SUPPLY CHAIN SIMULATION MODEL

MNA1094 – Supply Chain Management

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Introduction

Vietnam is the leading exporter of robusta coffee and hence, the country holds an influential position in the global coffee market. Production in the country is mainly centred in the Central Highland, specifically, in the provinces of Dak Lak and Lam Dong due to favourable climatic conditions and rich nutrient soils, making it an ideal place to produce coffee (Nguyen et al., 2021). However, the industry continues to face numerous challenges that impede its effectiveness and competitiveness. The value chain faces significant logistical challenges, including transport delays and inadequate storage facilities, causing bottlenecks from production to distribution. Seasonal demand fluctuations driven by climate changes, such as shifts in precipitation and temperature, and demand reductions due to poor conditions further complicate inventory management and operations (Nguyen and Sarker, 2018).

This project analyses Vietnam's coffee supply chain through a simulation model. The model highlights the performance and limitations of each stage, from production to distribution, by considering key variables such as inventory levels, logistical delays, costs, and the effects of climatic and seasonal fluctuations on supply and demand. Specific examples include sudden high demand due to heavy rain, low demand due to bad weather conditions, or even strikes that may disrupt production.

Research and Background

Coffee is a widely consumed resource throughout the world, making it a resource whose supply chain is interesting to analyse. The supply chain is complex due to the large number of players involved and faces numerous challenges such as climate change and geopolitical risks. The following report reviews the various stages in the coffee supply chain and existing research on the subject.

Supply Chain Overview

The first stage in the coffee supply chain is production, mainly concentrated in tropical countries. Brazil, Vietnam, Colombia and Ethiopia are the largest producers, accounting for 70% of world production, with Brazil by far the world's largest producer. Most coffee farms are small (95% are less than 5 hectares in size). Two main types of coffee are produced: Arabica and Robusta. Arabica, which is appreciated for its more refined taste, accounts for 60% of world production and grows at high altitudes. Robusta, on the other hand, has a less subtle flavour, grows at lower altitudes and costs less to produce. (Bermudez, Voora and Larrea, 2022)

Once the coffee has been produced, it still has to be processed before it can be exported. This involves several stages: processing the coffee cherries to extract the beans, drying and finally sorting the beans. Two main processing methods are used:

1) Wet processing, which involves washing the beans using modern equipment.
2) Dry processing, which involves drying the whole cherries in the sun, is the traditional method. (National Coffee Association of U.S.A, no date)

The logistics chain for exporting coffee is complex. It brings together a number of players who transport the coffee from the rural areas where it is produced to the large urban areas where it is consumed. Transport of the beans begins locally, where they are taken to the export ports in the producing countries, usually by cooperatives or private companies. The product is then exported to consumer countries by sea. Finally, the product is distributed and roasted in consumer markets such as Europe, Asia and North America. (Bermudez, Voora and Larrea, 2022; National Coffee Association of U.S.A, no date)

Key Industry Challenges

Coffee production is largely dependent on environmental factors (temperature, rainfall, etc.). Climate change therefore has a major impact on agricultural yields, lowering productivity and increasing farm costs (Bermudez, Voora and Larrea, 2022). For example, In some regions, such as Vietnam in 2023, there may be a significant drop in production when the weather is unfavourable (ICO, 2023).

In addition, smallholders, who account for the lion's share of world coffee production, are under great pressure to comply with standards such as FairTrade. Although these standards can increase revenues in the long term, they require substantial initial investment, which sometimes jeopardises farmers' financial health (FAO, 2023).

Transporting coffee beans also poses its own set of challenges. Firstly, some producing countries do not necessarily have the appropriate infrastructure to export their products efficiently and reliably (Bermudez, Voora and Larrea, 2022). Furthermore, in recent years, the rising cost of maritime freight and recent disruptions (COVID-19, blockage of the Suez Canal, etc.) have also made coffee transport more complex (FAO, 2023). Finally, transporting coffee beans is no simple matter either, due to the quality standards required to preserve the product properly, as coffee needs precise levels of humidity (michalkwasniewski.com, 2021)

Coffee production can also be disrupted by geopolitical circumstances. Several major coffee producers, such as Colombia and Ethiopia, have unstable political climates, and their production is regularly disrupted by internal conflicts (FAO, 2023).

