Abstract
Introduced in 2012, the Nike Flyknit shoe has received attention as both a performance and sustainability innovation. The Flyknit features a woven upper made from mainly recycled PET, producing an athletic shoe that is lightweight and provides a snug fit. It also uses an automated manufacturing process that is marketed as reducing waste by weaving only what is necessary, rather than the traditional method of cutting and stitching materials. The purpose of this study is to holistically explore the Flyknit’s sustainability. The team conducted an economic analysis, an environmental LCA comparing the Flyknit to a traditional running shoe and a social LCA. Results found that production of the Flyknit upper did indeed have a lower environmental impact than traditional running shoes when considering such factors as global warming potential, acidification, ecotoxicity and non-carcinogenic human health impacts. Given relatively low environmental impacts in these categories, however, the team conducted an additional distribution assessment, finding that the “last mile” delivery to consumer greatly impacts the product’s sustainability performance. The Flyknit generally has a higher cost than traditional shoes to consumers, although it may provide indirect savings in lowering environment, health and safety costs. Findings from the social LCA centered on high risks of low wages, loss of life years by airborne particulates in occupation and forced labor. The study generated questions regarding how Nike might mitigate these longstanding social risks, such as seeking “Shared Responsibility” opportunities, harnessing worker-driven solutions and digging deeper for answers to these persistent challenges.

Keywords: Sustainability; Footwear; Life cycle assessment; Environmental impacts; Social impacts

1. Introduction
The Flyknit was introduced by Nike in 2012. The athletic shoe features a woven upper and introduces a more automated manufacturing process, both of which are perceived as big moves for the footwear industry given its antiquated manufacturing processes. Flyknit has been marketed by Nike as both a performance and sustainability innovation, providing advantages to the consumer and the company alike.

At the consumer level, the Flyknit provides a lightweight and snug sock-like fit, which Nike describes as a longstanding unmet desire of its athletes. The Flyknit potentially addresses a consumer pain point, then, of desiring a lighter weight and better fitting athletic shoe, as well as the fact that there has been minimal innovation in shoe design over the past several decades. The fact that Flyknit has been adopted across multiple shoe models and replicated by competitors suggests that the product has been commercially successful.

At the business level, Nike uses sustainability as a driver of innovation, but acknowledges creating significant environmental impacts in the production of footwear. Materials make up 60% of the lifecycle environmental impacts (e.g., water, land, energy and chemical use; greenhouse gas emissions; wastewater discharge; and solid waste) of Nike’s shoes [1]. The Flyknit potentially addresses a company pain point, then, of needing to reduce materials waste in the highest impact portion of its value chain, with little improvements having taken place in the past several decades. Nike estimates that the Flyknit reduces footwear waste by 80% relative to other “traditional” shoes [2]. However, without access to LCA capabilities, consumers are reliant on Nike marketing communication for information on product sustainability.

This project sought to explore the sustainability of Nike Flyknit shoes in a holistic manner, including economic and social factors in addition to environmental. This allowed the team to investigate further the waste-reducing potential of Flyknit as communicated by Nike, and also consider additional potential impacts of the shoe, such as those associated with product distribution. It is important to use an expanded “necessary conditions” approach when assessing the sustainability of the Flyknit in order to more fully consider all potential outcomes of introducing this product.

2. Literature Review
Apparel companies have begun to operate in a more sustainable manner, focusing on sustainable product design and supply chain practices such as supplier selection and monitoring for compliance with codes of conduct [3]. Top drivers to adopt sustainability are corporate values, top management commitment and market requirements [4].

Nike identifies the following as priority sustainability opportunities: “sustainability and business growth are complementary,” “materials matter,” and “climate change requires business change” [5]. Nike’s gains in sustainability are related to the same “core strengths” that drive its economic performance: “leadership, organizational design, market strength, market positioning, and culture” [6].

Nike’s “Considered” approach to product design was the company’s initial effort to integrate sustainability principles into
decision making. A case study about the Considered initiative outlines challenges surrounding sustainability product design, including: performance, design, time, profit margins, supply chain partners and consumer preferences [7]. The Flyknit emerged from the Considered campaign.

