-Gayar & Fritz, 2006, p. 2). On the other hand, an environmental management system or EMS is a set of management policies, business processes, and metrics for improving a firm's environmental performance (Pun et al., 2002).

The following are a number of studies on the use of DSS to support an organization's environmental sustainability. Pereira and Quintana (2002) studied the development of the DSS for environmental issues covering waste management, water management, land-use planning, etc. by a research group at the Joint Research Centre (JRC). The ten-year evolution of the DSS was traced from the time it was a more specialized DSS targeted at expert decision makers who used expert knowledge databases and multi-criteria engines, requiring skilled domain users to perform analysis work. The DSS, then, was modified to be more inclusive in order to be accessible to the variety of stakeholders involved in the decision making process, who were encouraged to actively debate issues that arose in the decision making process.

Koh et al. (2013) make the case for a state-of-the-art DSS for carbon emissions accounting and management for

product supply chains which would be inclusive of both the firm of focus and its supply chain trading partners. The system has an interorganizational orientation in approaching the decision making process involved in reducing carbon emissions along the entire supply chain, using the hybrid life cycle analysis method in assessing direct and indirect carbon emissions in key business processes. This supply chain environmental analysis tool (SCEnAT) was developed using supply chain (SC) mapping, SC carbon accounting, SC interventions, and SC intervention evaluations on a range of key performance indicators. Finally, the authors narrate how the SCEnAT system was tested in a specific setting.

Foxon, et al. (2013) studied the implementation of the Sustainable Water Industry Asset Resource Decisions Project, which adopted a multi-criteria analysis DSS to support water providers in the UK in assessing the sustainability of the water/wastewater system asset development decisions. The set of sustainability criteria embedded in this system was developed and tested with project partners in the UK and Romania.

This study looks at how Nike, a premier sports shoe and apparel firm, implemented its EMIS in the form of a DSS to enable its “Considered Index” environmental sustainability initiative and as a component of its EMS. The theoretical framework used for understanding how Nike deployed its DSS oriented EMIS is Tornatzky and Fleischer’s (1990) technology-organization-environment framework.

2. Research Question

This study seeks to answer this research question: “How can we explain the implementation of an EMIS, specifically, a DSS focused on supporting environmental and sustainability goals of Nike using the TOE framework?”

3. Literature Review on the Technology-Organization-Environment (TOE) Framework

This study will use the technology-organization-environment (TOE) framework introduced by Tornatzky and Fleischer (1990) that uses three elements that influence technological adoption—the environmental context, the organization context, and the technological context.

3.1 Environmental Context

The environmental context is the arena surrounding a firm, consisting of multiple stakeholders such as industry members, competitors, suppliers, customers, the government, the community, etc. They can influence how a firm interprets the need for innovation, its ability to acquire the resources for pursuing innovation, and its capability for actually deploying it. These stakeholders could either support or block technological innovation.

Changing market and competitive conditions prod firms to use various forms of innovation. Government regulation is also another powerful tool for constraining a firm’s operational activities, increasing costs of production, and instigating an investigation of technologies that must meet specified criteria. Finally, dominant customer firms could exert their power to shift their suppliers’ production activities to comply with its requirements.

3.2 Organizational Context

A range of descriptive measures characterize the “organizational context”: firm size; the centralization, formalization, and complexity of its managerial structure; the quality of its human resources; the amount of slack resources available internally; formal and informal linkages within and outside the firm; decision making and internal communication methods; and boundary spanning mechanisms to communicate with the external environment. “Organic” and “mechanistic” organizational systems are also relevant here (Burns & Stalker, 1961). Frequent lateral communication, decentralization of leadership and control, and active networking both within and outside the firm are hallmarks of the “organic” system. Building interorganizational collaboration mechanisms is fundamental in meeting the needs of electronic coordination linkages enabling supply chain partnerships.

Top executives can energize major organizational changes by (Tushman & Nadler, 1986): (1) communicating a clear image of the firm’s strategy, core values, and role of technology in meeting this strategy; (2) sending consistent signals within and outside the firm about the value of the innovation; and (3) creating a team responsible for crafting a vision relevant to the innovation.

3.3 Technological Context

The TOE framework suggests a method of implementing a technology innovation which will be referenced in the analysis of the deployment of the sustainability initiative by 7G. The following steps described below comprise the “systems design” perspective depicted by Tornatzky and Fleischer (1990), which incorporates the best aspects of the following methods used in implementing technology solutions : technocentric, sociocentric,

conflict/bargaining, systems life cycle, and socio-technical systems approaches. Different aspects of these approaches could be more prominent in the one or more steps discussed below.

The technocentric approach was derived primarily from industrial engineering and its key distinguishing feature is its exclusive focus on the hardware components and embedded knowledge domains to the exclusion of social, human end user needs and issues (Lawson et al., 1983; Gunn, 1982).

In direct contrast, the sociocentric approach focuses on the organizational and social setting of the IT innovation, with its origins from organizational sociology (Perrow, 1972; Hall, 1982), organizational behavior (Lawrence & Lorsch, 1967), and communications (Rogers, 1983). The sociocentric approach espouses the following implementation activities: (1) measure the innovation's effectiveness in terms of the social system's social functioning; (2) consider the social and organizational issues when planning and pacing the implementation of the innovation; (3) allow for flexibility in the organizational design while keeping coordination and organizational purpose; and (4) support the innovation implementation with appropriate human resource development practices (Tornatzky & Fleischer, 1990).

The conflict/bargaining perspective recognizes that decisions involving initiatives that include multiple parties will be challenged by their clashing interests (Elmore, 1978; Pressman & Wildavsky, 1973). Thus, the implementation initiative should embrace all affected stakeholders and promote practices and processes that encourage cooperation and collaboration to resolve their differences.

The systems life cycle approach, also commonly referred to as the SDLC, is a methodology used to develop IS solutions (Clarke, 1987; Pressman, 1987). SDLC encompasses the following phases: (1) systems planning and selection (i.e., identification, planning, and selection of a development project based on priorities); (2) systems analysis (i.e., gaining a thorough understanding of the current business processes surrounding the problem area of the project); (3) systems design (i.e., identification of the specifications of the design solution); (4) systems implementation and operation (i.e., transforming the IS design solution into a operational working version); and (5) systems maintenance (i.e., the repair, improvement, and updating of the operational system solution) (Valacich & Schneider, 2012).

The socio-technical approach (STS) has its beginnings from both organization change practice (Trist & Bamforth, 1951) and social psychology (Katz & Kahn, 1978). It seeks the resolution of the main concerns of the social system (i.e., organizational design, reward systems, communication patterns) and the technical system (i.e., process, technology, tools, machines, and methods) in pursuing the implementation of an IT innovation in an organization (Tornatzky & Fleischer, 1990).

