THE PENNSYLVANIA STATE UNIVERSITY

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DEPARTMENT OF SUPPLY CHAIN AND INFORMATION SYSTEMS

ENVIRONMENTAL SUSTAINABILITY METRICS FOR BECTON DICKINSON

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Abstract

The purpose of this thesis is to consider the best options for the transportation team within Becton Dickinson's Medical Devices group in pursuing an environmental sustainability metric. The team wanted to know what current practices existed and what would be the best method to pursue. In order to supply this information, a literature review and survey were conducted. Through these methods, a recommendation will be made on how this team should move forward with pursuing their sustainability initiative.

Table of Contents

ABSTRACT	i
TABLE OF CONTENTS	ii
CHAPTER 1: INTRODUCTION	1
GREENHOUSE GAS PROTOCOL	2
BECTON DICKINSON'S SUSTAINABILITY INITIATIVE	3
CHAPTER 2: LITERATURE REVIEW	4
WHY COMPANIES PURSUE SUSTAINABILITY	4
HOW COMPANIES PURSUE SUSTAINABILITY	5
ISSUES THAT COMPANIES RUN INTO	8
CHAPTER 3: INDUSTRY REVIEW	10
CHAPTER 4: RESEARCH METHODOLOGY	13
CHAPTER 5: SURVEY ANALYSIS	15
FOLLOW-UP PHONE INTERVIEWS	21
CHAPTER 6: RECOMMENDATIONS AND DISCUSSION	
RECOMMENDATIONS	23
LIMITATIONS	24
APPENDIX	
ZOOMERANG SURVEY TEXT	
BD: COMPANY OVERVIEW	27
ADDITIONAL RESOURCES	
BIBLIOGRAPHY	

Chapter 1: Introduction

Greenhouse gases have been a hot topic lately because of their effects on global warming. Greenhouse gases include carbon dioxide, methane, and nitrous oxide, with carbon dioxide making up the majority of emissions. Activities such as the production, transport, and burning of fossil fuels (oil, natural gas, and coal) all release greenhouse gases into the atmosphere. These gases trap heat in the atmosphere resulting in climate change that could affect the balance of the ecosystem.

Companies can emit a significant amount of GHGs through their manufacturing, transportation, and warehousing operations. In 2010, the estimated amount of greenhouse gases released into the environment totaled 6633.2 million metric tons (2011 U.S. Greenhouse Gas Inventory Report). There was a relatively steady rise in GHG emissions in the U.S. since the Industrial Revolution up through 2007. Before the Industrial Revolution, the concentration of carbon dioxide was at 280 ppm, compared to the 380 ppm found today (Blasing 2011). Figure 1 shows the historical levels of various greenhouse gases with a significant spike starting around the 18th century when the Industrial Revolution started. Historical greenhouse gas levels are typically measured through analysis of trapped air bubbles in glaciers.



Figure 1: Historical GHG levels (kent.gov.uk)

With the recent economic downturn, product manufacturing declined resulting in decreased GHG emissions. The slight decrease can also be attributed to companies becoming more conscious of the environment and taking measures to increase their sustainability.

Greenhouse Gas Protocol

The Greenhouse Gas Protocol is the result of a 10-year collaboration between the World Resources Institute (WRI) and the World Business Council for Sustainable Development (WBCSD). Its goal is to provide companies and government agencies with the information and tools they need to "understand, quantify, and manage greenhouse gases" (Greenhouse 2011). It is currently the most widely used accounting tool of its kind.

The GHG Protocol has defined three different scopes for emissions, labeled I, II, and III. Scope I emissions are from sources that are owned and directly controlled by the company. For example, the emissions from trucks that a company owns and uses would fall under Scope I. Scope II emissions include emissions from the generation of electricity that the company uses. Scope III emissions encompasses all emissions that result from the company's activities. This can include employee business travel, customer use of company products, etc.