Previous Studies or Models

Several studies have already been carried out on the coffee supply chain, given the size of the market. The first point that seems to emerge from the various analyses is the high degree of fragmentation in the coffee supply chain. According to a report by the International Coffee Organization, there are many different players, including producers, cooperatives, transporters and roasters (ICO, 2023). The large number of players can lead to coordination challenges and logistical inefficiencies (Eckschmidt, 2020).

Another finding is the beneficial role that new technologies can have for the market supply chain. Indeed, certain digital tools can improve the traceability of coffee and provide a better understanding of coffee flows around the world (Jena & Grote, 2017).

Various simulation models have also already been tested. Sterman et al (2018), for example, used system dynamics to model the different coffee flows and thus identify bottlenecks. This enables us to better understand the impact that unpredictable weather and logistical disruptions can have on the entire supply chain.

Design & Development

Objectives

The simulation serves as a strategic tool to identify and address supply chain vulnerabilities, optimise operations, and enhance decision-making. The primary objective is to uncover weak points, such as bottlenecks, insufficient safety stock, and long lead times, and to propose strategies to mitigate their impact. The simulation also analyses the effects of weather fluctuations, such as temperature and rainfall, on both demand and production, highlighting the need for adaptive planning. By testing resilience strategies, the simulation evaluates the supply chain's adaptability to recover from disruptions, such as factory production halts and demand surges. It will emphasise the importance of aligning production and disruption plans with seasonal variability to reduce unmet demand, optimise costs, and maintain customer satisfaction.

Additionally, the simulation facilitates scenario testing, providing actionable insights for refining logistics, production, and inventory management. Overall, it offers a comprehensive framework for continuous improvement, ensuring the supply chain remains efficient, resilient, and responsive to both market demands and external disruptions.

Roles for Each Member

During the initial group meeting, the primary objective was to assess the individual skills of each member to determine the most appropriate allocation of roles. Laeeq volunteered to take the lead in developing the simulation model as he had the most experience in coding and could provide us with a sophisticated model. As a result, Hugh, Hang, Lucas, and Baptiste focused on conducting the research and analysis necessary to support the model's successful construction. Laeeq was able to provide the group with an understanding of the model's components and operational mechanisms. This collaborative effort enabled the group to develop a comprehensive understanding of the model, ensuring its elements could be effectively explained in the final report.

Project Timeline

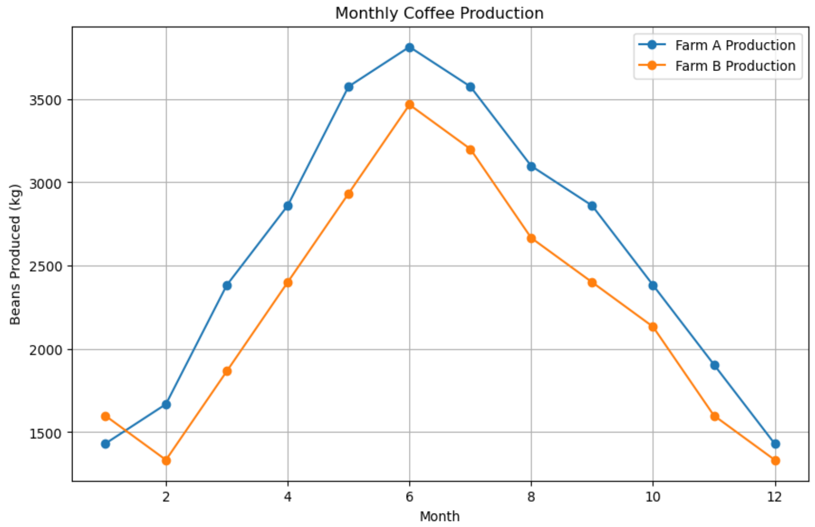
Week	Phase	Objectives Reached
1-2	**Research & Planning**	Researched supply chain models and tools Chose the industry of focus Developed project plan – assigned roles and outlined key milestones
3-5	**Design & Development**	Designed the core components of the simulation Determined inputs, algorithms, and decision rules for the model
6	**Testing & User Guide Development**	Ran test scenarios to determine model accuracy and identify bugs Gained feedback from peers who used our model – made respective improvements Developed a user guide outlining simulation functions
7	**Final Report Write-Up**	Wrote a detailed report outlining the stages of the project and reflecting on outcomes
8	**Finalisation & Presentation**	Prepared a presentation outlining the project components and simulation