An LCA study done in 2013 on a pair of Asics running shoes estimated that a typical pair has a carbon footprint of 14 ± 2.7 kg CO2-equivalent, in line with previous research done on Puma and Timberland shoes [8]. This includes producing the entire shoe, excess scrap material, packaging and distribution, which explains variations between these studies. Additionally, most of the emissions in shoe production are released during the material processing and manufacturing phases, particularly when creating shoe uppers [9]. The Flyknit attempts to address this, with shoe uppers knitted from mainly recycled PET rather than polyester fibers made from virgin raw materials [10].

Similar to other apparel companies, Nike faces risk in waste production and use of toxic materials and water, as well as public criticism surrounding factory conditions [11]. Working conditions in the apparel industry in China, where a portion of Nike shoes are manufactured, face significant challenges such as low wages, overtime for little or no pay, restrictive collective bargaining rights, unsafe working conditions, forced labor and child labor [12]. Another area of concern is the effect of automated technology on the low-skilled labor force. Technological innovation that is process-based tends to reduce labor needs; since developing countries are more likely to import technological change, these innovations may lead to labor-reducing impacts [13].

The apparel industry has long struggled with labor issues associated with global manufacturing. Richard Locke contends that current “top-down” auditing model for social compliance is ineffective and should shift instead to one rooted in partnership and long term investments [14].

Based on the above work, the team identified and focused this study on addressing two outstanding needs: 1) Product-specific sustainability information on the Flyknit to inform consumer choices; 2) Complete sustainability information on the Flyknit, including expanded environmental information beyond one specific environmental advantage (waste reduction), as well as economic and social considerations.

3. Methods

To investigate the sustainability of Nike Flyknit shoes, economic, environmental and social analyses were conducted as outlined below.

3.1. Economic methods

The team conducted an economic analysis of the Flyknit and traditional shoes by examining several dimensions. The first was a total cost of ownership (TCO) analysis, focusing on costs from the customer point of view, as the consumer was determined to be the main stakeholder in the system. The costs included variations of shoe purchase prices (full and sale prices), method of purchase (driving to the store versus purchasing online) and end-of-life costs. It was assumed that the shoe purchase price already incorporated costs from earlier stages in the lifecycle, such as manufacturing, labor, distribution, and mark-up. The consumer was considered to be a runner living in Ann Arbor, purchasing shoes either from the Foot Locker at Briarwood Mall or on Nike.com.

Costs were estimated based on current Flyknit and traditional shoe prices on Nike.com (similar to in-store prices), current fuel prices for transportation and average waste and recycling costs. Hidden costs that the consumer may incur later, such as for extra shoelaces or orthotics, were also considered. The team additionally examined life cycle costs borne by other stakeholders that were not included in the TCO; mainly end-of-life disposal and recycling costs handled by Ann Arbor (landfill) or Nike (recycling).

Economic impacts from environmental, health and safety issues related to the production were also taken into consideration, although from a qualitative perspective as quantitative data was not easily accessible. Results from the environmental LCA and a literature review were used to inform qualitative environmental, health, and safety cost considerations, including how these costs may differ between Flyknit and traditional shoes.

3.2. Environmental methods

The team conducted an LCA using Umberto’s internal database, other related studies [15,16] and TRACI metrics to compare the environmental impacts of the Flyknit with traditional shoes. The analysis focused on the environmental impacts of the shoe’s upper as that is the main point of differentiation between the Flyknit and traditional shoe. Both shoes were assumed to be a man’s size 9. Considering only the upper, a single Flyknit shoe weighs 34 grams and is comprised of recycled PET (95%), nylon (5%) and spandex (5%); while a traditional shoe weighs 97.8 grams and is comprised primarily of polyurethane, polyester, nylon, and olefin copolymer [17].

The LCA factored in life cycle stages from material extraction, processing, manufacturing, distribution (to the point of sale), use and end-of-life. This initial study was complemented by an additional distribution assessment, considering “last mile” delivery of the product to the consumer across online and in-store commerce channels (Section 4.4).