Becton Dickinson's Sustainability Initiative

One of BD's corporate values includes Environmental Stewardship. In 2009, the company as a whole laid out sustainability goals that it wanted to achieve by 2015. These goals include:

- Reduce energy consumption from operations by 30%
- Increase renewable energy use in BD's portfolio to 25 %
- Reduce the use of water by 15%
- Reduce hazardous waste generation by 10%
- Reduce non-hazardous waste generation by 15%

The Logistics team within the BD Diagnostics group wanted to find the best method to accurately calculate and track its own sustainability. This team's main function is to oversee the transport of BD's diagnostic products around the world. The focus of this thesis will be to discern the best metric(s) and strategies that a company such as BD can use to track its sustainability.

Chapter 2: Literature Review

Much literature has been written on the topic of sustainability within the supply chain. In order to get a better idea of the current state of supply chain sustainability, a literature review was conducted on academic research that has already been completed.

Why companies pursue sustainability

Companies today are being put under pressure to become more sustainable from a variety of sources, both external and internal (Seuring 2008). Internally, the desire to become more sustainable can be attributed to a couple factors.

The first is a genuine desire to support "development that meets the needs of the present without compromising the ability of future generations to meet their needs" (WCED 1987). This idea is based on the idea of resource and environmental equality, both inter- and intra-generational. Inter-generational equality states that subsequent generations should have access to the same resources and environmental quality that is currently enjoyed. Intra-generational equality states that all people of the same generation ought to have access to the resources they need, rather than a select few acquiring all of the resources at the expense of others (Clift 2003). The second internal pressure is the desire to lower bottom-line costs. Efforts that support sustainability often support lower bottom lines, such as route optimization, decreased waste, and decreased utility usage.

The numerous external factors that can create the impetus for initialization of a sustainability effort include legal demands and regulations, customer demands, and reputation loss.

Legal demands and regulations that companies may face include the Environmental Protection Agency (EPA) Clean Air Act, which aims to limit the amount of contaminants and pollutants that are released into the atmosphere by various sources (EPA 2011). The end goal of these reductions is improved air quality that will improve overall human health and result in longer life spans.

With more consumers becoming informed on the benefits of sustainability, more companies are finding themselves pressured to show some sustainability initiative (Seuring 2008). Although customers may not base their purchase decisions solely on the basis of a company's sustainability, it can play some factor. If a company's competition begins promoting itself as being environmentally conscious, the target company may find itself forced to act similarly to stay competitive (Mollenkopf 2010).

A company's reputation can also be seriously tarnished if consumers find it in violation of environmental sustainability efforts. For example, BP's oil spill seriously damaged its reputation in the eyes of the general public, not just the environmentally conscious. Although BP had previously built up a stronger reputation for sustainability from its inclusion of renewable energy sources in its portfolio, the 2010 oil spill was enough to turn the public's opinion (Hoffman 2011).

How companies pursue sustainability

There are two schools of thought for how companies can pursue environmental sustainability. Results can be recognized by either improving the supply process or improving the product (Bowen 2001). Both methods can lead to effective improvements and the best method is up to each company to decide. Figure 2 shows the results of

Bowen's respondents when asked which types of sustainability initiatives they were pursuing.



Figure 2: Green supply initiatives implemented in the sample operating units (Bowen 2001)

Improving the supply process can include a myriad of possibilities. Some examples include sourcing, transportation, warehousing, and manufacturing. Requiring a company's supplier to be engaging in sustainable practices on their own can be one way to reduce a company's environmental footprint. Since the supplier's processes are included in the company's operations, any improvements and changes made to the supplier's processes will result in improvements for both parties. Companies can either work with their suppliers to identify and take action on sustainability initiatives, or they can select certain vendors based on their current sustainability programs (Sloan 2010).

Planning more efficient truck routes, reducing standing time, and using more fuelefficient trucks can reduce the amount of GHGs released into the atmosphere. Building and maintaining more efficient warehouses can also reduce the amount of electricity and water needed. One way to ensure warehouse efficiency is to have it LEED certified. LEED, or Leadership in Energy and Environmental Design, is an internationally recognized and widely used certification system that identifies buildings that are "implementing practical and measurable green building design, construction, operations and maintenance solutions (LEED)." LEED Manufacturing operations can also have their buildings certified by the same method, as well as have the actual manufacturing process assessed for possible efficiency improvements. Processes that cut down on electricity and water usage, as well as cut down on hazardous material usage and disposal are all possible enhancements.

