Sustainable Operations
Fuqua School of Business
Duke University

OPERATNS 894: Sustainable Operations

Syllabus – Fall 2, 2024

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The US Environmental Protection Agency (EPA) defines sustainability as "to create and maintain the conditions under which humans and nature can exist in productive harmony to support present and future generations." In the last decade, this concept has garnered significant attention due to growing concerns about the adverse effects of climate change, pollution, and environmental damage on both present and future generations. In today's business environment, sustainability has become an important issue for firms to address. For one reason, companies are facing more pressure from customers, competitors, legislative requirements, and investors. However, an important concept beyond this passive thinking is that sustainability is often a source of business innovation. Many novel operations and supply chain practices have been invented and implemented when firms aim to improve their environmental performance. Examples include using renewable energy and sustainable materials in the manufacturing process; optimizing supply chains to reduce greenhouse gas emissions; recycling and remanufacturing waste. These practices not only achieve sustainability goals but also reduce operational costs, leading to higher profits for firms. In other words, profitability and sustainability are not mutually exclusive. Many firms have incorporated sustainability as an important corporate strategy to guide future growth and development. This emphasis on integrating sustainability can also catalyze social entrepreneurs to develop new business models that address broader social and environmental challenges.

In this course, we aim to acquaint you with sustainability-related challenges and provide insight into novel strategies for managing these challenges, using the lens of operations and supply chains. We delve into the concept of life cycle assessment (LCA), a technique that allows us to measure the environmental impacts at every phase of the supply chain involved in the production of goods and delivery of services. These phases encompass the sourcing of materials, the manufacturing process, transportation, services, and implementation of a circular business model at the end of a product's life. The LCA provides a framework to pinpoint pivotal issues, potential

risks, and opportunities for enhancing environmental performance across the entire supply chain. Further, we delve into the unique challenges presented at each stage of the supply chain and explore various tools and methodologies that can assist in making more sustainable decisions. Specific objectives of the course are to:

- Discuss challenges, opportunities, and risks of organizations facing environmental and sustainability issues;
- Introduce fundamental concepts of sustainability related to operations and supply chains;
- Evaluate the performance of organizations regarding environmental efforts;
- Introduce tools and methodologies aimed at facilitating decision-making to attain environmental objectives.
- Introduce best supply chain practices and novel models for improving sustainability.
- Inspire social entrepreneurs to develop business models that address environmental issues.

Topics covered in this course include life-cycle analysis, carbon footprint calculation, sustainable resources, green transportation and logistics, green inventory and warehousing, industrial symbiosis, closed-loop supply chain, recycling and remanufacturing, circular business models, and sustainable business innovation.

Who should take this course? If you have ever wondered how firms and entrepreneurs can leverage operational means to mitigate environmental risks and identify business opportunities that create value, this course is designed for you. If you haven't, perhaps this is the time to start thinking about this question. There are many reasons to care about businesses interacting with the environment from the basic effect of cost reduction and legal compliance to the inspiring goal of business innovation and opportunities. This course will prepare you to face and manage these environmental challenges.

Assignments and Grading

Grades will be based upon the following components weighted by the given percentages.

Component	% of Total Grade	*Due Date*
Attendance	10%	---
Class Participation	15%	---
Individual Assignment 1	15%	*See Below*
Individual Assignment 2	15%	*See Below*
Team Slides, Recorded Presentation, Q&A	15%	*December 9, 11:59 pm*
Team Report	20%	*December 14, 11:59 pm*
Team Evaluation	10%	---

Attendance

Students are expected to attend every class session. The instructor uses the app "Fuqua Check-in" to record the attendance. Students are expected to install the app before the class. Please note the following:

- You must be physically in the classroom to check in for the class.
- Checking in for class begins 10 minutes before its start time. Students are marked as Late 1 minute after the class begins. Students are marked as "Absent" if they do not check in within 30 minutes of the end of class.
- The "Left Class Early" option available through the Check-in app and in the Attendance tab allows you to self-report days you leave early after checking in.
- Fuqua Check-in usage is covered by the Honor Code: (i) If you are Checked In for a class session, then you must attend the entire session in person. (ii) If you leave class early, you must report this in Canvas/Absences. (iii) All statements reported in Canvas/Absences must be accurate.
- If you have an excusable reason for class absence, please request an "excusable absence" via Canvas/Attendance function to keep a record. Examples of excusable reasons:
    - Illness or injury requiring medical attention for student or spouse/partner or child.
    - Death or diagnosed life-threatening illness of a spouse/partner or a close family member.
    - Motor vehicle accident of student or spouse/partner or child.
    - Student or spouse/partner entering childbirth labor.
    - A criminal act against a student, spouse/partner, or child; Jury duty, or court hearing.
- Students who have three or more inexcusable absences may receive an F for the course.
- The professor may not accept a late check-in after a session is finished.