Simulation Components

The Vietnam Coffee Supply Chain Simulation is designed to model the flow of goods, costs, and decisions across multiple stages in the supply chain, providing insights into operational efficiencies and bottlenecks. It focuses on tracking inventory, managing production, and responding to changing demand influenced by weather variability. The model is structured around five core components:

a. Suppliers (Farm A and Farm B):

Farms represent the foundation of the coffee supply chain. The simulation incorporates two farms (Farm A in Dak Lak Province and Farm B in Lam Dong Province) with unique production capacities and seasonal output variations. These farms are influenced by weather patterns (e.g., temperature and rainfall), which are modelled using monthly multipliers. An adequate balance of rainy and dry seasons is necessary to ensure the effective production of coffee through the flowering and development aided by rainfall, to the drying stage in post-harvest processing with more severe seasons negatively affecting this. The farms contribute raw coffee beans to processing facilities, ensuring an adequate supply to meet downstream demand.



b. Processing Facilities:
The processing centre aggregates coffee beans from both farms. This stage includes activities such as cleaning, grading, and packaging beans for distribution. Safety stock (10% of monthly demand) is maintained to buffer against supply chain variability, while lead times (default: 2 months) account for delays in processing and transportation.

c. Logistics:
Logistics bridges the gap between the processing centre and distribution channels. This component accounts for transportation lead times, costs, and bottlenecks that affect inventory flow. It ensures that coffee beans move efficiently from processing facilities to distribution centres or retailers, maintaining service levels despite potential disruptions such as strikes or equipment failures.

d. Distribution Channels:
Distribution centres supply processed coffee to retailers and exporters. This level balances inventory to prevent shortages or overstocking while ensuring the timely fulfilment of retailer and exporter orders. The simulation tracks orders placed by retailers and exporters, which depend on seasonal demand and weather-influenced multipliers. Lead times and safety stock thresholds further influence inventory levels.

e. Retailers:
Retailers serve as the final link in the supply chain, meeting customer and export demand. Retail performance is evaluated based on its ability to meet monthly demand without generating unmet demand or excessive inventory. Retailers' operations are directly influenced by demand fluctuations, which are modelled using weather and market trends.

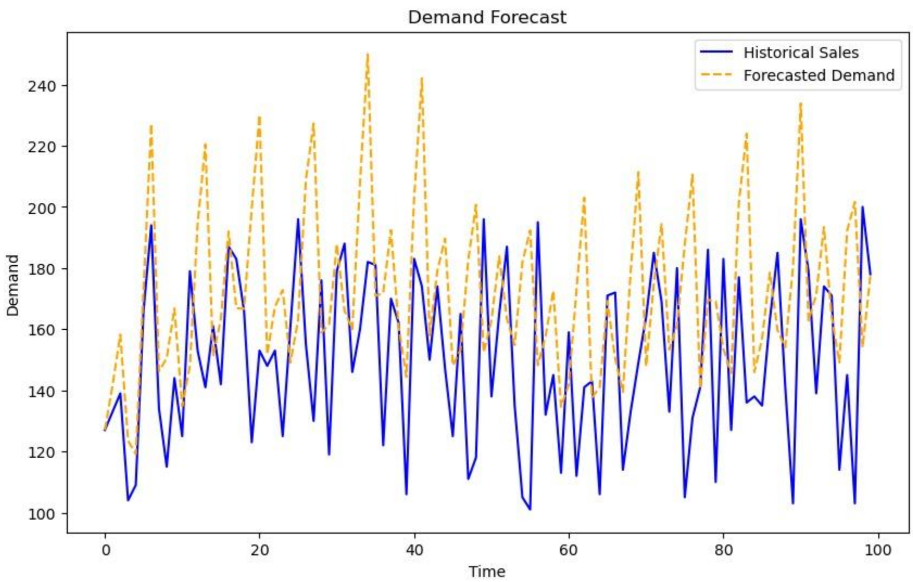
The simulation framework captures these interconnected components to provide a comprehensive view of the supply chain. It highlights dependencies, tracks performance metrics, and offers actionable insights to improve efficiency and resilience.