Changes to a company's actual products can also result in significant improvements. One method that is commonly used today is reducing the amount of packaging associated with each product. Reductions in the amount of plastic and/or cardboard used for each product can not only reduce product costs, but can also reduce on the amount of waste that results from each product sold. This can also work upstream from the supplier when shipping product. Eliminating unnecessary boxes and packaging from this step is also a possibility. Another method cited that could be effective is to have recycling initiatives for the products. This often requires cooperation with a supplier, but can have a large impact on the environment, especially if the products contain hazardous materials, such as mercury (Bowen 2001). In some circumstances, mandatory recycling programs have been put in place by governing officials. This occurs

because some products are more expensive to recycle than to produce. There are no economic benefits for companies in these circumstances, but they can have sizeable impacts on the amounts of toxic materials released into the environment.

Issues that companies run into

Despite the fact that many companies have a strong desire to make their operations more sustainable, there are many barriers that can prevent companies from effectively measuring and managing their sustainability. According to Seuring, three common barriers include coordination complexity, higher costs, and insufficient or missing communication.

To have a robust and successful sustainability program, buy-in and support is required from a wide range of teams, especially top management. Without this, beginning any kind of sustainability project can result in frustration and confusion. Coordinating the different roles and tasks that each party is responsible for can be very difficult especially if there is not a centralized team responsible for the overall project.

There can also be significant costs associated with initiating a sustainability program. These costs can come from a variety of sources such as new software or extra team members needed to complete the project. Because supply chain professionals are usually in the cost-cutting mindset, added costs for the project can be seen as a deterrent for undertaking it. However, a cost-benefit analysis would be useful in such situations since economic benefits can often result from sustainability projects (Sloan 2010).

The final barrier that Seuring mentions is insufficient or missing communication. Without clear communication, most projects can easily fall apart. For sustainability projects, this is especially dangerous because it is unlikely that any one team or group has

direct control over it. Rather, it is most likely made up of individuals from various teams and functions that are trying to work together. If the individuals are unable to communicate clearly, the project could fail to even get initiated.

Chapter 3: Industry Review

In order to better understand the current trends in the sustainability practices in industry, research was done on the practices of various Fortune 500 companies. The companies included in the research included Wal-Mart, Proctor & Gamble, Toyota, General Electric, and Dell. The companies were chosen based on the availability of their sustainability reports online.

Wal-Mart has been measuring their sustainability through their GHG emissions, which they measure by metric tons of CO_2 . One of their metrics is GHG Intensity, which is measured by GHG emissions per million dollar sales.



Source: Wal-Mart

Through measuring and goal setting, the company has realized large reductions in GHG emissions in their raw material extraction, product manufacturing, transportation, customer use, and product end-of-life cycle areas. In their transportation sector, they

have a goal to double the efficiency of their fleet by 2015. Figure 3 shows the their year over year improvement in this measurement since 2005. They measure their efficiency as:

(Number of Cases Delivered/Number of Miles Traveled)

(Miles per Gallon)

So far, they have improved their efficiency by 60% since 2005 by reducing the miles driven by their trailers and by more efficiently loading them. They have also avoided releasing 145,000 metric tons of Co_2 (Walmart 2010).

Proctor and Gamble measures multiple sustainability metrics including waste, air emissions, energy consumption, greenhouse gases, and water consumption. To collect their information, they use a supplier scorecard, which measures the supplier's water use, waste, energy use, and GHG emissions. The measurement used to measure GHG is metric tons of CO_2 released. They focus on their direct CO_2 emissions, which is included in the GHG Protocol Scope 1 standard. Since 2002, the company has reduced their direct CO_2 emissions by 53% (P&G 2010).

Toyota focuses their sustainability measurements on Scope 1 CO_2 emissions. From 2008 to 2009, the company reduced their emissions from logistics operations by 10,000 tons. They achieved this by increasing the loading efficiency of their trucks, promoting modal shift, and improving the fuel-efficiency of their fleet with their logistics partners (Toyota 2010).

General Electric is focused on reducing the GHG and water usage. They measure their operational GHG emissions, which is million metric tons of CO₂ equivalent emissions (GE 2010). Figure 4 shows their improvements in various GHG emissions measurements from 2004 to 2010.

