# Designing an Efficient Supply Chain for Specialty Coffee from Caldas-Colombia

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## ABSTRACT

The coffee industry generates annual revenues of approximately US$250 billion, with more than 60 million people dependingon it globally. However, coffee farmers in producing countries are operating at a loss due to selling at low pricesto intermediaries who control the downstream channels. Recent studies highlighted the need to open channels for farmers to access the market of finished products (roasted coffee). However, most farmers do not have the skills and resources to create these alternatives. In this research,we developa cost minimization model that determines the most cost-efficient supply chain network configuration, starting from the farmers in Caldas, Colombia, to the Northeastern region of the United States. We formulated a MILP network model with a cost minimization objective. We considered several candidate facilities, transportation modes, and coffee processing technologies in our model. Our model also considers multiple periods, multiple echelons, single product, and weight and volume variations along the supply chain. The model was solved for different demand scenarios and the optimal solution was analyzed for each. Theoutcome is a better understanding and a framework of the optimum cost network configuration, which can be implemented by producers.

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# 1. INTRODUCTION

The coffee industry has grown to be one of the biggest industries in the world, witharound US$250 billion annual revenues. Every year, around 400 billion cups of coffee are consumed and at least 60 million people are economically depending on it (Sachs, Cordes, Rising, Toledano, & Maennling, 2019). Also, within an otherwise slow-growing food and beverages market, coffee sales are estimated to grow quickly at a compounded annual growth rate (CAGR) of 5.5% from the year 2019 to 2024 (Mordor Intelligence, 2019)

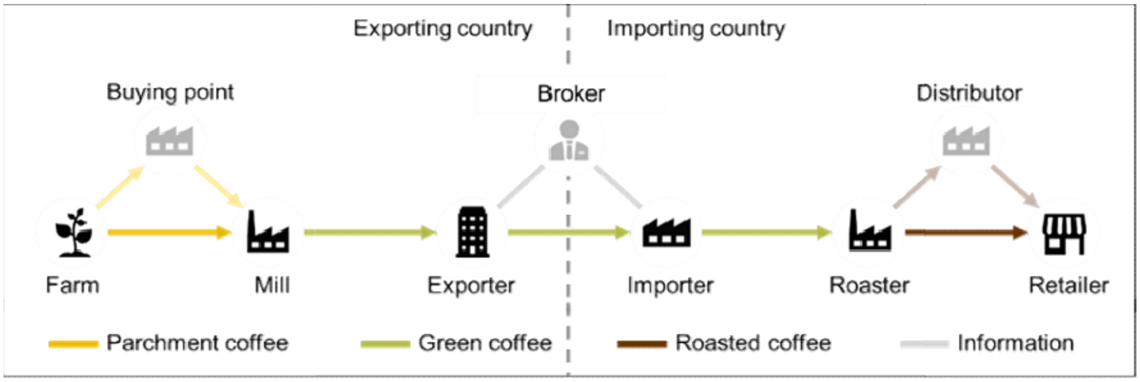


*Figure 1. Coffee value chain*

Figure 1 illustrates the stages in the coffee value chain and the intermediaries involved. Coffee undergoes three main transformation stageswhere it loses 89% of its mass. These stages are1) Pulping at farms: where the skin and pulp of the farmed coffee beans (known as red cherry coffee bean)are separated to get parchment coffee beans, 2) Milling: where the dried husk is removed from parchment coffee beans to get green coffee beans, and 3) Roasting: where the green coffee beans are heated and transformed into the aromatic brown roasted coffee beans we buy. Farmers are responsible for pulping operations at the start of the value chain while milling and roasting are doneby companies downstream in the supply chain.The additional intermediaries only trade the product without transforming it. Although the intermediaries provide important distribution functions such as transportation, roasting, and sales,producers can take more steps downstream to capture a higher share of value(Sachs et al, 2019).

In existingcoffee supply chains, there can be up to 12 entities across multiple points along the value chain.Intermediaries such as roasters and retailers are the largest beneficiaries of value gained. Some of the industry leaders are reporting operating profit margins above 15%(Macrotrends, 2019).Consolidation of intermediary industry leaders has created a monopsonist power that allows them to put pressure on producers, forcing them to lower prices(Sachs et al, 2019). Thus, at a global level, the gap between producer and retail prices has increased over time and the largest actors are capturing a higher share of the price paid by consumers.

Intermediaries provide important distribution functions such as transportation, roasting, and sales. However, producers can take more steps downstream to capture a higher share of the retail price. These steps include downstream optimization of the supply chain, partnerships with entities which provide downstream services, utilizing new roasting technology to improve productivity, and other downstream strategies(Sachs et al, 2019). In recent years, producers have managed to capture only 2% to 17% of the retail price of standard coffee(UNCTAD, 2016) and only 1% to 2% of the price paid for a cup of specialty coffee (Sachs et al, 2019). This situation is causing an increasing proportion of farmers to fall under the poverty line with daily incomes below US$1.90 (ICO, 2019b).

## 1.1. COLOMBIAN COFFEE INDUSTRY AND CALDAS REGION

Coffee is one of the main industries in Colombia and a source of income for more than 540,000 families involved in its cultivation(FNC, 2019). It is the third biggest producing country, with $2.7 billion worth of exported goods in 2017, which represented 8.9% of the total global trade in monetary value. Colombia’s main customer is the United States, since 43% of its coffee is exported there.

The United States imported $6.03 billion of coffee in 2017, which represented 20% of global production. This was more than any other country (OEC, 2019). American consumers spent more than $74 billion on coffee in 2015 and the industry had a total economic impact of $225.2 billion in the same year (NCA, 2019).From Colombia, the United States imported $1.16 billion of coffee in 2019, which represented 19% of its total coffee import(OEC, 2019). However, this has not protected Colombia from the global coffee crisis. In 2019, one-third of Colombian producers were unable to cover their cash outlays and 53% of them operated at a loss when the full costs of production are considered (ICO, 2019a).

The Caldas Department (A Department in Colombia is like a State in the US) stands out within the Colombian coffee industry for two reasons. First, it is one of the biggest producers in the country with more than US$500 million of yearly exports. Second, its geographic conditions allow it toproduce very high-quality coffee. There are more than 33,000 coffee producers in the department and over 300,000 people depend on this industry(Comite de Cafeteros de Caldas, 2019). Out of all the exporting markets, the Northeastern United States is the biggest for Caldas. In 2018 alone, the department exported more than $225 million of coffee to the United States (43.89% of the total exports), with over $120 million destined to the Northeastern region of the country.

## 1.2. CAFÉ BOTERO

The Botero family has been producing coffee in Caldas since 1907, and like most producers worldwide, they have beenimpactedby the low prices. Café Botero, a company that was founded in 2013, has been dedicated to roasting and commercializing coffee in Colombia as a finished product. Café Botero's strategy was to increase their share of revenue by implementing downstream integration in the coffee supply chain.Until 2019, the company has focused on the Colombian B2B market of specialty roasted coffee.

The main problem forfarmersisthe low price at which they are selling their coffee.This creates a value propositionfor producers to evaluate downstream integration options. Café Botero has decided to cater to this value proposition by opening international selling channels, starting from the Northeastern region of the United States. Thus, Café Boterodecided to collaborate with other producers from Caldas.The reasonsfor the collaboration were twofold: First, to open a higher revenue alternative for other producers who do not have the capacity to integrate downstream. Second, to gain competitive advantage by broadening their coffee portfoliowith a bigger selection of flavors, origins, altitudes, and coffee varieties. The latter will provide a competitive advantage because customers in the specialty coffee market value the option to choose between coffees of different botanical varieties, altitudes, milling processes, flavors, aromas, etc., which can be achieved only by offering beans from multiple farms.

To open its international selling channel, Café Botero needs to design a supply chain that allows the company to process and transport coffee from different farms in Caldas to distributors in the Northeast region of the United States. The aim is to create a cost-effectivesupply chain to guarantee a competitive selling price and an improved mark-up to enable a higher payment to farmers. A cost-effective downstream integration by Café Botero can create higher income opportunities for other producers. These producers can partner with and utilize Café Botero's distribution channel instead of selling their products to intermediaries at low prices.

## 1.3. MOTIVATION AND RESEARCH QUESTION

The income of coffee farmersis estimated at 2% to 17% of the final priceof their products which is very low. This situation is causing an increasing proportion of farmers to fall under the poverty line (ICO, 2019b). Therefore, to provide higher income to coffee farmers, effective integration of downstream operations is vital. This supply chain should include all the intermediate processes and transportation of coffee from farms in Caldas to distributors in Northeast United States. This needs to be achieved in a cost-effective manner to guarantee a competitive selling price while improving share of revenue for farmers.

Given the current situation of the coffee industry and the opportunity for farmers to take control of downstream operations through an efficient supply chain, the proposed research question is: How can Café Botero design acost-effective supply chain network from Caldas to Northeastern USA for specialty coffee?

# 2. LITERATURE REVIEW

We start our literature review with an overview of the coffee production and distribution process, which helps understand the structure and properties of the supply chain. Next,we dive into relevant literature on supply chain network design and the methods utilized to solve them. This information is a guidance for designing andoptimizing a customized network for Café Botero from Colombia to Northeastern USA.

## 2.1. COFFEE PRODUCTION AND SUPPLY CHAIN

Coffee beans undergo several transformation operations at different locations along the supply chain, and each of them impacts the total weight and volume of the beans (Hicks, 2002). These weight and volume variations are mainly due to the removal of the layers that cover the coffee bean, the loss of water and the physical transformation when exposed to the high temperatures of roasting (Mutua, 2000).

Table 1shows the operating processesstarting from the moment coffee is picked from the tree, until it is ready to be sold to consumers. The table also presents the typical location at which each of the operations is performed (Bee, et al., 2005),and the weight yields and density at each step of the process (Mutua, 2000).

***Table 1. Operations along the coffee production process***

| Process | Location | OutputCoffee Product | Final weight yield (kg) | Density (kg/lt) |
|---|---|---|---|---|
| Picking | Farm | Cherry coffee | 6.88 | 0.80 |
| Pulping and washing | Farm | Wet coffee | 2.82 | 0.80 |
| Drying | Farm | Parchment coffee | 1.50 | 0.40 |
| Hulling | Hulling mill | Green coffee | 1.25 | 0.66 |
| Sorting | Hulling mill | Excelso green coffee | 1.16 | 0.66 |
| Roasting | Roaster | Roasted whole bean coffee | 1.00 | 0.37 |
| Grinding | Roaster | Roasted ground coffee | 1.00 | 0.31 |

Coffee is not a highly perishable product, but its quality is affected through time (Bladyka, 2013). However, it is important to consider that the rate at which coffee loses its quality depends on its state.

There are 3 main states: The initial state is called cherry coffee, which is picked by farmers. The second state is called green coffee, which is a result of the milling process. Green coffee, when packed under the right conditions, can be stored without significantly losing quality for at least 12 months (Meira Borém, et al., 2013) and up to 15 months (Tripetch & Borompichaichartkul, 2019).  The third state is roasted coffee, which is a result of the roasting process (Bee, et al., 2005).

The case of roasted coffee is more complexin terms of freshness and shelf life. One of the most determinant factors in slowing the loss of freshness is the packaging technology (Bladyka, 2013). Previous research has shown that the use of high barrier aluminum packaging and controlled atmospheres can extend the product's shelf life for up to 46 weeks without significantly affecting the quality (Glöss, Schönbächler, Rast, Deuber, & Yeretzian, 2014). Research focused on Colombian specialty coffee suggests that experts can perceive a loss of quality in only 10 days, but regular customers won't significantly notice it even 60 days after roasting when packed in traditional bags (Bladyka, 2013).

A holistic view is necessary to design a supply chain network that accommodates various facilities and related operational processes. In addition, the design also needs to consider the constraints that arise due to the change in physical characteristics of coffee beans such as weight and freshness as well as transportation constraints.

## 2.2. SUPPLY CHAIN NETWORK DESIGN (SCND)

Supply chain network design (SCND) determines the structure of a supply chain and impacts its cost and performance. Its goal is to design an efficient network structure or to reengineer an existing network to increase its total value. Multiple decisions about the number of chain tiers, locations, and facility capacities in each tier and the flow of material/product throughout the network are made during the SCND process (Reza, et al., 2014).

The first step in building a SCND model is data collection. Related data includes transportation data, facilities data, current flows, and flow units. Transportation data consists of mainly inbound (IB) and outbound (OB) data. Facilities data consists of cost and capacity data. Costs can be further broken down into fixed costs of facilities and variable costs of units. The flow data consists of volumes flowing between nodes,which is essential in understanding the impact on network design (Watson, et al., 2014).

A key benefit of SCND model is the ability to run different scenarios to test how different constraints affect the optimal solution (Chopra, et al., 2014). SCND is a strategic decision that is conducted with multiyear time horizons and has a very high potential impact on return on assets or investment. The transactional and tactical problems are conducted more frequently but have a lower potential impact. All these solutions should align with the overall supply chain strategy and network design (Ellet, Steve, 2015)

## 2.3. METHODS FOR SOLVING SUPPLY CHAIN NETWORK DESIGN MODELS

SCND models are solved through different methods, from exact mathematical solvers to near-optimal algorithms (Eskandarpour, Dejax, Miemczyk, & Péton, 2015). Considering the high-dimension(many variables) and complexity of SCND problems, selecting an adequate solving methodcan be challenging. These methods can be classified into four categories: mathematical techniques, simulation, heuristics and metaheuristics (Fahimnia, Farahani, Marian, & Luong, 2013). This project adopts mathematical techniques to tackle our problem.

Supply chain models have been mathematically solved through Linear programming, Mixed Integer programming and Lagrangian Relaxation models (Fahimnia, Farahani, Marian, & Luong, 2013). Linear programming (LP) is applied when the objective function and constraints of the model are strictly linear(Chinneck, 2017). Mixed Integer Programming (MIP) models consider both real-valued and binary variables. Within MIPs, there are Mixed Integer Linear Programming (MILP) models that have linear mathematical expressions, and Mixed Integer Non-Linear Programming (MINLP), which are harder to solve (Chinneck, 2017). Lagrangian Relaxation focuses on simplifying the problem by eliminating the constraints that make it difficult to solve and including those constraints in the objective function. Then, the problem can be solved using simpler models (Bertsekas, 1998).

# 3. DATA AND METHODOLOGY

The objective of our research is to design a cost-effective supply chain network from Caldas to the Northeastern region of the United States for Café Botero’s specialty coffee. To do this, we follow the seven-step methodology described in Figure 2. The supply chain was initiallycharacterizedby analyzing different sources of information and identifying the main variables, parameters and constraints of the network. Then, the complete network of candidate nodes and arcs was constructed and mathematically modeled.

The next step after the formulation of the optimization model was to gather and clean the data for the model’s parameters. The model was programmed into GurobiOptimizer and solved for different demand scenarios. The results and conclusions of the project are presented in sections 4 and 5.

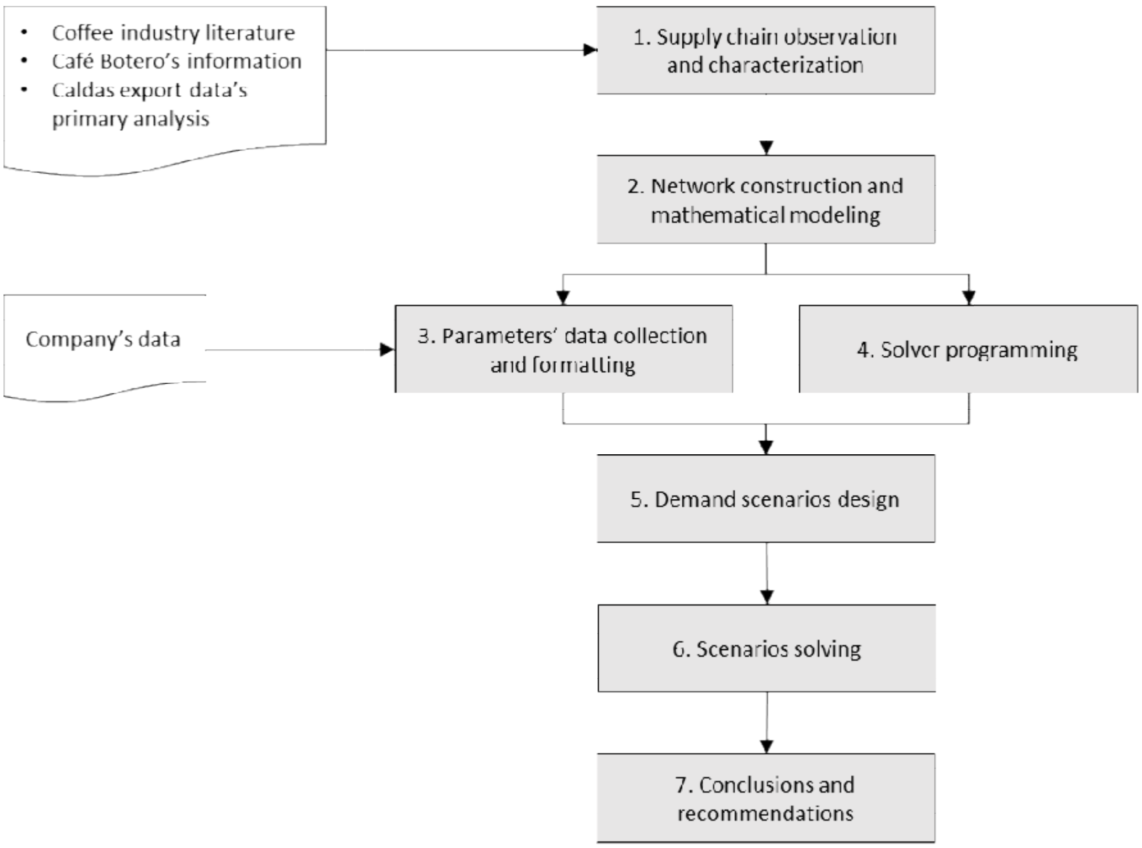


*Figure 2. Adapted from Project'smethodology diagram(Winston & Venkataramanan, 2002)*

## 3.1. SUPPLY CHAIN OBSERVATION AND CONCEPTUALIZATION

The main goal of this section is to identify the structure of the supply chain, the candidate nodes, arcs, and their attributes. We use this information to formulate the variables, parameters and constraints of the optimization modelin Section 3.2.

First, we gathered and analyzed information about the coffee supply chain from different sources. This analysis led us to understand the journey of coffee from the farms in Caldas to the distributors in the Northeastern region of the United States. It also allowedus to understand the constraints in terms of time (shelf life), transportation options and product transformation.

### *3.1.1. Sources of Information*

We used two main sources of information to understand the structure of the coffee supply chain from Caldas to the Northeast USA, which are the coffee industry literature and Caldas' coffee exports historical data.

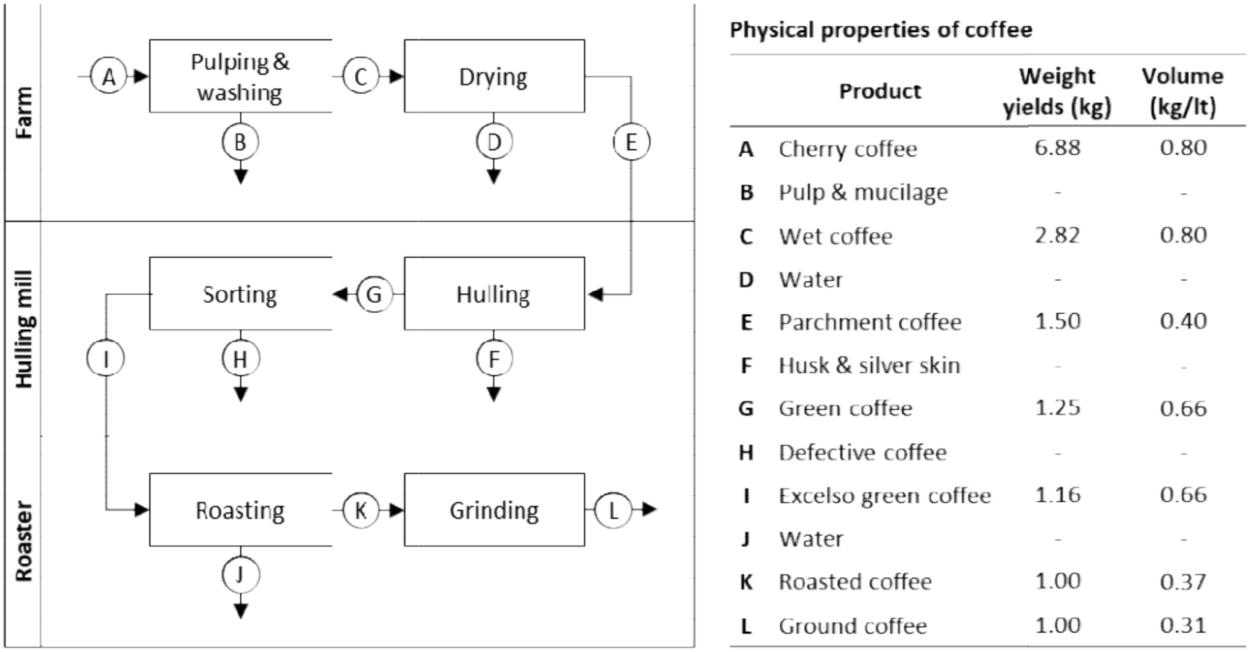
**Coffee industry literature:** The literature review of the coffee production and its supply chain is explained in Section 2.1. We used thatinformation to understand three points. First, the stages of the production process and the location at which they take place. Second, the variation of the volume and weight of the coffee beans as they move downstream in the supply chain. Finally, the stability of the product's quality through time.

**Caldas'coffee exports historicaldata:**Café Botero does not have a structured channel for exports yet. Therefore, the information that the company can provide regarding international operations is very limited. We needed other sources to understand the current structure of the global supply chain of Caldas' coffee.

The *Universidad Nacional de Colombia* provided us the data for every single coffee export from Caldas between 2009 and 2018, totaling28,086 shipments. We conducted a primary analysis with this data tounderstandthe destinations for the product, its demand andtransportation channels. The data's metadata can be found in Appendix A.

**Preliminary Analysis and Insights:** The analysis of the data and information gathered provided us insights on different aspects of the coffee supply chain. These insights are explained below.

***Coffee production process:*** After the coffee leaves the farm, it is transported into two types of facilities: hulling mills and roasters (Bee, et al., 2005). The product changes considerably in volume and mass due to the physical and chemical processes involved at each of these facilities (Mutua, 2000). Figure 3illustrates thesetransformation processes.



**Physical properties of coffee**

| | Product | Weight yields (kg) | Volume (kg/lt) |
|---|---|---|---|
| **A** | Cherry coffee | 6.88 | 0.80 |
| **B** | Pulp & mucilage | - | - |
| **C** | Wet coffee | 2.82 | 0.80 |
| **D** | Water | - | - |
| **E** | Parchment coffee | 1.50 | 0.40 |
| **F** | Husk & silver skin | - | - |
| **G** | Green coffee | 1.25 | 0.66 |
| **H** | Defective coffee | - | - |
| **I** | Excelso green coffee | 1.16 | 0.66 |
| **J** | Water | - | - |
| **K** | Roasted coffee | 1.00 | 0.37 |
| **L** | Ground coffee | 1.00 | 0.31 |

***Figure 3. Coffee transformation process***

***Coffee´s quality stability:*** As explained in Section 2.1, coffee is not highly perishable, but its quality diminishes through time (Bladyka, 2013). The stability of the beans depends on the stage of the process and the storage conditions. Table 2 shows the amount of time that coffee can be stored after a certain process without significantly losing quality.

***Table 2. Coffee stability after each processing stage***

| Process | Coffee Output | Stability after processed (months) |
|---|---|---|
| Hulling | Green | 12 |
| Sorting | GreenExcelso | 12 |
| Roasting & packing | Roasted | 2 |
| Roasting & packing with controlled atmosphere | Roasted | 10.6 |

***Demand through time:***Yearly coffee exports from Caldas to the United States present a clear upward trend between 2009 and 2018.Figure 4 shows the total yearly weight in millions of tons exported. Until 2016 the trend was positive, but in 2017 and 2018 the increase was dramatically higher.

We also calculated the monthly seasonality index of the shipments(Lembke, 2015).Figure 5shows the shipments' seasonality. It illustrates that the seasonality index of the yearly shipments has a positive trend throughout the second semester of the year. It peaks in December and declines in February.

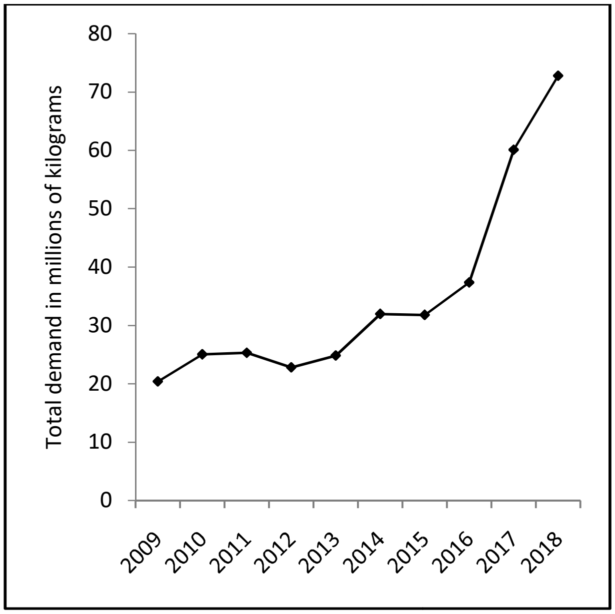


*Figure 4. Yearly demand (2009-2018)*

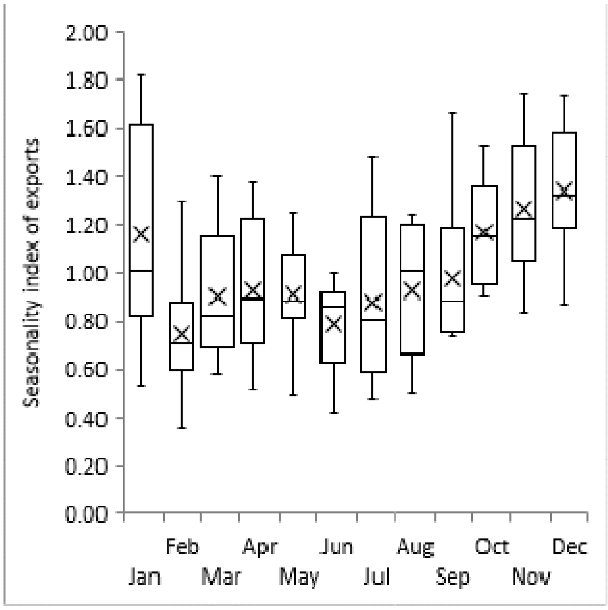


*Figure 5. Seasonal index of yearly coffee exports per month (2009-2018)*

**Shipping route:** The percentage of the total coffee shipped through each of the ports and airports in Colombia during the last three years is shown inTable 3.The data shows that maritime transportation is the primary option.Almost all (99.9%) of the green coffee that Caldas exports to the United States is shipped by sea. However, for roasted coffee, it is only 54.97%. The rest is sent by air.

*Table 3. Caldas' coffee exports by exporting port and type of product (2009 to 2018)*

| Port | Type | Percentage per product | |
|---|---|---|---|
| | | **Green** | **Roasted** |
| Buenaventura | Port (Pacific) | 56.06% | 54.97% |
| Cartagena | Port (Atlantic) | 39.97% | 0.00% |
| Santa Marta | Port (Atlantic) | 3.96% | 0.00% |
| Bogotá | Airport | 0.01% | 35.52% |
| Cali | Airport | 0.00% | 7.26% |
| Medellin | Airport | 0.00% | 2.25% |
| **Total** | | **100%** | **100%** |

**Size of shipments and transportation modes:**Shipping units determine the candidate modes of transportation to be considered in the model.This analysis also helped us understand the most common size of each sale, and thus the behavior of the demand and shipping.

As shown in Table 3, 99.9% of green coffee is exported by sea. The cases in which green coffee was shipped by air were exceptions. Therefore, we do not consider air as a transportation mode for green coffee in our optimization model.

Figure 6 shows the density of shipments of green coffee by weight in tons. The graph presents a peaking pattern every approximately 19 tons. This indicates that the product is predominantly shipped in full container loads (FCL), since coffee is bulky and 20 feet containers (TEUs) have a total capacity of 19 to 21 tons. While consolidating cargo is possible for this type of export, it is difficult and not recommended due to the risk of contamination (International Trade Centre, 2011). Therefore, the only transportation mode considered for green coffee in the optimization model is FCL by sea.