Data Inputs and Integration

To ensure the simulation is both realistic and adaptable, we have integrated diverse data inputs that mirror real-world supply chain operations. These inputs include:

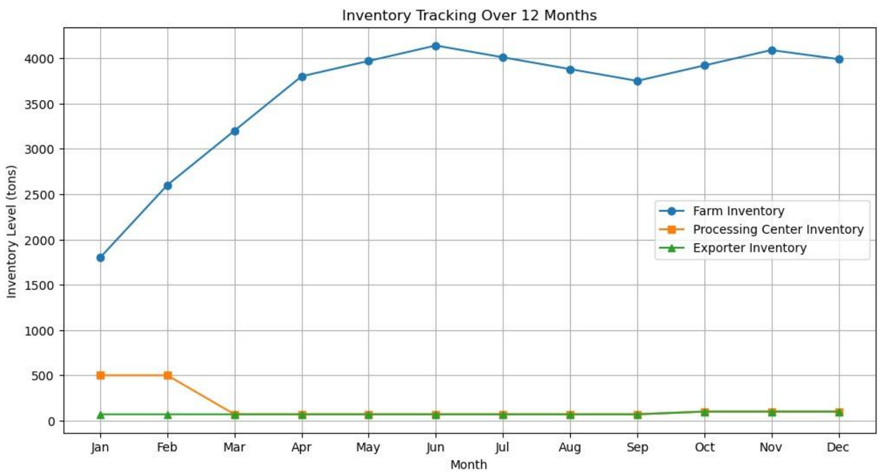
a. Demand Forecasts:

Monthly demand forecasts form the backbone of the simulation, representing customer and export requirements. We set the following multipliers to forecast demand:



b. Inventory Levels:

Initial inventory levels are set for each stage of the supply chain (5,000 kg at farms, processing centres, and distribution centres). These levels are user-defined in the input sheet, providing flexibility to simulate various starting conditions.



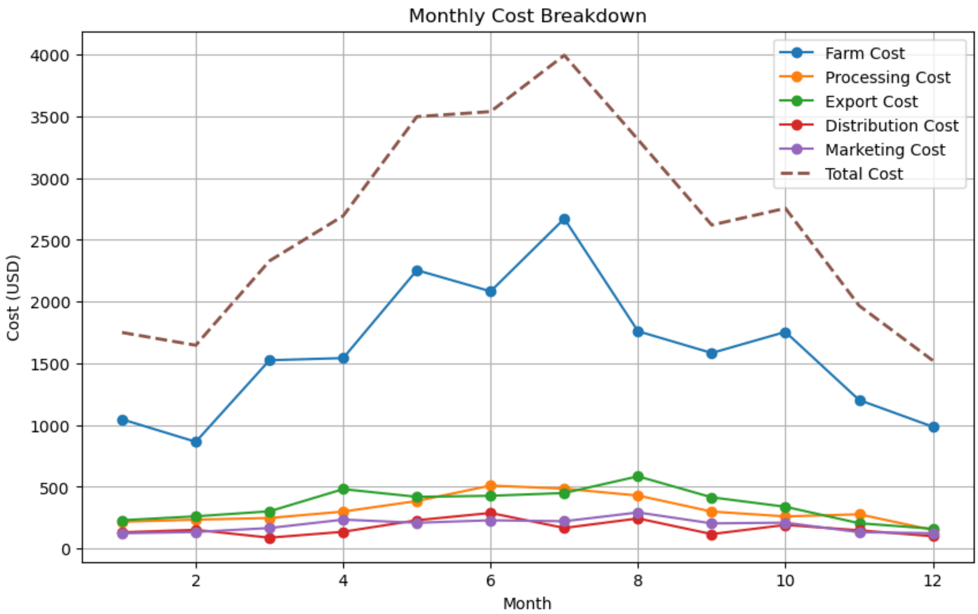
c. Lead Times:

Lead times represent delays in production and transportation. The default lead time is set at 2 months but can be adjusted for scenario testing. For example, a shorter lead time (1 month) improves responsiveness, while longer delays exacerbate inventory shortages.

d. Cost Structures:

Costs are calculated for each stage of the supply chain:

- **Farm Costs:** Variable production costs influenced by seasonal yields.
- **Processing Costs:** Fixed costs for cleaning, grading, and packaging beans.
- **Distribution Costs:** Transportation expenses between stages.
- **Marketing and Export Costs:** Costs incurred to promote and deliver coffee to international markets.



e. Weather Data:

Seasonal temperature and rainfall patterns are critical inputs that influence production and demand. For example:

- Temperature <22°C increases demand by 20% (multiplier: 1.2).
- Rainfall >150 mm increases demand and production, while <50 mm reduces both.