Based on research and conversations with Nike, sourcing and manufacturing for both types of shoes were assumed to take place in Ningbo, China. The shoes were then shipped to a port in Los Angeles, CA and then driven to Nike’s distribution center in Memphis, TN, before being driven to Ann Arbor, MI.

The functional unit of measure was the service provided (protective and comfortable footwear) to a runner living in Ann Arbor for 1,000 miles. The reference flow was the number of shoes used over a one-year period. This took into account the average number of miles possible per pair of shoes and an assumed number of miles run per week.

3.3. Social methods

To investigate the social impacts of the Flyknit, the team conducted an in depth social scoping analysis of ten sectors:
Textiles; Wearing Apparel; Manufactures (China/US); Plant based fibers; Chemical, rubber, plastic products; Petroleum, coal products; Machinery and equipment; Water and Coal. These were selected as integral to Flyknit’s production and representing significant social risks relative to other sectors [18,19].

To arrive at the above country-specific priority risks, the team assessed existing standards for these sectors, conducted a literature review and used the Social Hotspot Database. As numerous “very high” risks were identified through this process, the ten most prominent issues were selected based on the following criteria: Significance of the risk, connection to company mission and/or existing sustainability commitments, company ownership of risk, company leverage in addressing risk and likelihood or history of public/regulatory pressure.

The team then identified the five highest priority Country Specific Sectors: China manufactures, China textiles, China wearing apparel, China plant based fibers, China chemical, rubber, plastic products; ultimately narrowing the key country-specific issues to those mentioned below in Results.

4. Results
Economic, Environmental and Social findings from the above analyses are outlined below.

4.1. Economic findings
The results of the economic analysis showed that, from the consumer point of view, Flyknit had the highest direct costs. The TOC ranged from $95.37 to $190.74 for the Flyknit and $79.47 to $164.24 for the traditional shoe. This is due to the Flyknit’s purchase price, which typically has a price premium of around $25 compared to traditional Nike shoes. The other costs (method of purchase and end-of-life) in the TOC were smaller in comparison and were the same for both Flyknit and traditional shoes (Table 1); after consumers purchase shoes, they use them in generally the same way. Hidden costs (such as extra shoelaces and orthotics) and peripheral life cycle costs were similar for both types of shoes. Table 2 offers a sensitivity analysis on various price possibilities.

Table 1. Total cost of ownership

<table>
<thead>
<tr>
<th>Shoe Model: Nike Lunar 3</th>
<th>Flyknit</th>
<th>Traditional shoe</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Shoe purchase price</strong> (Source: Nike.com)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Full price</td>
<td>$159 ($150 + 6% sales tax)</td>
<td>$132.50 ($125 + 6% sales tax)</td>
</tr>
<tr>
<td>Sale price</td>
<td>$95.37; $100.67 ($99.97; $94.97 + 6% sales tax)</td>
<td>$79.47; $84.77 ($74.97; $79.97 + 6% sales tax)</td>
</tr>
</tbody>
</table>

| Method of purchase | | |
| Transportation cost to Briarwood Mall | $0.34 | $0.34 |

Table 2. Sensitivity analysis of total cost of ownership

<table>
<thead>
<tr>
<th>Price level</th>
<th>Shoe Model: Nike Lunar 3</th>
<th>Traditional shoe</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MAX</strong></td>
<td>Shoe purchase price (full price): $159 + purchased online with next day shipping: $25 + drop off at Nike store for Reuse A Shoe program: $6.74</td>
<td>Shoe purchase price (full price): $132.50 + purchased online with next day shipping: $25 + drop off at Nike store for Reuse A Shoe program: $6.74</td>
</tr>
<tr>
<td>TOTAL: $190.74</td>
<td>TOTAL: $164.24</td>
<td></td>
</tr>
<tr>
<td><strong>Nominal</strong></td>
<td>Shoe purchase price (full price): $159 + purchased at the Briarwood Mall: $0.34 + landfill: $0</td>
<td>Shoe purchase price (full price): $132.50 + purchased at the Briarwood Mall: $0.34 + landfill: $0</td>
</tr>
<tr>
<td>TOTAL: $159.34</td>
<td>TOTAL: $132.84</td>
<td></td>
</tr>
<tr>
<td><strong>MIN</strong></td>
<td>Shoe purchase price (lowest sale price): $95.37 + purchased online with free shipping: $0 + landfill for end-of-life disposal: $0</td>
<td>Shoe purchase price (lowest sale price): $79.47 + purchased online with free shipping: $0 + landfill for end-of-life disposal: $0</td>
</tr>
<tr>
<td>TOTAL: $95.37</td>
<td>TOTAL: $79.47</td>
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</tr>
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</table>