GE GREENHOUSE GAS EMISSIONS ^{(b)(h)}	2004	2010
GE Operational GHG Emissions (million metric tons of CO2-equivalent emissions)	7.44	5.65
GE Operational GHG Intensity (metric tons per \$ million revenue)	60.06	37.62
GE Operational Energy Intensity (MMBtu per \$ million revenue)	498.7	335.4
GE Operational Energy Use (million MMBtu)	61.7	50.4

Figure 4: GE GHG Emissions Data (GE 2010)

Dell measures their Scope 1, 2, and 3 emissions. Their GHG are measured in metric tons, as well as GHG Intensity which is Metric Tons of GHG per Sales \$. They collect their data by expecting suppliers to report their emissions through a standardized registry, and the suppliers are expected to set and meet reduction goals (Dell 2010).

Chapter 4: Research Methodology

In order to get information from a larger pool of companies, a survey was created to send out to companies with relations to the CSCR. The survey questions were developed together with the Becton Dickinson team and were approved by Dr. Skip Grenoble, Executive Director of the Center for Supply Chain Research at the Pennsylvania State University. The questions were developed in order to get a better idea of whether companies were measuring their sustainability and, if so, what they were using to measure it. Participants were chosen out of the CSCR's corporate sponsors as well as other companies with whom the CSCR has a good relationship. Because the selection method was a convenience sample, the results of the survey cannot be generalized to all industries. The mode of distribution for the survey was determined to be Zoomerang.com, which the University regularly uses to gather information from its students and faculty.

When creating the survey, the team wanted to be sure that it would be quick, easy, and straightforward to complete in order to get maximum results. It was recognized that if the survey was too long or required too much effort to complete, busy recipients would simply choose to ignore it altogether.

Data for the study was collected between March 2011 and April 2011. During that period multiple survey reminders were sent out to recipients in order to try to get more completed surveys.

Out of 400 survey invites sent out via Zoomerang.com, 43 responses were received, giving a 10.7% response rate. The following industries were represented:

- 3PL
- Building Materials (2)
- Business Products
- Chemicals (4)
- Clothing
- Construction
- Consumer Electronics (2)
- Consumer Products (5)
- Distribution
- Food (6)
- Grocery (2)
- Healthcare Products

- Industrial (2)
- Lab Supplies
- Logistics (3)
- Materials
- Medical Supplies (2)
- Oil
- Pharmaceuticals (2)
- Retail
- Technology
- Transportation

Because of the variety of industries represented and the fact that research findings would be shared with participating companies, company names remained anonymous throughout the duration of the project.

Of the companies who completed the online survey, 13 were available for a brief phone interview. The aim of the phone interview was to get a deeper understanding into each specific company's sustainability efforts. Phone interviews were set up on a oneon-one basis and lasted for approximately 30 minutes. Additional questions were again developed together with the BD team.

ry (2)

• IT

Chapter 5: Survey Analysis

Zzoomerang Is your Company familiar with the Greenhouse Gas (GHG) Protocol Scope 3 Standard? *Prefer not to answer 1 (2%) Not interested 3 (7%) Not familiar, but 8 (19%) interested Yes, somewhat 19 (44%) 12 (28%) Yes, very 0 2 6 8 20 4 10 12 14 16 18

Question 1

The majority (72%) of the surveyed companies know of the GHG Protocol Scope 3 Standards. This shows that the GHG Scope 3 Standards are widely recognized within various industries. This also shows that many companies are interested in measuring their company's emissions and working towards improving the sustainability of their supply chains.



In the next 12 months, do you have plans to apply this to Transportation? (Check all that apply)

Zzoomerang

37% of responding companies had no plans to measure their GHG Protocol Scope 3 Emissions. Of companies that did plan on measuring these emissions, more planned to measure downstream emissions rather than upstream emissions. Most companies who had international operations were also planning on measuring the emissions from their international partners.



If yes above, do you have a methodology in place to quantify and track

More companies preferred calculating their GHG emissions by using a distance-based method rather than a fuel-based method. The distance-based method requires that the company translate the distance traveled by their shipping vessels into GHG emissions using some sort of formula. The fuel-based method requires that companies have access to data on the amount of fuel that each truck driver uses. Other methods included an algorithm for per-carton and per-cube ratios and also a mode-based method.