Average Monthly Temperature and Rainfall in Vietnam:		
Month	**Temperature (°C)**	**Rainfall (mm)**
Jan	20.8	20
Feb	21.5	30
Mar	23.5	40
Apr	26.5	80
May	27.8	150
Jun	28.1	200
Jul	28	220
Aug	27.8	240
Sep	27.2	180
Oct	25.5	100
Nov	23	50
Dec	21	30

Parameter Table for Vietnam Coffee Demand	
Parameter	**Demand Multiplier**
Temperature < 22°C	1.2
Temperature 22-26°C	1
Temperature > 26°C	0.9
Rainfall > 150 mm	1.15
Rainfall 50-150 mm	1
Rainfall < 50 mm	0.9

f. Safety Stock:
Safety stock thresholds ensure sufficient inventory is available to buffer against demand variability. By default, safety stock is set at 10% (multiplier: 1.1), though this can be adjusted for resilience testing.

Algorithms and Decision Rules

The simulation operates on a set of predefined algorithms and decision rules, ensuring logical and consistent outputs. These include:

a. Production Rules:
Farm production is calculated monthly based on weather multipliers. The formula is:

Monthly Production (kg)= Base Production × Weather Multiplier

For example, if Farm A's base production is 8,000 kg and the weather multiplier is 1.2, its adjusted production for the month is 9,600 kg.

b. Inventory Management Rules:
Inventory is updated at each stage based on production, demand, and orders. The formula is:

New Inventory = Previous Inventory + Production − Demand

Negative inventory values indicate unmet demand, signalling supply chain weaknesses.

c. Order Fulfilment Rules:
Orders are placed to replenish inventory, adjusted for safety stock:

Order Volume = Forecasted Demand × Safety Stock Multiplier

d. Demand Adjustment:
Demand is adjusted for weather multipliers:

Adjusted Demand = Base Demand × Demand Multiplier

e. Cost Calculations:
Costs are calculated for each stage:

Total Cost = Farm Cost + Processing Cost + Logistics Cost + Export Cost

f. Disruption Handling:
In disruption scenarios (e.g., factory strike), production is set to zero for affected months. The model calculates unmet demand and recovery times.

Model Assumptions and Limitations

a. Assumptions:

The input sheet (below) outlines the assumptions for the model which drives the simulation outputs. By modifying these inputs, users can see the effect it has on each stage of the supply chain.

Parameter	Value
Initial Farm A Inventory	5,000 kg
Initial Farm B Inventory	5,000 kg
Initial Processing Center Inventory	6,000 kg
Initial Distribution Center Inventory	5,000 kg
Initial Retailer Inventory	4,000 kg
Factory Production Capacity	8,000 kg/month
Retailer Lead Time	1 month
Distribution Lead Time	1 month
Processing Lead Time	2 months
Production Cost per Unit (kg)	€200
Holding Cost per Unit (kg)	€5
Transportation Cost per Unit (kg)	€10
Retail Value per Unit (kg)	€500

b. Limitations:

1. **Simplistic Weather Modelling:**
   Linear weather impacts may oversimplify real-world dynamics, such as unexpected droughts or floods.
2. **Static Cost Structures:**
   The model uses fixed cost ranges and does not account for inflation, market fluctuations, or geopolitical factors.
3. **Limited Disruption Types:**
   Only production halts and lead time changes are considered, omitting external disruptions like currency fluctuations or global trade restrictions.
4. **No Real-Time Adaptation:**
   The model is static and does not incorporate real-time updates to parameters or data.
5. **Regional Demand Variations:**
   The model assumes uniform demand patterns, excluding regional differences or export-specific trends.

Testing Scenarios

We use two different farms: Farm A located in Buon Ma Thuot, Dak Lak Province and Farm B located in Da Lat, Lam Dong Province.

Farm A: Located in Buon Ma Thuot, Dak Lak Province. This region is known for its moderate and predictable rainfall.

Farm B: Located in Da Lat, Lam Dong Province. Situated in a wetter microclimate with slightly higher rainfall.

Based on data we established our baseline rainfall index for both of the farms in the table below.