Note: The nominal costs assume that the average consumer will: 1) pay full price to obtain certain styles/colors, 2) purchase in-person at the Foot Locker in the Briarwood Mall to try on the sneakers and 3) throw out the worn sneakers for curbside disposal (due to recycling drop off locations not being convenient and services like Goodwill seeking products in better condition).

It can be assumed that Flyknit is financially successful since Nike continues to introduce the technology to new shoe models and competitors like Adidas have released their own versions. Since Flyknit requires less material and fewer labor hours, it may also be produced at a lower cost; however, proprietary
information regarding the materials and manufacturing process, which the team did not have access to, would be needed to understand the cost and markup detail. For example, it could be the case that recycled PET costs more than the materials used for traditional shoes [20]. The team also qualitatively examined costs stemming from the environmental, health and safety issues associated with the production of the Flyknit and traditional shoes. Environmental LCA results showed that the Flyknit produces less global warming potential, acidification, ecotoxicity and non-carcinogenic human health impacts than traditional shoes. This may lead to lower medical and energy bills, less worker absenteeism as a result of poor health and fewer costs involved in cleaning up or containing manufacturing wastes from terrestrial and aquatic ecosystems. In addition, since Flyknit production involves a highly automated technology that uses fewer materials, safety costs borne by the manufacturing facility to protect the safety of the workers may also be reduced, as well as those involved in securing the product and equipment. However, the team does not have access to the information necessary to confirm the degree to which Flyknit impacts environmental, health and safety costs.

4.2. Environmental findings

This study confirms Nike’s message that the Flyknit reduces waste. A comparison of mass alone supports this logic, as the Flyknit upper weighs 34 grams to the traditional shoe’s 97.8 grams. While a mass difference certainly suggests that less finished product will go to landfill or incinerator, this information does not address material wasted during manufacturing. A lack of information detailing how much source raw material is required for each finished section of a shoe is perhaps the major shortcoming of this analysis. However, a separate running shoe LCA showed that material scrap loss in the total use of polyurethane to produce the traditional shoes was about 50% [21]. This gives an idea that material scrap loss in traditional shoes is not insignificant, while Flyknit is assumed to be even lower due to its knit model.

As calculated in Umberto, the Flyknit appears to generate less environmental impact across a variety of TRACI categories, as detailed in Table 3 below. Much of this reduced impact can be attributed to the fact that the Flyknit upper has a far lower mass. This savings in mass is realized across several phases of the shoe’s life cycle, with substantial savings during transportation from the factory in Ningbo, China, where the shoe is produced, to the point of sale in Ann Arbor, MI.

<table>
<thead>
<tr>
<th>Impact</th>
<th>TRACI impacts (absolute values)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Unit</td>
</tr>
<tr>
<td>Environmental impact, acidification</td>
<td>moles of H⁺ Eq</td>
</tr>
<tr>
<td>Environmental impact, ecotoxicity</td>
<td>kg 2,4-D-Eq</td>
</tr>
</tbody>
</table>

The impact of “last mile” distribution on the environmental impact of each shoe is detailed below (Section 4.4). Both shoes traveled the same distance, by the same method (lorry and ship) to arrive at the point of sale and, post use-phase, eventually to a facility of final disposal, either landfill or incinerator.

Global warming potential (GWP): Extraction and purification of raw materials and distribution create significant environmental impacts in shoe production. A reduction in GWP during any of these categories could yield substantial benefits when implemented on a global scale. Particularly noteworthy is that the Flyknit upper is responsible for 1.29 kg CO2 eq of GWP over the life of the shoe, which is less than half that of the traditional shoe. Maintaining current levels of consumption, a switch to Flyknit in an industry which sold 46.25 million pairs of shoes to US consumers in 2013 [22] could result in a GWP reduction of over 67,525,000 kg CO2 eq. annually.