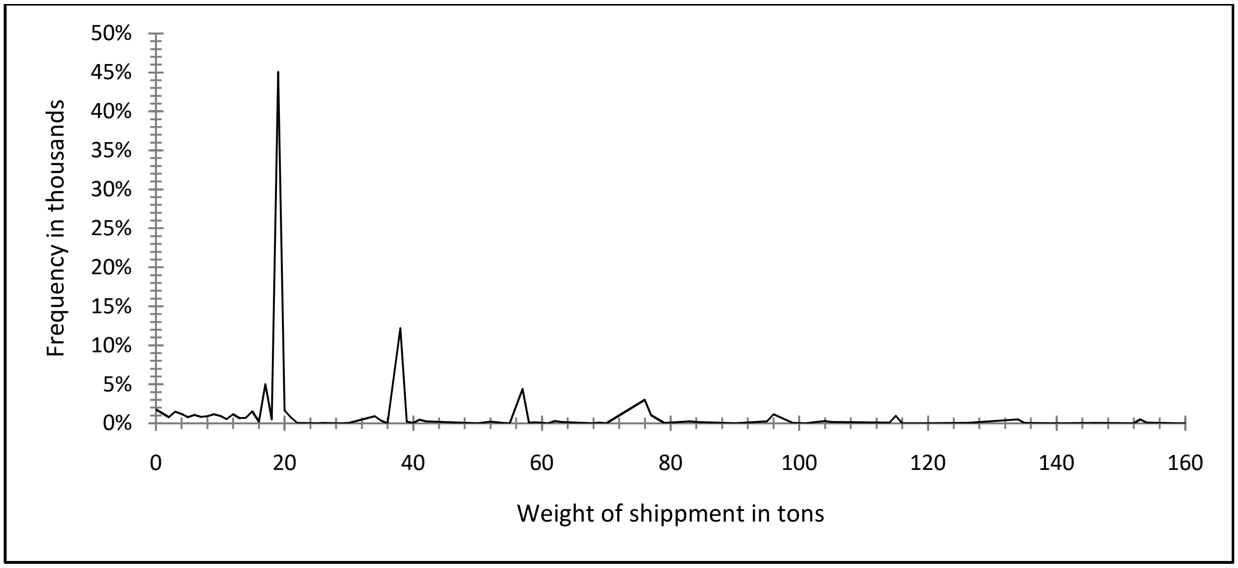
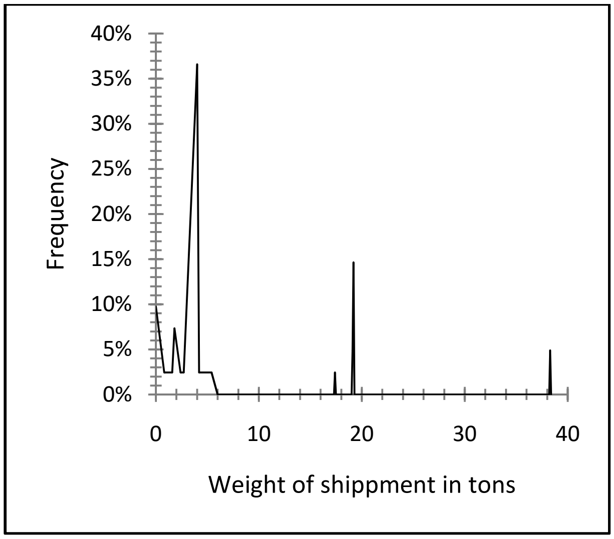


***Figure 6. Frequency of green coffee shipments by sea (2009-2018)***

Figure 7 and Figure 8 show the density of roasted coffee shipments sent by sea and air. It is clear in the data that the amount of roasted coffee shipments transported by air falls dramatically after 0.5 tons, and remains close to zero after one ton. Considering that one pallet has a capacity of 500 to 800 kilograms of roasted coffee, we argue that companies prefer to ship pallets by sea as soon as the quantity reaches the necessaryweight to fill one pallet. Just like with green coffee, the shipments of roasted coffee by sea shows peaks every 19 tons, meaning that the product is transported in full container loads.



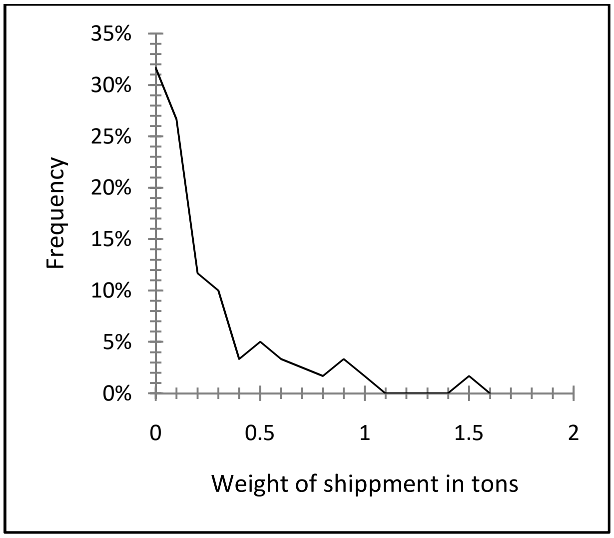


***Figure 7. Frequency of roasted coffee shipments by sea (2009-2018)***

***Figure 8. Frequency of roasted coffee shipments by air (2009-2018)***

### *3.1.2. Supply chain mapping*

To characterize Café Botero's supply chain, it is important to understand the different types of facilities involved in the process, their locations, and the transportation options between them.We explain them below.

**Facilities:** There are six types of facilities within the coffee supply chain which include farms, mills, roasters with traditional packing technology, roasters with controlled atmosphere packing technology, warehouses, and distributors.Product transformation occurs only at mills and roasters. This transformation generates physical and chemical changes in the coffee beans, affecting their weight, density, and shelf life, as explained in Section 2.1. At roasting facilities, coffee can be packed using two different technologies: Traditional and controlled atmosphere packing. The second option extends its stability by avoiding oxidation.

Table 4 shows for each type of node: the product input and output, the weight and density variations occurring and the stability of the product after leaving the facility. For this case, stability does not refer to the expiration date, but to the time it takes for the product to significantly lower quality in the eye of the final consumer.

***Table 4. Types of Facilities and theircharacteristics***

| Facility type | Notation | Coffee Input | Coffee Output | Weight variation | Density variation | Stability (months) |
|---|---|---|---|---|---|---|
| Farm | *s* | N/A | Parchment | -22.67% | 65.00% | N/A |
| Mill | *m* | Parchment | Green | -22.67% | 65.00% | 12 |
| Roaster – T1 | *r(t1)* | Green | Roasted | -17.50% | -48.48% | 2 |
| Roaster – T2 | *r(t2)* | Green | Roasted | -17.50% | -48.48% | 10.6 |
| Warehouse / DC | *w* | Green/Roasted | Green/Roasted | 0% | 0% | N/A |
| Distributor | *c* | Roasted | N/A | 0% | 0% | N/A |

*Note: T1: Traditional packing technology    T2: Controlled atmosphere packing technology*

The model also considers multiple capacities for the roasting facilities. This capacity depends mainly on the equipment used. It is important to consider the capacity, especially for those candidate nodes that imply setting up new facilities.

**Transportation modes:** It is vital that our model includes multiple transportation modes, since the choice between them modifies the whole supply chain configuration. The difference in costs, capacities and transit times impacts the decision on where to locate facilities and where to do transformation processes, particularly when considering the product's weight and density variations and its stability.

Also, due to the difference in weight and volume capacities, it is important to consider both 40feet containers (FEUs) and 20 feet containers (TEUs). Green coffee is normally shipped in TEUs,but since it is bulky, the payload capacity cannot be fully utilized(International Trade Centre, 2011). Roasted coffee's density is even lower, so it is important to consider the option of shipping it in FEUs to better utilize containers.

Table 5 shows the transportation modes to be considered. Different transportation modes can be used at different stages along the supply chain. To determine if a transportation mode can be used between two nodes, two key factors must be considered: 1) transit time and 2) product applicability, which captures product safety and storage during transportation.

***Table 5. Transportation modes' characteristics***

| Transportation mode | Notation | Applicable products | Applicable region | Shipping unit | Transit time (days) |
|---|---|---|---|---|---|
| Bulk | *b* | Parchment/Green | Colombia | kg | 1-2 |
| Maritime – FEU | *f* | Green/Roasted | International | FEU | 15-25 |
| Maritime – TEU | *t* | Green/Roasted | International | TEU | 15-25 |
| Maritime – Consolidated pallet | *p* | Roasted | International | Pallet | 15-25 |
| Air freight | *a* | Roasted | International | kg | 5-10 |
| Delivery | *d* | Green/Roasted | United States | kg | 1-2 |

**Network structure:** We mappedthe network structure considering the facility types, transportation transportation modes and the process's constraints.

shows a simplified network diagram that considers the feasible configurations of the supply chain, following the notations presented inTable 4 and Table 5. This structure is further developed in Section 3.2.1 considering all the candidate facilities for each type of node.

We designed the network in a way that every route complies with the constraints. Thereby, we ensure the product is delivered to the customer within its stability time constraint.

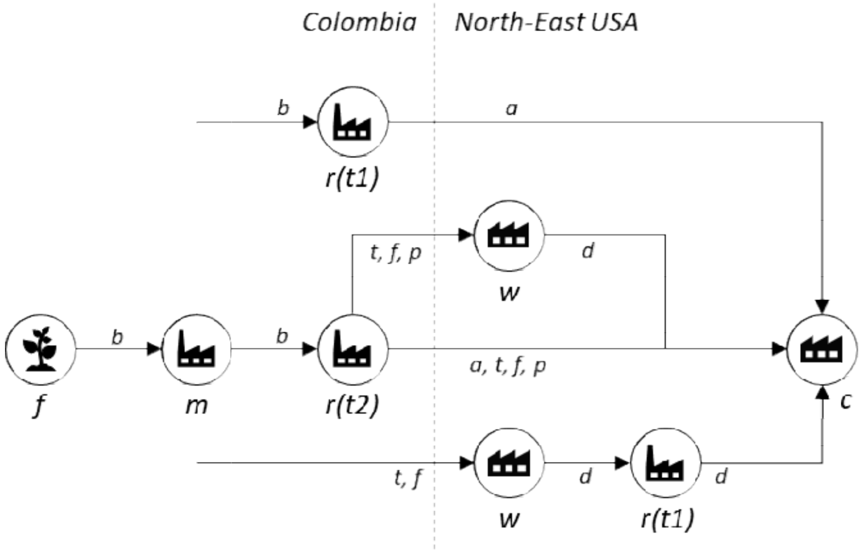


*Figure 9. Simplified supply chain network diagram model formulation*

### 3.1.3. *General description of a supply chain network design problem*

In this study, we propose asupply chain network design (SCND) for creatingan efficient network that meets the demand of the customersof Café Botero and ensures the lowest possible cost to serve the network, while meeting the capacity constraints. In general, we specify a SCND problem by the following information and notations:

- A set of $m$ supply points from which the goodsare shipped. Supply point $i$ can supply at most $S_i$ units.
- A set of $n$ demand points to which the goodsare shipped. Demand points $j$ must receive at least $D_j$ units of the shipped good.
- Each unit produced at supply point $i$ and shipped to demand point $j$ incurs a variable cost of $c_{ij}$
- $S$ and $D$ are the supply and demand constraints.
- $M_{ij}$isan arbitrary large number, specific to each arc (but the value could be the same between arcs)

- $\forall ij$ are the linking constraints to ensure we do not allocate shipments to a location that is not used.
- $P_{min}$and$P_{max}$are constraints on the number of facilities to use. The sum of the Y-variables will be the total number of facilities in use.
- $\forall ij$ and $\forall i$ are the non-negativity constraints (for x's) and the binary constraints (for the Y's).

Minimize$z = \Sigma_i \Sigma_j c_{ij} X_{ij} + \sum_i f_i Y_i$

Subject to,

$\Sigma_j x_{ij} \leq s_i \quad \forall i \ \in S$(Supply Constraints)
$\Sigma_i x_{ij} \geq Dj \quad \forall j \in D$(Demand Constraints)
$x_{ij} - M_{ij} Y_i \leq 0 \quad \forall ij$(Linking Constraints)
$\Sigma_i Y_i \geq P_{min}$(Minimum facilities constraint)
$\Sigma_i Y_i \leq P_{max}$(Maximum facilities constraint)
$x_{i_i} \geq 0 \quad \forall ij$(Non-negativity constraint)
$Y_i = \{0, 1\} \quad \forall i$(Binary constraint)

The SCND model involves two phases of data collection and analysis:

**Transportation data:**The goal here is to understand the costs and capacities associated with both inbound and outbound transportation. Transportation costs are assumed to be linear in SCND with transportation volumes. This may not always be the case in reality; however, to build a model, we need to find a linear approximation. There are several ways for that:

a. Using regression analysis to find costs.
b. Using benchmark rates from other sources.
c. Analyzing historical data to determine average transport cost.
d. Using list prices.

**Facilitiesdata:**Facility costs include be both fixed and variable costsin the SCND model. These facilities can be owned by the company and/or operated by a thirdparty, and the parameters of the model must be adjusted accordingly. Capacity is a key element in the facilities data. The capacity is the maximum throughputover a specified unit of time.

The overall formulation of the Supply Chain Network Model is a Mixed Integer Linear Program (MILP) as indicated in Section 2.3 of literature review.

### *3.1.4. Formulation of the Optimization model*

In this section, we present the formulation of the SCND model and the variables and parameters we consider in the solution. The proposed model finds the route of least cost from the supply nodes to the demand nodes within the network of feasible solutions.

The general structure of the supply chain network from Caldas to Northeast USA is presented in Figure 9. In Figure 10we illustrate a complete layout of the network, including all the candidate nodes and arcs considered by the model.

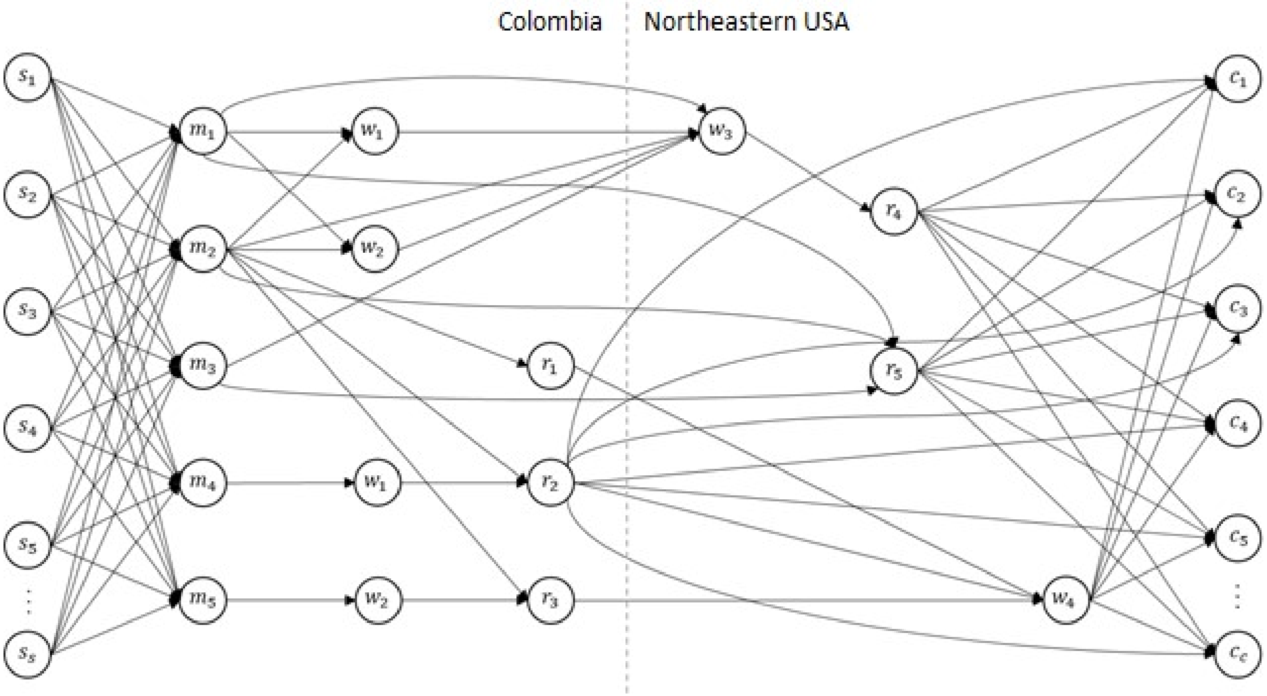


***Figure 10. Complete network layout***

Figure 10 illustrates the candidate locations for each facility and the transportation modes between them. The candidate locations are all the facilities that Café Botero would be willing to utilize or set up within its supply chain distribution network. Multiple locations are considered for each facility type, and multiple transportation modes can be considered between every pair of nodes.

Each arc between two nodes can contemplate multiple options of transportation modes. In the case of roasting facilities, technologies will be modeled as variable indexes, so each node has the option to adopt either of the two technologies.

To define our SCND model, we use the following decision variables.

| | |
|---|---|
| $y_f^p$ | binary variable to operate candidate facility *f* on period *p* |
| $x_f^p$ | flow(kg) of product tofacility *f* on period *p* |
| $ry_{rek}^p$ | binary variable to operate roasting facility *r*using technology *e* and capacity *k* on period *p* |
| $rx_{rek}^p$ | flow(kg) of product to roasting facility *r* with technology *e* and capacity *k* on period *p* |
| $ty_{ijt}^p$ | binary variable to flow product from nodes$i \in N$ to $j \in N$ on transportation mode *t* on period *p* |
| $tx_{ijt}^p$ | flow(kg) of product from node $i \in N$ to node $j \in N$ on the transportation mode *t* on period *p* |
| $tz_{ijt}^p$ | flow (shipping units) from node $i \in N$ to node $j \in N$ on the transportation mode *t* on period *p* |

It is important to mention that number of shipping units $tz_{ijt}^p$is an integer to avoid fractional shipments. Having defined the decision variables, we now define all relevant costs and capacities. In order to set constraints of our model, let the following parameters of the model be

| | |
|---|---|
| $f_f^p$ | fixed cost of opening the candidate facility *f* on period *p* |
| $c_f^p$ | cost of transforming or storing one kilogram of product at candidate facility *f* on period *p* |
| $rf_{rek}^p$ | fixed cost of opening roasting facility *r* with technology *e* and capacity level *k* on period *p* |
| $rc_{rek}^p$ | cost of roasting 1kg of green coffee at facility *r* with technology *e* and capacity *k* on period *p* |
| $tf_{ijt}^p$ | fixed cost of transporting product from nodes $i \in N$ to $j \in N$ on transport mode *t* on period *p* |
| $tc_{ijt}^p$ | cost of transporting 1kg of product from nodes $i \in N$ to $j \in N$ on transport mode *t* on period *p* |
| $tq_{ijt}^p$ | cost of transporting 1 shipping unit from nodes $i \in N$ to $j \in N$ on transport mode *t* on period *p* |
| $dem_c^p$ | demand (kg) of roasted coffee on node *c* on period *p* |

| | |
|---|---|
| $M$ | constant with very high value used for the binary linking constraints |
| $cap_f$ | maxcapacity (kg) per period of candidate facility *f* |
| $rcap_{rek}$ | maxcapacity (kg) per period of roasting facility *r* with technology *e*& capacity level *k* |
| $twc_{ijt}$ | maxweight (kg) per period to transport from nodes$i \in N$ to $j \in N$ on transport mode *t* |
| $tvc_{ijt}$ | max volume (liters) per period to transport from nodes$i \in N$to $j \in N$ on transport mode *t* |
| $suw_t$ | max weight (kg) of product per shipping unit for transportation mode *t* |
| $suv_t$ | max volume (liters) of product per shipping unit for transportation mode *t* |
| $den_{ij}$ | density ($kg\ /\ m^3$) of product being transported from node $i \in N$ to node $j \in N$ |
| $wv_n$ | % weight reduction of product in node n |

The SCND model is mapped according to index sets as follows

$P$ : Set of time periods, $p \in P = \{1, 2, 3, \dots, 12\}$

$T$ : Set of transportation modes, $t \in T = \{bulk,\ air,\ pallet, TEU, FEU, distribution\}$

$E$ : Set of roasting and packing technologies, $e \in E = \{Traditional, Controlled\ atmosphere\}$

$K$ : Set of roaster capacities levels (kg/period), $k \in K = \{15000, 42000, 72000, 150000\}$

$S$ : Sourcing farms

$C$ : Demand nodes

$M$ : Candidate milling facilities

$W$ : Candidate warehousing and distribution facilities

$R$ : Candidate roasting and packing facilities

$N$: Set of all nodes $\{S \cup C \cup M \cup W \cup R\}$

$F$: Set of non-roasting nodes $\{S \cup C \cup M \cup W\}$

Then, the general formulation of our transportation problem is given by

Minimize
$$\sum_{p\in P}\left(\sum_{f\in F}\left(y_f^p f_f^p + x_f^p c_f^p\right) + \sum_{r\in R}\sum_{e\in E}\sum_{k\in K}\left(ry_{rek}^p rf_{rek}^p + rx_{rek}^p rc_{rek}^p\right) + \sum_{i\in N}\sum_{j\in N}\sum_{t\in T}\left(ty_{ijt}^p tf_{ijt}^p + tx_{ijt}^p tc_{ijt}^p + tz_{ijt}^p tq_{ijt}^p\right)\right) \tag{1}$$

The first two terms of the expression in brackets define the facilities bucket. It includes both fixed and variable cost of operating the two types of facilities which are non-roasting facilities (first bracket) and roasting facilities (second bracket).

The third bracket in the expression defines the transportation bucket. It includes fixed costs of using a transportation mode, variable cost per kilogram and variable cost per shipping unit of transportation. The fourth term represents the inventory storage cost.

Subject to

$$x_c^p \geq dem_c^p \qquad c \in C, p \in P \tag{2}$$

$$x_f^p \leq y_f^p\, M \qquad f \in F, p \in P \tag{3}$$

$$rx_{rek}^p \leq ry_{rek}^p\, M \qquad r \in R, e \in E, k \in K, p \in P \tag{4}$$

$$tc_{ijt}^p \leq ty_{ijt}^p\, M \qquad i \in N, j \in N, t \in T, p \in P \tag{5}$$

$$x_f^p \leq cap_f \qquad f \in F, p \in P \tag{6}$$

$$rx_{rek}^p \leq rcap_{rek} \qquad r \in R, e \in E, k \in K, p \in P \tag{7}$$

$$tx_{ijt}^p \leq tcap_{ijt} \qquad i \in N, j \in N, t \in T, p \in P \tag{8}$$

$$tz_{ijt}^p \geq \frac{tx_{ijt}^p}{suw_t} \qquad i \in N, j \in N, t \in T, p \in P \tag{9}$$

$$tz_{ijt}^p \geq \frac{tx_{ijt}^p den_{ij}}{suv_t} \qquad i \in N, j \in N, t \in T, p \in P \tag{10}$$

$$x_j^p(1 + wv_n) \geq \sum_{i \in N} \sum_{t \in T} \left( tx_{jit}^p \right) \qquad j \in M, j \in R, t \in T, p \in P \tag{11}$$

$$x_j^p \leq \sum_{i \in N} \sum_{t \in T} \left( tx_{ijt}^p \right) \qquad j \in M, j \in R, t \in T, p \in P \tag{12}$$

$$x_s^p - \sum_{i \in I} \sum_{t \in T} tx_{sit}^p = 0 \qquad s \in S, p \in P \tag{13}$$

$$x_c^p - \sum_{i \in I} \sum_{t \in T} tx_{ict}^p = 0 \qquad c \in C, p \in P \tag{14}$$

$$y_i^p \geq y_i^{p-1} \qquad i \in N, p \in P \tag{15}$$

$$y_f^p \quad binary \qquad f \in F, p \in P \tag{16}$$

$$ry_{rek}^p \quad binary \qquad r \in R, e \in E, k \in K, p \in P \tag{17}$$

$$ty_{ijt}^{p} \quad binary \qquad i \in N, j \in N, t \in T, p \in P \tag{18}$$

$$tz_{ijt}^{p} \quad integer \qquad i \in N, j \in N, t \in T, p \in P \tag{19}$$

$$x_{f}^{p} \geq 0 \qquad f \in F, p \in P \tag{20}$$

$$rx_{rek}^{p} \geq 0 \qquad r \in R, e \in E, k \in K, p \in P \tag{21}$$

$$tx_{ijt}^{p} \geq 0 \qquad i \in N, j \in N, t \in T, p \in P \tag{22}$$

$$tq_{ijt}^{p} \geq 0 \qquad i \in N, j \in N, t \in T, p \in P \tag{23}$$

The constraints above represent the area in which the mixed integer linear program has flexibility to find an optimal solution, satisfying the requirements for the customer, suppliers, and logistics capacities.

Equation (2) guarantees that the demand of every customer *d* is fulfilled for every time period. Constraints (3), (4) and (5) ensure that whenever product flows through a node or arc, the binary variable associated takes a value of 1. This forces the model to consider the fixed costs incurred when utilizing nodes and arcs.

Constraints (6), (7) and (8) maintain the utilization levels of every node and arc equal to or below its maximum capacity.

Constraint (9) ensures that the necessary amount of shipping units are used for each arc based on the product's weight, for every transportation mode. It does so by forcing the shipping units to take an equal or higher integer value than the total amount of product in kilograms divided by the shipping unit's weight capacity.

Constraint (10) ensures that the necessary amount of shipping units are used for each arc based on the product's volume, for every transportation mode. It does so by forcing the amount of shipping units to take an equal or higher integer value than the total amount of product in liters divided by the shipping unit's volume capacity. The product's volume is calculated by multiplying its weight and density in kg/lt.

Constraints (11) to (14) guarantee network continuity. Equation (11) and (12) imply that the total amount of product in kilograms that goes into a node is equal to the amount that goes out plus the waste. The waste is calculated by multiplying the total weight input and the weight variation factor. This only applies for nodes that transform coffee (mills *m* and roasters *r*).

Constraints (13) and (14) create exceptions for farms and customer nodes, to ensure that they behave as sources and sinks. Equation (13) guarantees that the amount of product going out of each supply node through transportation arcs is equal to the amount of product that the node supplies. Constraint (14) implies that the amount of product going into every demand node through transportation arcs is equal to the amount of product that the node demands.

Equation (15) ensures that whenever a node is opened, it remains open for every remaining period. This is particularly important for the facilities that imply investment to open.

Constraints (16), (17) and (18) declare the binary variables used to calculate the fixed cost of opening nodes and arcs. Constraint (19) declares the integer variable that counts the shipping units flowing through every arc for each transportation mode. Equations (20) to (23) represent the variables' non-negativity constraints.

### ***3.1.5. Computational solving of the Optimization model***

The optimization model was programmed and solved using Gurobi Optimizer. See Appendix B for the script. In the following chapter, we analyze outputs of our model using scenario analysis. First, our baseline scenario will validate the model using historical data from Café Botero. We then analyze other scenarios which include different demand levels, seasonality, and growth trend.

Table 6shows all the nodes considered in the network. The detailed list of arcs is included in Appendix C.

In the following chapter, we analyze outputs of our model using scenario analysis. First, our baseline scenario will validate the model using historical data from Café Botero. We then analyze other scenarios which include different demand levels, seasonality, and growth trend.

***Table 6. Nodes of the network considered by the model.***

| Node | Type | Location | Property | Capacity | Technology | Volume variation |
|---|---|---|---|---|---|---|
| s_1 | Farm | Caldas | Own | NA | NA | NA |
| s_2 | Farm | Caldas | Own | NA | NA | NA |
| s_3 | Farm | Caldas | Own | NA | NA | NA |
| m_1 | Mill | Chinchina, Caldas | Third | NA | NA | -22.67% |
| m_2 | Mill | Manizales, Caldas | Own | NA | NA | -22.67% |
| m_3 | Mill | Manizales, Caldas (at roaster) | Own | NA | NA | -22.67% |
| m_4 | Mill | Buenaventura, Port on Pacific | Own | NA | NA | -22.67% |
| m_5 | Mill | Buenavenura (at roaster) | Own | NA | NA | -22.67% |
| m_6 | Mill | Cartagena, Port on Atlantic | Own | NA | NA | -22.67% |
| m_7 | Mill | Cartagena (at roaster) | Own | NA | NA | -22.67% |
| w_1 | Warehouse | North East USA | Third | NA | Green | 0.00% |
| w_2 | Warehouse | North East USA | Third | NA | Roasted | 0.00% |
| r_1 | Roaster | Manizales, Caldas | Third | NA | T | -17.50% |
| r_2 | Roaster | Manizales, Caldas | Third | NA | CA | -17.50% |
| r_3 | Roaster | Manizales, Caldas | Own | 15,000 | T | -17.50% |
| r_4 | Roaster | Manizales, Caldas | Own | 15,000 | CA | -17.50% |
| r_5 | Roaster | Manizales, Caldas | Own | 42,000 | T | -17.50% |
| r_6 | Roaster | Manizales, Caldas | Own | 42,000 | CA | -17.50% |

| | | | | | | |
|---|---|---|---|---|---|---|
| r_7 | Roaster | Manizales, Caldas | Own | 72,000 | T | -17.50% |
| r_8 | Roaster | Manizales, Caldas | Own | 72,000 | CA | -17.50% |
| r_9 | Roaster | Manizales, Caldas | Own | 150,000 | T | -17.50% |
| r_10 | Roaster | Manizales, Caldas | Own | 150,000 | CA | -17.50% |
| r_11 | Roaster | Buenaventura, Port on Pacific | Own | 72,000 | CA | -17.50% |
| r_12 | Roaster | Buenaventura, Port on Pacific | Own | 150,000 | CA | -17.50% |
| r_13 | Roaster | Cartagena, Port on Atlantic | Own | 72,000 | CA | -17.50% |
| r_14 | Roaster | Cartagena, Port on Atlantic | Own | 150,000 | CA | -17.50% |
| r_15 | Roaster | North East USA | Third | NA | T | -17.50% |
| r_16 | Roaster | North East USA | Own | 72,000 | T | -17.50% |
| r_17 | Roaster | North East USA | Own | 150,000 | T | -17.50% |
| c_1 | Customer | North East USA | Third | NA | NA | NA |
| c_2 | Customer | North East USA | Third | NA | NA | NA |
| c_3 | Customer | North East USA | Third | NA | NA | NA |
| c_4 | Customer | North East USA | Third | NA | NA | NA |
| c_5 | Customer | North East USA | Third | NA | NA | NA |
| c_6 | Customer | North East USA | Third | NA | NA | NA |
| c_7 | Customer | North East USA | Third | NA | NA | NA |
| c_8 | Customer | North East USA | Third | NA | NA | NA |
| c_9 | Customer | North East USA | Third | NA | NA | NA |
| c_10 | Customer | North East USA | Third | NA | NA | NA |

# 4. RESULTS AND DISCUSSION

In this section we validate the model, design different demand scenarios and analyze the resulting supply chain design for those scenarios.