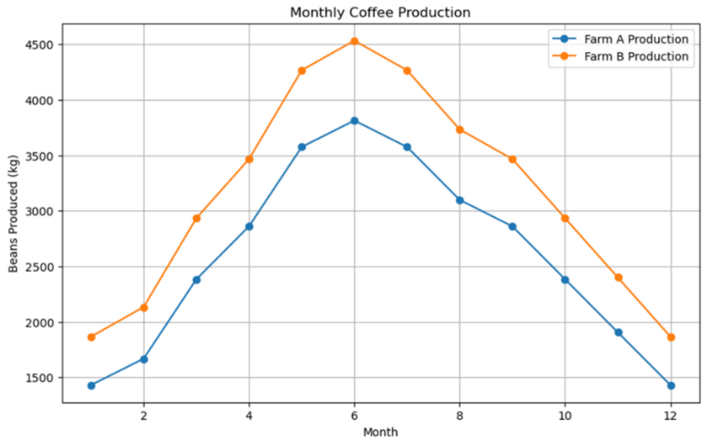
Rainfall index (Original)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Farm A	0.5	0.5	0.6	0.8	1	1.2	1.2	1.1	1	0.9	0.7	0.5
Farm B	0.6	0.5	0.7	0.9	1.1	1.3	1.2	1	0.9	0.8	0.6	0.5

We conducted two weather simulation scenario tests:

- ## Test 1 - Worse than Usual weather conditions (Extended Monsoon)

We have established that the data for the Rainfall Index covers 12 months of the monsoon season. This data input was then simulated on Spyder software to create the graph below, which illustrates monthly coffee production. The simulation results indicate that coffee production peaks during June and July when rainfall is at its highest. Farm B, which receives more rainfall, consistently produces more coffee throughout the year than Farm A. This suggests that higher rainfall leads to better coffee production, indicating that coffee yield is highly seasonal, with increased production during the rainy season and lower yields in the drier months from September to December.

Rainfall index (Extended Monsoon)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Farm A	0.6	0.7	1	1.2	1.5	1.6	1.5	1.3	1.2	1	0.8	0.6
Farm B	0.7	0.8	1.1	1.3	1.6	1.7	1.6	1.4	1.3	1.1	0.9	0.7

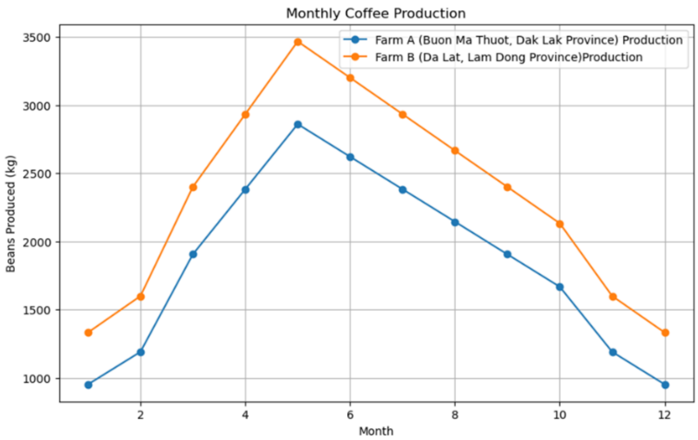


- ## Test 2 - Better than Usual weather conditions (Mild Monsoon)

In this scenario, we examined how coffee production is affected by better-than-usual weather conditions, specifically the mild monsoon. The data indicates that rainfall peaks for both farms in May and June, with Farm A reaching a maximum rainfall index of 1.2 and Farm B reaching 1.3.

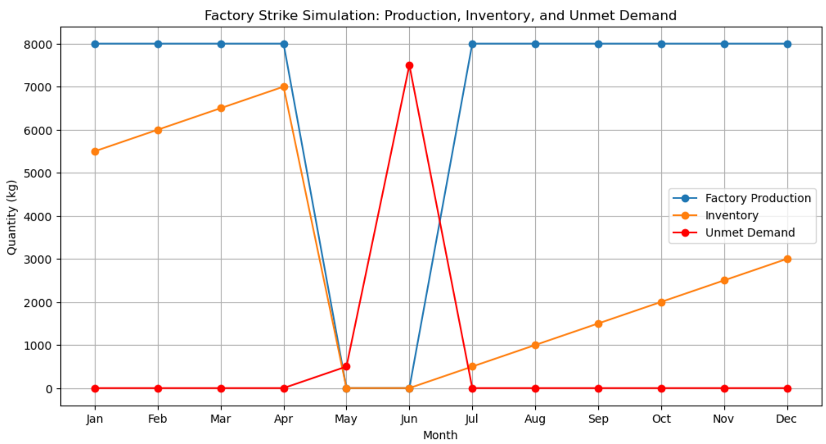
Throughout the year, Farm B consistently receives slightly more rainfall than Farm A, although the differences are relatively minor, and both farms exhibit a similar overall trend. Rainfall begins to increase in February, peaks in May and June, and then gradually declines, reaching its lowest levels in December (0.4 for Farm A and 0.5 for Farm B). Similar to Test 1, coffee production benefits from increased rainfall and Farm B has a higher yield in terms of coffee production.

