Minimizing CO2 Emissions along Nike's Supply Chain

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Business Background

- Nike is a global consumer goods company that designs, markets, and distributes athletic footwear, apparel, equipment, and accessories.
- **Objective Function & Strategic Priority:** Maximize shareholder value by sustaining market dominance.
  - Revenue growth strategies include continuing global expansion and new product development and release.
- **Financial Statistics:**
  - Enterprise Value: $163.32B
- **Competitive Advantages:**
  - Brand equity (“Swoosh” logo)
  - Innovative products
  - Low-cost structure with large gross margins (outsourced production)
  - Effective marketing strategies (athlete endorsement)

Problem Statement

- Consumer preferences are shifting towards sustainability.
- As a global company with outsourced manufacturers, a significant portion of Nike's operating costs come from the transportation of products throughout their supply chain.
- The company has experienced backlash in the past from consumers related to the infringement of labor laws in manufacturing facilities and lack of supply chain transparency.
- Nike's brand equity is the company's main core competency. In order to protect this and maintain market share leadership, the company needs to abide by shifting consumer preference towards sustainability.

Business Case

- To address this issue, we created a model that could allow Nike to minimize how much CO2 they emit along their supply chain and calculate the associated cost.
- Nike could then compare this model to their current supply chain and evaluate opportunities for implementation to reduce CO2 emissions.
- Posting this model publicly along with a sustainability plan could improve consumer trust in the brand. This would ultimately improve sales, and Nike could even consider charging a product premium due to this ”supply chain sustainability” initiative.

Model Inputs & Assumption

- Distance Inputs:
  - Distance between each distribution centers in the USA and manufacturers in China (calculated via the Spherical Law of Cosines to account for the Earth's curvature)
    - We decided to focus our model on the 119 Nike manufacturers located in China, as they account for the largest proportion of manufacturing output.
- Transportation Modality Inputs (for cargo ship and airplane):
  - Carbon Emission Factor for each mode of transport
  - Speed (mph)
  - Capacity (tons)
  - **Used to Calculate:** Travel time between each distribution center and manufacturer

Model Inputs & Assumptions Cont.

- Manufacturer Capacity Inputs:
  - Number of shoes manufactured and average show factory per month
  - Average number of workers per factory
  - Capacity of one worker per month
    - Ex. How many shoes one worker can produce per month
  - **Used to Calculate:** Capacity in tons of each Nike manufacturer
- Demand Calculation Inputs & Assumption:
  - Annual US Nike Revenue
  - Average Price of Nike Shoe
  - Average Weight of Nike Shoe
  - **Assumption:** Percentage of total monthly demand needed by each DC
  - **Assumption:** Percentage of demand that must come within one week
  - **Used to Calculate:** Capacity in tons of each manufacturer

Model Objective & Decision Variables

- Objective:
  - Minimize Nike's CO2 emissions when moving product from manufacturers in China to distribution centers in the United States
  - **Function to be Minimized:**

$$E_{CO2} = W_{goods} * D * F_{mode}$$

    - E_CO2: emissions in kilograms of CO2 equivalent (kgCO2eq)
    - W_goods: weight of the goods (Ton)
    - D: distance from your warehouse to the final destination(km)
    - F_mode: emissions factor for each transportation mode (kgCO2eq/t.km)
- Decision Variables:
  - Amount of product transported via cargo ship (in tons)
  - Amount of product transported via plane (in tons)

Model Constraints

- Constraint 1: Capacity of the manufacturers
  - The amount shipped from each manufacturer cannot exceed the capacity of that manufacturers
  - Capacity of the manufacturers depends on the number of workers at every manufacturing facility and the capacity of the workers
    - The capacity of the workers is defined as how many shoes per worker per month can be produced
- Constraint 2: Demand of the distribution centers
  - Monthly demand of the distribution centers must be met
  - Demand of the distribution centers depend on the zip code of the distribution center
- Constraint 3: Time
  - 10% of the monthly demand must arrive to the distribution centers by 1 week
    - Requires transportation by plane

Model Solution & Analysis

- We created a small version of the model in Excel because Simplex LP can only handle ~200 decision variables
  - In this model, we had the 6 distribution centers and only used 8 manufacturers
- We replicated the small version of the model in Python so that we could crosscheck the output found in Excel to confirm it was correct
  - From there, we applied our small model in Python to a model with all the manufacturing centers in China
- Optimal Solution (found in Python):
  - Total CO2 emissions: roughly 16,126,504 kilograms of CO2
- Nike's current CO2 emissions output for sneaker transportation:
  - Total CO2 emissions: roughly 2,620,785,404 kilograms of CO2
- Evidently, the model constructed minimizes CO2 emissions immensely
  - We also created a cost calculation based upon the decision variables. This allows executives to compare cost and CO2 emissions of the new vs. current supply chains models.

Business Applications

- Any supply chain company can use this model to minimize their CO2 emissions after loading all the inputs needed.
- Supply chain companies can compare their current CO2 emissions with the output of this model to check by what percentage they can reduce emissions while meeting the demands of their distribution centers and staying within manufacturing capacity.
- Examine and compare the cost of implementing the new supply chain versus the current supply chain.
- Gain consumer trust and improve brand equity by implementing this model into a Sustainability Initiative and creating a transparent supply chain.

Challenges & Limitations

- We faced challenges while searching for the supply chain data needed to for our model
- It was challenging to calculate distance between manufacturers in China and distribution centers in USA based on the latitude & longitude of all the locations
- **Limitation:** We did not use shipping distances, which account for travel routes; this could impact the emissions produced between locations since our distance calculations aren't exact.

Ideas for Next Steps

- Create a second model that applies the same objective function to the distances between distribution centers and US retailers.
- Expand the model globally to capture all of Nike's manufacturers, distribution centers, and retailers
- Scenario Analysis:
  - Nike can manipulate the monthly demand assumption that must be delivered by 1 week to the distribution centers to see how that affects their CO2 emissions in comparison to their current output and weigh that with the cost of transportation.

Files

- 1. Excel Mini Model (uses only 8 manufacturers)
- 2. Python Mini Model (uses only 8 manufacturers)
- 3. Python Final Model

Sources

- https://ycharts.com/companies/NKE/enterprise_value
- https://www.samirsaci.com/supply-chain-sustainability-reporting-with-python/

Statement of Contribution

- Everyone did everything together!
  - We met up and worked on the Excel model, Python model, and presentation together and in-person.
  - Everyone attended every meeting.