For the validation, we developed a prediction experiment for a baseline scenario [SC01]. In this scenario the model's parameters were fixed at historic real levels and the results were compared with the real world observed values (McCarl & Apland, 1986).

Then, we present eight different demand scenarios. These scenarios were designed with different combinations of demand level, seasonality and growth trend. We compared the results of the eight scenarios with the baseline and assessed the impact of the optimization model and its robustness.

The objective of our model is to minimize the total network costs, including those incurred at facilities and transportation. The cost of facilities is represented in the model by the nodes, and the transportation costs by the arcs. We evaluate each scenario with the change in transportation and production cost across the network. In addition, we observe the variation of our solution compared to the historic baseline.

## 4.1. MODEL VALIDATION

Before generating optimal solutions for different demand scenarios, we validated the model. Linear programming models must be validated to generate confidence on their representativeness of the real behavior of the systems (McCarl & Apland, 1986).

For the validation of our model we utilized a prediction experiment. Prediction experiments are done in an attempt to replicate a previously observed behavior of the real-life system. The model´s parameters are fixed at historical levels and its results are compared with the real world observed values. If the outcome of the model is similar enough to the historically observed values, there is confidence that the model is representative of the real system (McCarl & Apland, 1986).

The validation of our model was done by replicating previous roasted coffee shipments done by Café Botero to the United States in 2018. The results of this validation are presented on our baseline scenario [SC01].

#### *4.1.1. BASELINE SCENARIO [SC01]*

We designed a baseline scenario for validation purposes, based on previous shipments of roasted coffee done by Café Botero in 2018. For these shipments, the company milled and roasted the coffee in Caldas at nodes $m_1$ and $r_1$. Both processes were outsourced at third party facilities. The roasted coffee was then shipped directly to the customer in the United States via air.

To replicate the historic scenario, we fixed all the demand and cost parameters, and forced the model to utilize the same nodes and arcs that were used for the real shipments in 2018. Then, we compared the total cost per kilogram calculated by the model and the real cost per kilogram observed in 2018. We present the results in Table 7.

***Table 7. Result of baseline scenario analysis***

| Cost Driver | Historic baseline | Model's output baseline | Variation |
|---|---|---|---|
| Transportation | $ 3.91 | $ 3.68 | -6.00% |
| Production | $ 0.54 | $ 0.62 | 13.46% |
| **Total Cost** | **$ 4.45** | **$ 4.29** | **-3.63%** |

There was a 6.00% variation for transportation (arcs) and 13.46% for production (nodes). The total cost per kilogram calculated by the model was 3.63% lower than the real observed cost per kilogram of the historic shipments.Therefore, we can conclude that the model is accurate, and its solutions are representative of the real supply chain.

### 4.2. DEMAND SCENARIOS

To assess the robustness of the model we designed eight demand scenarios and optimized the supply chain network for them. The scenarios considered different combinations of three factors: demand level, seasonality and growth trends.

We considered two demand levels: low and high. For each of these levels we designed a scenario with stable demand throughout the year, one with seasonality, one with a positive growth trend and one combining seasonality and growth.

### 4.2.1. *Low Stable Demand Scenario [SC02]*

The first scenario considers a stable demand of 14,200 kg/month, for a total of 170,400 kg in the entire year, as shown in Figure 11Figure 13.

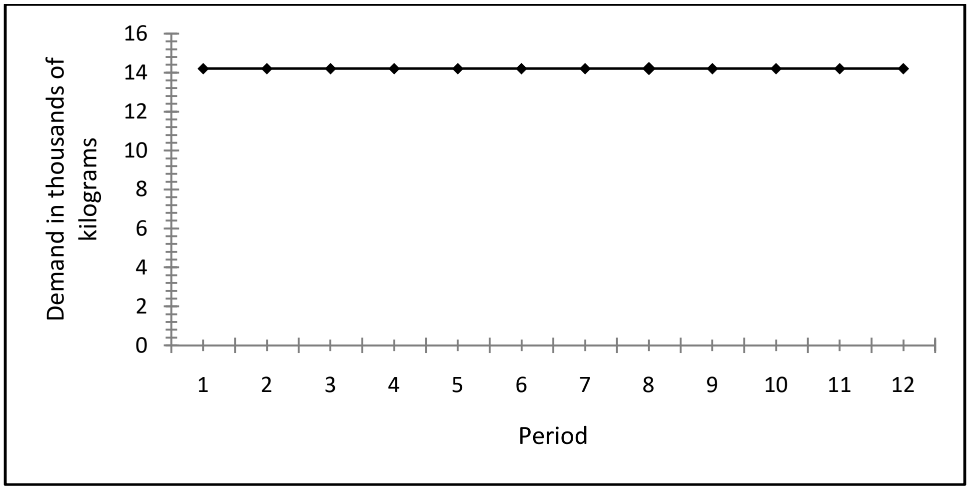


***Figure 11. Demand level for the Low Stable Demand Scenario [SC02]***

The optimal solution for this scenario recommends to mill and roast the coffee at the same facility, represented by nodes $m_3$and $r_8$. These processes should not be outsourced, and instead the company should invest in setting them up. The milling and roasting facility should be located in Manizales, Caldas. The recommended capacity level for the roaster is of 72,000 kg per month, and the controlled atmosphere technology is recommended for packing to extend the shelf life of the product.

After roasting in Caldas, coffee should be shipped directly to the customers by sea. Depending on the volume of each order, it should be shipped in pallets or full 20 feet container loads (TEUs). This structure is presented in Figure 12, and the complete solution can be found on Appendix E.

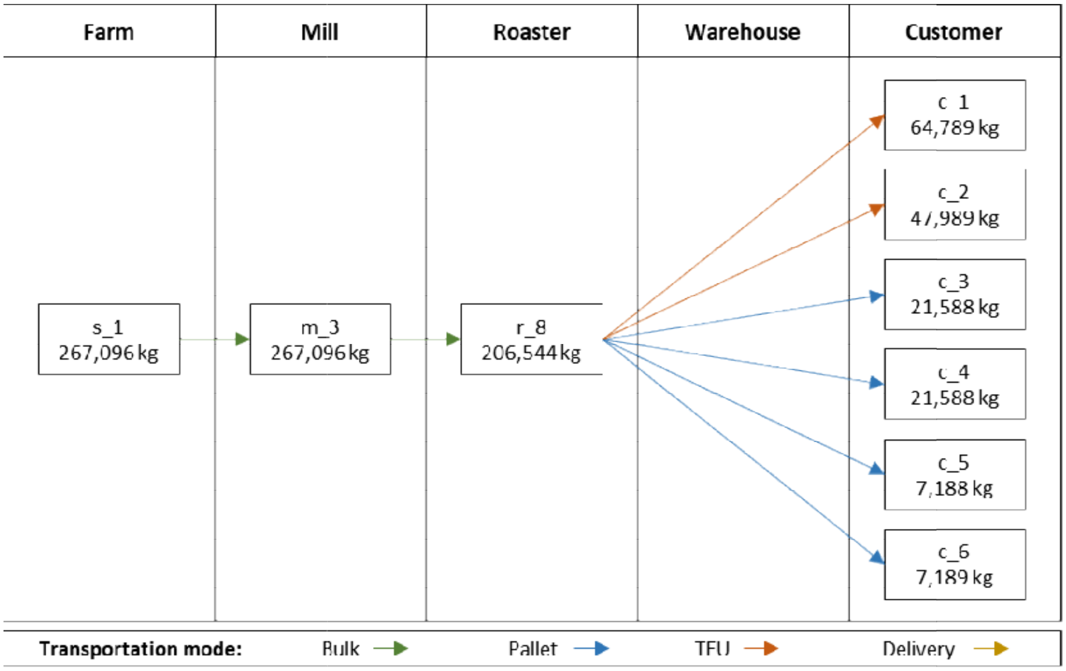


*Figure 12. Supply Chain structure for the Low stable demand scenario [SC02]*

We present the economic performance of this solution in Table 8. For this scenario, the total cost reduction was of 52.42%. The main driver for this cost reduction was the cost of transportation, with an improvement of 57.66%. This improvement was achieved by implementing sea shipping instead of air. A cost reduction of 14.78% was achieved in the facilities, due to the savings attained by operating own facilities instead of outsourcing the production processes.

*Table 8. Result of scenario [SC02] – Low stable demand*

| Cost Driver | Historic baseline | Optimized solution | Variation |
|---|---|---|---|
| Transportation | $ 3.91 | $ 1.66 | -57.66% |
| Production | $ 0.54 | $ 0.46 | -14.78% |
| **Total Cost** | **$ 4.45** | **$ 2.12** | **-52.42%** |

### *4.2.2. High Stable Demand Scenario [SC03]*

This scenario also considers stable demand, but at a higher level. For scenario [SC03], the demand is 53,600 kg/month for a total of 653,200 kg in the year, as shown in Figure 13.

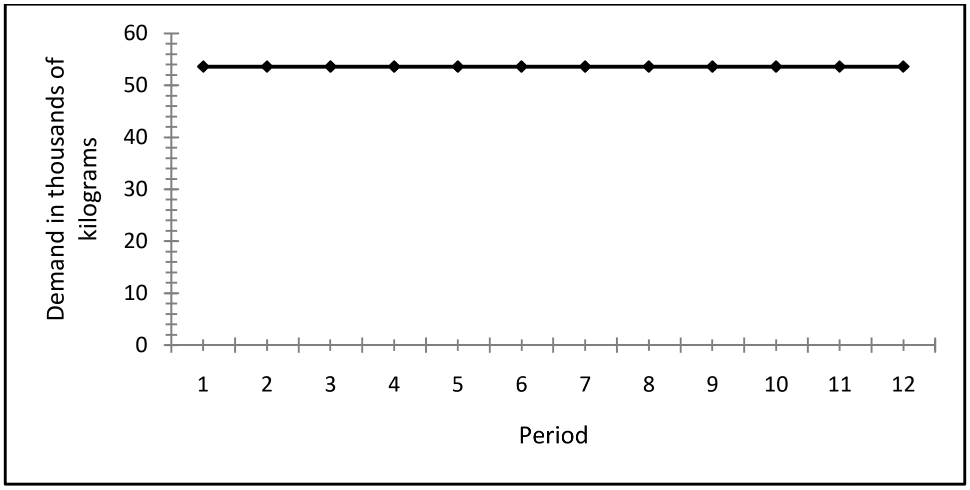


*Figure 13. Demand level for the High Stable Demand Scenario [SC03]*

As Figure 14 shows, the optimal solution for this scenario recommends to mill and roast the coffee at facilities $m_3$ and $r_{10}$, both located in Caldas. For these two processes we recommend Café Botero to set up facilities instead of outsourcing, and the capacity of the roaster should be of 150,000 kg per month. The controlled atmosphere packing technology is also recommended to extend the shelf life and allow maritime shipping. Once roasted, coffee should be shipped directly to the customers in 20 feet containers (TEUs), always by sea. The detailed solution is presented in Appendix F.

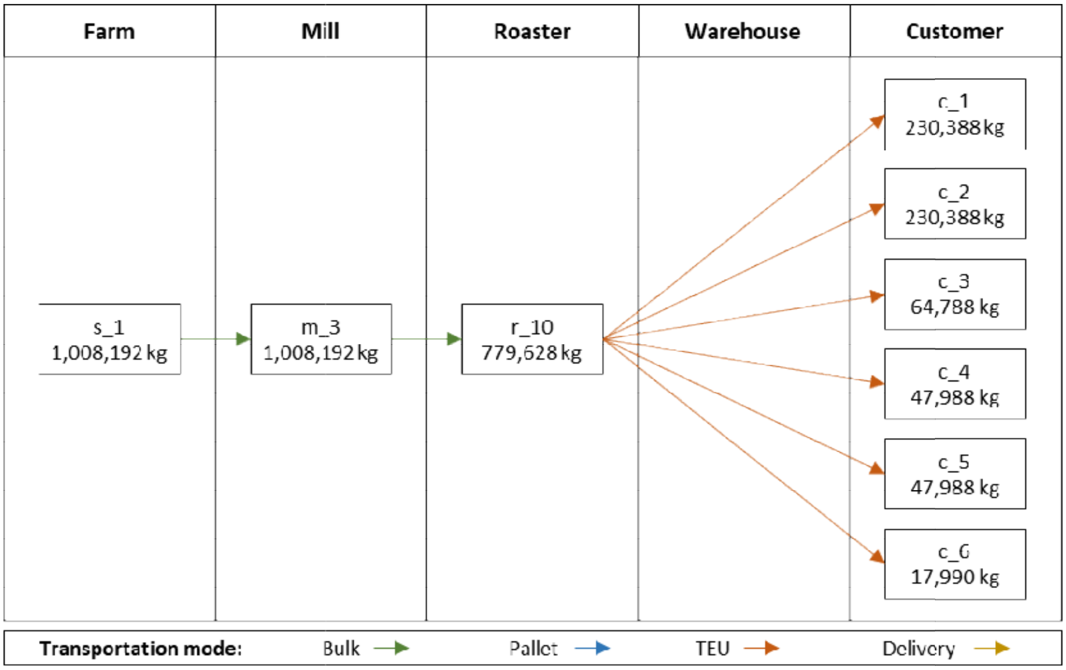


*Figure 14. Supply Chain structure for the high stable demand scenario [SC03]*

This solution generates savings of 78.96% when compared to our baseline scenario. This cost reduction is mainly generated by transportation, where we achieved savings of 83.54% due to the implementation of maritime full container load shipping. A cost reduction of 46.00% is also achieved in the facilities, by operating own facilities instead of outsourcing the production processes. This scenario also shows big cost reductions due to the economies of scale of a larger demand. The costs per kilogram are present in Table 9.

***Table 9. Result of scenario [SC03] – High stable demand***

| **Cost Driver** | **Historic baseline** | **Optimized solution** | **Variation** |
|---|---|---|---|
| Transportation | $ 3.91 | $ 0.64 | -83.54% |
| Production | $ 0.54 | $ 0.29 | -46.00% |
| **Total Cost** | $ 4.45 | $ 0.94 | -78.96% |

### 4.2.3. *Seasonality with Low Demand Scenario* [SC04]

For this scenario, the total yearly demand was of 170,400 kg the same as in scenario [SC02]. However, we adjusted the monthly demand with the seasonality indexes presented in section 3.1.1., generating a fluctuation between 40,200 kg and 71,824 kg per month. The monthly demand is presented in Figure 15.

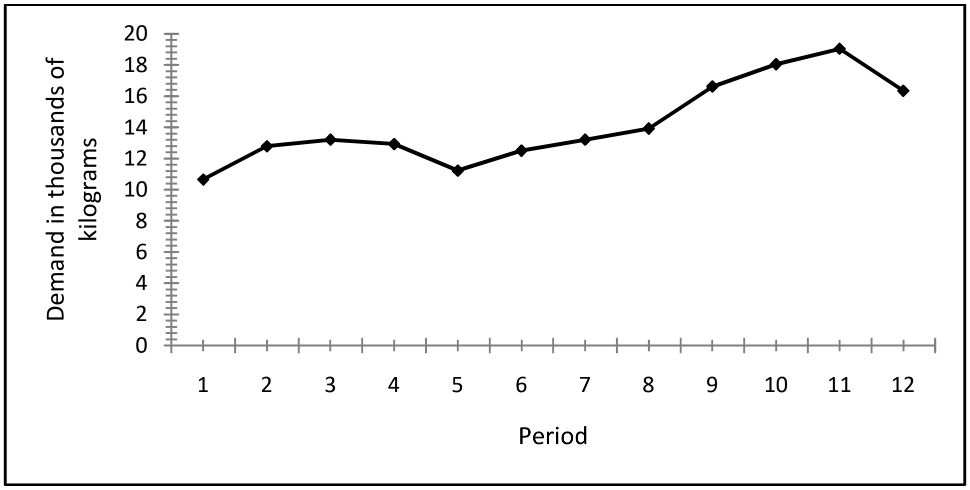


***Figure 15. Demand level for the Low Seasonal Demand Scenario [SC04]***

The optimal supply chain structure for this scenario is presented on Figure 16. The complete solution is presented on Appendix G.As the figure shows, the optimal solution recommends to mill and roast the coffee at the same facility, and these processes should not be outsourced. The milling and roasting facility should be located in Caldas. The recommended capacity level for the roaster is of 42,000 kg per month, using the controlled atmosphere technology for packing.

Coffee should then be shipped directly to the customers, always by sea. Depending on the volume of each order, it should be shipped in pallets or full 20feet container loads (TEUs).

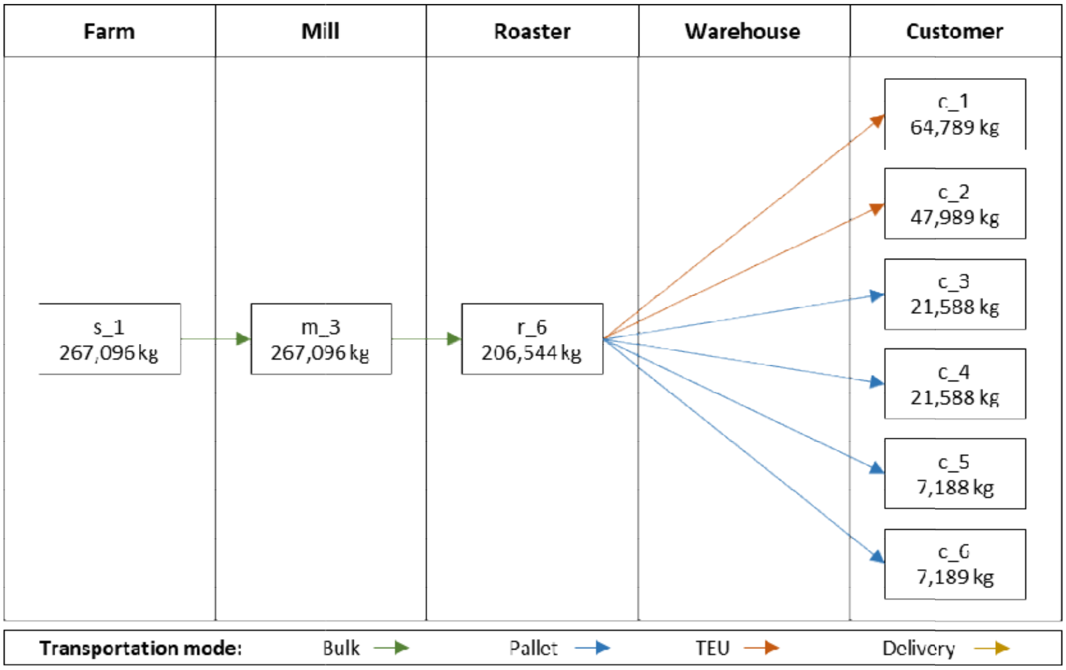


*Figure 16. Supply Chain structure for the low seasonal demand scenario [SC04]*

For this scenario, we achieved a 50.82% cost reduction. We generated saving of 19.58% at the facilities, but the main driver for cost reduction was transportation. By shipping exclusively through sea, we reached a 55.16% improvement in transportation costs. These figures can be seen on Table 10.

*Table 10. Result of scenario [SC04] – Low demand with seasonality*

| Cost Driver | Historic baseline | Optimized solution | Variation |
|---|---|---|---|
| Transportation | $ 3.91 | $ 1.75 | -55.16% |
| Production | $ 0.54 | $ 0.44 | -19.58% |
| **Total Cost** | $ 4.45 | $ 2.19 | -50.82% |

### *4.2.4. Seasonality with High Demand Scenario* [SC05]

This scenario also considers fluctuations computed with the seasonality indexes presented on section 3.1.1, but at a higher demand level. For scenario [SC05], the demand ranges between 10,650 and 19,028 kg per month, for a total of 653,200 kg in the year. This demand is shown in Figure 17.

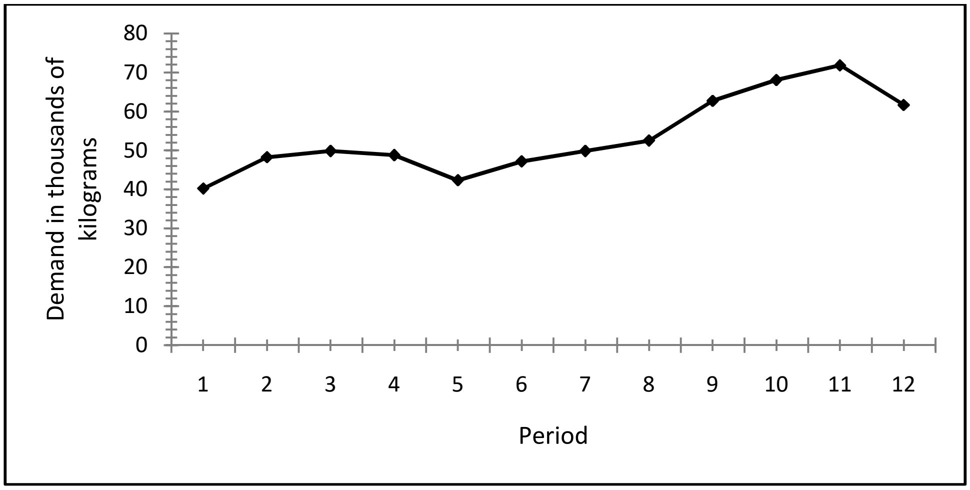


*Figure 17. Demand level for the HighSeasonal Demand Scenario [SC05]*

As Figure 18 shows, the optimal solution for this scenario recommends to mill the coffee at two different facilities: $m_1$ and $m_3$. $m_3$ should be a new facility set up by Café Botero to fulfil most of the milling demand. However, due to peaks in demand the capacity of $m_3$ would be slightly insufficient in some months. For those months, we recommend milling the excess flow at outsourced facility $m_1$.

For this scenario we recommend roasting at in Caldas, at facility $r_{10}$. Which should have a capacity of 150,000 kg per month. The controlled atmosphere packing technology is also recommended to extend the shelf life and allow maritime shipping. Once roasted, coffee should be shipped directly to the customers in 20 feet containers (TEUs), always by sea. The detailed solution is presented in Appendix H.

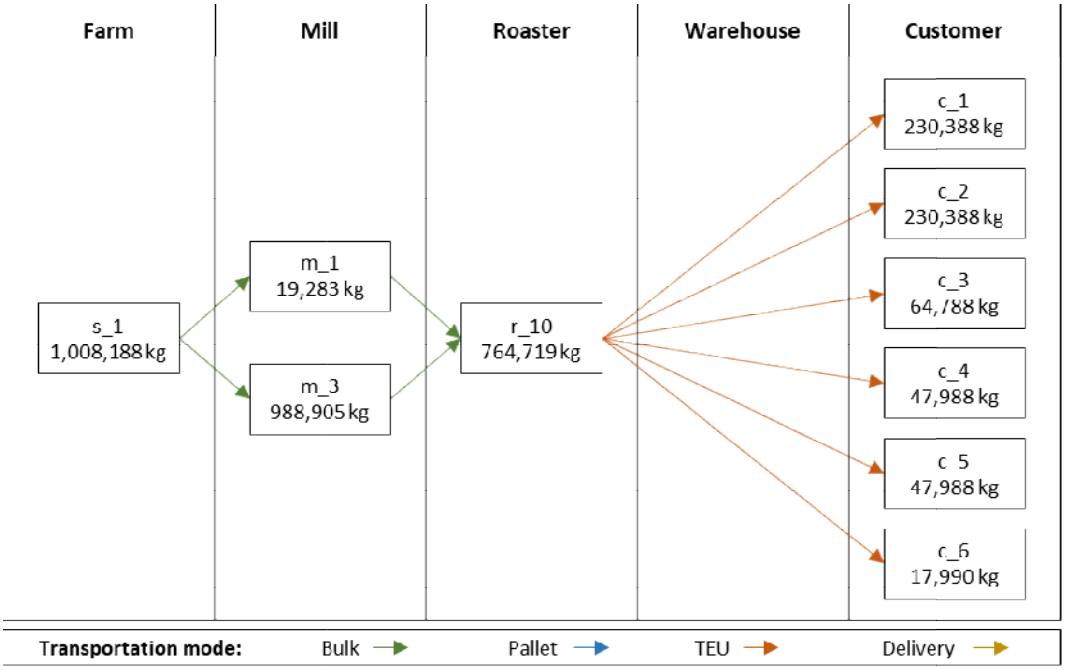


*Figure 18. Supply Chain structure for the high seasonal demand scenario [SC05]*

As Table 11shows, there is a total reduction in costs of 79.03%. The main driver for this cost reduction is transportation, with an improvement of 83.68%. This improvement is achieved by implementing sea shipping instead of air. A cost reduction of 45.56% is achieved in the facilities, due to the savings attained by operating own facilities instead of outsourcing the production processes. By comparing the solutions for scenarios [SC04] and [SC05], we can also conclude that economies of scale generate big savings throughout the whole supply chain.

*Table 11. Result of scenario [SC05] – High demand with seasonality*

| **Cost Driver** | **Historic baseline** | **Optimized solution** | **Variation** |
|---|---|---|---|
| Transportation | $ 3.91 | $ 0.64 | -83.68% |
| Production | $ 0.54 | $ 0.30 | -45.56% |
| **Total Cost** | $ 4.45 | $ 0.93 | -79.03% |

### *4.2.5. Monthly Growth with Low Demand Scenario [SC06]*

For scenario [SC06] we considered the same total yearly demand of 170,400 kg, but with a monthly 5% growth rate. Therefore, demand increased from 10,705 kg in month 1 to 18,316 kg in month 12 as shown in Figure 19Figure 22.

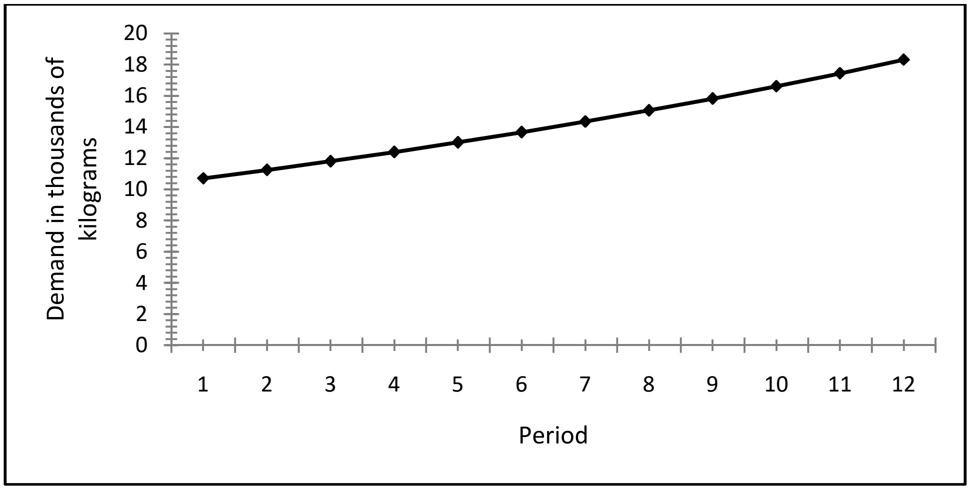


***Figure 19. Demand level for the LowGrowing Demand Scenario [SC06]***

The optimal supply chain structure for this scenario is presented on Figure 20Figure 16. The complete solution is presented on Appendix I.The optimal solution recommends to mill and roast the coffee at the facilities $m_3$ and $r_6$, both at the same location in Caldas. These processes should not be outsourced, and the recommended capacity for the roaster is of 42,000 kg per month, using the controlled atmosphere technology for packing.

Apart from all the other scenarios, our solution for [SC06] recommends utilizing a warehouse in the United States to receive and deconsolidate the customer’s orders. However, the use of this facility is only optimal in one of the 12 months. Once roasted, the shipping of coffee to the warehouse and customers should always be done by sea, either in pallets or full 20 feet container loads (TEUs) depending on the volume.