Energy usage: The innovative weaving manufacturing process for the Flyknit more closely resembles sock manufacturing. Using energy figures for sock production, energy savings of .48 kwh are realized per pair of shoes, resulting in savings of 79,920 GJ if all shoes sold to the U.S. industry were produced using this technology.

Human health, non-carcinogenics: Another large reduction in TRACI metrics created by the Flyknit are non-carcinogenic human health impacts. According to the team’s analysis, the Flyknit reduces non-carcinogenic emissions by almost 30% from those created by the manufacture of traditional shoes.

The Flyknit appears to have a lower negative impact on environment and human health than traditional shoes. A smaller mass is sent to landfill, less energy is used during the manufacturing phase and lower GWP is realized throughout the life of the shoe (Appendix A.1. and A.2.).

4.3. Social findings

Following the methodology outlined above, the team identified three country-specific social risks of particular concern:

1. China wearing apparel: Risk of sector average wage being lower than country’s minimum wage (Labor and Decent Work)

2. (.74 kwh - .26 kwh) * 46,250,000 shoes sold in US
2. China wearing apparel: Risk of loss of life years by airborne particulates in occupation (Health and Safety)
3. China wearing apparel: Risk of forced labor (Labor and Decent Work)

Each of these issues is classified as “very high” risk by the Social Hotspot Database. In addition, these issues are relevant to Nike because they: are internationally acknowledged as significant human rights issues; are specifically mentioned in the company’s sustainability commitments through its Code of Conduct; relate directly to the company’s contracted manufacturing facilities, where Nike has significant leverage (when Nike’s factory presence is high, which is often the case with footwear more so than apparel); and are directly tied to incidents in the past that generated negative public attention for the company.

While Nike has come to be recognized for its leadership in transparency and proactive engagement in its manufacturing facilities through a number of efforts already underway, the company is also open in expressing the fact that issues still exist. These country-specific risks are therefore important for Nike to address. In addition to being the “right thing to do,” it is in the company’s best interests to contribute to an engaged and healthy workforce and also uphold its brand reputation, in particular due to historical labor standards challenges dating back to the 1990’s. Specific ideas for action are offered in the conclusion.

4.4. Distribution assessment

Upon identifying relatively minor unit-level environmental impacts in Flyknit’s production, as well as no known use phase impacts due to the nature of the product, the team explored the environmental impacts associated with Flyknit’s distribution in order to complete its sustainability story.

When considering the environmental impacts of consumer goods, two trends have made distribution particularly significant. The first is the current globalized manufacturing model, with raw materials and goods being shipped great distances even prior to the point of sale. The offshoring of manufacturing has continued to increase over the past twenty years [23]; the apparel industry in particular operates at a significant trade deficit, with only 7% of apparel products purchased by U.S. consumers being domestically made. [24]

The second trend is the rise of digital retail as a commercial channel for consumers, offering low cost or often free product delivery from a retailer’s distribution center directly to the consumer. 69% of the U.S. online population reports regularly buying online, with $334 billion in 2015 sales and anticipated growth of 13.4% through 2020 [25]. Digital retail is therefore increasingly replacing traditional in-store or retail shopping as a preferred product delivery method. This trend comes with visible impacts such as packaging, with over 35.4 million tons of containerboard produced in the U.S. in 2014 and e-commerce one of the fastest growing users of it [26].

Nike could address both trends, while consumers have more control over the latter by selecting their preferred product delivery method (whether in-store or digital and the specific terms, such as type of transportation to the store or speed of digital retail delivery). A recent study [27] calculated the GWP associated with three different product delivery methods for an identical bundle of goods, including factors such as transportation, packaging and energy used at the point of sale. It identified standard online delivery to be the best option (1.21 kg CO2 eq), expedited online delivery the worst option (9.64 kg CO2 eq) and in-store in between (5.03 kg CO2 eq).