Class Participation

This course heavily relies on your class participation. Reading the materials before class and participating in class discussions is important. Students should be prepared for case discussion; this syllabus provides suggested questions you must prepare.

Individual Assignments

Students need to submit two individual assignments via the Canvas course website before the due date. These individual assignments are the mini-cases provided in Sessions 3, 4, and 5.

Session 3: Dawn Foods, Inc.: Cost and Carbon Tradeoffs
Session 4: DHL Supply Chain: Production and Transportation Planning
Session 5: PrintPro: Integration of Remanufactured and New Production
Session 6: Gogoro: Optimal Amount of Batteries

Students can choose *two out of four* mini-cases to submit based on their time and skills. (Students are encouraged to solve more than two mini-cases. If they do, the individual assignment grades

will be based on their two highest scores.) Solving these mini-case questions requires some prior knowledge regarding inventory management, queueing analysis, and optimization (linear programming) offered in the first-year curriculum. The instructor may provide references for those who do not have such prior knowledge. The due date for the assignment depends on the assignment that you choose. For example, if you choose "Dawn Foods, Inc." and "PrintPro", the due dates would be at the beginning of Session 3 and Session 5. Note that after a problem is analyzed in class, students are not allowed to submit the same problem.

Team Project

Students need to present and submit a final project. Depending on the enrollment, the professor will form random teams. The team project grade is determined by the following two items.

- *Team Project Slides and Recorded Presentation*
  Each team should upload their project slides and a recorded presentation video (about 15-20 minutes) to Canvas before the deadline. Students are expected to review all teams' slides and presentation videos and prepare questions for teams to answer in Session 6.
- *Team Report*
  Each team is required to submit a team report to Canvas before the due date. The main body of the team report should not exceed 10 pages with 1.5-line spacing.

Note that all students will be involved in grading the first item. The professor will weigh in on students' feedback to determine the team project grade. In Session 6, depending on the class size, the professor will invite some teams for Q&A about their projects. Each chosen team has five minutes to summarize the project in class and answer questions from the class. The team may create 3-5 slides to facilitate the summary presentation.

The project topic must relate to sustainability issues in operations and supply chains. Choosing unrelated topics will significantly impact your team project grade. If you are unsure whether your topic is relevant, please consult your professor. Examples of project topics:

- Conduct a life-cycle of a product (e.g., electric vehicles) from production to disposal. What trade-offs exist compared to conventional vehicles, and how can manufacturers minimize negative impacts?
- Calculate and analyze the carbon footprint of e-commerce supply chains. What are the main emission sources, and what innovative strategies can further reduce the carbon footprint?
- Explore sustainable resource management practices for an industry or a firm. What practices can reduce energy, water, and raw material usage?
- Investigate green transportation solutions, including electric vehicles and bike couriers. What challenges exist for urban implementation, and how do these solutions impact delivery efficiency and customer satisfaction?

- Assess green inventory and warehousing practices, focusing on energy-efficient warehousing and sustainable packaging. What barriers hinder adoption, and how can they be overcome to promote widespread use?
- Explore circular business models, including clothing rental, resale, and recycling programs. What models are most effective for sustainability, and what challenges exist in their implementation?
- Develop a new innovative business model and justify why this model is effective for sustainability from the perspective of operations and supply chains.

As students are expected to submit individual assignments starting from Session 3, they are encouraged to start working on the final project early in the term. The professor is readily available to provide advice and guidance on the team's request.

Team Evaluation

As part of our team project assessment, students are responsible for conducting a peer evaluation of each team member's contribution to the final project. The team evaluation link is provided in Canvas.