More companies have baseline and reduction targets at a corporate level rather than at a regional or functional level. This shows that the sustainability is being looked at and measured at a very high level by the companies.

Zzoomerang



Does your Company intend to publicly report Scope 3 GHG emissions? (Check all that apply)

35% of the surveyed companies plan to publicly report their Scope 3 GHG Emissions. Of these companies, 67% of them planned to report their indirect emissions, and 33% of them planned to report their direct emissions.



What other "Green" initiatives do you have in place for your supply chain (Check all that apply)

Finally, other popular green initiatives that companies were undertaking included intermodal shipping, reusable packaging, improving network design, participating in EPA Smartway, and TMS routing and scheduling improvements.

Follow-up Phone Interviews

The majority of companies who were currently measuring their GHG emissions in some form were gathering their data internally rather than having an outside party gather it for them. Many of these companies were gathering data from their SAP software systems where the distance traveled by their shipping vessels and mode used were available to be translated into GHG emissions. In order to get their GHG emissions from distance traveled, some companies used additional software such as Credit 360 or PC Miler. These software programs did require a financial investment, but the companies who made this investment said that the investment was worth the ability to better capture their sustainability metrics.

When the companies were asked whether their sustainability projects were created more for a financial benefit to the company or for an environmental benefit, the majority of companies responded that it was for an environmental benefit. Most of the projects began as ways for companies to become more environmentally conscious. Some companies also began looking at sustainability metrics because they were becoming a key component in supplier bid requests. There is also a substantial financial incentive to increase the efficiency of a supply chain, such as decreased fuel costs, but most companies said that these benefits were a secondary factor in their decision-making processes.

One of the common barriers that companies said they ran into when trying to implement a sustainability metric was the lack of labor resources. Most companies did not have a team dedicated to this task from the start which made it difficult do set and

meet goals. Without a dedicated team, the workload has to spread between different team members who may not be able to give the project their full focus and time.

Only a few of the companies responded that they had set reduction goals for their fuel consumption and/or GHG emissions. These goals varied from an approximately 2% to 3.5% reduction year over year.

Chapter 6: Recommendations and Discussion

Recommendations

Based on our findings from the survey and follow-up phone calls, there are a few recommendations that can be made for BD's sustainability initiative. GHG emissions are a very widely used metric for companies to measure sustainability with, so BD should also focus on GHGs, especially given the nature of their business. The GHG Protocol Scope III standard is a popular tool used to help companies more accurately measure the emissions. BD should follow suit and strive to track their emissions using the GHG Protocol standards.

In terms of actually capturing the data, the research suggests that the best way to move forward with creating a sustainability metric tracking system would be to consult an outside party or software provider to come in and aid BD with their efforts. With the use of an outside party, it would allow BD to leverage the past knowledge and experience of others to provide them with the most accurate and efficient method of measuring their greenhouse gases. This would also alleviate the problem that other companies faced of not having sufficient internal resources to fully invest in a sustainability effort.

An outside provider would also be able to make sure that BD's measurements are accurate and consistent. Through the course of the project, tools were found that were supposed to aid in the calculation of GHG emissions based on various factors. For BD, these calculators did not seem to be able to fully and accurately measure their emissions because of the complexities and specifications of the business. For example, current tools could not take into account the specific fuel and truck type that BD used in their

transportation. In order to best measure the emissions from these sources, as well as accurately compare the benefits of switching fuel types or truck types, more detailed and specific tools need to be developed.

Limitations

This project was limited in its capabilities by a few factors. The first was that information from companies was based on a purely voluntary basis so the amount of information was somewhat limited. The second limitation was that information on specific GHG emissions data was limited to what was publicly available. Combustion data for more specific fuel types would have been useful when trying to calculate BD's emissions, but public information was not available.

Appendix

Figure 1: Zoomerang Survey Text

Penn State CSCR Sustainable Supply Chain Survey

Questions marked with an asterisk (*) are mandatory.