Tornatzky and Fleischer (1990) presented their "systems design perspective," which is a synthesis of the following approaches: technocentric, sociocentric, conflict/bargaining, systems life cycle, and socio-technical systems.

(1) Understand the characteristics of the innovation

The technocentric approach espouses the notion that technological factors dominate the implementation experience, thus, leading to the following consequences: (a) there should be a detailed technical plan for implementation; (b) methods engineering should help in the redesign of business processes and jobs; (c) the innovation should be able to be integrated with the existing technical system; and (d) technical criteria should be used in measuring implementation effectiveness (Rousseau, 1988). The "systems design perspective" also calls for a technology-organization match. The technology innovation also influences how different parts of a firm need to coordinate. Implementation of information systems supporting environmental goals extends the level of coordination needed from internal integration to interorganizational integration within the supply chain context.

(2) Develop measures of implementation effectiveness

A wholistic approach to measuring implementation effectiveness would include metrics that are relevant to the technocentric, systems development life cycle, sociocentric, and conflict/bargaining approaches.

(3) Plan and pace implementation

Pacing technology implementation refers to the speed at which changes are unfolded, which could range anywhere from gradual to radical (Roitman et al., 1987).

(4) Design or redesign the organization

The sociocentric approach focuses on making the organization more flexible, humanistic, and open to changes brought about by the innovation (Tornatzky & Fleischer, 1990).

(5) Modify human resources policies

Human resource policies involving employee selection, compensation, appraisal, and training—all of which have important implications for innovation implementation have to be modified to fit the innovation (Ettlie, 1988).

(6) Design or redesign jobs

The design and/or redesign of jobs are needed to ensure that the affected workers and the work system required by the innovation are linked (Tornatzky & Fleischner, 1990).

(7) Install the innovation and integrate with the existing system

The systems design approach prescribes the following: (a) incorporating end user needs into the requirements definition phase; (b) designing the new system so that it can integrate with the larger IT system that encompasses the firm; and (c) ensuring the provision of resources for reliable system maintenance and providing for both incremental and radical system changes if called for.

EMSs which would need some form of IS to capture, collect, store, and analyze data and distribute information in the form of reports for various stakeholders. Chen et al. (2008, pp. 2–3) define green information system (IS) as "...the design and implementation of information systems that contribute to sustainable business processes."

Using automation in establishing information baselines on inputs (energy, water, materials, etc.) and outputs (waste, greenhouse gas (GHG) emissions, etc.), a green IS can strongly support an EMS in monitoring an organization's environmental performance (Melville, 2010).

The different elements of a green IS (i.e., hardware, software, procedures, data, networking, people) have a critical contribution to the EMS that oversees the improvement of the natural environment and addressing climate change (Melville 2010). Support for meeting the Global Reporting Initiative (GRI) standard, an internationally recognized sustainability reporting framework used for firms in all industries, would be a good example of the how a green IS application can enable the high report generation requirements of an EMS (Souto et al., 2012).

The TOE framework has been a helpful tool in understanding how firms adopt technological innovations as indicated by the following studies. Lin (2009) used TOE to explain the factors involved in the adoption of radio frequency identification (RFID) in the logistics industry in Taiwan. Zhu et al. (2006) used TOE in deriving a technology diffusion perspective on e-business adoption in 10 countries. Hackney et al. (2006) used TOE in analyzing the adoption of Web services in five U.K. firms using the case study approach. In 2005, Sharma and Citurs (2005) used some elements of TOE in their model as antecedent conditions to explain the adoption of RFID in 16 firms. In 2001, Kuan and Chau (2001) investigated the factors of electronic data interchange (EDI) adoption among 575 small Hong Kong firms using TOE. In 2000, Ryan et al. (2000) used some TOE elements to explain the adoption of knowledge management technologies using data obtained from the U.S., Mexico, and Japan.

4. Research Methodology

This paper uses a single case study approach in aligning the concepts and guidelines prescribed by the TOE framework to Nike. The case study approach is an appropriate methodology in testing the application of a conceptual framework to a real firm. This study used the qualitative research method of content analysis in analyzing secondary sources such as Nike corporate sustainability reports, journal articles, case study materials, trade publication articles, etc. Most of these materials are freely available on the web. The following are accepted definitions of the content analysis method:

"Content analysis is any research technique for making inferences by systematically and objectively identifying specified characteristics within text." (Stone et al., 1966, p. 5)

"Content analysis is a research technique for making replicable and valid inferences from data to their context." (Krippendorff, 1980, p. 21).

"Content analysis is a research method that uses a set of procedures to make valid inferences from text." (Weber, 1990, p. 9).

In this study, the concepts used for conducting content analysis were derived from the TOE framework. This framework forms the "context" of the content analysis method as applied to Nike's sustainability initiative in its supply chain.

"A context is always someone's construction, the conceptual environment of a text, the situation in which it plays a role. In a content analysis, the context explains what the analyst does with the texts; it could be considered the

analyst's best hypothesis for how the texts came to be, what they mean, what they can tell or do. In the course of a content analysis, the context embraces all the knowledge that the analyst applies to given texts, whether in the form of scientific theories, plausibly argued propositions, empirical evidence, grounded intuitions, or knowledge of reading habits.... The context specifies the world in which texts can be related to the analyst's research questions." (Krippendorff, 2004, p. 33).

TOE concepts were used in analyzing the secondary materials within the context provided by the different theoretical frameworks or "prior theory." "Analytical constructs operationalize what the content analyst knows about the context, specifically the network of correlations that are assumed to explain how available text are connected to the possible answers to the analyst's questions and the conditions under which these correlations could change....analytical constructs ensure that an analysis of given texts models the texts' context of use..."(Krippendorff, 2004, p. 34).

The following key conceptual elements of the content analysis method as stipulated by Krippendorff (2004) were used in this study: (1) body of text selected for the analysis; (2) research question that needed to be addressed; (3) a context of analysis within which interpretations will be made; (4) analytical constructs that operationalize what the analyst knows about the context; and (5) inferences that will be arrived at to address the research question.

5. Findings

5.1 Environmental Context

Nike dealt with a number of public relations issues in the mid-nineties as protests were mounted against the firm on account of substandard working conditions in the Asian factories where Nike outsourced the manufacturing of its shoes (Harish, 2010). Then, in 1992, Nike was widely criticized for the use of sulfur hexafluoride (SF6), a powerful greenhouse gas, in its Nike Air shoe. In response, Nike launched a firm-wide training program in 2000 focused on product sustainability and gathering of sustainability metrics (Henderson et al., 2009). These incidents accelerated Nike's subsequent corporate social responsibility exercises and scenario planning sessions (Henderson et al., 2009). Nike acknowledged its reliance on oil-based raw materials for its production needs and, thus, was exposed to rising oil prices and inevitable carbon emission restrictions embodied in government regulations.