Honor Code and Collaboration Policy

The Fuqua School Honor Code will be strictly enforced in this class. It is each student's responsibility to understand and abide by the Honor Code as it applies to each class activity. Failure to adhere to any of these requirements constitutes a violation of the Honor Code. If there is any question as to whether an activity is or is not permissible (in this class) under the Honor Code, consult the professor prior to undertaking the activity.

Individual Assignments & Team Project

<u>All work for the individual assignments is to be done on an individual basis.</u> You may not discuss or exchange information regarding your assignment. The team project should be completed by teams.

Classroom Policies and Norms

1. You should complete the check-in process before attending the class. The professor may not accept a late check-in after a session is finished.
2. You should arrive at the class on time.
3. Always bring your name tent.
4. Do not walk to the front to pick up handouts once a class has started.
5. If you arrive late, take a seat at the back of the room. You can move to a better seat during the break.
6. All electronic devices should be turned off or in vibration mode during class.

7. You are not allowed to use laptops in class unless you are instructed to do so.
8. Do not leave the classroom while the class is in session. If you need to leave early, sit at the back of the classroom.
9. Listen carefully to your professor and classmates. Do not interrupt someone who is speaking or repeat a comment someone else has already made.
10. Come to class having completed all the assigned readings, cases, and other assignments.
11. Cold calls are expected, although it is better if you initiate the discussion.

Artificial Intelligence (AI), Generative AI Policy

You may use AI tools, such as ChatGPT, to complete your assignment. Nevertheless, please clearly indicate any parts where you received assistance from these AI tools. This transparency ensures that we acknowledge your efforts and the support you have utilized during the assignment process. We encourage you to make the most of this resource while maintaining academic honesty and integrity.

Course Materials

Required:

The only required materials for the class are contained in the course pack. The instructor will post the PDF slides before each class session.

Optional:

1. "Environmental Life Cycle Assessment," by O. Jolliet, M. Saade-Sbeih, S. Shaked, A. Jolliet, and P. Crettaz, CRC Press, Taylor & Francis Group, 2016. (You can download a free Kindle copy from Amazon.)
2. "This Changes Everything: Capitalism vs. The Climate," by N. Klein, Simon & Schuster, 2014.
3. "Green to Gold: How Smart Companies Use Environmental Strategy to Innovate, Create Value, and Build Competitive Advantage," by D.X. Esty, A.S. Winston, Tale University Press, 2006.

Sustainable Operations At-a-Glance

#	Date	Description	Major Readings
1	Oct 29	Sustainable Strategy Life Cycle Assessment	Streamlined Life Cycle Assessment Study Green Supply Chains *Sustainability at Millipore*
2	Nov 5	Sustainable Resource Renewable Energy Carbon Emission Calculation	*Fiji Water: Carbon Negative?* Carbon Footprints: Methods and Calculations Corporate Sourcing of Renewables
3	Nov 12	Green Production and Services, Inventory, and Warehousing Industrial Symbiosis	*Cook Composites and Polymers* *Dawn Foods, Inc. (Mini-case)* Industrial Symbiosis: Literature and Taxonomy Moving from a Product-Based Economy to a Service-Based Economy
4	Nov 19	Green Transportation Omnichannel Retailing	'Greening' Transportation in the SC *Sian Flowers: Fresher by Sea?* *DHL Supply Chain (Mini-case)*
5	Nov 26	Circular Business Model Reverse Logistics	The Circular Business Model *On* *PrintPro (Mini-case)*
6	Dec 3	Sustainable Innovation Final Project Presentation	Why Sustainability Is Now the Key Driver of Innovation *Better Place: The EV Renaissance* *Gogoro (Mini-case)*

Course Outline

Class 1 **Tuesday, October 29**

Sustainable Strategy, Life Cycle Assessment

In this session, we will deeply explore sustainable supply chains and their connection to the triple bottom line: profit, people, and planet. We will use life cycle assessment to measure environmental impacts and establish actionable sustainability targets. Furthermore, we will analyze the potential risks and benefits of sustainable strategies for organizations. This session aims to deepen your understanding of the balance between sustainability and business strategy, emphasizing the importance of their integration in building successful, responsible, and resilient organizations.