Expedited shipping holds the highest environmental impact due to its use of air freight. While standard online delivery appears to be the best option, this is driven by a number of factors, such as distance traveled to the store (the study assumed 20 miles round trip), level of shopping bundling in that trip (the study assumed that the trip was made just for this good) as well as the retailer’s distribution model (the study assumed a centralized distribution model -- which is consistent with Nike -- with the good traveling from California to Michigan). The below sensitivity analysis demonstrates how a shorter distance traveled to the store, as well as an increase in shopping bundling (as indicated by a lower percentage of overall weight) would make in-store shopping a more favorable option from an environmental perspective.

<table>
<thead>
<tr>
<th>GWP (kg CO2)</th>
<th>4.14</th>
<th>90%</th>
<th>80%</th>
<th>70%</th>
<th>60%</th>
<th>50%</th>
<th>40%</th>
<th>30%</th>
<th>20%</th>
<th>10%</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>1.33</td>
<td>1.18</td>
<td>1.04</td>
<td>0.89</td>
<td>0.74</td>
<td>0.59</td>
<td>0.44</td>
<td>0.36</td>
<td>0.29</td>
<td>0.21</td>
</tr>
<tr>
<td>9</td>
<td>1.60</td>
<td>1.42</td>
<td>1.24</td>
<td>1.06</td>
<td>0.90</td>
<td>0.71</td>
<td>0.53</td>
<td>0.48</td>
<td>0.41</td>
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<tr>
<td>7</td>
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<td>1.45</td>
<td>1.24</td>
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<td>0.62</td>
<td>0.49</td>
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<td>1.42</td>
<td>1.18</td>
<td>0.95</td>
<td>0.71</td>
<td>0.50</td>
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<td>2.07</td>
<td>1.77</td>
<td>1.48</td>
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<td>0.30</td>
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<tr>
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<td>3.31</td>
<td>2.90</td>
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<td>3.99</td>
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<td>17</td>
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<td>4.02</td>
<td>3.52</td>
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<td>2.51</td>
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<td>1.51</td>
<td>1.01</td>
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<td>2.13</td>
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<td>4.14</td>
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<td>2.37</td>
<td>1.77</td>
<td>1.18</td>
<td>0.59</td>
<td>0.42</td>
</tr>
</tbody>
</table>

In comparing the GWP across these two studies, it is clear that production of the Flyknit and traditional shoes is significantly lower than even the “last mile” distribution of these products (Table 3). Given this, coupled with Nike’s anticipated digital retail growth consistent with market trends, it is important that the company include product distribution as a key component within its sustainability efforts.

4.5. Necessary conditions

Assessing the Flyknit against the four necessary conditions for sustainable product design allows for a comprehensive summary of the product’s sustainability performance.

1. Significant progress toward unmet challenge

This study explored whether the Flyknit makes significant progress toward producing a more sustainable athletic shoe option. Nike markets the Flyknit as reducing production waste by 80% which, combined with using 90% recycled materials, allows Nike to address its environmental impacts where they are highest, given that 60% of a shoe’s environmental impact is from
materials. The team assessed both this specific claim and the broader sustainability implications of the Flyknit.

Despite the data limitations mentioned above, the Flyknit appears to make improvements relative to the traditional shoe in three TRACI environmental-impact categories: GWP, energy usage, and in one human health category: non-carcinogensics. While seemingly minor on an individual product level, these advances are more significant when extrapolated across total athletic shoe sales [28].

However, the net benefit of the Flyknit is also tied to the product’s “last mile” distribution to the consumer. Traditionally, these responsibilities have fallen outside the scope of Nike’s sustainability work; however, this study highlights a potential emerging role for Nike to embrace both internal practices and external educational efforts to achieve lower impact distribution methods.

2. Potential to lead to undesirable consequences in lifecycle

Based on the team’s environmental LCA, during the manufacture of an identical quantity of shoes, there does not appear to be negative consequences associated with switching to the Flyknit. While the automated Flyknit production process could lead to higher skilled and paying work opportunities, it is possible that this will result in either a loss of jobs for those who need them most, or shifting of jobs away from current producing regions altogether. The notion of “near” and “on” shoring is emerging as an alternative to the perceived increase in risk associated with global manufacturing; however, this has been cited as a “trend” in various business briefs for several years without significant movement in this direction. In addition to the social concerns these shifts raise, longer term implications of a higher skilled workforce could include shifting geographies or investing in workforce development programs.