Nike publicly declared its shift towards more collaborative participation in the global environmental sustainability conversation. In July 2000, Nike expressed support for the United Nation's Global Compact, an initiative that enlists corporate support in reporting firm compliance in the factories they use with core labor standards relevant to sustainability (Doorey, 2011). Nike also introduced its "Transparency 101" initiative made public through a website that posted results of its overseas factory audits. Nike also joined CERES, an environmental sustainability non-government organization that enjoins corporations to sponsor sustainability efforts and report these using the Global Reporting Initiative standards. Nike is also being proactive as its industry competitors launch similar sustainability initiatives in the sports apparel industry.

5.2 Organizational Context

The organizational changes Nike put in motion are characteristic of features of an "organic" organizational system. In 1998, Nike created the Corporate Responsibility and Compliance Division (CRD) which encompassed a number of departments, and a Corporate Responsibility Committee as part of the board of directors committee structure to oversee Nike's social responsibility performance in the areas of labor, the environment, and charitable contributions (Nike 2010-2011). These moves clearly demonstrated top management support. After joining CERES in 2000, Nike fully endorsed CERES environmental sustainability principles and immediately implemented policies reflecting these principles (IISD 2012).

Nike clearly spelled out environmental sustainability as a strategic key driver for the firm's growth (Nike 2010-2011). Nike is using environmental sustainability through the use of initiatives such as its "Considered Index." Four key pillars support the sustainability strategy: materials (i.e., creating a portfolio of environmentally sustainable raw materials); sourcing and manufacturing (i.e., prototyping and scaling sustainable production models); market transformation (i.e., motivating sustainable consumption among customers); and digital services (i.e., deriving revenues from sources other than scarce natural resources) (Nike 2010-2011).

Nike uses formal linking structures to promote "lateral relations" supporting sustainability internally. In 2006, Nike created a management framework that assumes a firm-wide integrating role to ensure accountability in the execution of corporate responsibility programs. The Vice President for Sustainable Business & Innovation (SB&I) reports directly to the CEO and oversees concerns related to development and review of environmental sustainability policies, approval of relevant investments, and evaluation of initiatives involving cross-functional

teams that have recruited business and functional executives. Nike has created a permanent SB&I cross-functional team that requires direct contact among managers to ensure the provision of sustainability domain and content expertise companywide in all affected business operations; collaborates with sustainability specialists in other parts of Nike; drives sustainability integration especially through the supply chain; mitigates risks and ensures compliance with sustainability regulations; engages affected stakeholders; and conducts regular reporting of sustainability performance (Nike 2010–2011). Nike uses interorganizational collaboration mechanisms in ensuring supplier compliance with a number of its indices—“Considered Index,” Manufacturing Sustainability Index (MSI), Sourcing and Manufacturing Sustainability Index, Country Risk Index, and Innovation Index (Nike 2010-2011).

5.3 Technological Context

Only selected steps in the technological context framework will be discussed using the Nike data. Data was available only for the steps discussed below.

1) Understand characteristics of the innovation (understand technical characteristics of innovation and social/technical context of subsystems)

Nike took a number of steps prior to finalizing the “Considered Index.” In 1998, Nike consulted with The Natural Step, a non-profit organization specializing in environmental sustainability, and used its framework grounded in the natural sciences as the basis of its Considered Index initiative (Stoner, 2006). Also in 1998, Nike consulted with McDonough Braungart Design Chemistry (MBDC), a global sustainability consulting and product certification firm, to ascertain the chemical composition of its products and use the findings for transforming its sourcing and manufacturing business processes (Stoner, 2006).

Founded on the principles of systems thinking, Nike’s “Considered Design” initiative encompasses the domains of product design, manufacturing, and the product life cycle (Nike 2007-2008-2009). The initiative’s goal is for Nike to design products across product categories using the fewest materials and enabling easy disassembly to facilitate recycling of products that have reached their end of life into new products or the safe return of the remnants to nature.

Raw materials used for Nike products are a major concern when thinking about the sustainability. Nike uses more than 16,000 different raw materials such as natural fibers like cotton and wool to technical synthetic materials like polyester, nylon, rubber, synthetic leather, and ethylene vinyl acetate (EVA) in an average year for its entire product line (Nike 2010-2011). This wide range of choice for raw material use makes the product design and development processes considerably complex.

2) Develop measures of implementation effectiveness (technical measures, social system measures, and organizational measures)

Nike uses a suite of sustainability indices to assess implementation effectiveness (Nike 2010-2011). The following are the most important indices Nike uses. The Nike “Considered Index” enables the evaluation of specific footwear and apparel products against environmental impacts of water consumption, energy use, waste generation, and toxin generation. The Material Sustainability Index (MSI) is an integral part of the “Considered Index” designed to measure the environmental impacts of raw material used. The “Manufacturing Index” measures the performance of contracted product manufacturers in terms of costing, delivery, quality, and sustainability using a balanced scorecard. The “Sourcing and Manufacturing Sustainability Index” is part of the Manufacturing Index and measures factory progression in seeking improvements in sustainable manufacturing behaviors and processes. The “Sustainability Integration Index” evaluates if sustainability is embedded in the strategy, structure, people, and operations of Nike. “The Innovation Index” measures how sustainability is integrated in Nike’s innovative product portfolios to drive business growth.

3) Plan and set pace of implementation (create technical plan; pace implementation; take social, organizational, and technical issues into account)

Nike implemented its “Considered Index incrementally. First, all its products (e.g., footwear, apparel, equipment, accessories) will be required to meet the baseline Considered design standards with targeted dates for each product category (Nike 2007-2008-2009). Nike sought to share the index with senior leadership and roll it out to all product categories and footwear manufacturing base within the period 2007–2009. In 2009, Nike went live with the full-featured online Considered Index tool intended for its product design teams and liaison offices. The first apparel product line developed using the online tool was rolled out in 2010. Once the suite of index tools are fully developed, Nike will share these with the public via the GreenExchange, the Nike-sponsored creative and open digital commons for sharing environmental sustainability innovations with other companies.

4) Install and integrate with the existing technical system (will include integration of social and technical considerations and involvement of affected stakeholders)

Nike introduced the “Considered Index,” an online tool that embodies a set of metrics that are a product of Nike’s research efforts addressing raw material selection, solid waste, fabric treatments, and solvent use, to be used by Nike’s product design teams (Nike 2007-2008-2009). Based on product life cycle thinking concepts, this online systems-integrated tool evaluates the environmental footprint of Nike’s product line, drawing product information from Nike’s database. For more than 10 years, Nike has been collecting data on solid waste and solvent use of its footwear product line and data on the waste footprint of its both its footwear and apparel items across all sports categories, involving a range of some 80,000 possible raw materials Nike could use (Nike 2007-2008-2009; Nike 2010-2011). After conducting the evaluation process, the tool generates a “Considered Index” score using the Index framework based on Nike’s known environmental footprint in the key impact areas of solvent, materials, and energy use and waste generation. Products that earn the “Considered” designation are those whose “Considered Index” score exceeds the corporate average.