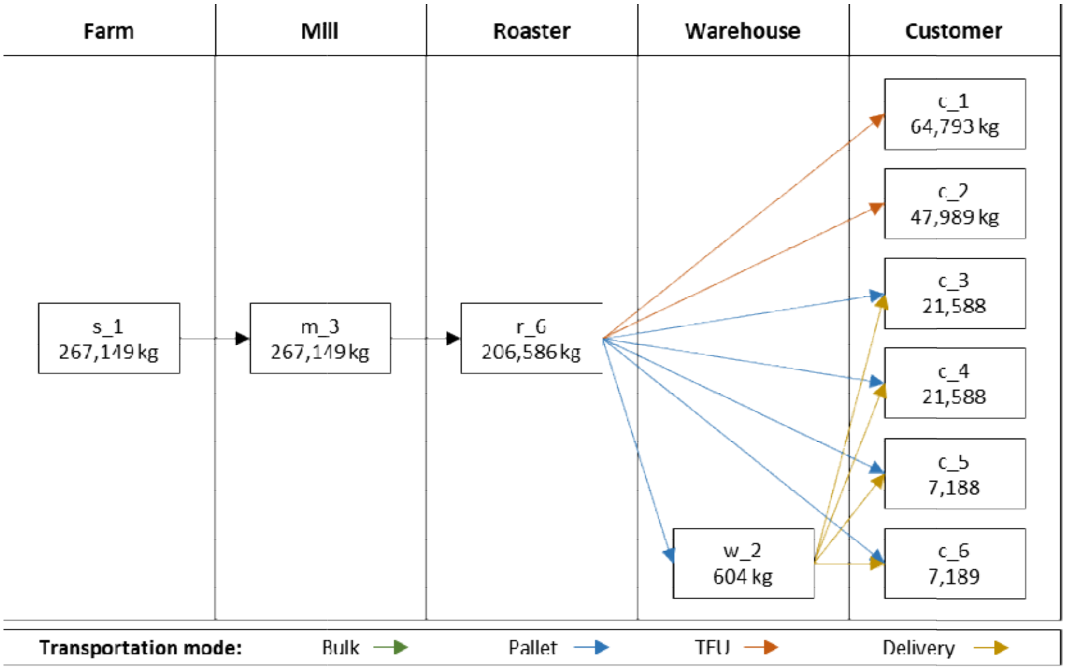


*Figure 20. Supply Chain structure for the low growing demand scenario [SC06]*

We present the economic performance of this solution in Table 12. For this scenario, the total cost reduction was of 52.42%. The main driver for this cost reduction was the cost of transportation, with an improvement of 57.66%. This improvement was achieved by implementing sea shipping instead of air. A cost reduction of 14.78% was achieved in the facilities, due to the savings attained by operating own facilities instead of outsourcing the production processes.

*Table 12. Result of scenario [SC06] – Low demand with monthly growth*

| **Cost Driver** | **Historic baseline** | **Optimized solution** | **Variation** |
|---|---|---|---|
| Transportation | $ 3.91 | $ 1.78 | -54.37% |
| Production | $ 0.54 | $ 0.44 | -19.24% |
| **Total Cost** | $ 4.45 | $ 2.22 | -50.08% |

### 4.2.6. *Monthly Growth with High Demand Scenario [SC07]*

For this scenario, the total yearly demand was of 653,200 kg. A monthly 5% growth throughout the year was considered, which means that demand increased from 40,410 kg in month 1 to 69,119 kg in month 12.

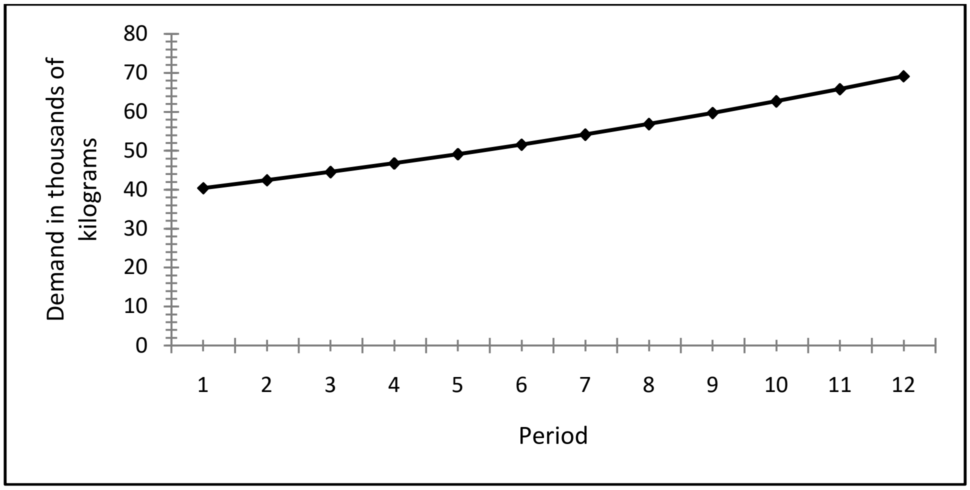


***Figure 21. Demand level for the High Growing Demand Scenario [SC07]***

As Figure 22 shows, the optimal solution recommends to mill the coffee at facilities $m_1$ and $m_3$, and roast it at facility $r_{10}$. All these facilities should be located in Caldas, and we recommend the roaster to have a capacity of 150,000 kg per month, using the controlled atmosphere technology for packing.

Due to the effects of demand growth, there are periods in which the capacity of the milling facility is not enough to cover the demand. In those periods, the solution recommends to outsource the process for the excess flow.

After roasting, coffee should be shipped directly to the customers, always by sea in 20 feet containers. The complete solution is presented on Appendix J.

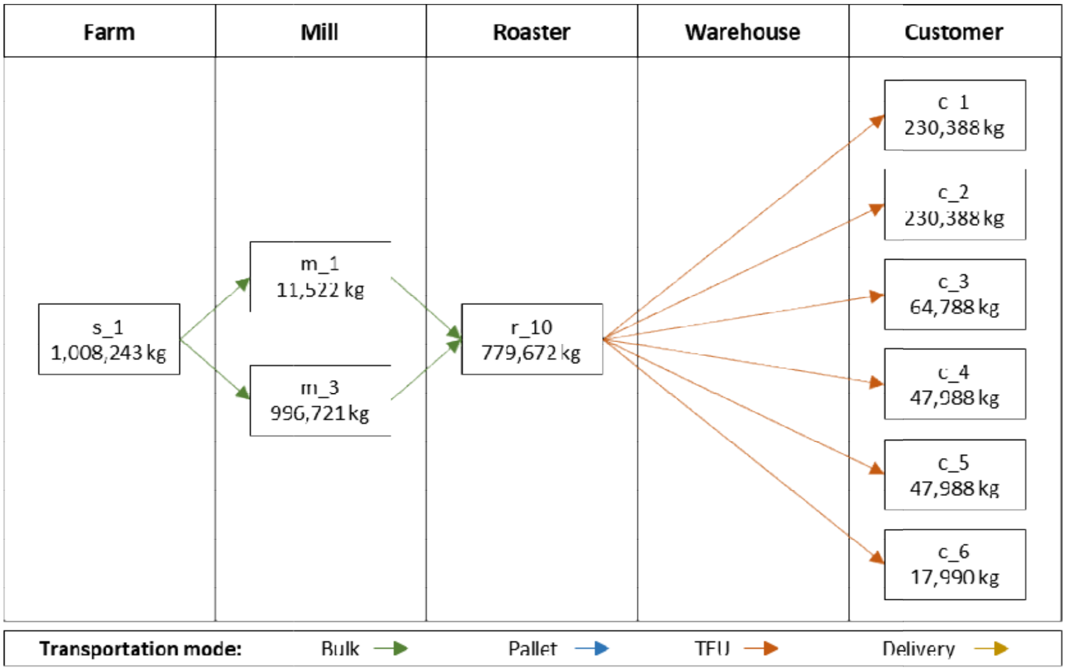


*Figure 22. Supply Chain structure for the high growing demand scenario [SC07]*

As Table 13 shows, there is a total reduction in costs of 78.93%. The main driver for this cost reduction is transportation, with an improvement of 83.55%. This improvement is achieved by implementing sea shipping instead of air. A cost reduction of 45.73% is achieved in the facilities, due to the savings attained by operating own facilities instead of outsourcing the production processes. By comparing the solutions for scenarios [SC06] and [SC07], we can also conclude that economies of scale play an important role in reducing costs throughout the whole supply chain.

*Table 13. Result of scenario [SC07] – High demand with monthly growth*

| **Cost Driver** | **Historic baseline** | **Optimized solution** | **Variation** |
|---|---|---|---|
| Transportation | $ 3.91 | $ 0.64 | -83.55% |
| Production | $ 0.54 | $ 0.30 | -45.73% |
| **Total Cost** | $ 4.45 | $ 0.94 | -78.93% |

### 4.2.7. *Low Demand with Monthly Growth and Seasonality [SC08]*

To calculate the demand of scenario [SC08], we considered a 5% monthly growth. Then, we adjusted the values using the demand seasonality indexes calculated in section 3.1.1. The total yearly demand was of 170,400 kg, fluctuating between 9,623 kg and 27,561 kg as shown in Figure 23.

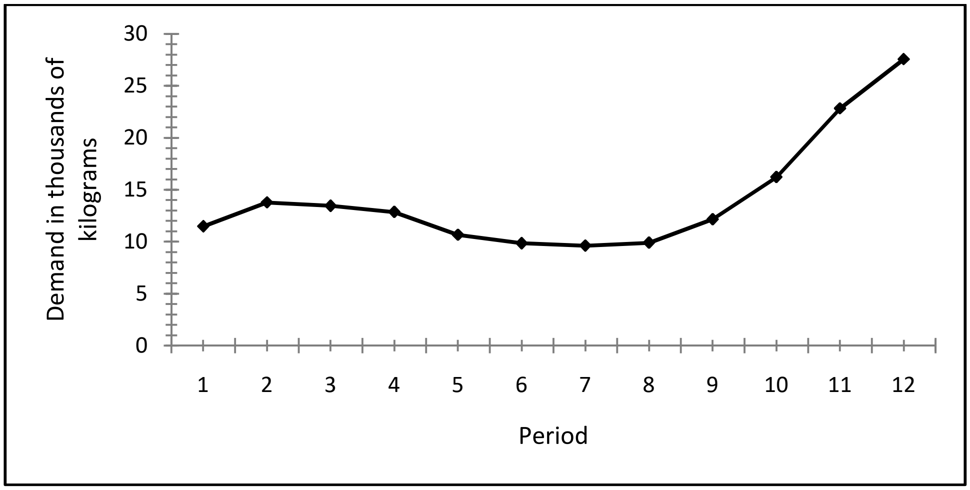


***Figure 23. Demand level for the Low Demand with Monthly Growth and Seasonality [SC08]***

As Figure 24shows, the optimal solution for this scenario recommends to mill and roast the coffee at facilities $m_3$ and $r_{10}$, both located in Caldas. For these two processes we recommend Café Botero to set up facilities instead of outsourcing, and the capacity of the roaster should be of 42,000 kg per month. The controlled atmosphere packing technology is also recommended to extend the shelf life and allow maritime shipping. Once roasted, coffee should be shipped directly to the customers in 20 feet containers (TEUs), always by sea. The detailed solution is presented in Appendix K.

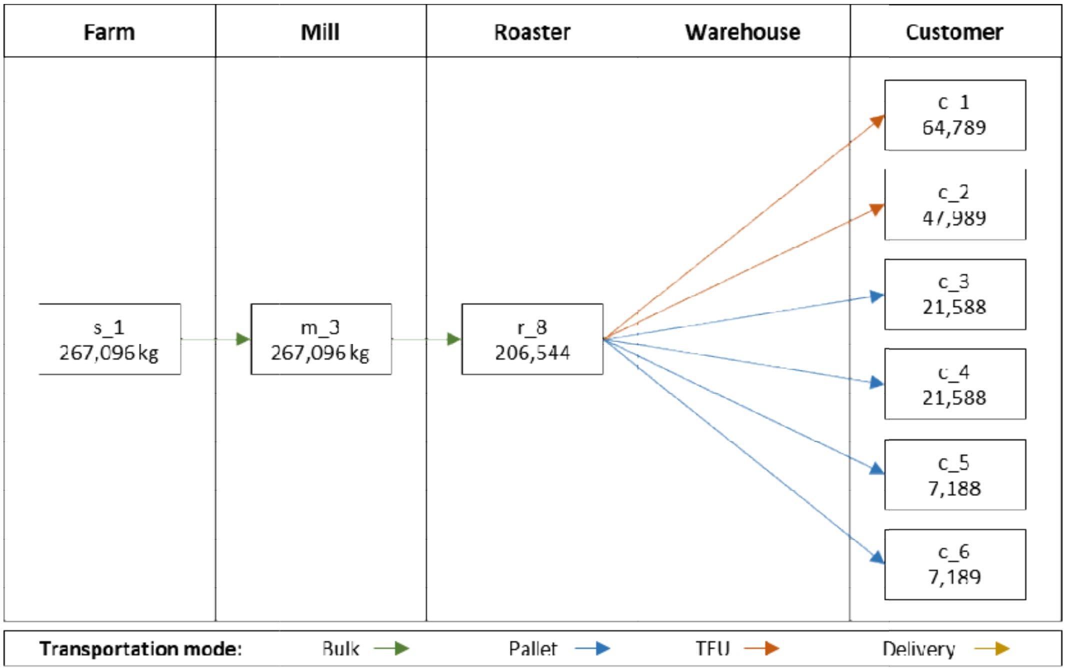


*Figure 24. Supply Chain structure for the low demand scenario with seasonality and growth [SC08]*

We present the economic performance of this solution in Table 14Table 8. For this scenario, the total cost reduction was of 51.26%. The main driver for this cost reduction was the cost of transportation, with an improvement of 55.66%. This improvement was achieved by implementing sea shipping instead of air. A cost reduction of 19.58% was achieved in the facilities, due to the savings attained by operating own facilities instead of outsourcing the production processes.

*Table 14. Result of scenario [SC08] – Low demand with monthly growth and seasonality*

| Cost Driver | Historic baseline | Optimized solution | Variation |
|---|---|---|---|
| Transportation | $ 3.91 | $ 1.73 | -55.66% |
| Production | $ 0.54 | $ 0.44 | -19.58% |
| **Total Cost** | $ 4.45 | $ 2.17 | -51.26% |

### *4.2.8. High demand with monthly growth and seasonality [SC09]*

The total yearly demand for this scenario was of 653,200 kg, and we considered both seasonality and a monthly 5% growth. Therefore, the demand fluctuated between 36,325 kg and 104,034 kg. The demand for this scenario is presented on Figure 26.

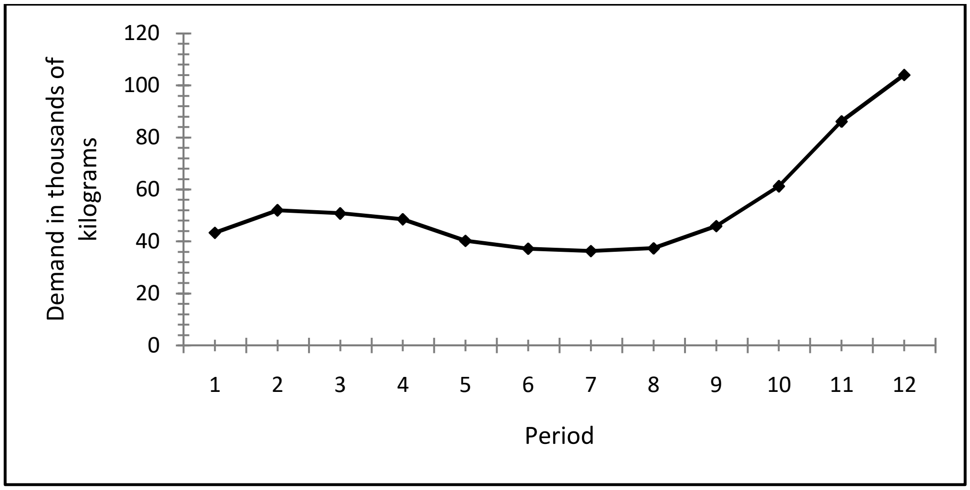


*Figure 25. Demand level for the High Demand with Monthly Growth and Seasonality [SC09]*

The optimal supply chain structure for this scenario is presented on Figure 26, and the complete solution on Appendix L. For this scenario we recommend to mill and roast the majority of the coffee at the same facility. These processes should not be outsourced, and instead the company should invest in setting them up. This facility should be located in Caldas, with a roasting capacity of 150,000 kg per month. Like in the previous scenarios, we recommend the use of controlled atmosphere technology for packing to extend the coffee's shelf life and allow for maritime transportation.

Due to the effects of seasonality and growth there are periods in which the capacity of the milling and roasting facility is not enough to cover the demand. In those periods, the solution recommends to outsource the milling process for the excess flow, and to extend the capacity of the roaster with an additional 42.000 kg/month of capacity. Coffee should then be shipped directly to the customers, always by sea in 20 feet full container loads (TEUs).

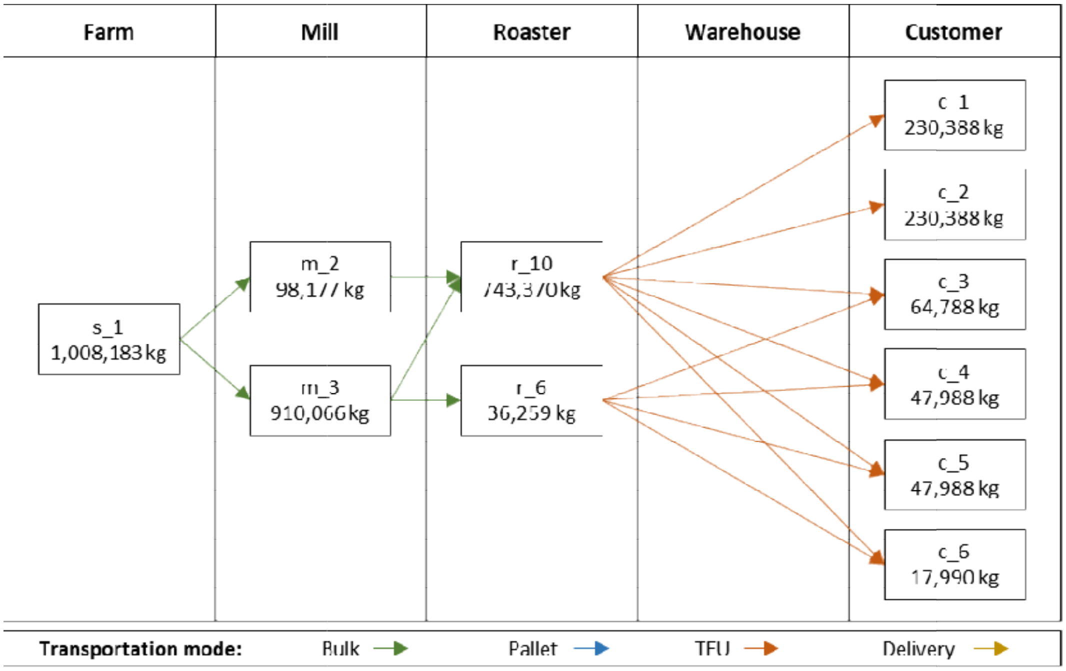


***Figure 26. Supply Chain structure for the high demand scenario with seasonality and growth [SC09]***

The economic performance for this solution is presented in Table 15.There is a total reduction in costs of 77.64%. The main driver for this cost reduction is transportation, with an improvement of 83.09%. This improvement is achieved by implementing sea shipping instead of air. A cost reduction of 38.47% is achieved in the facilities, due to the savings attained by operating own facilities instead of outsourcing the production processes.

***Table 15. Result of scenario [SC09] – High demand with monthly growth and seasonality***

| **Cost Driver** | **Historic baseline** | **Optimized solution** | **Variation** |
|---|---|---|---|
| Transportation | $ 3.91 | $ 0.66 | -83.09% |
| Production | $ 0.54 | $ 0.33 | -38.47% |
| **Total Cost** | $ 4.45 | $ 1.00 | -77.64% |

# 5. CONCLUSION AND RECOMMENDATIONS

## 5.1. CONCLUSION

Cafe Botero is a specialty coffee company located in Caldas, Colombia. The company has followed a vertical integration strategy since 2013, selling roasted coffee as a finished product in Colombia, mainly to mitigate the impact of the low coffee prices in the last years. Café Botero is now opening an international sales channel to commercialize its roasted product in the Northeastern region of the United States. For this research we developed a Supply Chain Network Design model to minimize the transportation and production costs of the new international sales channel.

To formulate the model, we first analyzed historical data and constructed the network of candidate facility nodes and transportation arcs. Then we formulated a cost minimization model and programmed it on the Gurobi optimization software. Lastly, we used the model to optimize the network for nine different demand scenarios.

The model's solution showed significant improvement opportunities in terms of production and transportation costs for all the scenarios. These scenarios involved different demand levels, seasonality and growth rates. Since the resulting supply chain configuration was consistent for the solutions of all the scenarios, we can conclude that the proposed design is optimal and robust.

Our research uncovered various findings in terms of the optimal supply chain configuration. First, coffee must be roasted in Caldas to minimize the overall supply chain cost. The company should set up their own facilities there instead of outsourcing, and coffee should be packed using controlled atmosphere technologies to enable the longer time of maritime transportation without significantly losing quality. The capacity of the roaster must be determined based on more precise demand forecasts, but it should not be lower than 42,000 kilograms per month.

Second, the milling process should not be outsourced, and it should be done in the same facility in which coffee is roasted. Doing both milling and roasting at the same location reduces the supply chain cost by eliminating unnecessary transportations and reducing the fixed costs of facilities.

Third, coffee should be transported by sea in all cases. By implementing a controlled atmosphere packing technology, the shelf life of the product can be extended enough to withstand the longer time of maritime transportation compared to air. Depending on the volume of each order, it can be shipped in full 20 feet container loads (TEUs) or in consolidated pallets. 40 feet full container loads are not optimal since coffee is a bulky product and the larger volume cannot be taken advantage of.

Additionally, implementing warehousing facilities in the United States is not recommended. The additional costs of transportation, handling and storage in warehouses cannot be balanced by the cost efficiency of shipping exclusively full container loads. Therefore, orders should be fulfilled directly from the roasting facilities to the customers.

Lastly, this research uncovered the impact of economies of scale to reduce costs. The results of the optimization model suggest that the total production and transportation costs of the network can be reduced by 51% to 78% depending on the total demand of the new sales channel. This improvement is mainly driven by the savings in transportation.

To conclude, we can say that our Supply Chain Network design model can help Café Botero design a more cost-efficient supply chain to commercialize roasted coffee from Caldas, Colombia in the North Eastern region of the United States.

## 5.2. RECOMMENDATIONS

Our research generates multiple recommendations for Café Botero. First, to minimize the amount of facilities in the supply chain and place them in Caldas. This generates cost savings for three main reasons: 1) The lower costs of operating facilities in Colombia compared to the United States reduces production costs. 2) Reducing the number of facilities eliminates unnecessary transportation and handling costs. 3) Coffee loses weight as it is processed along the supply chain. Therefore, doing the production processes closer to the farms reduces the total weight to be transported.

Second, to prioritize growth in sales volume. The scenario analysis demonstrated big impact of economies of scale in the total supply chain cost. Thereby, generating higher demand would rapidly decrease the total costs and could generate competitive advantage.

Third, that coffee should be packed utilizing controlled atmosphere technologies to prolong its shelf life and quality stability. By doing that, the company can ship all the coffee through sea and generate savings in transportation.

Lastly, we recommend the company to re-run the model as more and better data is available as mentioned in section 5.3. Once the new international sales channel starts operating, Café Botero must store the supply chain data to later recalculate the model's parameters and re-run it. This iterative process will generate continuous improvement on both the company's supply chain and the model itself.

# 6. LIMITATIONS AND FUTURE RESEARCH

## 6.1. LIMITATIONS

The main limitation for the development of our research was the scarcity of data relevant to the international roasted coffee supply chain. Since Café Botero does not have an international sales channel stablished, and less than 1% of the coffee from Caldas is exported roasted, the access to historical data is very limited.

Having more data would allow us to improve the calculation and quality of our model's parameters. This would generate better result and more accurate results. Therefore, we recommend the company to adjust and re-run the proposed model in the future, once they have more and better data. This iterative process will generate continuous improvement on both the company's supply chain and the model itself.

## 6.2. FUTURE DIRECTIONS FOR RESEARCH

Our research demonstrates the opportunity to improve the Colombian coffee supply chain through network design. This improvement has the potential to impact the life of thousands of families that depend on coffee production.

Therefore, we see three areas for further research. First, expanding our model for more or bigger geographies. By covering larger production and consumption territories, our model could be improved to positively impact the income of more producers.

Second, developing similar supply chain network design models for other similar industries. Like coffee, other crops are produced in developing countries were producers could benefit from efficient vertical integration of supply chains. Designing optimal supply chains for those products could also generate higher income for farmers in other industries that may have similar problems.

Lastly, we recommend extended research in particular aspects of our proposed supply chain. Further developing the packing technologies, the production processes within the facilities and the commercialization processes would help improve and materialize the recommendations proposed by our research.

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# 8. APPENDICES

## APPENDIX A. CALDAS' EXPORTS METADATA

**Source:** Universidad Nacional de Colombia

**Original language:**Spanish

**Description:**The dataset includes information on all the coffee exports done by companies from Caldas, Colombia, between the years 2009 and 2018.