Required Reading

Case: Sustainability in Millipore, HBS 9-610-012
"Streamlined Life Cycle Assessment Study," by Environmental Resources Management (read this online)
"Green Supply Chains," UV2049

Case Discussion Questions

1. Do you think the Sustainability Initiative's focus on environmental rather than social issues is appropriate?

2. How should Millipore prioritize projects for the Sustainability Initiatives?

3. What factors should Millipore consider when setting its next greenhouse gas reduction target? Recall that key parameters include the choice of absolute or relative reduction, a percentage reduction target, its duration, and the scope of emissions covered.

4. Considering the pros and cons, should Millipore purchase carbon offsets as part of its strategy to meet its greenhouse gas reduction objectives?

5. What are pros and cons of joining the Carbon Disclosure Project to reveal its carbon reduction?

6. What changes, if any, would you recommend to David Newman to improve the Sustainability Initiative?

Class 2 **Tuesday, November 5**

Sustainable Resources, Renewable Energy, Carbon Emission Calculation

In this class session, we will delve into the ways in which firms harness natural resources, such as water and energy, within their supply chains and the corresponding carbon emissions created during the production and delivery of goods. We introduce the concept of carbon emissions calculation, an essential metric in understanding a company's environmental impact. Lastly, we will discuss renewable energy sources, a key strategy for firms to mitigate carbon emissions. We aim to shed light on the integral role of natural resources in supply chains, and the significance of sustainable practices in reducing carbon emissions.

Required Reading **Case:** FIJI Water: Carbon Negative?, HBS 9-611-049
"Carbon Footprints: Methods and Calculations," HBS 9-611-075
Corporate Sourcing of Renewables: Market and Industry Trends (read this report online)

Case Discussion Questions

1. When Resnicks (Roll International Corp.) acquired FIJI Water in 2005, the bottled water industry was very crowded; even so, FIJI Water soon became a leading US importer of bottled water. What accounts for FIJI Water's success?

2. Calculate the carbon footprint of shipping a metric ton (1,000 1-liter bottles) of FIJI Water to Durham. Hint: Use the "Carbon Footprints: Method and Calculations" note. How would you go about estimating the carbon footprint of a liter of tap water?

3. What is greenwashing and why do companies engage in greenwashing? How can one tell when a claim constitutes greenwashing?

4. What is additionality? Do the tests for additionality make sense?

5. In light of the lawsuit, should FIJI Water amend its carbon-negative strategy?

Class 3 **Tuesday, November 12**

Green Production and Services, Green Inventory and Warehousing, Industrial Symbiosis

In this session, we initiate the exploration of the overlap between lean and green production processes. We start by identifying shared synergies between these two paradigms and how lean principles can initially serve to reduce carbon emissions. Many lean improvements represent low-hanging fruit for enhancing environmental impact. However, as we progress, the challenge amplifies and a trade-off emerges between cost and sustainability. We will introduce innovative concepts and practices, such as by-product synergy (industrial symbiosis) and servicizing, which pave the way toward win-win solutions. This session will provide insight into the intersection of efficiency and sustainability in production processes.

Required Reading **Case:** Cook Composites and Polymers Co., HBS 9-608-055
"Industrial Symbiosis: Literature and Taxonomy," Annual Review of Energy and the Environment 25 (2000): 331-337.
"Moving from a Product-Based Economy to a Service-Based Economy for a More Sustainable Future" Chapter 16, *Sustainable Supply Chains*. (2017). Bouchery, E., Corbett, C. J., Fransoo, J. C., & Tan, T. (Eds.). Springer.

Mini-Case: Dawn Foods, Inc.: Cost and Carbon Tradeoffs

Case Discussion Questions

CCP faces three options for addressing its rinse styrene waste stream. (See case for details.)

1. What criteria should Mike Cromacki consider when deciding whether to pursue the waste exchange or the concrete-coating by-product?

2. Compared to business as usual, what are the financial implications of selling rinse styrene to a waste exchange or producing the concrete coating by-product that affect the production of gel coats? Assume that the gel coat production process is operating at capacity. (Note: $4620 includes the total cost of a 10-drum batch of gel coats, and the procurement and disposal costs of 550 pounds of styrene; the average revenue of a 10-drum batch is $550*10 = $5500.)

3. Compared to business-as-usual, how would you evaluate the relative environmental impact of producing the concrete coating by-product? For this question, consider the impact on carbon dioxide (CO2) emissions, but consider the impacts system-wide (i.e., not just at CCP's factory). What tradeoffs are involved? Assume that CCP's sales of concrete coatings would substitute for sales by other concrete coating producers (i.e., CCP's sales would not alter the total sales quantity in the concrete coatings market).