In conjunction with the “Considered Index” tool, Nike uses its Materials Sustainability Index (MSI) to identify what it calls “environmentally preferred materials” (EPM) (Nike 2007-2008-2009). EPMs are defined as those raw materials that have low environmental impact in terms of chemistry, energy and water use, and waste generation. The MSI tool evaluates raw materials according to these four criteria: (1) chemistry: risks to human health are determined using a number of toxicology indicators such as presence of carcinogens, acute hazards, chronic hazards, and endocrine disruptors/teratogens; (2) energy intensity: amount of energy consumed per unit of raw material processed; (3) physical waste generated: recycled inputs used, manufacturing waste generated, and product end-of-life disposition; and (4) water intensity: amount of water required to process raw material.

The Nike MSI tool assigns a numeric value to the raw materials used, which is, then, translated into the final sustainability score for the finished product. The Nike MSI is also an online tool that uses red-yellow-green color coding to indicate the environmental impacts of specific raw materials evaluated throughout their life cycle phases. The green color means that the raw materials have a low environmental impact, whereas, red means that an opportunity for significant improvement and perhaps, even, further research is recommended.

The upgraded MSI tool includes a rating system for raw material vendors in order to incentivize them to become environmentally sustainable using the following criteria (Nike 2010-2011): (1) whether or not they are complying with the Restricted Substance List (RSL) testing requirements and the Nike Water Program requirements; (2) if they are participating in the materials certification processes such as the Global Recycle Standard; and (3) if they have the ISO 14001 certification or conduct their production operations in “green” buildings.

6. Discussion of Findings

Nike primarily used some form of DSS tool in designing a selected number of indices to help its decision makers address sustainability related issues: Considered Index; Materials Sustainability Index (MSI); Manufacturing Index; Sourcing and Manufacturing Sustainability Index; and Country Risk Index. Turban et al. (2005) refer to a DSS as “...a computer-based information system that combines models and data in an attempt to solve semi-structured and some unstructured problems with extensive user involvement.”

Nike evaluates basically two general categories of raw materials. There are the naturally sourced materials, which are plant-, animal-, or mineral-based, and there are the synthetic (fossil-fuel based) textiles and component part materials. Standardized environmental information and/or relevant supply chain-related information may not be available for all raw materials Nike uses. The functional unit used is one kilogram of finished textile or component part material. The MSI tool accounts for the weight of the raw material at the finished product stage using material utilization metrics (Nike, 2012, p. 13).

The MSI score reflects points earned by a specific raw material in three areas—a base material score, material environmental attributes, and supplier practices (Nike 2012). Raw materials can earn a maximum of 100 points; the higher the MSI score earned, the more sustainable the raw material is. The MSI score also includes the four environmental impact areas taken into consideration by Nike: energy; greenhouse gas (GHG) intensity; water and land use intensity; and physical waste. Evaluation of the environmental impacts of raw materials depends on “life cycle analysis,” (LCA) which tracks the environmental impacts of the product from the raw material stage through to manufacturing, distribution, and consumption.

6.1 Base Material Score

Life cycle information (LCI) is used to compute the Base Material Score. LCI is derived using a method that

tracks the “cradle-to-gate life cycle” environmental impact of the raw material, which spans the origin of the raw materials, processing and pre-manufacturing activities, material manufacturing, and post-manufacturing processing (Nike 2012). The MSI framework uses a mathematical function to transform energy and GHG intensity, water and land use intensity, and physical waste data into a percentile score for each indicator.

6.1.1 Data Issues with Base Material Scores

Nike uses primary data sources such as government and/or utilities data assembled by the World Resources Institute for the GHG protocol, and for ancillary data concerning electricity grids such as GHG intensity factors. Processes associated with textiles and component materials could be widely variable and because of this data ranges may be all that is available. In cases like this, Nike uses the midpoint in the data range (Nike, 2012, p. 14). When LCI data is not available for a particular raw material, Nike uses estimates based on the firm’s professional experience and judgment. Nike also uses supplier data provided through completed questionnaires for some raw materials. Supplier questionnaire data, however, is limited to specific process stages representing only certain segments of the cradle-to-gate life cycle. Thus, supplier questionnaire data is integrated with secondary generic information and is used “as is” and not subjected to additional validation.

The MSI framework uses multiple data sources when converting information into functional units: (1) for generic materials, Nike uses literature reviews covering peer-reviewed and publicly available publications, and (2) when LCI data is unavailable, Nike uses published studies where the data may be converted into the functional unit Nike uses. Nike chooses published materials that use similar structure and production processes in making certain calculations. For instance, Nike could use chicken LCI data for process stages applicable to goose down or use polyethylene data for ethylene vinyl acetate (EVA) (Nike, 2012, p. 13).

6.1.2 Modeling Issues with Base Material Scores

The worksheets used to calculate Base Material Scores are a modified version of a process flow chart, which tracks the origin of the raw material and continues through up to about 11 processes (Nike, 2012, p. 14). A wide range of materials from textiles to foam are analyzed. Ideally analysis should start at the earliest raw material stage indicating the origins of the raw material, but it could also start with pellet, polymer, fiber, or foam rather than the origin of the raw material. When data is available, loss and waste values are incorporated into the individual process steps in the cradle-to-gate life cycle of the raw material.

LCI conventions are followed for calculating energy, GHG, and water intensity (Nike, 2012, p. 15). In computing water intensity, for instance, the average rainfall in the geographic region is subtracted from the water requirement for a given crop and assume that the remaining requirement is met by irrigation. The MSI framework allows the use of data “proxies” for raw materials that lack appropriate LCI data in order to calculate use of water, for instance, so that these elements are not eliminated from the tool. Estimates of process energy and water for yarn and textiles are taken from a study conducted for the Danish EPA report on the environmental impacts of textiles (Nike, 2012, p. 15).

6.2 Material Environmental Attributes

Nike positively scores a finished material for incorporating elements of green chemistry, recycled and organic content, and water conservation (Nike 2012). Point reductions occur when blending or compositing two or more raw materials takes place as more resources are needed for the manufacture and recycling of the resulting products at the end of their lives.