**Shape:** 28,086 rows, 42 columns

**Columns:**

1. Index
2. Year
3. Month
4. Day
5. Customs Tariff Chapter
6. Customs
7. Boarding Customs
8. Customs Agent
9. Exporters NIT
10. Exporters Company Name
11. Municipality
12. Exporters Address
13. Exports class
14. Importers Company Name
15. Importers Address
16. Customs Tariff
17. Customs Tariff Description
18. Commercial Unit
19. Quantity
20. Net weight in kg
21. Gross weight in kg
22. Number of articles
23. Destination Country
24. Destination City
25. Department of origin

26. Department of precedence
27. Exit port
28. Transport mode
29. Country of transport vessel
30. Exporting regime
31. Export mode
32. Origin certificate
33. Special system
34. Negotiation currency
35. Payment method
36. FOB Value (USD)
37. FOB Value (COP)
38. National Added Value (VAN)
39. Transport value
40. Insurance value
41. Other values
42. Destination Continent

**Number of Records**: 28,086

## APPENDIX B. GUROBI OPTIMIZER SCRIPT

```
from gurobipy import *
from SolverStudio import *

m = Model("Capstone_Botero_Chaudhry")

# Declaring variables

y={}
x={}
ty={}
tx={}
tz={}


# Create variables for model

for s in p:
   for j in n:
      y[s,j] = m.addVar(vtype=GRB.BINARY, obj=f[s,j], name = '%s.%s' % (s,j))

for s in p:
   for j in n:
      x[s,j] = m.addVar(vtype=GRB.CONTINUOUS, lb=0, name = '%s.%s' % (s,j))

for s in p:
   for a in arcs:
      j=a_origin[a]
      k=a_dest[a]
      l=a_mode[a]
      ty[s,j,k,l] = m.addVar(vtype=GRB.BINARY)

for s in p:
   for a in arcs:
      j=a_origin[a]
      k=a_dest[a]
      l=a_mode[a]
tx[s,j,k,l] = m.addVar(vtype=GRB.CONTINUOUS, lb=0.0)

for s in p:
   for a in arcs:
      j=a_origin[a]
      k=a_dest[a]
      l=a_mode[a]
tz[s,j,k,l] = m.addVar(vtype=GRB.INTEGER, lb=0)

m.update()

# Objective function
```

```
m.setObjective(quicksum([y[s,j]*f[s,j]+x[s,j]*c[s,j] for s in p for j in n])+quicksum([ty[s,a_origin[a],a_dest[a],a_mode[a]]*tf[s,a]+tx[s,a_origin[a],a_dest[a],a_mode[a]]*tc[s,a]+tz[s,a_origin[a],a_dest[a],a_mode[a]]*tq[s,a] for s in p for a in arcs]))

m.modelSense = GRB.MINIMIZE


# Constraints

# Constraint 2
for s in p:
    for j in non_c:
m.addConstr(x[s,j]>=dem[s,j])

# Constraints 3&4
for s in p:
    for j in n:
m.addConstr(x[s,j]<=(y[s,j]*99999))

# Constraint 5
for s in p:
    for a in arcs:
        m.addConstr(tx[s,a_origin[a],a_dest[a],a_mode[a]]<=(ty[s,a_origin[a],a_dest[a],a_mode[a]]*99999))

# Constraints 6&7
for s in p:
    for j in n:
m.addConstr(x[s,j]<=cap[j])

# Constraint 8
for s in p:
    for a in arcs:
m.addConstr(tx[s,a_origin[a],a_dest[a],a_mode[a]]<=twc[a])

# Constraint 9
for s in p:
    for a in arcs:
        m.addConstr(tz[s,a_origin[a],a_dest[a],a_mode[a]]>=(tx[s,a_origin[a],a_dest[a],a_mode[a]]/suw[a]))

# Constraint 10
for s in p:
    for a in arcs:
        m.addConstr(tz[s,a_origin[a],a_dest[a],a_mode[a]]>=((tx[s,a_origin[a],a_dest[a],a_mode[a]]*den[a])/suv[a]))

# Constraint 11
for s in p:
    for j in non_s:
m.addConstr((x[s,j]*(1+wv[j])) >= (quicksum([tx[s,j,a_dest[a],a_mode[a]] for a in arcs if a_origin[a]==j])))

# Constraint 12
for s in p:
    for j in non_s:
m.addConstr(x[s,j] <= (quicksum([tx[s,a_origin[a],j,a_mode[a]] for a in arcs if a_dest[a]==j])))
```

```
# Constraint 15
for s in p:
    for j in n:
m.addConstr(y[s,j] >= y[p[p.index(s)-1],j])


# Print solution
def printSolution():
    if m.status == GRB.status.OPTIMAL:
        #print('\n \n SOLUTION \n')
        for s in p:
            for j in n:
                if y[s,j].x>0:
                    print ('y(%s.%s) = %d'%(s,j,y[s,j].x))

            for j in n:
                if x[s,j].x>0:
                    print ('x(%s.%s) = %d'%(s,j,x[s,j].x))

            for a in arcs:
                if ty[s,a_origin[a],a_dest[a],a_mode[a]].x>0:
                    print ('ty(%s.%s.%s.%s) =
%d'%(s,a_origin[a],a_dest[a],a_mode[a],ty[s,a_origin[a],a_dest[a],a_mode[a]].x))

            for a in arcs:
                if tx[s,a_origin[a],a_dest[a],a_mode[a]].x>0:
                    print ('tx(%s.%s.%s.%s) =
%d'%(s,a_origin[a],a_dest[a],a_mode[a],tx[s,a_origin[a],a_dest[a],a_mode[a]].x))

            for a in arcs:
                if tz[s,a_origin[a],a_dest[a],a_mode[a]].x>0:
                    print ('tz(%s.%s.%s.%s)
=%d'%(s,a_origin[a],a_dest[a],a_mode[a],tz[s,a_origin[a],a_dest[a],a_mode[a]].x))

    print ('\n \n Total Cost: $', m.objVal, '\n \n')

# Compute optimal solution

m.Params.MIPGap=0.01

m.optimize()
printSolution()
```

## APPENDIX C. BASELINE SCENARIO SOLUTION

| Origin | Origin Location | Dest. | Destination Location | Mode | Density | Ship. U Weight Capacity | Ship. U Volume Capacity |
|---|---|---|---|---|---|---|---|
| s_1 | Farm - Caldas | m_1 | Mill - Caldas | bulk | 0.40 | 800 | 3000 |
| s_1 | Farm - Caldas | m_2 | Mill - Caldas | bulk | 0.40 | 800 | 3000 |
| s_1 | Farm - Caldas | m_3 | Mill - Caldas (at roaster) | bulk | 0.40 | 800 | 3000 |
| s_1 | Farm - Caldas | m_4 | Mill - Port - Pacific | bulk | 0.40 | 28800 | 60000 |
| s_1 | Farm - Caldas | m_5 | Mill - Port - Pacific (at roaster) | bulk | 0.40 | 28800 | 60000 |
| s_1 | Farm - Caldas | m_6 | Mill - Port - Atlantic | bulk | 0.40 | 28800 | 60000 |
| s_1 | Farm - Caldas | m_7 | Mill - Port - Atlantic (at roaster) | bulk | 0.40 | 28800 | 60000 |
| m_1 | Mill - Caldas | w_1 | Warehouse - NE USA | TEU | 0.66 | 28200 | 30000 |
| m_1 | Mill - Caldas | w_1 | Warehouse - NE USA | FEU | 0.66 | 28800 | 60000 |
| m_1 | Mill - Caldas | r_1 | Roaster - Caldas | bulk | 0.66 | 800 | 3000 |
| m_1 | Mill - Caldas | r_2 | Roaster - Caldas | bulk | 0.66 | 800 | 3000 |
| m_1 | Mill - Caldas | r_3 | Roaster - Caldas | bulk | 0.66 | 800 | 3000 |
| m_1 | Mill - Caldas | r_4 | Roaster - Caldas | bulk | 0.66 | 800 | 3000 |
| m_1 | Mill - Caldas | r_5 | Roaster - Caldas | bulk | 0.66 | 800 | 3000 |
| m_1 | Mill - Caldas | r_6 | Roaster - Caldas | bulk | 0.66 | 800 | 3000 |
| m_1 | Mill - Caldas | r_7 | Roaster - Caldas | bulk | 0.66 | 800 | 3000 |
| m_1 | Mill - Caldas | r_8 | Roaster - Caldas | bulk | 0.66 | 800 | 3000 |
| m_1 | Mill - Caldas | r_9 | Roaster - Caldas | bulk | 0.66 | 800 | 3000 |
| m_1 | Mill - Caldas | r_10 | Roaster - Caldas | bulk | 0.66 | 800 | 3000 |
| m_1 | Mill - Caldas | r_11 | Roaster - Port - Pacific | bulk | 0.66 | 28800 | 60000 |
| m_1 | Mill - Caldas | r_12 | Roaster - Port - Pacific | bulk | 0.66 | 28800 | 60000 |
| m_1 | Mill - Caldas | r_13 | Roaster - Port - Atlantic | bulk | 0.66 | 28800 | 60000 |
| m_2 | Mill - Caldas | w_1 | Warehouse - NE USA | TEU | 0.66 | 28200 | 30000 |
| m_2 | Mill - Caldas | w_1 | Warehouse - NE USA | FEU | 0.66 | 28800 | 60000 |
| m_2 | Mill - Caldas | r_1 | Roaster - Caldas | bulk | 0.66 | 800 | 3000 |
| m_2 | Mill - Caldas | r_2 | Roaster - Caldas | bulk | 0.66 | 800 | 3000 |
| m_2 | Mill - Caldas | r_3 | Roaster - Caldas | bulk | 0.66 | 800 | 3000 |
| m_2 | Mill - Caldas | r_4 | Roaster - Caldas | bulk | 0.66 | 800 | 3000 |
| m_2 | Mill - Caldas | r_5 | Roaster - Caldas | bulk | 0.66 | 800 | 3000 |
| m_2 | Mill - Caldas | r_6 | Roaster - Caldas | bulk | 0.66 | 800 | 3000 |
| m_2 | Mill - Caldas | r_7 | Roaster - Caldas | bulk | 0.66 | 800 | 3000 |
| m_2 | Mill - Caldas | r_8 | Roaster - Caldas | bulk | 0.66 | 800 | 3000 |
| m_2 | Mill - Caldas | r_9 | Roaster - Caldas | bulk | 0.66 | 800 | 3000 |
| m_2 | Mill - Caldas | r_10 | Roaster - Caldas | bulk | 0.66 | 800 | 3000 |
| m_2 | Mill - Caldas | r_11 | Roaster - Port - Pacific | bulk | 0.66 | 28800 | 60000 |
| m_2 | Mill - Caldas | r_12 | Roaster - Port - Pacific | bulk | 0.66 | 28800 | 60000 |
| m_2 | Mill - Caldas | r_13 | Roaster - Port - Atlantic | bulk | 0.66 | 28800 | 60000 |
| m_2 | Mill - Caldas | r_14 | Roaster - Port - Atlantic | bulk | 0.66 | 28800 | 60000 |
| m_3 | Mill - Caldas (at roaster) | r_2 | Roaster - Caldas | bulk | 0.66 | 800 | 3000 |
| m_3 | Mill - Caldas (at roaster) | r_3 | Roaster - Caldas | bulk | 0.66 | 800 | 3000 |
| m_3 | Mill - Caldas (at roaster) | r_4 | Roaster - Caldas | bulk | 0.66 | 800 | 3000 |
| m_3 | Mill - Caldas (at roaster) | r_5 | Roaster - Caldas | bulk | 0.66 | 800 | 3000 |
| m_3 | Mill - Caldas (at roaster) | r_6 | Roaster - Caldas | bulk | 0.66 | 800 | 3000 |
| m_3 | Mill - Caldas (at roaster) | r_7 | Roaster - Caldas | bulk | 0.66 | 800 | 3000 |
| m_3 | Mill - Caldas (at roaster) | r_8 | Roaster - Caldas | bulk | 0.66 | 800 | 3000 |
| m_3 | Mill - Caldas (at roaster) | r_9 | Roaster - Caldas | bulk | 0.66 | 800 | 3000 |
| m_3 | Mill - Caldas (at roaster) | r_10 | Roaster - Caldas | bulk | 0.66 | 800 | 3000 |
| m_4 | Mill - Port - Pacific | w_1 | Warehouse - NE USA | TEU | 0.66 | 28200 | 30000 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| m_4 | Mill - Port - Pacific | w_1 | Warehouse - NE USA | FEU | 0.66 | 28800 | 60000 |
| m_5 | Mill - Port - Pacific (at roaster) | r_11 | Roaster - Port - Pacific | bulk | 0.66 | 1 | 3.5 |
| m_5 | Mill - Port - Pacific (at roaster) | r_12 | Roaster - Port - Pacific | bulk | 0.66 | 1 | 3.5 |
| m_6 | Mill - Port - Atlantic | w_1 | Warehouse - NE USA | TEU | 0.66 | 28200 | 30000 |
| m_6 | Mill - Port - Atlantic | w_1 | Warehouse - NE USA | FEU | 0.66 | 28800 | 60000 |
| m_7 | Mill - Port - Atlantic (at roaster) | r_13 | Roaster - Port - Atlantic | bulk | 0.66 | 1 | 3.5 |
| m_7 | Mill - Port - Atlantic (at roaster) | r_14 | Roaster - Port - Atlantic | bulk | 0.66 | 1 | 3.5 |
| w_1 | Warehouse - NE USA | r_15 | Roaster - NE USA | delivery | 0.66 | 1 | 3.5 |
| w_1 | Warehouse - NE USA | r_16 | Roaster - NE USA | delivery | 0.66 | 1 | 3.5 |
| w_1 | Warehouse - NE USA | r_17 | Roaster - NE USA | delivery | 0.66 | 1 | 3.5 |
| w_2 | Warehouse - NE USA | c_1 | Customer - NE USA | delivery | 0.34 | 1 | 3.5 |
| w_2 | Warehouse - NE USA | c_2 | Customer - NE USA | delivery | 0.34 | 1 | 3.5 |
| w_2 | Warehouse - NE USA | c_3 | Customer - NE USA | delivery | 0.34 | 1 | 3.5 |
| w_2 | Warehouse - NE USA | c_4 | Customer - NE USA | delivery | 0.34 | 1 | 3.5 |
| w_2 | Warehouse - NE USA | c_5 | Customer - NE USA | delivery | 0.34 | 1 | 3.5 |
| w_2 | Warehouse - NE USA | c_6 | Customer - NE USA | delivery | 0.34 | 1 | 3.5 |
| w_2 | Warehouse - NE USA | c_7 | Customer - NE USA | delivery | 0.34 | 1 | 3.5 |
| w_2 | Warehouse - NE USA | c_8 | Customer - NE USA | delivery | 0.34 | 1 | 3.5 |
| w_2 | Warehouse - NE USA | c_9 | Customer - NE USA | delivery | 0.34 | 1 | 3.5 |
| w_2 | Warehouse - NE USA | c_10 | Customer - NE USA | delivery | 0.34 | 1 | 3.5 |
| r_1 | Roaster - Caldas | c_1 | Customer - NE USA | air | 0.34 | 1 | 6 |
| r_1 | Roaster - Caldas | c_2 | Customer - NE USA | air | 0.34 | 1 | 6 |
| r_1 | Roaster - Caldas | c_3 | Customer - NE USA | air | 0.34 | 1 | 6 |
| r_1 | Roaster - Caldas | c_4 | Customer - NE USA | air | 0.34 | 1 | 6 |
| r_1 | Roaster - Caldas | c_5 | Customer - NE USA | air | 0.34 | 1 | 6 |
| r_1 | Roaster - Caldas | c_6 | Customer - NE USA | air | 0.34 | 1 | 6 |
| r_1 | Roaster - Caldas | c_7 | Customer - NE USA | air | 0.34 | 1 | 6 |
| r_1 | Roaster - Caldas | c_8 | Customer - NE USA | air | 0.34 | 1 | 6 |
| r_1 | Roaster - Caldas | c_9 | Customer - NE USA | air | 0.34 | 1 | 6 |
| r_1 | Roaster - Caldas | c_10 | Customer - NE USA | air | 0.34 | 1 | 6 |
| r_2 | Roaster - Caldas | c_1 | Customer - NE USA | air | 0.34 | 1 | 6 |
| r_2 | Roaster - Caldas | c_2 | Customer - NE USA | air | 0.34 | 1 | 6 |
| r_2 | Roaster - Caldas | c_3 | Customer - NE USA | air | 0.34 | 1 | 6 |
| r_2 | Roaster - Caldas | c_4 | Customer - NE USA | air | 0.34 | 1 | 6 |
| r_2 | Roaster - Caldas | c_5 | Customer - NE USA | air | 0.34 | 1 | 6 |
| r_2 | Roaster - Caldas | c_6 | Customer - NE USA | air | 0.34 | 1 | 6 |
| r_2 | Roaster - Caldas | c_7 | Customer - NE USA | air | 0.34 | 1 | 6 |
| r_2 | Roaster - Caldas | c_8 | Customer - NE USA | air | 0.34 | 1 | 6 |
| r_2 | Roaster - Caldas | c_9 | Customer - NE USA | air | 0.34 | 1 | 6 |
| r_2 | Roaster - Caldas | c_10 | Customer - NE USA | air | 0.34 | 1 | 6 |
| r_2 | Roaster - Caldas | c_1 | Customer - NE USA | TEU | 0.34 | 28200 | 30000 |
| r_2 | Roaster - Caldas | c_2 | Customer - NE USA | TEU | 0.34 | 28200 | 30000 |
| r_2 | Roaster - Caldas | c_3 | Customer - NE USA | TEU | 0.34 | 28200 | 30000 |
| r_2 | Roaster - Caldas | c_4 | Customer - NE USA | TEU | 0.34 | 28200 | 30000 |
| r_2 | Roaster - Caldas | c_5 | Customer - NE USA | TEU | 0.34 | 28200 | 30000 |
| r_2 | Roaster - Caldas | c_6 | Customer - NE USA | TEU | 0.34 | 28200 | 30000 |
| r_2 | Roaster - Caldas | c_7 | Customer - NE USA | TEU | 0.34 | 28200 | 30000 |
| r_2 | Roaster - Caldas | c_8 | Customer - NE USA | TEU | 0.34 | 28200 | 30000 |
| r_2 | Roaster - Caldas | c_9 | Customer - NE USA | TEU | 0.34 | 28200 | 30000 |
| r_2 | Roaster - Caldas | c_10 | Customer - NE USA | TEU | 0.34 | 28200 | 30000 |
| r_2 | Roaster - Caldas | c_1 | Customer - NE USA | FEU | 0.34 | 28800 | 60000 |
| r_2 | Roaster - Caldas | c_2 | Customer - NE USA | FEU | 0.34 | 28800 | 60000 |
| r_2 | Roaster - Caldas | c_3 | Customer - NE USA | FEU | 0.34 | 28800 | 60000 |
| r_2 | Roaster - Caldas | c_4 | Customer - NE USA | FEU | 0.34 | 28800 | 60000 |

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|---|---|---|---|---|---|---|---|
| r_2 | Roaster - Caldas | c_5 | Customer - NE USA | FEU | 0.34 | 28800 | 60000 |
| r_2 | Roaster - Caldas | c_6 | Customer - NE USA | FEU | 0.34 | 28800 | 60000 |
| r_2 | Roaster - Caldas | c_7 | Customer - NE USA | FEU | 0.34 | 28800 | 60000 |
| r_2 | Roaster - Caldas | c_8 | Customer - NE USA | FEU | 0.34 | 28800 | 60000 |
| r_2 | Roaster - Caldas | c_9 | Customer - NE USA | FEU | 0.34 | 28800 | 60000 |
| r_2 | Roaster - Caldas | c_10 | Customer - NE USA | FEU | 0.34 | 28800 | 60000 |
| r_2 | Roaster - Caldas | c_1 | Customer - NE USA | pallet | 0.34 | 600 | 1320 |
| r_2 | Roaster - Caldas | c_2 | Customer - NE USA | pallet | 0.34 | 600 | 1320 |
| r_2 | Roaster - Caldas | c_3 | Customer - NE USA | pallet | 0.34 | 600 | 1320 |
| r_2 | Roaster - Caldas | c_4 | Customer - NE USA | pallet | 0.34 | 600 | 1320 |
| r_2 | Roaster - Caldas | c_5 | Customer - NE USA | pallet | 0.34 | 600 | 1320 |
| r_2 | Roaster - Caldas | c_6 | Customer - NE USA | pallet | 0.34 | 600 | 1320 |
| r_2 | Roaster - Caldas | c_7 | Customer - NE USA | pallet | 0.34 | 600 | 1320 |
| r_2 | Roaster - Caldas | c_8 | Customer - NE USA | pallet | 0.34 | 600 | 1320 |
| r_2 | Roaster - Caldas | c_9 | Customer - NE USA | pallet | 0.34 | 600 | 1320 |
| r_2 | Roaster - Caldas | c_10 | Customer - NE USA | pallet | 0.34 | 600 | 1320 |
| r_2 | Roaster - Caldas | w_2 | Warehouse - NE USA | TEU | 0.34 | 28200 | 30000 |
| r_2 | Roaster - Caldas | w_2 | Warehouse - NE USA | FEU | 0.34 | 28800 | 60000 |
| r_2 | Roaster - Caldas | w_2 | Warehouse - NE USA | pallet | 0.34 | 600 | 1320 |
| r_3 | Roaster - Caldas | c_1 | Customer - NE USA | air | 0.34 | 1 | 6 |
| r_3 | Roaster - Caldas | c_2 | Customer - NE USA | air | 0.34 | 1 | 6 |
| r_3 | Roaster - Caldas | c_3 | Customer - NE USA | air | 0.34 | 1 | 6 |
| r_3 | Roaster - Caldas | c_4 | Customer - NE USA | air | 0.34 | 1 | 6 |
| r_3 | Roaster - Caldas | c_5 | Customer - NE USA | air | 0.34 | 1 | 6 |
| r_3 | Roaster - Caldas | c_6 | Customer - NE USA | air | 0.34 | 1 | 6 |
| r_3 | Roaster - Caldas | c_7 | Customer - NE USA | air | 0.34 | 1 | 6 |
| r_3 | Roaster - Caldas | c_8 | Customer - NE USA | air | 0.34 | 1 | 6 |
| r_3 | Roaster - Caldas | c_9 | Customer - NE USA | air | 0.34 | 1 | 6 |
| r_3 | Roaster - Caldas | c_10 | Customer - NE USA | air | 0.34 | 1 | 6 |
| r_4 | Roaster - Caldas | c_1 | Customer - NE USA | air | 0.34 | 1 | 6 |
| r_4 | Roaster - Caldas | c_2 | Customer - NE USA | air | 0.34 | 1 | 6 |
| r_4 | Roaster - Caldas | c_3 | Customer - NE USA | air | 0.34 | 1 | 6 |
| r_4 | Roaster - Caldas | c_4 | Customer - NE USA | air | 0.34 | 1 | 6 |
| r_4 | Roaster - Caldas | c_5 | Customer - NE USA | air | 0.34 | 1 | 6 |
| r_4 | Roaster - Caldas | c_6 | Customer - NE USA | air | 0.34 | 1 | 6 |
| r_4 | Roaster - Caldas | c_7 | Customer - NE USA | air | 0.34 | 1 | 6 |
| r_4 | Roaster - Caldas | c_8 | Customer - NE USA | air | 0.34 | 1 | 6 |
| r_4 | Roaster - Caldas | c_9 | Customer - NE USA | air | 0.34 | 1 | 6 |
| r_4 | Roaster - Caldas | c_10 | Customer - NE USA | air | 0.34 | 1 | 6 |
| r_4 | Roaster - Caldas | c_1 | Customer - NE USA | TEU | 0.34 | 28200 | 30000 |
| r_4 | Roaster - Caldas | c_2 | Customer - NE USA | TEU | 0.34 | 28200 | 30000 |
| r_4 | Roaster - Caldas | c_3 | Customer - NE USA | TEU | 0.34 | 28200 | 30000 |
| r_4 | Roaster - Caldas | c_4 | Customer - NE USA | TEU | 0.34 | 28200 | 30000 |
| r_4 | Roaster - Caldas | c_5 | Customer - NE USA | TEU | 0.34 | 28200 | 30000 |
| r_4 | Roaster - Caldas | c_6 | Customer - NE USA | TEU | 0.34 | 28200 | 30000 |
| r_4 | Roaster - Caldas | c_7 | Customer - NE USA | TEU | 0.34 | 28200 | 30000 |
| r_4 | Roaster - Caldas | c_8 | Customer - NE USA | TEU | 0.34 | 28200 | 30000 |
| r_4 | Roaster - Caldas | c_9 | Customer - NE USA | TEU | 0.34 | 28200 | 30000 |
| r_4 | Roaster - Caldas | c_10 | Customer - NE USA | TEU | 0.34 | 28200 | 30000 |
| r_4 | Roaster - Caldas | c_1 | Customer - NE USA | FEU | 0.34 | 28800 | 60000 |
| r_4 | Roaster - Caldas | c_2 | Customer - NE USA | FEU | 0.34 | 28800 | 60000 |
| r_4 | Roaster - Caldas | c_3 | Customer - NE USA | FEU | 0.34 | 28800 | 60000 |
| r_4 | Roaster - Caldas | c_4 | Customer - NE USA | FEU | 0.34 | 28800 | 60000 |
| r_4 | Roaster - Caldas | c_5 | Customer - NE USA | FEU | 0.34 | 28800 | 60000 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| r_4 | Roaster - Caldas | c_6 | Customer - NE USA | FEU | 0.34 | 28800 | 60000 |
| r_4 | Roaster - Caldas | c_7 | Customer - NE USA | FEU | 0.34 | 28800 | 60000 |
| r_4 | Roaster - Caldas | c_8 | Customer - NE USA | FEU | 0.34 | 28800 | 60000 |
| r_4 | Roaster - Caldas | c_9 | Customer - NE USA | FEU | 0.34 | 28800 | 60000 |
| r_4 | Roaster - Caldas | c_10 | Customer - NE USA | FEU | 0.34 | 28800 | 60000 |
| r_4 | Roaster - Caldas | c_1 | Customer - NE USA | pallet | 0.34 | 600 | 1320 |
| r_4 | Roaster - Caldas | c_2 | Customer - NE USA | pallet | 0.34 | 600 | 1320 |
| r_4 | Roaster - Caldas | c_3 | Customer - NE USA | pallet | 0.34 | 600 | 1320 |
| r_4 | Roaster - Caldas | c_4 | Customer - NE USA | pallet | 0.34 | 600 | 1320 |
| r_4 | Roaster - Caldas | c_5 | Customer - NE USA | pallet | 0.34 | 600 | 1320 |
| r_4 | Roaster - Caldas | c_6 | Customer - NE USA | pallet | 0.34 | 600 | 1320 |
| r_4 | Roaster - Caldas | c_7 | Customer - NE USA | pallet | 0.34 | 600 | 1320 |
| r_4 | Roaster - Caldas | c_8 | Customer - NE USA | pallet | 0.34 | 600 | 1320 |
| r_4 | Roaster - Caldas | c_9 | Customer - NE USA | pallet | 0.34 | 600 | 1320 |
| r_4 | Roaster - Caldas | c_10 | Customer - NE USA | pallet | 0.34 | 600 | 1320 |
| r_4 | Roaster - Caldas | w_2 | Warehouse - NE USA | TEU | 0.34 | 28200 | 30000 |
| r_4 | Roaster - Caldas | w_2 | Warehouse - NE USA | FEU | 0.34 | 28800 | 60000 |
| r_4 | Roaster - Caldas | w_2 | Warehouse - NE USA | pallet | 0.34 | 600 | 1320 |
| r_5 | Roaster - Caldas | c_1 | Customer - NE USA | air | 0.34 | 1 | 6 |
| r_5 | Roaster - Caldas | c_2 | Customer - NE USA | air | 0.34 | 1 | 6 |
| r_5 | Roaster - Caldas | c_3 | Customer - NE USA | air | 0.34 | 1 | 6 |
| r_5 | Roaster - Caldas | c_4 | Customer - NE USA | air | 0.34 | 1 | 6 |
| r_5 | Roaster - Caldas | c_5 | Customer - NE USA | air | 0.34 | 1 | 6 |
| r_5 | Roaster - Caldas | c_6 | Customer - NE USA | air | 0.34 | 1 | 6 |
| r_5 | Roaster - Caldas | c_7 | Customer - NE USA | air | 0.34 | 1 | 6 |
| r_5 | Roaster - Caldas | c_8 | Customer - NE USA | air | 0.34 | 1 | 6 |
| r_5 | Roaster - Caldas | c_9 | Customer - NE USA | air | 0.34 | 1 | 6 |
| r_5 | Roaster - Caldas | c_10 | Customer - NE USA | air | 0.34 | 1 | 6 |
| r_6 | Roaster - Caldas | c_1 | Customer - NE USA | air | 0.34 | 1 | 6 |
| r_6 | Roaster - Caldas | c_2 | Customer - NE USA | air | 0.34 | 1 | 6 |
| r_6 | Roaster - Caldas | c_3 | Customer - NE USA | air | 0.34 | 1 | 6 |
| r_6 | Roaster - Caldas | c_4 | Customer - NE USA | air | 0.34 | 1 | 6 |
| r_6 | Roaster - Caldas | c_5 | Customer - NE USA | air | 0.34 | 1 | 6 |
| r_6 | Roaster - Caldas | c_6 | Customer - NE USA | air | 0.34 | 1 | 6 |
| r_6 | Roaster - Caldas | c_7 | Customer - NE USA | air | 0.34 | 1 | 6 |
| r_6 | Roaster - Caldas | c_8 | Customer - NE USA | air | 0.34 | 1 | 6 |
| r_6 | Roaster - Caldas | c_9 | Customer - NE USA | air | 0.34 | 1 | 6 |
| r_6 | Roaster - Caldas | c_10 | Customer - NE USA | air | 0.34 | 1 | 6 |
| r_6 | Roaster - Caldas | c_1 | Customer - NE USA | TEU | 0.34 | 28200 | 30000 |
| r_6 | Roaster - Caldas | c_2 | Customer - NE USA | TEU | 0.34 | 28200 | 30000 |
| r_6 | Roaster - Caldas | c_3 | Customer - NE USA | TEU | 0.34 | 28200 | 30000 |
| r_6 | Roaster - Caldas | c_4 | Customer - NE USA | TEU | 0.34 | 28200 | 30000 |
| r_6 | Roaster - Caldas | c_5 | Customer - NE USA | TEU | 0.34 | 28200 | 30000 |
| r_6 | Roaster - Caldas | c_6 | Customer - NE USA | TEU | 0.34 | 28200 | 30000 |
| r_6 | Roaster - Caldas | c_7 | Customer - NE USA | TEU | 0.34 | 28200 | 30000 |
| r_6 | Roaster - Caldas | c_8 | Customer - NE USA | TEU | 0.34 | 28200 | 30000 |
| r_6 | Roaster - Caldas | c_9 | Customer - NE USA | TEU | 0.34 | 28200 | 30000 |
| r_6 | Roaster - Caldas | c_10 | Customer - NE USA | TEU | 0.34 | 28200 | 30000 |
| r_6 | Roaster - Caldas | c_1 | Customer - NE USA | FEU | 0.34 | 28800 | 60000 |
| r_6 | Roaster - Caldas | c_2 | Customer - NE USA | FEU | 0.34 | 28800 | 60000 |
| r_6 | Roaster - Caldas | c_3 | Customer - NE USA | FEU | 0.34 | 28800 | 60000 |
| r_6 | Roaster - Caldas | c_4 | Customer - NE USA | FEU | 0.34 | 28800 | 60000 |
| r_6 | Roaster - Caldas | c_5 | Customer - NE USA | FEU | 0.34 | 28800 | 60000 |
| r_6 | Roaster - Caldas | c_6 | Customer - NE USA | FEU | 0.34 | 28800 | 60000 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| r_6 | Roaster - Caldas | c_7 | Customer - NE USA | FEU | 0.34 | 28800 | 60000 |
| r_6 | Roaster - Caldas | c_8 | Customer - NE USA | FEU | 0.34 | 28800 | 60000 |
| r_6 | Roaster - Caldas | c_9 | Customer - NE USA | FEU | 0.34 | 28800 | 60000 |
| r_6 | Roaster - Caldas | c_10 | Customer - NE USA | FEU | 0.34 | 28800 | 60000 |
| r_6 | Roaster - Caldas | c_1 | Customer - NE USA | pallet | 0.34 | 600 | 1320 |
| r_6 | Roaster - Caldas | c_2 | Customer - NE USA | pallet | 0.34 | 600 | 1320 |
| r_6 | Roaster - Caldas | c_3 | Customer - NE USA | pallet | 0.34 | 600 | 1320 |
| r_6 | Roaster - Caldas | c_4 | Customer - NE USA | pallet | 0.34 | 600 | 1320 |
| r_6 | Roaster - Caldas | c_5 | Customer - NE USA | pallet | 0.34 | 600 | 1320 |
| r_6 | Roaster - Caldas | c_6 | Customer - NE USA | pallet | 0.34 | 600 | 1320 |
| r_6 | Roaster - Caldas | c_7 | Customer - NE USA | pallet | 0.34 | 600 | 1320 |
| r_6 | Roaster - Caldas | c_8 | Customer - NE USA | pallet | 0.34 | 600 | 1320 |
| r_6 | Roaster - Caldas | c_9 | Customer - NE USA | pallet | 0.34 | 600 | 1320 |
| r_6 | Roaster - Caldas | c_10 | Customer - NE USA | pallet | 0.34 | 600 | 1320 |
| r_6 | Roaster - Caldas | w_2 | Warehouse - NE USA | TEU | 0.34 | 28200 | 30000 |
| r_6 | Roaster - Caldas | w_2 | Warehouse - NE USA | FEU | 0.34 | 28800 | 60000 |
| r_6 | Roaster - Caldas | w_2 | Warehouse - NE USA | pallet | 0.34 | 600 | 1320 |
| r_7 | Roaster - Caldas | c_1 | Customer - NE USA | air | 0.34 | 1 | 6 |
| r_7 | Roaster - Caldas | c_2 | Customer - NE USA | air | 0.34 | 1 | 6 |
| r_7 | Roaster - Caldas | c_3 | Customer - NE USA | air | 0.34 | 1 | 6 |
| r_7 | Roaster - Caldas | c_4 | Customer - NE USA | air | 0.34 | 1 | 6 |
| r_7 | Roaster - Caldas | c_5 | Customer - NE USA | air | 0.34 | 1 | 6 |
| r_7 | Roaster - Caldas | c_6 | Customer - NE USA | air | 0.34 | 1 | 6 |
| r_7 | Roaster - Caldas | c_7 | Customer - NE USA | air | 0.34 | 1 | 6 |
| r_7 | Roaster - Caldas | c_8 | Customer - NE USA | air | 0.34 | 1 | 6 |
| r_7 | Roaster - Caldas | c_9 | Customer - NE USA | air | 0.34 | 1 | 6 |
| r_7 | Roaster - Caldas | c_10 | Customer - NE USA | air | 0.34 | 1 | 6 |
| r_8 | Roaster - Caldas | c_1 | Customer - NE USA | air | 0.34 | 1 | 6 |
| r_8 | Roaster - Caldas | c_2 | Customer - NE USA | air | 0.34 | 1 | 6 |
| r_8 | Roaster - Caldas | c_3 | Customer - NE USA | air | 0.34 | 1 | 6 |
| r_8 | Roaster - Caldas | c_4 | Customer - NE USA | air | 0.34 | 1 | 6 |
| r_8 | Roaster - Caldas | c_5 | Customer - NE USA | air | 0.34 | 1 | 6 |
| r_8 | Roaster - Caldas | c_6 | Customer - NE USA | air | 0.34 | 1 | 6 |
| r_8 | Roaster - Caldas | c_7 | Customer - NE USA | air | 0.34 | 1 | 6 |
| r_8 | Roaster - Caldas | c_8 | Customer - NE USA | air | 0.34 | 1 | 6 |
| r_8 | Roaster - Caldas | c_9 | Customer - NE USA | air | 0.34 | 1 | 6 |
| r_8 | Roaster - Caldas | c_10 | Customer - NE USA | air | 0.34 | 1 | 6 |
| r_8 | Roaster - Caldas | c_1 | Customer - NE USA | TEU | 0.34 | 28200 | 30000 |
| r_8 | Roaster - Caldas | c_2 | Customer - NE USA | TEU | 0.34 | 28200 | 30000 |
| r_8 | Roaster - Caldas | c_3 | Customer - NE USA | TEU | 0.34 | 28200 | 30000 |
| r_8 | Roaster - Caldas | c_4 | Customer - NE USA | TEU | 0.34 | 28200 | 30000 |
| r_8 | Roaster - Caldas | c_5 | Customer - NE USA | TEU | 0.34 | 28200 | 30000 |
| r_8 | Roaster - Caldas | c_6 | Customer - NE USA | TEU | 0.34 | 28200 | 30000 |
| r_8 | Roaster - Caldas | c_7 | Customer - NE USA | TEU | 0.34 | 28200 | 30000 |
| r_8 | Roaster - Caldas | c_8 | Customer - NE USA | TEU | 0.34 | 28200 | 30000 |
| r_8 | Roaster - Caldas | c_9 | Customer - NE USA | TEU | 0.34 | 28200 | 30000 |
| r_8 | Roaster - Caldas | c_10 | Customer - NE USA | TEU | 0.34 | 28200 | 30000 |
| r_8 | Roaster - Caldas | c_1 | Customer - NE USA | FEU | 0.34 | 28800 | 60000 |
| r_8 | Roaster - Caldas | c_2 | Customer - NE USA | FEU | 0.34 | 28800 | 60000 |
| r_8 | Roaster - Caldas | c_3 | Customer - NE USA | FEU | 0.34 | 28800 | 60000 |
| r_8 | Roaster - Caldas | c_4 | Customer - NE USA | FEU | 0.34 | 28800 | 60000 |
| r_8 | Roaster - Caldas | c_5 | Customer - NE USA | FEU | 0.34 | 28800 | 60000 |
| r_8 | Roaster - Caldas | c_6 | Customer - NE USA | FEU | 0.34 | 28800 | 60000 |
| r_8 | Roaster - Caldas | c_7 | Customer - NE USA | FEU | 0.34 | 28800 | 60000 |