Rainfall index (Mild Monsoon)												
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**
Farm A	0.4	0.5	0.8	1	1.2	1.1	1	0.9	0.8	0.7	0.5	0.4
Farm B	0.5	0.6	0.9	1.1	1.3	1.2	1.1	1	0.9	0.8	0.6	0.5



After conducting the tests, the results indicate that coffee production closely aligns with rainfall patterns in both scenarios. Higher rainfall leads to increased coffee yields, while production declines significantly during drier months. Additionally, under both extended and mild monsoon conditions, Farm B consistently outperforms Farm A in coffee production, primarily due to slightly higher rainfall levels.

– Test 3 - How factory strikes affect the coffee production processes.



We simulated the factory strikes that occurred over two months, from May to June. As shown in the graph, production remained constant until April, allowing for a gradual buildup of inventory.

During the strike period, the inventory was completely depleted to meet demand. As a result, unmet demand spiked sharply in May and peaked in June, reflecting the inability to supply any products. Once the strikes ended, the factory gradually began to rebuild its inventory, but at a slower rate compared to the pre-strike period. This indicates either higher demand or tighter production margins.

Simulation Summary

The Vietnam Coffee Supply Chain Simulation provides a robust framework for analysing the impact of weather, demand fluctuations, and disruptions on production, inventory, and costs. While assumptions and limitations exist, the model's flexibility allows users to explore diverse scenarios, test resilience strategies, and optimize supply chain performance. Future enhancements could include real-time data integration, dynamic cost modelling, and broader disruption simulations.

User Guide Summary

Overview

The Simulation models the supply chain in the context of coffee in Vietnam, one of the leading coffee producers in the world. It looks at tracking inventory, production at different stages of the year, costs, and demand functions at various levels: Farm A (Buon Ma Thuot, Dak Lak Province), Farm B (Da Lat, Lam Dong Province), production, distribution and processing centres and retailers. It looks for bottlenecks, unmet demand, and opportunities for improvements, by identifying the weaknesses shown by the simulation model the Vietnam coffee industry will improve in supply chain optimisation.

Key Metrics

Below these metrics are essential for understanding and analysing the simulation:

1. Demand:

- This reflects the number of coffee beans(kg) willing to purchase at retail and export levels.

2. Inventory Levels:

- Farm A &B: Remaining inventory following season production changes.
- Processing facility: Remaining inventory after Coffee beans are processed from farms.
- Distribution facility: Inventory after distributing to retailers and exporters
- Retailer: Inventory left over after customer demand is not met.

3. Orders:

- Farm A and B : Based on forecasted demand for processing
- Processing facility: Orders are adjusted based on distributor and exporter needs

Distributor: Based on retailer requirements

4. Costs:

- Farm A and B : production costs per kg at both farms
- Processing: Costs at the facility due to handling and processing
- Export and Distribution Costs: Transportation, marketing and storage

5. Factory Production Plan

- Monthly production to satisfy demand and replace inventories with lead time

6. Unmet Demand:

- Negative inventory levels correspond to missed sales or unmet orders, indicating supply chain weakness.

Instruction for the use of Simulation

1. Input Parameters

- Input the desired expected demand that the supply chain will likely meet, adjust the base demand with multipliers (e.g 0.8 for decreases in demand and 1.2 for demand increases) to simulate changes in demand.
- Input the starting inventory at each stage of the supply chain (e.g 5000kg at Farm A and 6000kg at Farm B), this can be edited in the code of inventory levels, changes of value will change the inventory graph.
- Input Lead times, the delay can be in either in production or transportation, the default in our model is set at 2 months this can be adjusted.
- Adjust the safety stock at Farms A and B, Processing and distribution facilities, and retailers by changing the multiplier set as a percentage (10%).

2. Define Scenarios:

- Simulate demand fluctuations to observe the impacts on the data set
- Simulate disruptions at all levels of the supply chain.