6.2.1 Calculation of the Four Environmental Impacts

(1) Chemistry

The calculation used for the chemistry of the raw material encompasses important chemical substances used in all stages of the cradle-to-gate life cycle. For instance, in the cultivation of bio-based agricultural materials, the use of pesticides is significant. For polymers, on the other hand, significant chemical substances are those present in principal reactions, including known catalysts, from the raw material source through polymer formation. Chemistry tests are important in undertaking human health hazard evaluations for carcinogenicity, acute toxicity, chronic toxicity, and combined reproductive toxicity and endocrine disruptions.

Chemistry is assessed in the two general phases that raw materials undergo: (1) textiles: phase 1 spans the origins of the raw materials used up to the cone of yarn and phase 2 includes the “greige” fabric through to its finished textile stage; (2) component parts such as molded parts, foams, and buttons: phase 1 spans the origin of the raw material up to the formation of the basic material such as a polymer pellet, and phase 2 covers additional processes that transform the basic material into another form that is shipped to the assembly facility (e.g.,

processing pellets into a foam). Scores are computed for the two phases and then, averaged out in obtaining a final score. The collection of data is broken down into two phases to ensure that chemistry impacts in phase 1 do not overwhelm those in phase 2 and also, Nike would like to have greater transparency into processes where the potential for improvement exists.

(2) Energy and GHG Intensity

The MSI framework calculates energy intensity which includes process energy, transportation energy, and feedstock (i.e., caloric value) energy, using the GHG Protocol methods and known emission factors. For transportation-related GHG intensity, the calculation includes Scope 1 direct emission and for electricity, Scope 2 indirect emission is used. A mix of electrical and thermal data sources are used in calculating the energy intensity of most textile-related processes. For the GHG intensity of thermal processes, calculations are based on Scope 1 direct emission involving fuel oil or natural gas for water heating, etc. The use of either diesel-driven machinery such as farm equipment or heaters for dyeing and drying are assumed for electric and thermal energy intensity measurements.

Excluded are energy and GHG intensity in significant chemical substances or capital equipment used due to the added complexity, cost, and time in gathering data pertinent to these measures.

(3) Water and Land Use Intensity

The measurement of water intensity includes primary process water such as irrigation for agricultural crops, but excludes water used in transportation (Nike, 2012, p. 18). Excluded in water intensity calculations are rainfall in water calculations for agricultural crops and water embodied in significant chemical substances or capital equipment due to the added complexity, cost, and time in gathering data pertinent to these measures.

Land use intensity pertains to the amount of bio-based raw material produced per hectare of land. Producing bio-materials call for considerable land resources, thus, land intensity requirements of renewable fibers are distinguished from those of natural fibers.

Nike acknowledges its inability to identify an appropriate method for measuring the amount of fossil-fuel-based raw material required per hectare or the potential displacement of food production in its land intensity calculations.

(4) Physical Waste

Physical waste is usually characterized according to the following categories: hazardous, municipal solid waste, industrial, recyclable/compostable, and mineral wastes. The environmental impact of physical waste varies depending on whether the waste is disposed of in a landfill, incinerated for energy recovery, composted for beneficial use, or recycled into a new product. Waste generation has cost and management implications, which is why it is measured. Focusing on waste generation also motivates a firm's resolve to achieve the desired zero-waste goal in its product lines.

For measuring physical waste, Nike uses the European Union waste categories used in Eco-Profiles for both fossil-fuel-based fibers and bio-based fibers, for characterizing the physical waste generated through the cradle-to-gate life cycle (Nike, 2012, p. 19). Nike acknowledges having to make estimates in cases where physical waste data is unavailable, especially for bio-based materials, even when life cycle assessment data is identified. Estimates are based on assumptions Nike makes about the types of physical waste material most likely generated during different stages of the cradle-to-gate life cycle.

6.2.2 Nike Green Chemistry Program

The Nike Green Chemistry Program seeks to reduce the use of toxic chemicals in the raw materials and production processes used. A systematic method assesses the presence of toxins in both the raw materials and production processes used.

Through a number of initiatives, the Nike Green Chemistry Program seeks to reduce the use of toxic chemicals in the raw materials and production processes used. A systematic method is applied to assess the presence of toxins in both the raw materials and production processes used. The potential exposure of consumers, factory workers, and the environment to harmful chemicals is also evaluated in order to prioritize the elimination of chemicals in use that pose the highest risks. Suppliers that appraise chemical use within their factory facilities and encourage and use operational processes and technologies to cut back on the use of toxic chemicals in the production line are awarded positive points.

6.2.3 Water Conservation

Reuse and recycling of wet processing water in textile manufacturing are rewarded here. Points are awarded for the use of water-efficient or waterless processes for textiles and wet processing methods to color and/or finish the textiles, and for encouraging water reuse and recycling.

6.2.4 Recycled and Organic Content

Use of recycled and organic content in the raw materials is rewarded since these materials have low chemistry, energy and GHG intensity, and water and land use intensity requirements.

6.2.5 Blends and Composites

Raw materials are penalized for the use of blends of composites—the combination of two or more raw materials into a finished material—due to its higher resource impacts in terms of chemistry, energy and GHG intensity, and water and land use intensity.

6.3 Supplier Practices

Suppliers that comply with a number of Nike's programs are rewarded: Nike's Restricted Substances List (RSL) Program, Water Program, Energy and Carbon Program, and other non-Nike sustainability certifications and programs that can improve a supplier's sustainable practices.

6.4 MSI Output and User Interface Issues

The user interface for the MSI framework is governed by the three tiers used in reporting data (Nike 2012). The Tier 1 end user view shows enough details to help the end user understand the scoring framework behind the Base Material Scores. The report view in Tier 1 shows an alphabetical listing of the high-level summary impacts of Chemistry, Energy and GHG Intensity, and Water and Land Use Intensity. The Tier 2 end user view was designed to give the materials and life cycle practitioner enough data to understand the MSI framework. The Tier 3 end user view accentuates the sources of data used for calculating the MSI score, algorithms employed, and assumptions used in order to present the reports or views shown in Tiers 1 and 2.

7. SWOT Analysis and TOE Framework

Developed by Albert Humphrey from a research project conducted at the Stanford Research Institute, the “Strengths/Weaknesses/Opportunities/Threats” (SWOT) analysis framework is one tool for crafting a firm’s business strategy (Badal, 2006). SWOT looks at both the internal capabilities of the firm and the demands or challenges placed upon it by the different forces in the environment (Badal, 2006). The four elements of the SWOT framework consist of strengths, weaknesses, opportunities, and threats. Both strengths and weaknesses refer to internal attributes of the firm. Strengths represent capabilities that a firm does very well and both tangible and intangible resources available at its disposal such as intellectual capital, human resource expertise, information technology assets, etc., it could use in satisfying customer needs and demands. Weaknesses represent deficiencies and capability gaps that impede the firm from meeting demands of major stakeholders.