Class 4 **Tuesday, November 19**

Green Transportation, Freight Mode Choice, Omnichannel Retailing

In this class session, we discuss the significant impact of transportation on sustainability and carbon emissions, focusing on the context of perishable goods with recurrent inventory replenishment from overseas and nonperishable products manufactured and shipped from various sources. We explored how different transportation modes and routing choices can influence operational costs and carbon emissions. From both strategic and tactical perspectives, we discussed the necessary changes that companies should consider to mitigate their environmental footprint. Additionally, we explored the modern retail strategy of omnichannel retail and its potential implications on carbon emissions, particularly in the context of last-mile delivery. We analyzed various approaches to reduce the carbon impact, aiming to achieve a more sustainable and environmentally conscious supply chain.

Required Reading **Case:** Sian Flowers: Fresher by Sea?, HBS 9-623-008
"'Greening' Transportation in the Supply Chain," SMR338

Mini-Case DHL Supply Chain, W12888

Case Discussion Questions

As you read the case, please draw a process flow diagram that shows major process steps from harvesting flowers in Kenya through shipping to the Amsterdam distributor via air cargo and ocean cargo.

1. Estimate the cost and carbon footprint per rose stem for Sian's shipping from Kenya to Amsterdam via air cargo (peak and current charges) and ocean cargo. Compare the aggregate carbon footprint of a rose stem from both methods to that of one grown in the Netherlands.

2. How does the variability in demand for cut roses impact Sian's operational choices?

3. What operational changes could Sian make in order to sell more roses and offer a higher quality of roses selling in Amsterdam?

4. Starting next March, Chris Kulie wants to ship all of Sian's cut roses to the Amsterdam market via ocean, which takes 30 days from farm to market, while also leveling the amount shipped per month to avoid staffing surges. Sian wants to sell nine million rose stems per month except 21 million in February. How many rose stems should Sian ship every month? What is the longest amount of time rose stems would ever be held in inventory? (Assuming Sian draws inventory on a first-in-first-out basis.)

Class 5 **Tuesday, November 26**

Circular Business Model and Reverse Logistics

In this class session, we will dive into the comprehensive topic of waste management, specifically focusing on the strategies of reuse, re-manufacturing, and recycling. We will discuss the intricate process of integrating recycled or re-manufactured items into production lines that create new products. The aim is to identify the conditions under which incorporating re-manufactured products can be more advantageous for firms. The session aims to unravel the complexities of sustainable production processes, highlighting how efficient waste management can contribute to a firm's profitability and sustainability. It provides insights into striking a balance between resource conservation and economic benefits, promoting a circular economy.

Required Reading **Case**: On, HBS 9-723-430
The Circular Business Model, R2104D-PDF-ENG

Mini-Case PrintPro: Integration of Remanufactured and New Production

Case Discussion Questions

1. Would you launch *Cyclon*? If so, which pricing model would you choose? Why?
2. What are alternative models to introduce *Cloudneo*?
3. How did On manage to enter the global sports footwear and apparel industry?
4. Could incumbents have prevented On's growth?

Class 6 **Tuesday, December 3**

Sustainable Innovation and Final Project Presentation

In this class session, we will explore the dynamic intersection of innovation and sustainability, focusing on innovative practices that can further sustainable goals. We will spotlight how the integration of sustainability can act as a powerful springboard for creative idea generation that brings tangible benefits to organizations. By the end of the session, the aim is to inspire an understanding of how strategic sustainability can unlock a wealth of innovative opportunities for organizations.

Students present their final projects to enrich the course content.

Required Reading Case: Better Place: The Electronic Vehicle Renaissance, IN1164
"Why Sustainability Is Now the Key Driver of Innovation," HBR R0909E-PDF-ENG

Mini-Case Gorogo: Optimal Amount of Batteries

Case Discussion Questions

1. What was Better Place's business model?

2. Why is the battery the most important piece in the Better Place model?

3. Why did Better Place fail? If you were the CEO of Better Place, what would you have done differently?

4. Compare Better Place and Gogoro (https://www.gogoro.com/). Why does Gogoro, which also uses a similar battery-swapping model, succeed?