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|---|---|---|---|---|---|---|---|
| r_8 | Roaster - Caldas | c_8 | Customer - NE USA | FEU | 0.34 | 28800 | 60000 |
| r_8 | Roaster - Caldas | c_9 | Customer - NE USA | FEU | 0.34 | 28800 | 60000 |
| r_8 | Roaster - Caldas | c_10 | Customer - NE USA | FEU | 0.34 | 28800 | 60000 |
| r_8 | Roaster - Caldas | c_1 | Customer - NE USA | pallet | 0.34 | 600 | 1320 |
| r_8 | Roaster - Caldas | c_2 | Customer - NE USA | pallet | 0.34 | 600 | 1320 |
| r_8 | Roaster - Caldas | c_3 | Customer - NE USA | pallet | 0.34 | 600 | 1320 |
| r_8 | Roaster - Caldas | c_4 | Customer - NE USA | pallet | 0.34 | 600 | 1320 |
| r_8 | Roaster - Caldas | c_5 | Customer - NE USA | pallet | 0.34 | 600 | 1320 |
| r_8 | Roaster - Caldas | c_6 | Customer - NE USA | pallet | 0.34 | 600 | 1320 |
| r_8 | Roaster - Caldas | c_7 | Customer - NE USA | pallet | 0.34 | 600 | 1320 |
| r_8 | Roaster - Caldas | c_8 | Customer - NE USA | pallet | 0.34 | 600 | 1320 |
| r_8 | Roaster - Caldas | c_9 | Customer - NE USA | pallet | 0.34 | 600 | 1320 |
| r_8 | Roaster - Caldas | c_10 | Customer - NE USA | pallet | 0.34 | 600 | 1320 |
| r_8 | Roaster - Caldas | w_2 | Warehouse - NE USA | TEU | 0.34 | 28200 | 30000 |
| r_8 | Roaster - Caldas | w_2 | Warehouse - NE USA | FEU | 0.34 | 28800 | 60000 |
| r_8 | Roaster - Caldas | w_2 | Warehouse - NE USA | pallet | 0.34 | 600 | 1320 |
| r_9 | Roaster - Caldas | c_1 | Customer - NE USA | air | 0.34 | 1 | 6 |
| r_9 | Roaster - Caldas | c_2 | Customer - NE USA | air | 0.34 | 1 | 6 |
| r_9 | Roaster - Caldas | c_3 | Customer - NE USA | air | 0.34 | 1 | 6 |
| r_9 | Roaster - Caldas | c_4 | Customer - NE USA | air | 0.34 | 1 | 6 |
| r_9 | Roaster - Caldas | c_5 | Customer - NE USA | air | 0.34 | 1 | 6 |
| r_9 | Roaster - Caldas | c_6 | Customer - NE USA | air | 0.34 | 1 | 6 |
| r_9 | Roaster - Caldas | c_7 | Customer - NE USA | air | 0.34 | 1 | 6 |
| r_9 | Roaster - Caldas | c_8 | Customer - NE USA | air | 0.34 | 1 | 6 |
| r_9 | Roaster - Caldas | c_9 | Customer - NE USA | air | 0.34 | 1 | 6 |
| r_9 | Roaster - Caldas | c_10 | Customer - NE USA | air | 0.34 | 1 | 6 |
| r_10 | Roaster - Caldas | c_1 | Customer - NE USA | air | 0.34 | 1 | 6 |
| r_10 | Roaster - Caldas | c_2 | Customer - NE USA | air | 0.34 | 1 | 6 |
| r_10 | Roaster - Caldas | c_3 | Customer - NE USA | air | 0.34 | 1 | 6 |
| r_10 | Roaster - Caldas | c_4 | Customer - NE USA | air | 0.34 | 1 | 6 |
| r_10 | Roaster - Caldas | c_5 | Customer - NE USA | air | 0.34 | 1 | 6 |
| r_10 | Roaster - Caldas | c_6 | Customer - NE USA | air | 0.34 | 1 | 6 |
| r_10 | Roaster - Caldas | c_7 | Customer - NE USA | air | 0.34 | 1 | 6 |
| r_10 | Roaster - Caldas | c_8 | Customer - NE USA | air | 0.34 | 1 | 6 |
| r_10 | Roaster - Caldas | c_9 | Customer - NE USA | air | 0.34 | 1 | 6 |
| r_10 | Roaster - Caldas | c_10 | Customer - NE USA | air | 0.34 | 1 | 6 |
| r_10 | Roaster - Caldas | c_1 | Customer - NE USA | TEU | 0.34 | 28200 | 30000 |
| r_10 | Roaster - Caldas | c_2 | Customer - NE USA | TEU | 0.34 | 28200 | 30000 |
| r_10 | Roaster - Caldas | c_3 | Customer - NE USA | TEU | 0.34 | 28200 | 30000 |
| r_10 | Roaster - Caldas | c_4 | Customer - NE USA | TEU | 0.34 | 28200 | 30000 |
| r_10 | Roaster - Caldas | c_5 | Customer - NE USA | TEU | 0.34 | 28200 | 30000 |
| r_10 | Roaster - Caldas | c_6 | Customer - NE USA | TEU | 0.34 | 28200 | 30000 |
| r_10 | Roaster - Caldas | c_7 | Customer - NE USA | TEU | 0.34 | 28200 | 30000 |
| r_10 | Roaster - Caldas | c_8 | Customer - NE USA | TEU | 0.34 | 28200 | 30000 |
| r_10 | Roaster - Caldas | c_9 | Customer - NE USA | TEU | 0.34 | 28200 | 30000 |
| r_10 | Roaster - Caldas | c_10 | Customer - NE USA | TEU | 0.34 | 28200 | 30000 |
| r_10 | Roaster - Caldas | c_1 | Customer - NE USA | FEU | 0.34 | 28800 | 60000 |
| r_10 | Roaster - Caldas | c_2 | Customer - NE USA | FEU | 0.34 | 28800 | 60000 |
| r_10 | Roaster - Caldas | c_3 | Customer - NE USA | FEU | 0.34 | 28800 | 60000 |
| r_10 | Roaster - Caldas | c_4 | Customer - NE USA | FEU | 0.34 | 28800 | 60000 |
| r_10 | Roaster - Caldas | c_5 | Customer - NE USA | FEU | 0.34 | 28800 | 60000 |
| r_10 | Roaster - Caldas | c_6 | Customer - NE USA | FEU | 0.34 | 28800 | 60000 |
| r_10 | Roaster - Caldas | c_7 | Customer - NE USA | FEU | 0.34 | 28800 | 60000 |
| r_10 | Roaster - Caldas | c_8 | Customer - NE USA | FEU | 0.34 | 28800 | 60000 |

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|---|---|---|---|---|---|---|---|
| r_10 | Roaster - Caldas | c_9 | Customer - NE USA | FEU | 0.34 | 28800 | 60000 |
| r_10 | Roaster - Caldas | c_10 | Customer - NE USA | FEU | 0.34 | 28800 | 60000 |
| r_10 | Roaster - Caldas | c_1 | Customer - NE USA | pallet | 0.34 | 600 | 1320 |
| r_10 | Roaster - Caldas | c_2 | Customer - NE USA | pallet | 0.34 | 600 | 1320 |
| r_10 | Roaster - Caldas | c_3 | Customer - NE USA | pallet | 0.34 | 600 | 1320 |
| r_10 | Roaster - Caldas | c_4 | Customer - NE USA | pallet | 0.34 | 600 | 1320 |
| r_10 | Roaster - Caldas | c_5 | Customer - NE USA | pallet | 0.34 | 600 | 1320 |
| r_10 | Roaster - Caldas | c_6 | Customer - NE USA | pallet | 0.34 | 600 | 1320 |
| r_10 | Roaster - Caldas | c_7 | Customer - NE USA | pallet | 0.34 | 600 | 1320 |
| r_10 | Roaster - Caldas | c_8 | Customer - NE USA | pallet | 0.34 | 600 | 1320 |
| r_10 | Roaster - Caldas | c_9 | Customer - NE USA | pallet | 0.34 | 600 | 1320 |
| r_10 | Roaster - Caldas | c_10 | Customer - NE USA | pallet | 0.34 | 600 | 1320 |
| r_10 | Roaster - Caldas | w_2 | Warehouse - NE USA | TEU | 0.34 | 28200 | 30000 |
| r_10 | Roaster - Caldas | w_2 | Warehouse - NE USA | FEU | 0.34 | 28800 | 60000 |
| r_10 | Roaster - Caldas | w_2 | Warehouse - NE USA | pallet | 0.34 | 600 | 1320 |
| r_11 | Roaster - Port - Pacific | c_1 | Customer - NE USA | TEU | 0.34 | 28200 | 30000 |
| r_11 | Roaster - Port - Pacific | c_2 | Customer - NE USA | TEU | 0.34 | 28200 | 30000 |
| r_11 | Roaster - Port - Pacific | c_3 | Customer - NE USA | TEU | 0.34 | 28200 | 30000 |
| r_11 | Roaster - Port - Pacific | c_4 | Customer - NE USA | TEU | 0.34 | 28200 | 30000 |
| r_11 | Roaster - Port - Pacific | c_5 | Customer - NE USA | TEU | 0.34 | 28200 | 30000 |
| r_11 | Roaster - Port - Pacific | c_6 | Customer - NE USA | TEU | 0.34 | 28200 | 30000 |
| r_11 | Roaster - Port - Pacific | c_7 | Customer - NE USA | TEU | 0.34 | 28200 | 30000 |
| r_11 | Roaster - Port - Pacific | c_8 | Customer - NE USA | TEU | 0.34 | 28200 | 30000 |
| r_11 | Roaster - Port - Pacific | c_9 | Customer - NE USA | TEU | 0.34 | 28200 | 30000 |
| r_11 | Roaster - Port - Pacific | c_10 | Customer - NE USA | TEU | 0.34 | 28200 | 30000 |
| r_11 | Roaster - Port - Pacific | c_1 | Customer - NE USA | FEU | 0.34 | 28800 | 60000 |
| r_11 | Roaster - Port - Pacific | c_2 | Customer - NE USA | FEU | 0.34 | 28800 | 60000 |
| r_11 | Roaster - Port - Pacific | c_3 | Customer - NE USA | FEU | 0.34 | 28800 | 60000 |
| r_11 | Roaster - Port - Pacific | c_4 | Customer - NE USA | FEU | 0.34 | 28800 | 60000 |
| r_11 | Roaster - Port - Pacific | c_5 | Customer - NE USA | FEU | 0.34 | 28800 | 60000 |
| r_11 | Roaster - Port - Pacific | c_6 | Customer - NE USA | FEU | 0.34 | 28800 | 60000 |
| r_11 | Roaster - Port - Pacific | c_7 | Customer - NE USA | FEU | 0.34 | 28800 | 60000 |
| r_11 | Roaster - Port - Pacific | c_8 | Customer - NE USA | FEU | 0.34 | 28800 | 60000 |
| r_11 | Roaster - Port - Pacific | c_9 | Customer - NE USA | FEU | 0.34 | 28800 | 60000 |
| r_11 | Roaster - Port - Pacific | c_10 | Customer - NE USA | FEU | 0.34 | 28800 | 60000 |
| r_11 | Roaster - Port - Pacific | c_1 | Customer - NE USA | pallet | 0.34 | 600 | 1320 |
| r_11 | Roaster - Port - Pacific | c_2 | Customer - NE USA | pallet | 0.34 | 600 | 1320 |
| r_11 | Roaster - Port - Pacific | c_3 | Customer - NE USA | pallet | 0.34 | 600 | 1320 |
| r_11 | Roaster - Port - Pacific | c_4 | Customer - NE USA | pallet | 0.34 | 600 | 1320 |
| r_11 | Roaster - Port - Pacific | c_5 | Customer - NE USA | pallet | 0.34 | 600 | 1320 |
| r_11 | Roaster - Port - Pacific | c_6 | Customer - NE USA | pallet | 0.34 | 600 | 1320 |
| r_11 | Roaster - Port - Pacific | c_7 | Customer - NE USA | pallet | 0.34 | 600 | 1320 |
| r_11 | Roaster - Port - Pacific | c_8 | Customer - NE USA | pallet | 0.34 | 600 | 1320 |
| r_11 | Roaster - Port - Pacific | c_9 | Customer - NE USA | pallet | 0.34 | 600 | 1320 |
| r_11 | Roaster - Port - Pacific | c_10 | Customer - NE USA | pallet | 0.34 | 600 | 1320 |
| r_11 | Roaster - Port - Pacific | w_2 | Warehouse - NE USA | TEU | 0.34 | 28200 | 30000 |
| r_11 | Roaster - Port - Pacific | w_2 | Warehouse - NE USA | FEU | 0.34 | 28800 | 60000 |
| r_11 | Roaster - Port - Pacific | w_2 | Warehouse - NE USA | pallet | 0.34 | 600 | 1320 |
| r_12 | Roaster - Port - Pacific | c_1 | Customer - NE USA | TEU | 0.34 | 28200 | 30000 |
| r_12 | Roaster - Port - Pacific | c_2 | Customer - NE USA | TEU | 0.34 | 28200 | 30000 |
| r_12 | Roaster - Port - Pacific | c_3 | Customer - NE USA | TEU | 0.34 | 28200 | 30000 |
| r_12 | Roaster - Port - Pacific | c_4 | Customer - NE USA | TEU | 0.34 | 28200 | 30000 |
| r_12 | Roaster - Port - Pacific | c_5 | Customer - NE USA | TEU | 0.34 | 28200 | 30000 |
| r_12 | Roaster - Port - Pacific | c_6 | Customer - NE USA | TEU | 0.34 | 28200 | 30000 |

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|---|---|---|---|---|---|---|---|
| r_12 | Roaster - Port - Pacific | c_7 | Customer - NE USA | TEU | 0.34 | 28200 | 30000 |
| r_12 | Roaster - Port - Pacific | c_8 | Customer - NE USA | TEU | 0.34 | 28200 | 30000 |
| r_12 | Roaster - Port - Pacific | c_9 | Customer - NE USA | TEU | 0.34 | 28200 | 30000 |
| r_12 | Roaster - Port - Pacific | c_10 | Customer - NE USA | TEU | 0.34 | 28200 | 30000 |
| r_12 | Roaster - Port - Pacific | c_1 | Customer - NE USA | FEU | 0.34 | 28800 | 60000 |
| r_12 | Roaster - Port - Pacific | c_2 | Customer - NE USA | FEU | 0.34 | 28800 | 60000 |
| r_12 | Roaster - Port - Pacific | c_3 | Customer - NE USA | FEU | 0.34 | 28800 | 60000 |
| r_12 | Roaster - Port - Pacific | c_4 | Customer - NE USA | FEU | 0.34 | 28800 | 60000 |
| r_12 | Roaster - Port - Pacific | c_5 | Customer - NE USA | FEU | 0.34 | 28800 | 60000 |
| r_12 | Roaster - Port - Pacific | c_6 | Customer - NE USA | FEU | 0.34 | 28800 | 60000 |
| r_12 | Roaster - Port - Pacific | c_7 | Customer - NE USA | FEU | 0.34 | 28800 | 60000 |
| r_12 | Roaster - Port - Pacific | c_8 | Customer - NE USA | FEU | 0.34 | 28800 | 60000 |
| r_12 | Roaster - Port - Pacific | c_9 | Customer - NE USA | FEU | 0.34 | 28800 | 60000 |
| r_12 | Roaster - Port - Pacific | c_10 | Customer - NE USA | FEU | 0.34 | 28800 | 60000 |
| r_12 | Roaster - Port - Pacific | c_1 | Customer - NE USA | pallet | 0.34 | 600 | 1320 |
| r_12 | Roaster - Port - Pacific | c_2 | Customer - NE USA | pallet | 0.34 | 600 | 1320 |
| r_12 | Roaster - Port - Pacific | c_3 | Customer - NE USA | pallet | 0.34 | 600 | 1320 |
| r_12 | Roaster - Port - Pacific | c_4 | Customer - NE USA | pallet | 0.34 | 600 | 1320 |
| r_12 | Roaster - Port - Pacific | c_5 | Customer - NE USA | pallet | 0.34 | 600 | 1320 |
| r_12 | Roaster - Port - Pacific | c_6 | Customer - NE USA | pallet | 0.34 | 600 | 1320 |
| r_12 | Roaster - Port - Pacific | c_7 | Customer - NE USA | pallet | 0.34 | 600 | 1320 |
| r_12 | Roaster - Port - Pacific | c_8 | Customer - NE USA | pallet | 0.34 | 600 | 1320 |
| r_12 | Roaster - Port - Pacific | c_9 | Customer - NE USA | pallet | 0.34 | 600 | 1320 |
| r_12 | Roaster - Port - Pacific | c_10 | Customer - NE USA | pallet | 0.34 | 600 | 1320 |
| r_12 | Roaster - Port - Pacific | w_2 | Warehouse - NE USA | TEU | 0.34 | 28200 | 30000 |
| r_12 | Roaster - Port - Pacific | w_2 | Warehouse - NE USA | FEU | 0.34 | 28800 | 60000 |
| r_12 | Roaster - Port - Pacific | w_2 | Warehouse - NE USA | pallet | 0.34 | 600 | 1320 |
| r_13 | Roaster - Port - Atlantic | c_1 | Customer - NE USA | TEU | 0.34 | 28200 | 30000 |
| r_13 | Roaster - Port - Atlantic | c_2 | Customer - NE USA | TEU | 0.34 | 28200 | 30000 |
| r_13 | Roaster - Port - Atlantic | c_3 | Customer - NE USA | TEU | 0.34 | 28200 | 30000 |
| r_13 | Roaster - Port - Atlantic | c_4 | Customer - NE USA | TEU | 0.34 | 28200 | 30000 |
| r_13 | Roaster - Port - Atlantic | c_5 | Customer - NE USA | TEU | 0.34 | 28200 | 30000 |
| r_13 | Roaster - Port - Atlantic | c_6 | Customer - NE USA | TEU | 0.34 | 28200 | 30000 |
| r_13 | Roaster - Port - Atlantic | c_7 | Customer - NE USA | TEU | 0.34 | 28200 | 30000 |
| r_13 | Roaster - Port - Atlantic | c_8 | Customer - NE USA | TEU | 0.34 | 28200 | 30000 |
| r_13 | Roaster - Port - Atlantic | c_9 | Customer - NE USA | TEU | 0.34 | 28200 | 30000 |
| r_13 | Roaster - Port - Atlantic | c_10 | Customer - NE USA | TEU | 0.34 | 28200 | 30000 |
| r_13 | Roaster - Port - Atlantic | c_1 | Customer - NE USA | FEU | 0.34 | 28800 | 60000 |
| r_13 | Roaster - Port - Atlantic | c_2 | Customer - NE USA | FEU | 0.34 | 28800 | 60000 |
| r_13 | Roaster - Port - Atlantic | c_3 | Customer - NE USA | FEU | 0.34 | 28800 | 60000 |
| r_13 | Roaster - Port - Atlantic | c_4 | Customer - NE USA | FEU | 0.34 | 28800 | 60000 |
| r_13 | Roaster - Port - Atlantic | c_5 | Customer - NE USA | FEU | 0.34 | 28800 | 60000 |
| r_13 | Roaster - Port - Atlantic | c_6 | Customer - NE USA | FEU | 0.34 | 28800 | 60000 |
| r_13 | Roaster - Port - Atlantic | c_7 | Customer - NE USA | FEU | 0.34 | 28800 | 60000 |
| r_13 | Roaster - Port - Atlantic | c_8 | Customer - NE USA | FEU | 0.34 | 28800 | 60000 |
| r_13 | Roaster - Port - Atlantic | c_9 | Customer - NE USA | FEU | 0.34 | 28800 | 60000 |
| r_13 | Roaster - Port - Atlantic | c_10 | Customer - NE USA | FEU | 0.34 | 28800 | 60000 |
| r_13 | Roaster - Port - Atlantic | c_1 | Customer - NE USA | pallet | 0.34 | 600 | 1320 |
| r_13 | Roaster - Port - Atlantic | c_2 | Customer - NE USA | pallet | 0.34 | 600 | 1320 |
| r_13 | Roaster - Port - Atlantic | c_3 | Customer - NE USA | pallet | 0.34 | 600 | 1320 |
| r_13 | Roaster - Port - Atlantic | c_4 | Customer - NE USA | pallet | 0.34 | 600 | 1320 |
| r_13 | Roaster - Port - Atlantic | c_5 | Customer - NE USA | pallet | 0.34 | 600 | 1320 |
| r_13 | Roaster - Port - Atlantic | c_6 | Customer - NE USA | pallet | 0.34 | 600 | 1320 |
| r_13 | Roaster - Port - Atlantic | c_7 | Customer - NE USA | pallet | 0.34 | 600 | 1320 |