3. Likely to be adopted and self-sustaining

Flyknit has been adopted across multiple shoe models and by competitors. Given this level of adoption, the team assumes that the Flyknit is currently financially successful and self-sustaining, even though they are priced higher than traditional shoes. However, is it unknown if the Flyknit will be self-sustaining in the long-run, mainly because of the cyclical nature of fashion. Consumers may lose interest in the Flyknit after a few more years, which could result in Nike adjusting or ending the product line. The technology could be adapted for other products since it does offer environmental and social benefits important to Nike, but at this point it is unclear just how long Flyknit will be self-sustaining.

4. Potential for rebound effects

The Flyknit may encourages increased shoe consumption rather than acting as a replacement for traditional shoes. One scenario could be consumers using the sustainability progress of Flyknit manufacturing as a mental “crutch” to support greater consumption habits. A second scenario could be consumers purchasing Flyknit in multiple styles and colors in order to be trendy. Under both scenarios, the environmental benefits of switching to this new technology could be outweighed by increased consumption. However, given Nike’s commitment to sustainability as a driver of innovation, with an entire organization devoted to Sustainable Business Innovation, it is probable that Flyknit earnings will be reinvested in a manner that contributes to ongoing sustainability innovation efforts.

5. Conclusion

Nike considers itself to be on a “journey of sustainability integration.” Through innovative and commercially successful products such as the Flyknit, Nike has the opportunity to challenge traditional design and push the industry forward.

The team’s assessment of the Flyknit is that it holds great potential for sustainable product design based on the necessary conditions outlined above; it appears to achieve the highly desired “triple bottom line” standing through:

- Lower environmental impact relative to the traditional shoe
- Commercial viability
- Neither increasing nor decreasing short term social risks

However, a definitive conclusion is challenging due to a lack of information related to proprietary commercial, material and production information for the LCA and economic assessment. With this information, the team could enhance the Umberto model to confirm more confidently the findings offered in this report, and also conduct the economic analysis from the perspective of Nike as principal stakeholder, offering a more accurate assessment of the Flyknit’s commercial viability.

The social issues identified by this analysis are both “very high” and longstanding for Nike and many companies with a global manufacturing model. Therefore, the following actions are suggested in order to mitigate social risks in the production of the Flyknit and footwear/apparel products generally:

- Seek ongoing “Shared Responsibility” opportunities: A multistakeholder approach to addressing social challenges will facilitate more productive and sustainable progress on the social challenges identified.
- Utilize worker-driven solutions: A human-centered approach -- perhaps involving new technology solutions -- built on actual feedback and ideas from those impacted, will be essential in addressing social issues.
- Dig deeper for answers to persistent challenges: Social issues are inherently complex and require significant investment of time, presence and resources to truly understand and ultimately effectively address.

Through ongoing investment in sustainable product design such as Flyknit, Nike will set the tone for the industry to use sustainability as a driver of innovation.

“Innovation has never been more important than it is today. It’s not just about improving the products we make. It’s about how we invent better ones, work with other companies and organizations to develop markets that value and encourage the creation of new sustainable processes and products, and improve lives by leveraging sustainability as the world’s greatest innovation opportunity.” (Nike) [29]
References
[4] Ibid.
[9] Ibid.
[17] Ibid.
[27] This analysis was conducted as part of the NRE 557 Industrial Ecology course in March-April 2016 using SimaPro.
Appendix A.
A.1. Traditional shoe TRACI LCIA on a 100% scale. This figure accounts for all phases up to point of sale and after consumer use, excluding consumer delivery choice. (Figures were derived from an Umberto Environmental Life Cycle Analysis)

A.2. Flyknit shoe TRACI LCIA on a 100% scale. This figure accounts for all phases up to point of sale and after consumer use, excluding consumer delivery choice. (Figures were derived from an Umberto Environmental Life Cycle Analysis)
Discussion