3. Running simulation

- Enter the monthly demand, adjust the monthly demand, and enter into the simulation, using the demand multiplier which derives from temperature and rainfall data to reflect seasonal and weather-driven functions
- Fill the factory production plan, based on forecasted demand lead times and disruptions.
- Review orders and inventory levels from each stage of the supply chain

4. Interpretation of Results:

- Identify the weaknesses by examining inventory data for bottlenecks or stockouts. Look out for delays in order adjustments and response time and analyse the impact of times of unmet demand.

- Evaluate the system's overall responsiveness by assessing how well the supply chain reacts to scenarios such as increases or decreases in demand and factory halts.

Defining Example Scenarios

Specific scenarios can be run to analyse the performance of the coffee bean supply chain in Vietnam.

– Scenario 1: Demand increases due to heavy rainfall

This scenario showed an increase in base demand of 30% (1.3 Multiplier) combined with a rise of 15% due to high rainfall month (at >150mm). This resulted in processing facility inventory falling rapidly, simultaneously leading to shortages in both distribution and retail levels. This also impacted factory production, resulting in unmet demand in May and June. Additionally, costs increased significantly due to increases in logistics activity and overtime processing requirements. Key findings from this scenario demonstrated that a 10% safety stock multiplier would not be enough to mitigate the big increase, emphasizing the need for a larger percentage of safety stock, such as 20%, during peak months when production is at its highs. Also, logistics operations failed to keep up with the increased distribution volumes, which highlights the importance of more flexible transportation planning to efficiently address demand surges.

– Scenario 2: Demand decreases due to low rainfall

In this given scenario, we see a base demand reduction of 20%, calculated using a 0.8 multiplier, combined with an additional 10% reduction during low rainfall months where rainfall is > 50 mm. The simulation findings show considerable inventory build-ups at farms and processing sites, resulting in higher holding costs. Orders from retailers and distributors fell aggressively, reducing revenue for upstream supply chain members. Although less demand reduced transportation and production costs, a surge in inventory storage led to inefficiencies. Insights from this scenario revealed that the system in place was slow to adjust production schedules, resulting in persistent overstocking across many levels. The findings suggest that real-time demand forecasting and production planning could help to reduce overproduction in periods where demand is low. Additionally, operational costs were reduced, but the inefficiencies in inventory management emphasize the importance of dynamic safety stock adjustment and better response to order planning to align with demand fluctuations.

– Scenario 3: Factory worker strike (2-month halt in production)

In this scenario, we stimulate a complete factory production halt during May and June, with no changes made to demand or lead times. The findings revealed serious inventory shortages at every stage of the supply chain, including distribution, processing, and retail. Unmet demand spiked up in June, which coincided with high rainfall months when demand was inherently higher. Recovery from the disruption needed 3 months of increased production and logistical action, which resulted in additional expenses to stabilize inventory levels. Key insights showed that the system is quite vulnerable due to the lack of safety stock it holds at production facilities, emphasizing the impact of the production halt. The delay in recovery was a default of 2 2-month lead time, underlining the need for a shorter lead time, for instance maybe one month to improve responsiveness. Additionally, it would be important to mitigate these concerns through pre-emptive resilience strategies such as increasing safety stock having a staggered production schedule and holding a positive and close relationship with employees.

Learning outcomes, recommendations, and conclusion

This project has emphasized the vital role of simulation models in researching, analysing, and optimizing the Vietnamese coffee supply chain. The model includes crucial variables such as inventory levels, logistical delays, cost breakdowns, and the impact of weather fluctuations, and has highlighted the vulnerabilities and the interconnectedness between each stage of the supply chain, from manufacturing to distribution to retail. Scenarios such as sudden demand increases, and a production halt demonstrated how disruptions and seasonal demand changes can affect the supply chain. These scenarios highlight the need for dynamic safety stock modification, continuous demand forecasting, and effective recovery strategies.

The simulation provides key insights into optimizing safety stock and the critical need for shorter lead times. Recommendations include dynamic safety stock policies, reducing lead times, resilience strategies, and integrated supply chain collaboration. The findings also showed how predictive analytics can help predict weather-driven changes in demand and allow a better synchronization of production and logistics.

In conclusion, this study has highlighted the complexity and challenges involved in managing the Vietnamese coffee supply chain. The simulation model provided a detailed analysis of key performance indicators, identified bottlenecks, and evaluated robustness under various scenarios. The results have emphasized the need for proactive, fact-based approaches in managing stocks, optimizing costs, and reacting to disruptions.

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