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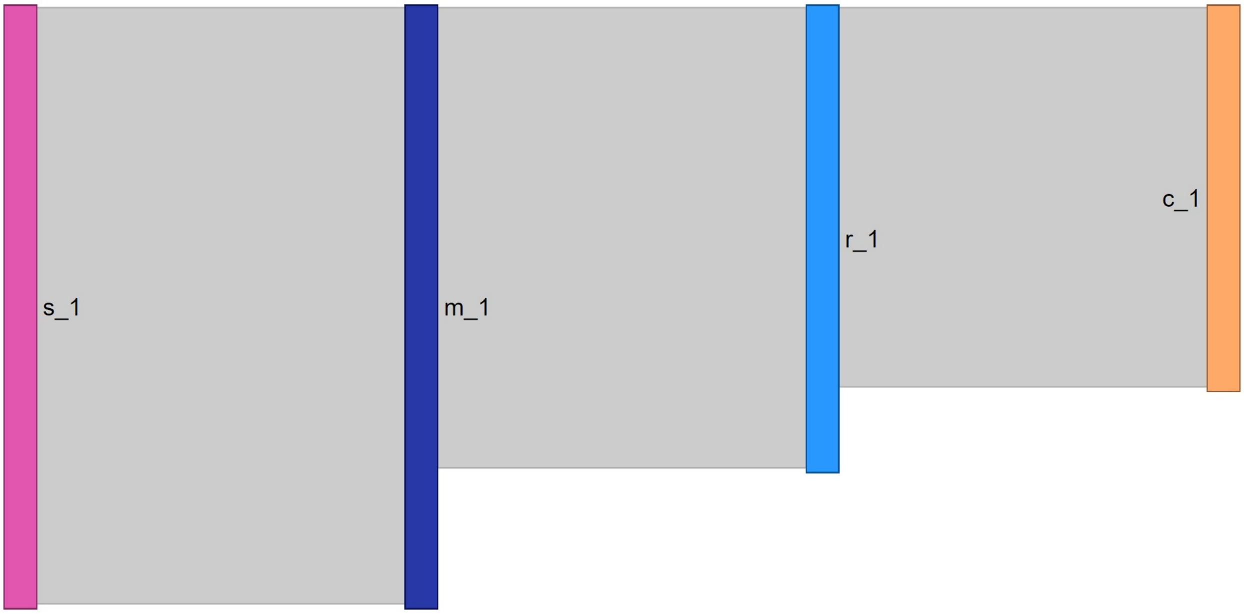
|---|---|---|---|---|---|---|---|
| r_13 | Roaster - Port - Atlantic | c_8 | Customer - NE USA | pallet | 0.34 | 600 | 1320 |
| r_13 | Roaster - Port - Atlantic | c_9 | Customer - NE USA | pallet | 0.34 | 600 | 1320 |
| r_13 | Roaster - Port - Atlantic | c_10 | Customer - NE USA | pallet | 0.34 | 600 | 1320 |
| r_13 | Roaster - Port - Atlantic | w_2 | Warehouse - NE USA | TEU | 0.34 | 28200 | 30000 |
| r_13 | Roaster - Port - Atlantic | w_2 | Warehouse - NE USA | FEU | 0.34 | 28800 | 60000 |
| r_13 | Roaster - Port - Atlantic | w_2 | Warehouse - NE USA | pallet | 0.34 | 600 | 1320 |
| r_14 | Roaster - Port - Atlantic | c_1 | Customer - NE USA | TEU | 0.34 | 28200 | 30000 |
| r_14 | Roaster - Port - Atlantic | c_2 | Customer - NE USA | TEU | 0.34 | 28200 | 30000 |
| r_14 | Roaster - Port - Atlantic | c_3 | Customer - NE USA | TEU | 0.34 | 28200 | 30000 |
| r_14 | Roaster - Port - Atlantic | c_4 | Customer - NE USA | TEU | 0.34 | 28200 | 30000 |
| r_14 | Roaster - Port - Atlantic | c_5 | Customer - NE USA | TEU | 0.34 | 28200 | 30000 |
| r_14 | Roaster - Port - Atlantic | c_6 | Customer - NE USA | TEU | 0.34 | 28200 | 30000 |
| r_14 | Roaster - Port - Atlantic | c_7 | Customer - NE USA | TEU | 0.34 | 28200 | 30000 |
| r_14 | Roaster - Port - Atlantic | c_8 | Customer - NE USA | TEU | 0.34 | 28200 | 30000 |
| r_14 | Roaster - Port - Atlantic | c_9 | Customer - NE USA | TEU | 0.34 | 28200 | 30000 |
| r_14 | Roaster - Port - Atlantic | c_10 | Customer - NE USA | TEU | 0.34 | 28200 | 30000 |
| r_14 | Roaster - Port - Atlantic | c_1 | Customer - NE USA | FEU | 0.34 | 28800 | 60000 |
| r_14 | Roaster - Port - Atlantic | c_2 | Customer - NE USA | FEU | 0.34 | 28800 | 60000 |
| r_14 | Roaster - Port - Atlantic | c_3 | Customer - NE USA | FEU | 0.34 | 28800 | 60000 |
| r_14 | Roaster - Port - Atlantic | c_4 | Customer - NE USA | FEU | 0.34 | 28800 | 60000 |
| r_14 | Roaster - Port - Atlantic | c_5 | Customer - NE USA | FEU | 0.34 | 28800 | 60000 |
| r_14 | Roaster - Port - Atlantic | c_6 | Customer - NE USA | FEU | 0.34 | 28800 | 60000 |
| r_14 | Roaster - Port - Atlantic | c_7 | Customer - NE USA | FEU | 0.34 | 28800 | 60000 |
| r_14 | Roaster - Port - Atlantic | c_8 | Customer - NE USA | FEU | 0.34 | 28800 | 60000 |
| r_14 | Roaster - Port - Atlantic | c_9 | Customer - NE USA | FEU | 0.34 | 28800 | 60000 |
| r_14 | Roaster - Port - Atlantic | c_10 | Customer - NE USA | FEU | 0.34 | 28800 | 60000 |
| r_14 | Roaster - Port - Atlantic | c_1 | Customer - NE USA | pallet | 0.34 | 600 | 1320 |
| r_14 | Roaster - Port - Atlantic | c_2 | Customer - NE USA | pallet | 0.34 | 600 | 1320 |
| r_14 | Roaster - Port - Atlantic | c_3 | Customer - NE USA | pallet | 0.34 | 600 | 1320 |
| r_14 | Roaster - Port - Atlantic | c_4 | Customer - NE USA | pallet | 0.34 | 600 | 1320 |
| r_14 | Roaster - Port - Atlantic | c_5 | Customer - NE USA | pallet | 0.34 | 600 | 1320 |
| r_14 | Roaster - Port - Atlantic | c_6 | Customer - NE USA | pallet | 0.34 | 600 | 1320 |
| r_14 | Roaster - Port - Atlantic | c_7 | Customer - NE USA | pallet | 0.34 | 600 | 1320 |
| r_14 | Roaster - Port - Atlantic | c_8 | Customer - NE USA | pallet | 0.34 | 600 | 1320 |
| r_14 | Roaster - Port - Atlantic | c_9 | Customer - NE USA | pallet | 0.34 | 600 | 1320 |
| r_14 | Roaster - Port - Atlantic | c_10 | Customer - NE USA | pallet | 0.34 | 600 | 1320 |
| r_14 | Roaster - Port - Atlantic | w_2 | Warehouse - NE USA | TEU | 0.34 | 28200 | 30000 |
| r_14 | Roaster - Port - Atlantic | w_2 | Warehouse - NE USA | FEU | 0.34 | 28800 | 60000 |
| r_14 | Roaster - Port - Atlantic | w_2 | Warehouse - NE USA | pallet | 0.34 | 600 | 1320 |
| r_15 | Roaster - NE USA | c_1 | Customer - NE USA | delivery | 0.34 | 1 | 3.5 |
| r_15 | Roaster - NE USA | c_2 | Customer - NE USA | delivery | 0.34 | 1 | 3.5 |
| r_15 | Roaster - NE USA | c_3 | Customer - NE USA | delivery | 0.34 | 1 | 3.5 |
| r_15 | Roaster - NE USA | c_4 | Customer - NE USA | delivery | 0.34 | 1 | 3.5 |
| r_15 | Roaster - NE USA | c_5 | Customer - NE USA | delivery | 0.34 | 1 | 3.5 |
| r_15 | Roaster - NE USA | c_6 | Customer - NE USA | delivery | 0.34 | 1 | 3.5 |
| r_15 | Roaster - NE USA | c_7 | Customer - NE USA | delivery | 0.34 | 1 | 3.5 |
| r_15 | Roaster - NE USA | c_8 | Customer - NE USA | delivery | 0.34 | 1 | 3.5 |
| r_15 | Roaster - NE USA | c_9 | Customer - NE USA | delivery | 0.34 | 1 | 3.5 |
| r_15 | Roaster - NE USA | c_10 | Customer - NE USA | delivery | 0.34 | 1 | 3.5 |
| r_16 | Roaster - NE USA | c_1 | Customer - NE USA | delivery | 0.34 | 1 | 3.5 |
| r_16 | Roaster - NE USA | c_2 | Customer - NE USA | delivery | 0.34 | 1 | 3.5 |
| r_16 | Roaster - NE USA | c_3 | Customer - NE USA | delivery | 0.34 | 1 | 3.5 |
| r_16 | Roaster - NE USA | c_4 | Customer - NE USA | delivery | 0.34 | 1 | 3.5 |
| r_16 | Roaster - NE USA | c_5 | Customer - NE USA | delivery | 0.34 | 1 | 3.5 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| r_16 | Roaster - NE USA | c_6 | Customer - NE USA | delivery | 0.34 | 1 | 3.5 |
| r_16 | Roaster - NE USA | c_7 | Customer - NE USA | delivery | 0.34 | 1 | 3.5 |
| r_16 | Roaster - NE USA | c_8 | Customer - NE USA | delivery | 0.34 | 1 | 3.5 |
| r_16 | Roaster - NE USA | c_9 | Customer - NE USA | delivery | 0.34 | 1 | 3.5 |
| r_16 | Roaster - NE USA | c_10 | Customer - NE USA | delivery | 0.34 | 1 | 3.5 |
| r_17 | Roaster - NE USA | c_1 | Customer - NE USA | delivery | 0.34 | 1 | 3.5 |
| r_17 | Roaster - NE USA | c_2 | Customer - NE USA | delivery | 0.34 | 1 | 3.5 |
| r_17 | Roaster - NE USA | c_3 | Customer - NE USA | delivery | 0.34 | 1 | 3.5 |
| r_17 | Roaster - NE USA | c_4 | Customer - NE USA | delivery | 0.34 | 1 | 3.5 |
| r_17 | Roaster - NE USA | c_5 | Customer - NE USA | delivery | 0.34 | 1 | 3.5 |
| r_17 | Roaster - NE USA | c_6 | Customer - NE USA | delivery | 0.34 | 1 | 3.5 |
| r_17 | Roaster - NE USA | c_7 | Customer - NE USA | delivery | 0.34 | 1 | 3.5 |
| r_17 | Roaster - NE USA | c_8 | Customer - NE USA | delivery | 0.34 | 1 | 3.5 |
| r_17 | Roaster - NE USA | c_9 | Customer - NE USA | delivery | 0.34 | 1 | 3.5 |
| r_17 | Roaster - NE USA | c_10 | Customer - NE USA | delivery | 0.34 | 1 | 3.5 |

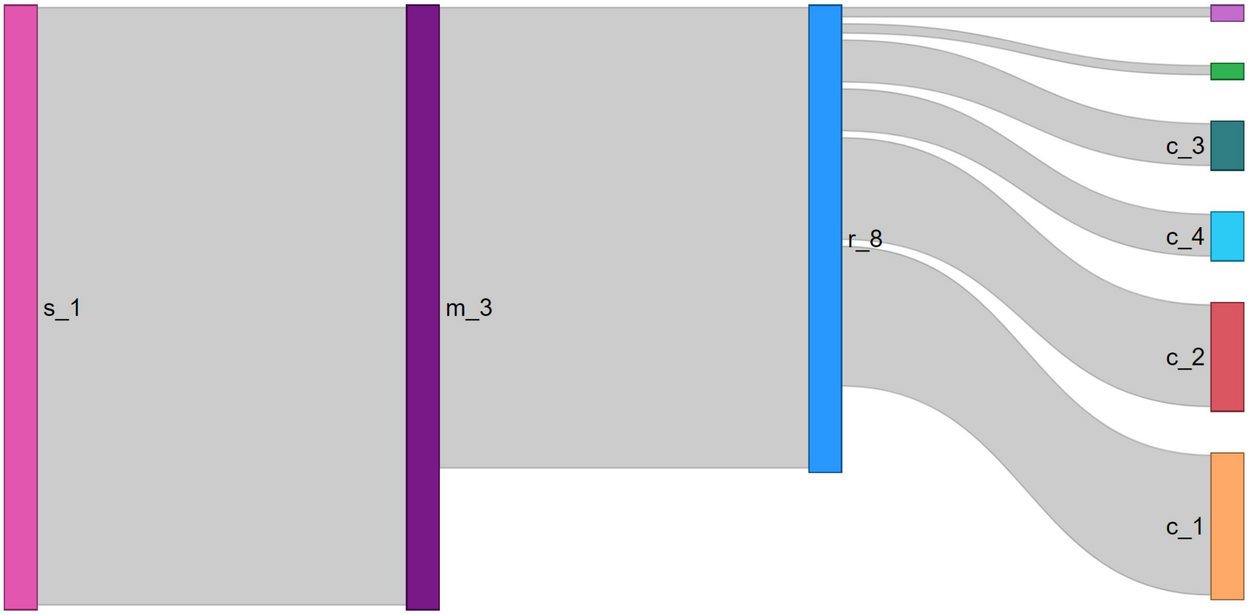
## APPENDIX D. BASELINE SCENARIO SOLUTION



## APPENDIX E. SCENARIO [SC02] SOLUTION – LOW STABLE DEMAND

| Node | Coffee flow in kilograms | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | p1 | p2 | p3 | p4 | p5 | p6 | p7 | p8 | p9 | p10 | p11 | p12 |
| **s_1** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **s_2** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **s_3** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **m_1** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **m_2** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **m_3** | 22.3 | 22.3 | 22.3 | 22.3 | 22.3 | 22.3 | 22.3 | 22.3 | 22.3 | 22.3 | 22.3 | 22.3 |
| **m_4** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **m_5** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **m_6** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **m_7** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **w_1** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **w_2** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_1** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_2** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_3** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_4** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_5** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_6** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_7** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_8** | 17.2 | 17.2 | 17.2 | 17.2 | 17.2 | 17.2 | 17.2 | 17.2 | 17.2 | 17.2 | 17.2 | 17.2 |
| **r_9** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_10** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_11** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_12** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_13** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_14** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_15** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_16** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_17** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **c_1** | 5.4 | 5.4 | 5.4 | 5.4 | 5.4 | 5.4 | 5.4 | 5.4 | 5.4 | 5.4 | 5.4 | 5.4 |
| **c_2** | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 |
| **c_3** | 1.8 | 1.8 | 1.8 | 1.8 | 1.8 | 1.8 | 1.8 | 1.8 | 1.8 | 1.8 | 1.8 | 1.8 |
| **c_4** | 1.8 | 1.8 | 1.8 | 1.8 | 1.8 | 1.8 | 1.8 | 1.8 | 1.8 | 1.8 | 1.8 | 1.8 |
| **c_5** | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 |
| **c_6** | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 |
| **c_7** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **c_8** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **c_9** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **c_10** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

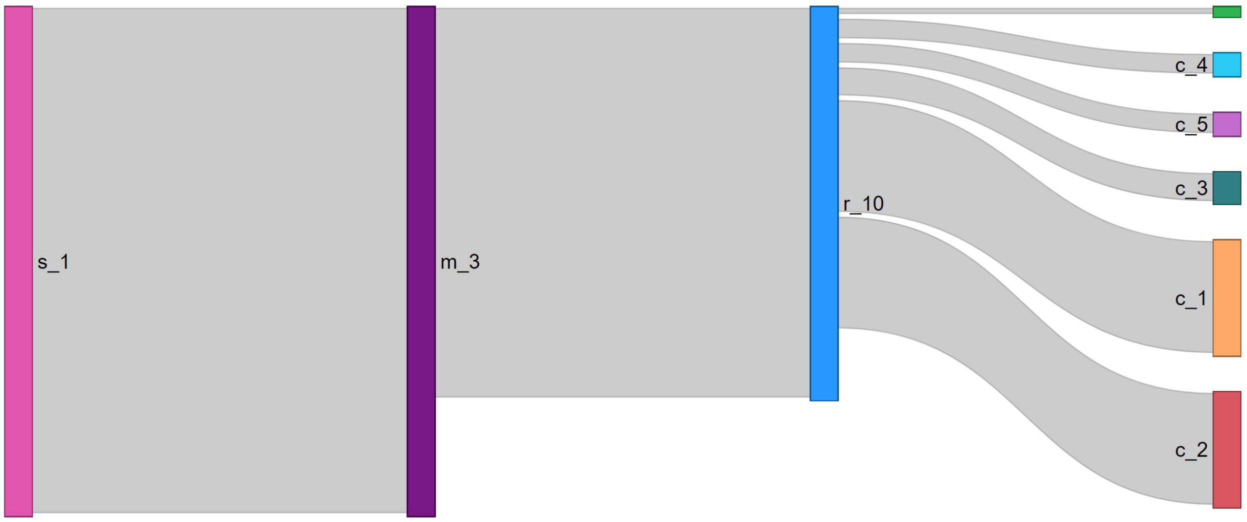
| **O** | **D** | **M** | **Coffee flow in kilograms** | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | **p1** | **p2** | **p3** | **p4** | **p5** | **p6** | **p7** | **p8** | **p9** | **p10** | **p11** | **p12** |
| **s_1** | **m_3** | **b** | 22.3 | 22.3 | 22.3 | 22.3 | 22.3 | 22.3 | 22.3 | 22.3 | 22.3 | 22.3 | 22.3 | 22.3 |
| **m_3** | **r_8** | **b** | 17.2 | 17.2 | 17.2 | 17.2 | 17.2 | 17.2 | 17.2 | 17.2 | 17.2 | 17.2 | 17.2 | 17.2 |
| **r_8** | **c_1** | **T** | 5.4 | 5.4 | 5.4 | 5.4 | 5.4 | 5.4 | 5.4 | 5.4 | 5.4 | 5.4 | 5.4 | 5.4 |
| **r_8** | **c_2** | **T** | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 |
| **r_8** | **c_3** | **p** | 1.8 | 1.8 | 1.8 | 1.8 | 1.8 | 1.8 | 1.8 | 1.8 | 1.8 | 1.8 | 1.8 | 1.8 |
| **r_8** | **c_4** | **p** | 1.8 | 1.8 | 1.8 | 1.8 | 1.8 | 1.8 | 1.8 | 1.8 | 1.8 | 1.8 | 1.8 | 1.8 |
| **r_8** | **c_5** | **p** | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 |
| **r_8** | **c_6** | **p** | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 |



## APPENDIX F. SCENARIO [SC03] SOLUTION – HIGH STABLE DEMAND

| Node | Coffee flow in kilograms | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **p1** | **p2** | **p3** | **p4** | **p5** | **p6** | **p7** | **p8** | **p9** | **p10** | **p11** | **p12** |
| **s_1** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **s_2** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **s_3** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **m_1** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **m_2** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **m_3** | 84.0 | 84.0 | 84.0 | 84.0 | 84.0 | 84.0 | 84.0 | 84.0 | 84.0 | 84.0 | 84.0 | 84.0 |
| **m_4** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **m_5** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **m_6** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **m_7** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **w_1** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **w_2** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_1** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_2** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_3** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_4** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_5** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_6** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_7** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_8** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_9** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_10** | 65.0 | 65.0 | 65.0 | 65.0 | 65.0 | 65.0 | 65.0 | 65.0 | 65.0 | 65.0 | 65.0 | 65.0 |
| **r_11** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_12** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_13** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_14** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_15** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_16** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_17** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **c_1** | 19.2 | 19.2 | 19.2 | 19.2 | 19.2 | 19.2 | 19.2 | 19.2 | 19.2 | 19.2 | 19.2 | 19.2 |
| **c_2** | 19.2 | 19.2 | 19.2 | 19.2 | 19.2 | 19.2 | 19.2 | 19.2 | 19.2 | 19.2 | 19.2 | 19.2 |
| **c_3** | 5.4 | 5.4 | 5.4 | 5.4 | 5.4 | 5.4 | 5.4 | 5.4 | 5.4 | 5.4 | 5.4 | 5.4 |
| **c_4** | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 |
| **c_5** | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 |
| **c_6** | 1.8 | 1.8 | 1.8 | 1.8 | 1.8 | 1.8 | 1.8 | 1.8 | 1.8 | 1.8 | 1.8 | 1.8 |
| **c_7** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **c_8** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **c_9** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **c_10** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

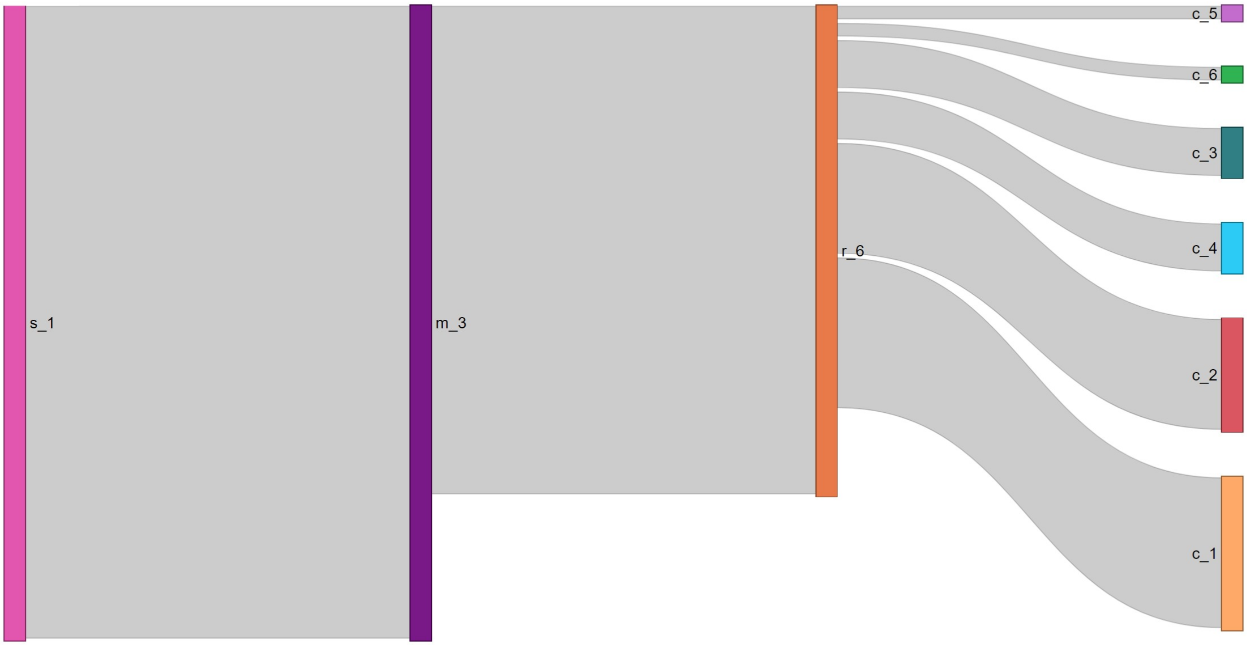
| O | D | M | Coffee flow in kilograms | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | **p1** | **p2** | **p3** | **p4** | **p5** | **p6** | **p7** | **p8** | **p9** | **p10** | **p11** | **p12** |
| **s_1** | **m_3** | **b** | 84.0 | 84.0 | 84.0 | 84.0 | 84.0 | 84.0 | 84.0 | 84.0 | 84.0 | 84.0 | 84.0 | 84.0 |
| **m_3** | **r_10** | **b** | 65.0 | 65.0 | 65.0 | 65.0 | 65.0 | 65.0 | 65.0 | 65.0 | 65.0 | 65.0 | 65.0 | 65.0 |
| **r_10** | **c_1** | **T** | 19.2 | 19.2 | 19.2 | 19.2 | 19.2 | 19.2 | 19.2 | 19.2 | 19.2 | 19.2 | 19.2 | 19.2 |
| **r_10** | **c_2** | **T** | 19.2 | 19.2 | 19.2 | 19.2 | 19.2 | 19.2 | 19.2 | 19.2 | 19.2 | 19.2 | 19.2 | 19.2 |
| **r_10** | **c_3** | **T** | 5.4 | 5.4 | 5.4 | 5.4 | 5.4 | 5.4 | 5.4 | 5.4 | 5.4 | 5.4 | 5.4 | 5.4 |
| **r_10** | **c_4** | **T** | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 |
| **r_10** | **c_5** | **T** | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 |
| **r_10** | **c_6** | **T** | 1.8 | 1.8 | 1.8 | 1.8 | 1.8 | 1.8 | 1.8 | 0.0 | 1.8 | 1.8 | 1.8 | 0.0 |
| **r_10** | **c_6** | **p** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.8 | 0.0 | 0.0 | 0.0 | 1.8 |



## APPENDIX G. SCENARIO [SC04] SOLUTION – LOW SEASONAL DEMAND

| **Node** | **Coffee flow in kilograms** | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **p1** | **p2** | **p3** | **p4** | **p5** | **p6** | **p7** | **p8** | **p9** | **p10** | **p11** | **p12** |
| **s_1** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **s_2** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **s_3** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **m_1** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **m_2** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **m_3** | 16.7 | 20.0 | 20.7 | 20.3 | 17.6 | 19.6 | 20.7 | 21.8 | 26.0 | 28.3 | 29.8 | 25.6 |
| **m_4** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **m_5** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **m_6** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **m_7** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **w_1** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **w_2** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_1** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_2** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_3** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_4** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_5** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_6** | 12.9 | 15.5 | 16.0 | 15.7 | 13.6 | 15.1 | 16.0 | 16.9 | 20.1 | 21.9 | 23.1 | 19.8 |
| **r_7** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_8** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_9** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_10** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_11** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_12** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_13** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_14** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_15** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_16** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_17** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **c_1** | 4.1 | 4.9 | 5.0 | 4.9 | 4.3 | 4.8 | 5.0 | 5.3 | 6.3 | 6.9 | 7.2 | 6.2 |
| **c_2** | 3.0 | 3.6 | 3.7 | 3.6 | 3.2 | 3.5 | 3.7 | 3.9 | 4.7 | 5.1 | 5.4 | 4.6 |
| **c_3** | 1.4 | 1.6 | 1.7 | 1.6 | 1.4 | 1.6 | 1.7 | 1.8 | 2.1 | 2.3 | 2.4 | 2.1 |
| **c_4** | 1.4 | 1.6 | 1.7 | 1.6 | 1.4 | 1.6 | 1.7 | 1.8 | 2.1 | 2.3 | 2.4 | 2.1 |
| **c_5** | 0.5 | 0.5 | 0.6 | 0.5 | 0.5 | 0.5 | 0.6 | 0.6 | 0.7 | 0.8 | 0.8 | 0.7 |
| **c_6** | 0.5 | 0.5 | 0.6 | 0.5 | 0.5 | 0.5 | 0.6 | 0.6 | 0.7 | 0.8 | 0.8 | 0.7 |
| **c_7** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **c_8** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **c_9** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **c_10** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

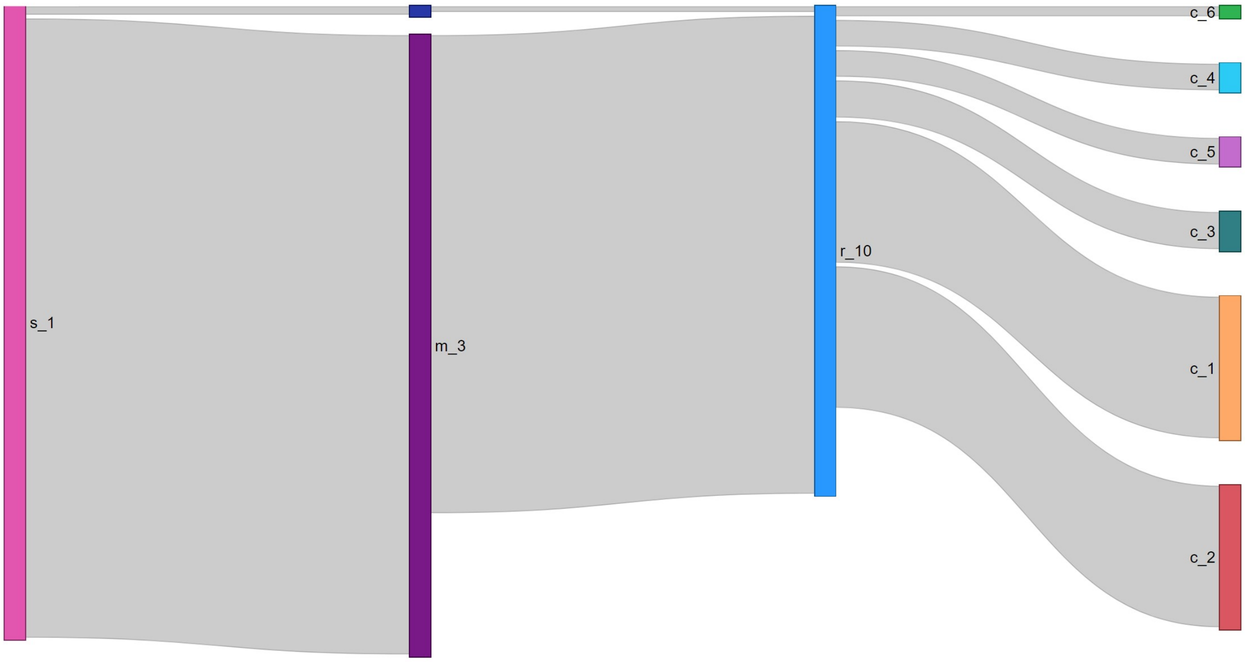
| O | D | M | Coffee flow in kilograms | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | **p1** | **p2** | **p3** | **p4** | **p5** | **p6** | **p7** | **p8** | **p9** | **p10** | **p11** | **p12** |
| **s_1** | **m_3** | **b** | 16.7 | 20.0 | 20.7 | 20.3 | 17.6 | 19.6 | 20.7 | 21.8 | 26.0 | 28.3 | 29.8 | 25.6 |
| **m_3** | **r_6** | **b** | 12.9 | 15.5 | 16.0 | 15.7 | 13.6 | 15.1 | 16.0 | 16.9 | 20.1 | 21.9 | 23.1 | 19.8 |
| **r_6** | **c_1** | **T** | 4.0 | 4.9 | 5.0 | 4.9 | 4.3 | 4.8 | 5.0 | 5.3 | 6.3 | 6.9 | 7.2 | 6.2 |
| **r_6** | **c_2** | **T** | 3.0 | 3.6 | 3.7 | 3.6 | 3.2 | 3.5 | 3.7 | 3.9 | 4.7 | 5.1 | 5.4 | 4.6 |
| **r_6** | **c_4** | **T** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 2.4 | 0.0 |
| **r_6** | **c_3** | **p** | 1.3 | 1.6 | 1.7 | 1.6 | 1.4 | 1.6 | 1.7 | 1.8 | 2.1 | 2.3 | 2.4 | 2.1 |
| **r_6** | **c_4** | **p** | 1.3 | 1.6 | 1.7 | 1.6 | 1.4 | 1.6 | 1.7 | 1.8 | 2.1 | 2.3 | 0.0 | 2.1 |
| **r_6** | **c_5** | **p** | 0.4 | 0.5 | 0.6 | 0.5 | 0.5 | 0.5 | 0.6 | 0.6 | 0.7 | 0.8 | 0.8 | 0.7 |
| **r_6** | **c_6** | **p** | 0.4 | 0.5 | 0.6 | 0.5 | 0.5 | 0.5 | 0.6 | 0.6 | 0.7 | 0.8 | 0.8 | 0.7 |