Opportunities and threats refer to elements in the external environment that could determine the firm’s fate and must be managed appropriately. Opportunities can come in the form of favorable market developments, exposure of competitors’ vulnerabilities, emerging technological developments, strong alliances and partnerships, etc., that the firm can take advantage of to enhance its current position. Threats, on the other hand, are unfavorable developments in the marketplace that bode potential barriers and challenges that the firm must overcome. Examples of these include unfavorable government regulations, increasing competitor dominance in the markets, impending price wars among the firm’s nearest competitors, emergence of substitute products/services, declining customer demand for the firm’s products/services, etc.

The SWOT analysis framework encourages firms to take advantage of both their internal strengths and external opportunities that could work in their favor to enhance their ability to serve customers and consequently, generate more revenues and/or improve their market share position. Conversely, firms are encouraged to manage and overcome internal weaknesses and external threats by planning ahead and wisely using their available resources to minimize the potential negative impact on these firms.

Table 1 shows the strengths and opportunities that Nike can capitalize on to improve its overall position. The strengths detailed in Table 1 describe elements of Nike’s organizational and technological contexts, which are all internal to the firm. Also included in Table 1 are opportunities in the external environment, thus, involving the environmental context of the TOE framework.

Table 1. Positive factors Nike can take advantage of: strengths (internal) and opportunities (external)

STRENGTHS (Internal)	OPPORTUNITIES (External)
Organizational Context:	Environmental Context:
<p><i>+ top-level leadership and commitment to sustainability</i></p> <p>1) Opportunity to change the Nike's business model and use sustainability as a foundation and basis for profit making (Kiron, et al., 2013). For example, "GE's eco-imagination initiative, poised to deliver \$25 billion in revenues in 2010, enabled CEO Jeff Immelt not just to reposition the company as an energy and environmental solutions provider but to build a green aura into the GE [General Electric] brand." (Lubin & Esty, 2010, p. 46).</p> <p>2) Firm-wide sustainability initiatives require C-level executive engagement and leadership. Since the "Considered Index" initiative approach already has top management support, this could be extended to other related sustainability drives as well that encompass other areas of Nike's business operations.</p> <p>Nike's "Chief Sustainability Officer" can help the CEO and executive team visualize sustainability goals and align vision with business strategy (Lubin & Esty, 2010, p. 46).</p> <p>3) Ability to introduce enterprise-wide sustainability initiatives quickly and embed it in the culture and business processes; at this time, the "Considered Index" decision support system tool is specific to product design and control in the use of raw materials. The sustainability concept is wider and includes other activities like fuel consumption involved in outbound logistics or the delivery of finished products to wholesalers/distributors and both organizational and individual end customers.</p> <p>4) Nike has the organizational mechanisms needed to launch sustainability-related new product initiatives that can give the firm competitive advantage, in addition to merely complying with government regulations stipulating environmental friendliness. Nike is already doing that with the "Considered Index" DSS tool, which can give its products the differentiating feature of being designed for and made with environmentally friendly raw materials (Haanaes et al., 2011).</p> <p><i>+ interfirm collaboration made possible by lateral integrating organizational mechanisms</i></p> <p>(1) Nike is already using the organizational collaboration mechanisms in place to cooperate with its key value chain trading partners, its suppliers, as government regulations now hold firms accountable for the sustainability of its entire value chain and product life cycle (Lubin & Esty, 2010). Nike extends support to suppliers by providing consulting expertise, training, and auditing exercises. Nike ensures that suppliers cooperate with the firm's Code of Conduct auditing procedures and incentivizes suppliers using rewards to encourage suppliers' consistent commitment to long-term sustainability.</p> <p>(2) Nike could use tight inter-organizational mechanisms with customers to find out if they are willing to pay premium prices for sustainable products/services (Kiron et al., 2013).</p> <p>(3) Nike uses its collaboration skills to continue supporting transparency about factories it does business with in terms of contract manufacturing; Nike collaborates with organizations like the Fair Labor Association (FLA), the Fair Factories Clearinghouse (FFC), and the Better Work Initiative, to ensure that these contracted manufacturers are observing codes of conduct and are responding to common assessment methods (Nike, 2012). Nike works with more than 900 contracted factories that employ more than 1 million workers in 50 countries to produce its footwear, apparel, and equipment products.</p> <p>(4) Nike can collaborate with key sustainability-oriented stakeholders such as suppliers, non-governmental organizations or NGOs, customers,</p>	<p>Environmental Context:</p>
	<p>(1) Government regulation stipulating increasing levels of environmental friendliness can be used by Nike to its advantage. By being and remaining proactive in using environmentally friendly raw materials and designs using its "Considered Index" decision support tool, Nike can turn antagonistic regulators into allies by leading the way and thus, be influential in shaping sustainability regulations (Nidumolu & Esty, 2009).</p>
	<p>(2) Nike can use government regulations involving environmental sustainability to influence its suppliers to comply with its green Code of Conduct requirements.</p>
	<p>(3) Nike is using its stakeholder pressure for sustainability to improve the firm's brand reputation (Haanaes et al., 2011)</p>
	<p>and thus, enhance its standing within its industry and the entire marketplace.</p>
	<p>(4) Nike can abide by voluntary general sustainability codes such as the Greenhouse Gas Protocol and other codes specific to the industry it belongs to. Examples of industry-specific codes include the Forest Stewardship Council code for the forestry industry and the Electronic Product Environmental Assessment Tool for the electronics industry, which their respective industry associations and nongovernmental agencies have drawn up in the last 20 years (Nidumolu et al., 2009); it's smart to comply with the strictest codes even before they are enforced by law.</p>
	<p>(5) Nike can meet emerging industry or marketplace norms on sustainability in order to gain time to experiment with alternative and more environmentally friendly raw materials, technologies, and business processes (Nidumolu et al., 2009). Nike can also experiment in different parts of the world as government regulations on sustainability vary worldwide.</p>
	<p>(6) Nike is already responding promptly to customer demand for sustainable products and services and demonstrate high levels of customer service.</p>
	<p>(7) Nike can meet gold sustainability standards globally and save money (Nidumolu et al., 2009).</p>
	<p>(8) Nike can continue collaborating with sustainability-oriented non-governmental organizations in order to increase its favorable standing with these types of stakeholders.</p>

other governments, even competitors. For example, Nike can collaborate with NGOs to help the firm identify credible and meaningful sustainability objectives and activities that do not smack of “greenwashing” (Kiron et al., 2013).