1. Is your Company familiar with the Greenhouse Gas (GHG) Protocol Scope 3 Standard?

Yes, very Yes, somewhat Not familiar, but interested Not interested Prefer not to answer

2. In the next 12 months, do you have plans to apply this to *Transportation*?

(Check all that apply)

Upstream Downstream Domestic International No, we don't intend to Prefer not to answer

3. If yes above, do you have a methodology in place to quantify and track Transportation-related GHG emissions over time? (Check all that apply)

Fuel based

Distance-based

Prefer not to answer / Replied "No" to previous question

Other Activity based (please specify)

4. Have baselines and reduction targets been established? If so at what level? (Check all that apply)

Yes No Corporate Function Region Site Prefer not to answer / No target has been established

5. Does your Company intend to publicly report Scope 3 GHG emissions? (Check all that apply)

Direct Indirect No, we don't intend to Prefer not to answer

6. What other "Green" initiatives do you have in place for your supply chain?

(Check all that apply)

Network Design LEED Construction of DC's and Warehouses Reverse Logistics Reusable Packaging Slip Sheets Telematics TMS Routing / Scheduling Inter-modal No Idle Policy

EPA Smart Way Participation

Prefer not to answer

Other, please specify

7. Based on the responses above, may we contact you to ask you additional questions and clarification about your company's initiatives?

Yes

No

8. Would you be interested to receive a copy of the final research paper?

Yes

No

Figure 2: BD Company Overview

Who they are

Becton Dickinson (BD) is an American-based, global medical technology company that develops, manufactures, and sells a variety of medical devices, instruments, and reagents. The company caters to a variety of science industries including researchers, the pharmaceutical industry, and the general public. The company manufactures and sells its products globally, including Europe, Africa, Asia Pacific, Latin American and Canada (Becton 2010).

How they are organized

BD is organized into three business segments: BD Medical, BD Diagnostics, and BD Biosciences. The BD Medical Team focuses on creating products to enhance diabetes treatments, reduce the spread of infection, and enhance drug delivery through innovation in injection and infusion based drug delivery. The BD Diagnostics team focuses on creating reliable and safe products that allow labs to accurately diagnose disease, infections, and cancers. BD Biosciences focuses on creating diagnostic and research tools to researchers and professionals in the life sciences (Becton 2010).

Financials

BD reported revenues of \$7.4 billion dollars in 2010, an increase of 5.5% over 2009. The company has seen continuous growth over the past 5 years. In 2010, roughly 55% of the company's revenues came from outside the United States (BD 2010).

Product/Service Offerings

Some of the company's main products include needles and syringes, intravenous catheters, integrated systems for specimen collection, safety-engineered blood collection products/systems, fluorescence-activated cell sorters and analyzers, and monoclonal antibodies and kits for cell analysis.

Major issues and trends in Industry

The medical devices and instruments industry is expected to see positive growth in the coming years thanks to an increasingly aging worldwide population in developed countries. The aging population will require increased medical attention and care which will require more medical devices and instruments. There has also been an increase in the number of patients preferring home-based treatments rather than hospital care. Emerging countries are also currently underserved in regards to the availability and quality of medical instruments and many companies in the industry see this as an opportunity for great growth.

Some of the major issues in the medical devices and instruments industry have been product recalls, unsuccessful clinical trials, and tighter governmental regulation (Emerging 2010).

Major issues and trends in Logistics

One of the major issues and trends in logistics involves sustainability. With the increase in costs of fuel and energy, companies are trying to find ways to improve their supply chains in order to decrease costs. Areas in the supply chain that are especially important for this are transportation and warehousing (Trunick 2008).

Additional Resources

Additional information on environmental sustainability can be found on the following sources:

EPA: Climate Change

http://www.epa.gov/gateway/learn/climatechange.html

Greenhouse Gas Protocol

http://www.ghgprotocol.org/

Dell Sustainability

http://content.dell.com/us/en/corp/brand-sustainability

Wal-Mart Sustainability

http://walmartstores.com/Sustainability/

Toyota Sustainability

http://www.toyota-global.com/sustainability/sustainability_report/

Procter & Gamble Sustainability

http://www.pg.com/en_US/sustainability/index.shtml

General Electric Sustainability

http://www.gecitizenship.com/metrics/environment-health-safety/

Bibliography

2011 U.S. Greenhouse Gas Inventory Report. EPA. April 2011. Web.

<http://www.epa.gov/climatechange/emissions/usinventoryreport.html>

BD 2010 Annual Report. Becton Dickinson and Co. Web.