Through this study, the team learned that the Nike Flyknit holds great potential for sustainable product design according to both the necessary conditions and triple bottom line principles. As a result of this process, the team generated a series of additional areas of exploration for Nike to consider on its sustainability journey:

Design and material procurement: Currently the predominant material in the Flyknit shoe is recycled PET. While it helps close the loop with plastic waste, Nike may want to conduct research on other types of material that can help achieve more environmental progress, such as using biodegradable or organic materials, so that even less waste is produced. With the “Conflict Minerals” Law, electronics and other industries are now examining their supply chains beyond manufacturing, to the conditions under which raw materials are extracted. This may create a comparable trend in apparel where the industry is required to dig deeper along its supply chains to include raw material procurement, for both social and environmental reasons. While advocacy efforts in the apparel industry have thus far focused on factory (“sweatshop”) conditions, this overlooks all processes beyond the factory and is focused on mainly social impacts. If materials are really what matter in driving environmental performance, Nike may want to look beyond factories and to identify new input materials altogether.

Distribution: Through a supplementary analysis, the team determined that GWP reductions during the manufacturing phase may be overshadowed by the “last mile” delivery of product to consumer. Nike has the opportunity to be a leader among U.S. retailers in identifying and addressing this crucial sustainability consideration through both internal and external measures. Internally, Nike could ensure that product delivery is bundled and appropriate sized packaging is used. The company could also move toward an integrated commerce model (already adopted by retailers like Gap) linking digital and in-store inventory to expand consumer delivery options for any given product. In addition, while consumers traditionally make product delivery decisions based on cost (e.g., fuel/total car operating cost, cost of shopping), Nike could educate consumers on the environmental impacts associated with various product delivery methods. One potential venue for this could be an educational platform on the Nike website which informs consumers at the point of sale on potential distribution options and their associated environmental impacts. Nike could then incentivize consumers (e.g., product discounts) to opt for less impactful delivery decision, such as bundling purchases together or choosing to purchase at a nearby store instead of online should that carry lower environmental impacts.

Footwear revolution: With the Flyknit technology, Nike has introduced a new method of shoe production, which may open the door for other footwear innovations as well. With 3D printing becoming increasingly popular and advanced, it may be possible to 3D print a fully functional sneaker in the near future. Nike may want to evaluate where and how knitting technology and 3D printing overlap and/or align. Additionally, a higher degree of customization may be possible with this automated technology. Nike currently offers some level of customization to consumers through its “NikeiD” program, but this process might become more advanced, with customers being able to dictate even more color and style specifications, effectively becoming designers of their own shoes.

Expansion into other products: The Flyknit is currently economically viable, but it is uncertain whether it will stay this way in the long-term, given factors such as changing fashion trends and competition. One way for Nike to reinforce the profitability of the knitting technology used to create Flyknit is to increase its economies of scale by broadening the product line to items such as bags or shirts. Given the reduced environmental impact in manufacturing the Flyknit, it is assumed that similar benefits would be passed on to other products as well. Introducing the technology into other products may also help signal that this technology is here to stay and not just a short-lived trend. Nike may be heralding a new method of apparel and footwear production to the larger fashion industry, helping it break away from the less sustainable cut and sew manufacturing used for decades.

Consumer education: As a company that publicly positions itself as prioritizing sustainability, Nike should examine its communications and the extent to which the company might educate consumers regarding the sustainability of its products. For example, the marketing of the sustainability attributes for the Flyknit (lower waste) may inherently bias the information provided and neglect other high impact areas (such as distribution) and unknown impacts (such as labor implications). Nike may provide a more comprehensive sustainability picture if it incorporates these additional considerations into its sustainability communications. Additionally, the apparel industry is fueled by consumer demand for clothes and footwear. If Nike truly wants to be a company that is dedicated to sustainability, the level of consumption that Nike may encourage with its marketing and new product releases may need to be evaluated. Nike may need to examine where the line is between being profitable and competitive versus encouraging overconsumption, and how to communicate that to consumers. Other leading apparel retailers such as Patagonia have addressed this by encouraging extended product use alongside product repair and recycling programs.