Another good example involves Wal-Mart: “In 2006, then-CEO [of Walmart] Lee Scott launched Sustainability 360, establishing explicit goals to purchase 100% renewable energy, create zero waste, slash greenhouse gas emissions, and sell ‘products that sustain our resources and the environment.’ To this end, Wal-Mart created a dozen Sustainable Value Networks, each comprising Wal-Mart team members, NGO experts, academics, government officials, and supplier representatives, all working under the direction of a Wal-Mart network captain. Each team focuses on a strategic issue targeted by the company’s sustainability agenda—such as facilities, packaging, and logistics—and tries to develop new ways of doing business that support the company’s sustainability goals. The payoffs are already showing up: One of the Sustainable Value Networks, tasked with fleet logistics, came up with a transportation strategy that improved efficiency by 38% saving Wal-Mart more than \$200 million annually and cutting its greenhouse gas emissions by 200,000 tons per year.” (Lubin & Esty, 2010, pp. 46-47).

(5) Nike can use its lateral, boundary spanning inter-organizational coordination mechanisms to collaborate with other firms to spot business opportunities inherent in government sustainability regulations (Nidumolu, et al., 2009). (For instance, Hewlett Packard “...learned that Europe’s Waste Electrical and Electronic Equipment regulations would require hardware manufacturers to pay for the cost of recycling products in proportion to their sales. Calculating that the government-sponsored recycling arrangements were going to be expensive, HP teamed up with three electronics makers—Sony, Braun, and Electrolux—to create the private European Recycling Platform. In 2007 the platform, which works with more than 1,000 companies in 30 countries, recycled about 20% of the equipment covered by the WEEE Directive. Partly because of the scale of its operations, the platform’s charges are about 55% lower than those of its rivals. Not only did HP save more than \$100 million from 2003 to 2007, but it enhanced its reputation with consumers, policy makers, and the electronics industry by coming up with the idea.” (Nidumolu et al., 2009, p. 60).

Technological Context: (Internal/Strengths)

(1) Nike is using different forms of information technologies to support its decision support system tool “Considered Index” in designing sustainable products/services and selecting environmentally friendly raw materials (Nidumolu et al., 2009).

(2) Nike could use its technological experience with the DSS-enabled “Considered Index” to extend its sustainability initiatives to other parts of its value chain: inbound logistics, outbound logistics, marketing and sales, and after sales service.

(3) Nike could use its technological resources and experience to track sustainability performance impacts in order to generate consistent, complete, and precise data needed to evaluate sustainability costs and benefits, help in benchmarking performance, and design sustainability focused business strategies (Lubin & Esty, 2010).

(4) Nike is using its technological resources and experience to support information transparency via sustainability reporting initiatives using guidelines such as the Global Reporting Initiative (GRI) (Lubin & Esty, 2010).

(5) Nike could use its technological resources to support social networking and mobile devices such as the Nike “fuel wristband” to promote Nike’s sustainability-related products/services.

Technological Context: (External/Opportunities)

(1) Nike is using its decision support system-enabled tools like “Considered Index” to gain leadership in the sports garment industry and greater credibility in terms of sustainability leadership within its industry.

(2) Through Nike Exchange, an open knowledge exchange website created by Nike, the firm is using its IT resources and experience to influence all other sports-related manufacturers in spreading sustainability related expertise in designing products and selecting raw materials.

Table 2, on the other hand, shows the weaknesses and threats that Nike should anticipate, manage, and eventually overcome to minimize the damage to the firm.

The weaknesses detailed in Table 2 describe elements of Nike's organizational and technological contexts, which are all internal to the firm. Also included in Table 2 are threats in the external environment, thus, involving the environmental context of the TOE framework.

Table 2. Negative factors Nike can learn to manage: weaknesses (internal) and threats (external)

WEAKNESSES (INTERNAL)	THREATS (EXTERNAL)
<p><i>Organizational Context:</i></p> <p>(1) Nike has to mandate contracted manufacturer compliance with its “Code of Conduct” which stipulates that suppliers must use environmentally friendly raw materials and conduct sustainable factory operations. Nike also conducts auditing procedures to ensure supplier compliance with this requirement. Suppliers that score Yellow or Red on the “Sourcing & Manufacturing Sustainability Index” or SMSI will need to fund third party audits until they can comply with Nike’s Code of Conduct standards (i.e., Bronze level performance) (Nike, 2012). If certain suppliers have considerable bargaining power and are among the few sources of valued raw materials, Nike will have less power in mandating compliance with its Code of Conduct and could possibly alienate these suppliers.</p> <p>(2) In assessing compliance of its suppliers with its Code of Conduct, Nike has to, in part, depend on supplier responses to Nike’s surveys. Suppliers could “fudge” their responses to these surveys just to appear favorable to Nike.</p> <p>(3) Nike has the greatest amount of control over the tier-1 suppliers that provide raw materials to the contracted manufacturers Nike deals with. Nike has less control over suppliers of raw materials in the far ends of the supply chain --- in other words, suppliers of the tier-1 suppliers.</p>	<p><i>Environmental Context:</i></p> <p>(1) Nike contracts manufacturing out and therefore, does not own the manufacturing facilities. These same manufacturers also serve Nike’s competitors. If these competitors gain the upper hand in their relationships with the same contracted manufacturers, it may be difficult for Nike to seek compliance with its sustainability initiatives or to preserve secrecy over certain proprietary information that is key to its competitive edge.</p> <p>(2) Nike intends to share sustainability findings and expertise gained such as the “Environmental Apparel Design Tool” via the “Nike Exchange”. While this effort is laudable and could gain Nike leadership in its industry, this could backfire and intensify competition with Nike’s nearest competitors.</p> <p>(3) Nike’s competitors in the sports equipment and apparel industry such as Adidas are also launching their own sustainability initiatives. It may get increasingly difficult for Nike to gain product differentiation especially if it seeks to share valued sustainability expertise with its competitors.</p> <p>(4) In designing its “Considered Index” tool and other sustainability tools Nike is using, the firm depends on scientific information concerning the environmental harms posed by certain raw materials. Scientific opinion could differ with respect to the level of harm posed by these raw materials. This could present some challenge in Nike’s ability to determine the suitability of raw materials.</p> <p>(5) Scientific information and data about a wide variety of issues involved in a firm’s sustainable business operations are available in many scattered data sources—government agencies such as the Environmental Protection Agency or EPA, research laboratory databases, published scientific journals, etc. Some of these sources are hard to get to. Data should be updated and yet, longitudinal and parallel scientific studies may not be conducted consistently in a way that could yield reliable and verifiable data.</p>
<p><i>Technological Context:</i></p> <p>(1) Nike’s information technology infrastructure as a whole can be relied upon to support its sustainability initiatives within the confines of the Nike firm itself. However, the weakest part of this infrastructure is the sustainability data itself that Nike needs to either generate or gather especially from a wide range of external sources, which it needs to make sustainability-related assessments on issues like: levels of toxicity or lack thereof with particular raw materials, carbon emissions of the different means of transportation used for both inbound and outbound logistics, etc.</p> <p>Nike needs to identify the full life cycle energy and greenhouse gas impacts of all Nike products. The largest source of greenhouse gas emissions in Nike’s operations has been identified as the manufacturing</p>	

operations. Since Nike contracts out manufacturing to outside firms, it is faced with the challenge of reliably and accurately capturing data on both greenhouse gas and carbon dioxide emissions in these factories. For instance, in the manufacture of footwear, Nike relies on 90 percent factory-reported primary data for sustainability related reporting; the other 10 percent of the data is extrapolated from various sources. It is not guaranteed, however, that its contracted manufacturers have appropriate electronically enabled-data gathering resources for reporting business operations related data that Nike needs.