<http://media.corporateir.net/media_files/irol/64/64106/reports/AR10/financial_hi ghlights.html>

Becton Dickinson and Co Profile. Reuters, Web.

<http://www.reuters.com/finance/stocks/companyProfile?rpc=66&symbol=BDX>

Becton, Dickinson and Co Profile. Yahoo! Finance. Web.

<http://finance.yahoo.com/q/co?s=BDX>

Blasing, T.J. Recent Greenhouse Gas Concentrations. Carbon Dioxide Information Analysis Center. August 2011. Web.

<http://cdiac.esd.ornl.gov/pns/current_ghg.html>

- Bowen, Frances, et al. "Horses for Courses: Explaining the Gap between the Theory and Practice of Green Supply". *GMI* (2001) : 41-58.
- Clean Air Act Permitting for Greenhouse Gases. EPA. Web. http://www.epa.gov/nsr/ghgpermitting.html
- Clift, Roland. "Metrics for supply chain sustainability". *Clean Techn Environ Policy* 5 (2003) : 240-247.
- Dell Corporate Responsibility Summary Report 2010. Dell. Web. <sites/content/corporate/corp-comm/en/Documents/dell-fy10-cr-report.pdf>

- Emerging trends in the medical equipment industry. Partnering News. May 19, 2010. Web. February 8, 2011 < http://ebdgroup.com/partneringnews/2010/05/emerging-trends-in-the-medical-equipment-industry/>
- GE Environment Health & Safety. General Electric. Web.

<http://www.gecitizenship.com/metrics/environment-health-safety/>

Greenhouse Gas Protocol. GHG. Web. 2011

<http://www.ghgprotocol.com>

- Hoffman, Andrew and Jennings, P. Devereaux. "The BP oil spill as a cultural anomaly? Institutional context, conflict, and change". *JMI* 20.2 (2011) : 100-112.
- Mollenkopf, Diane, et al. "Green, lean, and global supply chains". *IJPDLM* 40.1 (2010) : 14-41.
- P&G 2010 Sustainability Report. Procter & Gamble. Web.

<http://www.pg.com/en_US/downloads/sustainability/reports/PG_2010_Sustaina bility Report.pdf >

- Seuring, Stefan and Muller, Martin. "From a literature review to a conceptual framework for sustainable supply chain management". *Journal of Cleaner Production* (2008) : 1699-1710. Web.
- Sloan, Thomas W. Journal of Global Business Management. "Measuring the sustainability of global supply chains: current practices and future directions".
 6.1 (2010): 1-16.
- Toyota Sustainability Report 2010. Toyota. Web <http://www.toyota-global.com/sustainability/environmental_responsibil ity/global warming prevention initiatives/pdf/sr10 p24 p31.pdf)

Trunick, Perry A. Mean to be Green. Material Handling & Logistics. May 7, 2008. Web. http://mhlnews.com/distribution/outlog_story_9368

- Walmart 2010 Global Sustainability Report. Wal-Mart. Web. http://cdn.walmartstores.com/sites/sustainabilityreport/2010/WMT2010GlobalSustainabilityReport.pdf
- WCED (1987) World Commission on Environment and Development: our common future. Report of the Brundtland Commission. Oxford University Press, London.

What is Climate Change? Kent County Council. Web. <

<http://www.kent.gov.uk/environment_and_planning/environment_and_climate_ change/climate_change/what_is_climate_change.aspx>

What LEED Is. LEED. Web.

<http://www.usgbc.org/DisplayPage.aspx?CMSPageID=1988>

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Related Experience

McNeil Nutritionals, a Johnson & Johnson company Supply Planning Co-op Jan-Aug 2010

Johnson & Johnson Sales & Logistics Co. Supply Logistics Co-op Jan-July 2009

Awards

Schreyer Ambassador Travel Grant (2010) Academic Excellence Scholarship (2007-2011) Dean's List (2007-2011)

Activities

MBA Association (2011) Supply Chain Management Association (2011) Alliance Christian Fellowship Media Chair (2010-2011) McNeil Nutritionals Community Service Chair (2010)