Nike does not have electronic linkages with its contracted manufacturers so that it could capture manufacturing-related data with environmental sustainability implications.

(2) Once again, although the overall IT infrastructure of Nike is sound, there are limits to the accuracy and reliability of data the firm gathers to undertake an accurate carbon emission accounting methodology for its inbound transportation activities when covering shipments of finished goods from factories to distribution centers globally.

8. Conclusion and Future Research Direction

8.1 Implications for Future DSS Development

There are different types of DSS systems that could be developed to support environmental sustainability goals of supply chains. The Nike “Considered Index” experience typifies a context where decision automation is appropriate. This is where the decisions involved are primarily structured, well defined, routine, and programmed (Power, 2013). The DSS at Nike could also make good use of a hybrid of a DSS that combines the attributes of a data-driven, knowledge-driven, and model-driven DSS. A computerized DSS is also appropriate in situations characterized by complexity, the requirement of having the relevant domain knowledge, uncertainty, specific goals, multiple groups with a stake in the decision outcome, large amount of information is involved, information changes rapidly, or combination of these conditions (Power, 2013).

The Nike “Considered Index” example requires a wide range of data. For this reason, a data-driven DSS that has the following key features would be needed: ad hoc data filtering and retrieval; alerts and triggers; data display creation; data management and summarization; and predefined data displays and production reports (Power, 2013). The introduction of online analytical processing (OLAP) capabilities in the early 1990s ushered positive possibilities for a data-driven DSS. OLAP systems are characterized by multidimensional conceptual views, links to a variety of data sources, multi-user support, intuitive data manipulation, flexible reporting, and accessible analytical capabilities. A data-driven DSS depends on a robust data store and needs to be supplemented by an easy-to-use end user interface and managed using an effective data governance policy.

An environmental sustainability oriented DSS is also dependent on domain knowledge from experts who know about life cycle analysis, carbon emissions, water management, waste management, different natural and synthetic raw materials, electricity and energy management, etc. Thus, the following attributes of a knowledge-driven DSS are also needed to allow information exchange and discussion among experts involved in the DSS: (1) ability to ask questions; (2) backtracking capability that would allow end users to move backward through the questions and change their subjective judgment and recommendations; (3) ability to display confidence or certainty information: the DSS may be required to show numeric values like confidences, likelihoods/probabilities, ranks, etc. A “confidence interval” indicates the statistical range with a specific probability that a given result/recommendation/diagnosis could fall within that range; (4) ability to explain and justify the explanation: the DSS should be able to respond to end user request for an explanation of a recommendation arrived at by the system; (5) ability to initiate action: the DSS can be designed to enable end users, for instance, to send out email messages or implement a recommendation; and (6) ability to retrieve data about a specific case or instance: the DSS has the ability to allow and end user to retrieve data from some other computerized sources or even external data sources.

The need for being updated with scientific research findings from external sources in order to justify business rules that are built into decision making algorithms is very important. Also, divergence in scientific opinions amongst the experts could be a real challenge—thus, a DSS that forces the articulation of justification behind a decision is critical.

A model-driven DSS provides access to and manipulation of a quantitative model representing an abstraction of

relationships in a complex situation. For instance, a model-driven DSS could help a store manager use an inventory model to specify order quantities for different products sold in the store. Methods like optimization and linear programming could also be used. Linear programming, for instance, could be used to determine an optimum combination of raw materials used in the production of a laptop.

The following attributes of a model-driven DSS could be useful (Power, 2013): (1) change a model parameter as in a “what if” analysis exercise: this allows the end user to change a single model parameter and observe the results; (2) create and manage scenarios: the end user could change a combination of decision variable values belonging to a “scenario” and observe results; (3) extract specific historical data values from an external database; (4) select output formats; (5) specify and seek alternative goals: end users could specify an outcome and work backwards to identify decision variable values to arrive at the outcome; (6) elicit certain values and data input: a model-driven DSS could enable the end user to submit input data and elicit values by asking for a number, making the end user manipulate a graphical device like a slider, and asking the end user for a word or verbal input.

Research results demonstrate that the data based on Nike’s experience supports key elements of the TOE framework, which proves to be helpful in understanding why and how firms pursue their sustainability initiatives. Today’s DSSs could support group-based collaborative decision making initiatives, which are appropriate to environmental DSSs such as the one used by Nike (Shim et al., 2001). Features of group support systems linked by Internet-enabled connections using portals or extranets could be used in synchronous and asynchronous decision making scenarios of virtual teams involving experts in the different scientific disciplines covered by life sciences (e.g., chemistry, biology, industrial ecology, etc.). Also, electronic connections with regulatory agencies and sources of ever changing government regulations will be essential. Constantly updating and displaying supplier performance on the relevant Nike indices using digital dashboards with electronic scorecards could hasten supplier responsiveness to Nike sustainability requirements.

Data management aspects of environmental DSSs could be made more powerful by the use of datawarehouses linked to enterprisewide systems that collect data with direct environmental implications. Overwhelming data volume could be managed using intelligent agents that screen and filter usable data from multiple organizational data sources. Java-based components could be designed to search for specific data sources that meet user-defined search profiles (Shim et al., 2002). The modeling component of the environmental DSS could be improved through the use of current solution software embodying techniques of metaheuristics to solve combinatorial problems. Techniques that could be used include genetic algorithms, neural networks, and other artificial intelligence-based tools. More advanced mathematical programming behind the models could also be integrated with widely used tools like Microsoft Excel (Shim et al., 2002). User interface features could incorporate those supported by mobile device technologies, mobile e-services, and wireless protocols such as Wireless Application Protocol, Wireless Markup Language (WML), and iMode to encourage ubiquitous and rapid real-time communication and information exchange among decision makers (Shim et al., 2002).

Once a critical mass of firms across industries is found to be demonstrating corporate social responsibility through environmental sustainability, it would be feasible to conduct empirical research on the concepts embodied in the TOE framework. Relationships between appropriately operationalized TOE concepts and dependent variables like the firm’s economic performance, costs of supporting its green supply chain, customer satisfaction and loyalty, among others, could be tested.

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