# APPENDIX H. SCENARIO [SC05] SOLUTION – HIGH SEASONAL DEMAND

| Node | Coffee flow in kilograms | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | p1 | p2 | p3 | p4 | p5 | p6 | p7 | p8 | p9 | p10 | p11 | p12 |
| **s_1** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **s_2** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **s_3** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **m_1** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 6.7 | 12.6 | 0.0 |
| **m_2** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **m_3** | 63.0 | 75.6 | 78.1 | 76.5 | 66.4 | 73.9 | 78.1 | 82.3 | 98.3 | 100.0 | 100.0 | 96.6 |
| **m_4** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **m_5** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **m_6** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **m_7** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **w_1** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **w_2** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_1** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_2** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_3** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_4** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_5** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_6** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_7** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_8** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_9** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_10** | 48.7 | 58.5 | 60.4 | 59.1 | 51.3 | 57.2 | 60.4 | 63.7 | 76.0 | 82.5 | 87.1 | 74.7 |
| **r_11** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_12** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_13** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_14** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_15** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_16** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_17** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **c_1** | 14.4 | 17.3 | 17.9 | 17.5 | 15.2 | 16.9 | 17.9 | 18.8 | 22.5 | 24.4 | 25.7 | 22.1 |
| **c_2** | 14.4 | 17.3 | 17.9 | 17.5 | 15.2 | 16.9 | 17.9 | 18.8 | 22.5 | 24.4 | 25.7 | 22.1 |
| **c_3** | 4.1 | 4.9 | 5.0 | 4.9 | 4.3 | 4.8 | 5.0 | 5.3 | 6.3 | 6.9 | 7.2 | 6.2 |
| **c_4** | 3.0 | 3.6 | 3.7 | 3.6 | 3.2 | 3.5 | 3.7 | 3.9 | 4.7 | 5.1 | 5.4 | 4.6 |
| **c_5** | 3.0 | 3.6 | 3.7 | 3.6 | 3.2 | 3.5 | 3.7 | 3.9 | 4.7 | 5.1 | 5.4 | 4.6 |
| **c_6** | 1.4 | 1.6 | 1.7 | 1.6 | 1.4 | 1.6 | 1.7 | 1.8 | 2.1 | 2.3 | 2.4 | 2.1 |
| **c_7** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **c_8** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **c_9** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **c_10** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

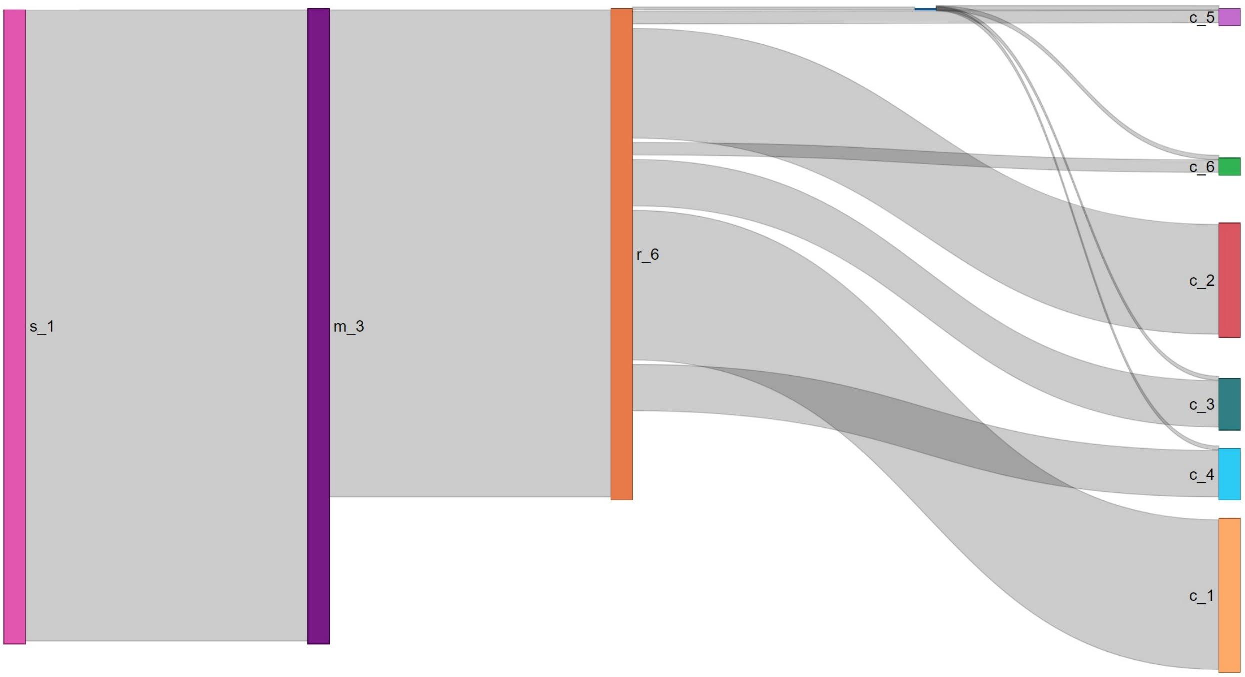
| O | D | M | Coffee flow in kilograms | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | **p1** | **p2** | **p3** | **p4** | **p5** | **p6** | **p7** | **p8** | **p9** | **p10** | **p11** | **p12** |
| **s_1** | **m_1** | **b** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 6.7 | 12.6 | 0.0 |
| **s_1** | **m_3** | **b** | 63.0 | 75.6 | 78.1 | 76.5 | 66.4 | 73.9 | 78.1 | 82.3 | 98.3 | 100.0 | 100.0 | 96.6 |
| **m_1** | **r_10** | **b** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 5.2 | 9.7 | 0.0 |
| **m_3** | **r_10** | **b** | 48.7 | 58.5 | 60.4 | 59.1 | 51.3 | 57.2 | 60.4 | 63.7 | 76.0 | 77.3 | 77.3 | 74.7 |
| **r_10** | **c_1** | **T** | 14.4 | 17.3 | 17.9 | 17.5 | 15.2 | 16.9 | 17.9 | 18.8 | 22.5 | 24.4 | 25.7 | 22.1 |
| **r_10** | **c_2** | **T** | 14.4 | 17.3 | 17.9 | 17.5 | 15.2 | 16.9 | 17.9 | 18.8 | 22.5 | 24.4 | 25.7 | 22.1 |
| **r_10** | **c_3** | **T** | 4.0 | 4.9 | 5.0 | 4.9 | 4.3 | 4.8 | 5.0 | 5.3 | 6.3 | 6.9 | 7.2 | 6.2 |
| **r_10** | **c_4** | **T** | 3.0 | 3.6 | 3.7 | 3.6 | 3.2 | 3.5 | 3.7 | 3.9 | 4.7 | 5.1 | 5.4 | 4.6 |
| **r_10** | **c_5** | **T** | 3.0 | 3.6 | 3.7 | 3.6 | 3.2 | 3.5 | 3.7 | 3.9 | 4.7 | 5.1 | 5.4 | 4.6 |
| **r_10** | **c_6** | **T** | 1.3 | 0.0 | 1.7 | 0.0 | 0.0 | 0.0 | 0.0 | 1.8 | 0.0 | 0.0 | 2.4 | 2.1 |



## APPENDIX I. SCENARIO [SC06] SOLUTION – LOW GROWING DEMAND

| Node | Coffee flow in kilograms | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | p1 | p2 | p3 | p4 | p5 | p6 | p7 | p8 | p9 | p10 | p11 | p12 |
| **s_1** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **s_2** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **s_3** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **m_1** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **m_2** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **m_3** | 16.8 | 17.6 | 18.5 | 19.4 | 20.4 | 21.4 | 22.5 | 23.6 | 24.8 | 26.0 | 27.3 | 28.7 |
| **m_4** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **m_5** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **m_6** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **m_7** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **w_1** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **w_2** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.6 | 0.0 | 0.0 | 0.0 |
| **r_1** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_2** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_3** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_4** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_5** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_6** | 13.0 | 13.6 | 14.3 | 15.0 | 15.8 | 16.6 | 17.4 | 18.3 | 19.2 | 20.1 | 21.1 | 22.2 |
| **r_7** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_8** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_9** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_10** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_11** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_12** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_13** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_14** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_15** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_16** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_17** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **c_1** | 4.1 | 4.3 | 4.5 | 4.7 | 4.9 | 5.2 | 5.5 | 5.7 | 6.0 | 6.3 | 6.6 | 7.0 |
| **c_2** | 3.0 | 3.2 | 3.3 | 3.5 | 3.7 | 3.8 | 4.0 | 4.2 | 4.5 | 4.7 | 4.9 | 5.2 |
| **c_3** | 1.4 | 1.4 | 1.5 | 1.6 | 1.7 | 1.7 | 1.8 | 1.9 | 2.0 | 2.1 | 2.2 | 2.3 |
| **c_4** | 1.4 | 1.4 | 1.5 | 1.6 | 1.7 | 1.7 | 1.8 | 1.9 | 2.0 | 2.1 | 2.2 | 2.3 |
| **c_5** | 0.5 | 0.5 | 0.5 | 0.5 | 0.6 | 0.6 | 0.6 | 0.6 | 0.7 | 0.7 | 0.7 | 0.8 |
| **c_6** | 0.5 | 0.5 | 0.5 | 0.5 | 0.6 | 0.6 | 0.6 | 0.6 | 0.7 | 0.7 | 0.7 | 0.8 |
| **c_7** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **c_8** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **c_9** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **c_10** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

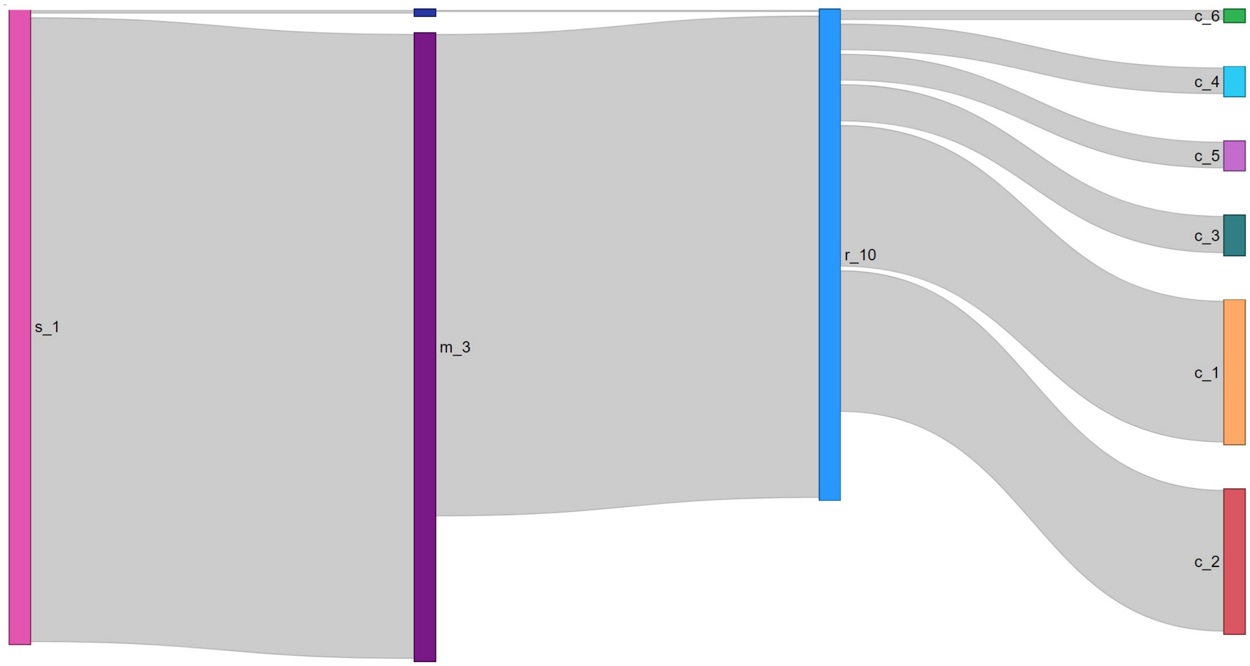
| O | D | M | Coffee flow in kilograms |  |  |  |  |  |  |  |  |  |  |  |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  |  |  | **p1** | **p2** | **p3** | **p4** | **p5** | **p6** | **p7** | **p8** | **p9** | **p10** | **p11** | **p12** |
| **s_1** | **m_3** | **b** | 16.8 | 17.6 | 18.5 | 19.4 | 20.4 | 21.4 | 22.5 | 23.6 | 24.8 | 26.0 | 27.3 | 28.7 |
| **m_3** | **r_6** | **b** | 13.0 | 13.6 | 14.3 | 15.0 | 15.8 | 16.6 | 17.4 | 18.3 | 19.2 | 20.1 | 21.1 | 22.2 |
| **w_2** | **c_3** | **d** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 | 0.0 |
| **w_2** | **c_4** | **d** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 | 0.0 |
| **w_2** | **c_5** | **d** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 |
| **w_2** | **c_6** | **d** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 |
| **r_6** | **c_1** | **T** | 4.1 | 4.3 | 4.5 | 4.7 | 4.9 | 5.2 | 5.5 | 5.7 | 6.0 | 6.3 | 6.6 | 7.0 |
| **r_6** | **c_2** | **T** | 3.0 | 3.2 | 3.3 | 3.5 | 3.7 | 3.8 | 4.0 | 4.2 | 4.5 | 4.7 | 4.9 | 5.2 |
| **r_6** | **c_3** | **p** | 1.4 | 1.4 | 1.5 | 1.6 | 1.6 | 1.7 | 1.8 | 1.9 | 1.8 | 2.1 | 2.2 | 2.3 |
| **r_6** | **c_4** | **p** | 1.4 | 1.4 | 1.5 | 1.6 | 1.6 | 1.7 | 1.8 | 1.9 | 1.8 | 2.1 | 2.2 | 2.3 |
| **r_6** | **c_5** | **p** | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.6 | 0.6 | 0.6 | 0.6 | 0.7 | 0.7 | 0.8 |
| **r_6** | **c_6** | **p** | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.6 | 0.6 | 0.6 | 0.6 | 0.7 | 0.7 | 0.8 |
| **r_6** | **w_2** | **p** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.6 | 0.0 | 0.0 | 0.0 |



## APPENDIX J. SCENARIO [SC07] SOLUTION – HIGH GROWING DEMAND

| Node | Coffee flow in kilograms | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | p1 | p2 | p3 | p4 | p5 | p6 | p7 | p8 | p9 | p10 | p11 | p12 |
| **s_1** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **s_2** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **s_3** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **m_1** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 3.2 | 8.3 |
| **m_2** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **m_3** | 63.3 | 66.5 | 69.8 | 73.3 | 77.0 | 80.8 | 84.9 | 89.1 | 93.6 | 98.3 | 100.0 | 100.0 |
| **m_4** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **m_5** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **m_6** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **m_7** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **w_1** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **w_2** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_1** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_2** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_3** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_4** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_5** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_6** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_7** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_8** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_9** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_10** | 49.0 | 51.4 | 54.0 | 56.7 | 59.5 | 62.5 | 65.6 | 68.9 | 72.4 | 76.0 | 79.8 | 83.8 |
| **r_11** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_12** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_13** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_14** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_15** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_16** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_17** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **c_1** | 14.5 | 15.2 | 16.0 | 16.8 | 17.6 | 18.5 | 19.4 | 20.4 | 21.4 | 22.5 | 23.6 | 24.8 |
| **c_2** | 14.5 | 15.2 | 16.0 | 16.8 | 17.6 | 18.5 | 19.4 | 20.4 | 21.4 | 22.5 | 23.6 | 24.8 |
| **c_3** | 4.1 | 4.3 | 4.5 | 4.7 | 4.9 | 5.2 | 5.5 | 5.7 | 6.0 | 6.3 | 6.6 | 7.0 |
| **c_4** | 3.0 | 3.2 | 3.3 | 3.5 | 3.7 | 3.8 | 4.0 | 4.2 | 4.5 | 4.7 | 4.9 | 5.2 |
| **c_5** | 3.0 | 3.2 | 3.3 | 3.5 | 3.7 | 3.8 | 4.0 | 4.2 | 4.5 | 4.7 | 4.9 | 5.2 |
| **c_6** | 1.4 | 1.4 | 1.5 | 1.6 | 1.7 | 1.7 | 1.8 | 1.9 | 2.0 | 2.1 | 2.2 | 2.3 |
| **c_7** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **c_8** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **c_9** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **c_10** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

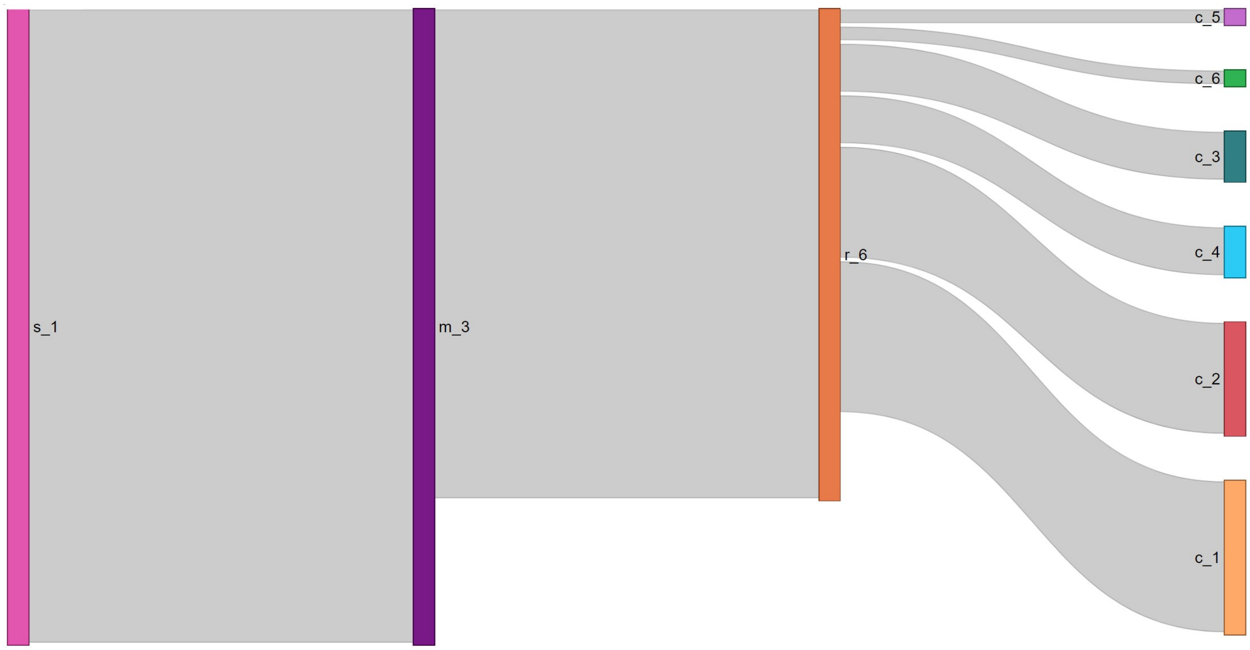
| **O** | **D** | **M** | **Coffee flow in kilograms** | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | **p1** | **p2** | **p3** | **p4** | **p5** | **p6** | **p7** | **p8** | **p9** | **p10** | **p11** | **p12** |
| **s_1** | **m_1** | **b** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 3.2 | 8.3 |
| **s_1** | **m_3** | **b** | 63.3 | 66.5 | 69.8 | 73.3 | 77.0 | 80.8 | 84.9 | 89.1 | 93.6 | 98.3 | 100.0 | 100.0 |
| **m_1** | **r_10** | **b** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 2.5 | 6.5 |
| **m_3** | **r_10** | **b** | 49.0 | 51.4 | 54.0 | 56.7 | 59.5 | 62.5 | 65.6 | 68.9 | 72.4 | 76.0 | 77.3 | 77.3 |
| **r_10** | **c_1** | **T** | 14.5 | 15.2 | 16.0 | 16.8 | 17.6 | 18.5 | 19.4 | 20.4 | 21.4 | 22.5 | 23.6 | 24.8 |
| **r_10** | **c_2** | **T** | 14.5 | 15.2 | 16.0 | 16.8 | 17.6 | 18.5 | 19.4 | 20.4 | 21.4 | 22.5 | 23.6 | 24.8 |
| **r_10** | **c_3** | **T** | 4.1 | 4.3 | 4.5 | 4.7 | 4.9 | 5.2 | 5.5 | 5.7 | 6.0 | 6.3 | 6.6 | 7.0 |
| **r_10** | **c_4** | **T** | 3.0 | 3.2 | 3.3 | 3.5 | 3.7 | 3.8 | 4.0 | 4.2 | 4.5 | 4.7 | 4.9 | 5.2 |
| **r_10** | **c_5** | **T** | 3.0 | 3.2 | 3.3 | 3.5 | 3.7 | 3.8 | 4.0 | 4.2 | 4.5 | 4.7 | 4.9 | 5.2 |
| **r_10** | **c_6** | **T** | 1.4 | 0.0 | 1.5 | 1.6 | 0.0 | 1.7 | 0.0 | 1.9 | 2.0 | 2.1 | 2.2 | 0.0 |
| **r_10** | **c_6** | **p** | 0.0 | 1.4 | 0.0 | 0.0 | 1.6 | 0.0 | 1.8 | 0.0 | 0.0 | 0.0 | 0.0 | 2.3 |



## APPENDIX K. SCENARIO [SC08] SOLUTION – LOW GROWING SEASONAL DEMAND

| Node | Coffee flow in kilograms | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | p1 | p2 | p3 | p4 | p5 | p6 | p7 | p8 | p9 | p10 | p11 | p12 |
| **s_1** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **s_2** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **s_3** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **m_1** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **m_2** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **m_3** | 18.0 | 21.6 | 21.1 | 20.2 | 16.7 | 15.4 | 15.1 | 15.5 | 19.1 | 25.4 | 35.8 | 43.2 |
| **m_4** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **m_5** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **m_6** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **m_7** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **w_1** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **w_2** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_1** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_2** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_3** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_4** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_5** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_6** | 13.9 | 16.7 | 16.3 | 15.6 | 12.9 | 11.9 | 11.7 | 12.0 | 14.7 | 19.7 | 27.7 | 33.4 |
| **r_7** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_8** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_9** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_10** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_11** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_12** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_13** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_14** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_15** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_16** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_17** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **c_1** | 4.4 | 5.2 | 5.1 | 4.9 | 4.1 | 3.7 | 3.7 | 3.8 | 4.6 | 6.2 | 8.7 | 10.5 |
| **c_2** | 3.2 | 3.9 | 3.8 | 3.6 | 3.0 | 2.8 | 2.7 | 2.8 | 3.4 | 4.6 | 6.4 | 7.8 |
| **c_3** | 1.5 | 1.7 | 1.7 | 1.6 | 1.4 | 1.2 | 1.2 | 1.3 | 1.5 | 2.1 | 2.9 | 3.5 |
| **c_4** | 1.5 | 1.7 | 1.7 | 1.6 | 1.4 | 1.2 | 1.2 | 1.3 | 1.5 | 2.1 | 2.9 | 3.5 |
| **c_5** | 0.5 | 0.6 | 0.6 | 0.5 | 0.5 | 0.4 | 0.4 | 0.4 | 0.5 | 0.7 | 1.0 | 1.2 |
| **c_6** | 0.5 | 0.6 | 0.6 | 0.5 | 0.5 | 0.4 | 0.4 | 0.4 | 0.5 | 0.7 | 1.0 | 1.2 |
| **c_7** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **c_8** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **c_9** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **c_10** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

| O | D | M | Coffee flow in kilograms | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | **p1** | **p2** | **p3** | **p4** | **p5** | **p6** | **p7** | **p8** | **p9** | **p10** | **p11** | **p12** |
| **s_1** | **m_3** | **b** | 18.0 | 21.6 | 21.1 | 20.2 | 16.7 | 15.4 | 15.1 | 15.5 | 19.1 | 25.4 | 35.8 | 43.2 |
| **m_3** | **r_6** | **b** | 13.9 | 16.7 | 16.3 | 15.6 | 12.9 | 11.9 | 11.7 | 12.0 | 14.7 | 19.7 | 27.7 | 33.4 |
| **r_6** | **c_6** | **a** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_6** | **c_1** | **T** | 4.4 | 5.2 | 5.1 | 4.9 | 4.1 | 3.7 | 3.7 | 3.8 | 4.6 | 6.2 | 8.7 | 10.5 |
| **r_6** | **c_2** | **T** | 3.2 | 3.9 | 3.8 | 3.6 | 3.0 | 2.8 | 2.7 | 2.8 | 3.4 | 4.6 | 6.4 | 7.8 |
| **r_6** | **c_3** | **T** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 2.9 | 3.5 |
| **r_6** | **c_4** | **T** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 2.9 | 3.5 |
| **r_6** | **c_3** | **p** | 1.5 | 1.7 | 1.7 | 1.6 | 1.4 | 1.2 | 1.2 | 1.3 | 1.5 | 2.1 | 0.0 | 0.0 |
| **r_6** | **c_4** | **p** | 1.5 | 1.7 | 1.7 | 1.6 | 1.4 | 1.2 | 1.2 | 1.3 | 1.5 | 2.1 | 0.0 | 0.0 |
| **r_6** | **c_5** | **p** | 0.5 | 0.6 | 0.6 | 0.5 | 0.5 | 0.4 | 0.4 | 0.4 | 0.5 | 0.7 | 1.0 | 1.2 |
| **r_6** | **c_6** | **p** | 0.5 | 0.6 | 0.6 | 0.5 | 0.5 | 0.4 | 0.0 | 0.4 | 0.5 | 0.7 | 1.0 | 1.2 |



# APPENDIX L. SCENARIO [SC09] SOLUTION – HIGH GROWING SEASONAL DEMAND

| Node | Coffee flow in kilograms | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **p1** | **p2** | **p3** | **p4** | **p5** | **p6** | **p7** | **p8** | **p9** | **p10** | **p11** | **p12** |
| **s_1** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **s_2** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **s_3** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **m_1** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **m_2** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 35.0 | 63.1 |
| **m_3** | 67.9 | 81.5 | 79.6 | 76.1 | 63.1 | 58.3 | 56.9 | 58.6 | 72.0 | 96.0 | 100.0 | 100.0 |
| **m_4** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **m_5** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **m_6** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **m_7** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **w_1** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **w_2** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_1** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_2** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_3** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_4** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_5** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_6** | 0.0 | 2.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 7.8 | 26.3 |
| **r_7** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_8** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_9** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_10** | 52.5 | 60.9 | 61.6 | 58.8 | 48.8 | 45.1 | 44.0 | 45.3 | 55.7 | 74.2 | 96.6 | 99.8 |
| **r_11** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_12** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_13** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_14** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_15** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_16** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_17** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **c_1** | 15.5 | 18.6 | 18.2 | 17.4 | 14.4 | 13.3 | 13.0 | 13.4 | 16.4 | 21.9 | 30.9 | 37.3 |
| **c_2** | 15.5 | 18.6 | 18.2 | 17.4 | 14.4 | 13.3 | 13.0 | 13.4 | 16.4 | 21.9 | 30.9 | 37.3 |
| **c_3** | 4.4 | 5.2 | 5.1 | 4.9 | 4.1 | 3.7 | 3.7 | 3.8 | 4.6 | 6.2 | 8.7 | 10.5 |
| **c_4** | 3.2 | 3.9 | 3.8 | 3.6 | 3.0 | 2.8 | 2.7 | 2.8 | 3.4 | 4.6 | 6.4 | 7.8 |
| **c_5** | 3.2 | 3.9 | 3.8 | 3.6 | 3.0 | 2.8 | 2.7 | 2.8 | 3.4 | 4.6 | 6.4 | 7.8 |
| **c_6** | 1.5 | 1.7 | 1.7 | 1.6 | 1.4 | 1.2 | 1.2 | 1.3 | 1.5 | 2.1 | 2.9 | 3.5 |
| **c_7** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **c_8** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **c_9** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **c_10** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

| **O** | **D** | **M** | **Coffee flow in kilograms** | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | **p1** | **p2** | **p3** | **p4** | **p5** | **p6** | **p7** | **p8** | **p9** | **p10** | **p11** | **p12** |
| **s_1** | **m_2** | **b** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 35.0 | 63.1 |
| **s_1** | **m_3** | **b** | 67.9 | 81.5 | 79.6 | 76.1 | 63.1 | 58.3 | 56.9 | 58.6 | 72.0 | 96.0 | 100.0 | 100.0 |
| **m_2** | **r_10** | **b** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 27.1 | 48.8 |
| **m_3** | **r_6** | **b** | 0.0 | 2.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 7.8 | 26.3 |
| **m_3** | **r_10** | **b** | 52.5 | 60.9 | 61.6 | 58.8 | 48.8 | 45.1 | 44.0 | 45.3 | 55.7 | 74.2 | 69.5 | 51.0 |
| **r_6** | **c_3** | **T** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 10.5 |
| **r_6** | **c_4** | **T** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 7.8 |
| **r_6** | **c_5** | **T** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 6.4 | 0.0 |
| **r_6** | **c_6** | **T** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 3.5 |
| **r_6** | **c_6** | **p** | 0.0 | 1.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **r_10** | **c_1** | **T** | 15.5 | 18.6 | 18.2 | 17.4 | 14.4 | 13.3 | 13.0 | 13.4 | 16.4 | 21.9 | 30.9 | 37.3 |
| **r_10** | **c_2** | **T** | 15.5 | 18.6 | 18.2 | 17.4 | 14.4 | 13.3 | 13.0 | 13.4 | 16.4 | 21.9 | 30.9 | 37.3 |
| **r_10** | **c_3** | **T** | 4.4 | 5.2 | 5.1 | 4.9 | 4.1 | 3.7 | 3.7 | 3.8 | 4.6 | 6.2 | 8.7 | 0.0 |
| **r_10** | **c_4** | **T** | 3.2 | 3.9 | 3.8 | 3.6 | 3.0 | 2.8 | 2.7 | 2.8 | 3.4 | 4.6 | 6.4 | 0.0 |
| **r_10** | **c_5** | **T** | 3.2 | 3.9 | 3.8 | 3.6 | 3.0 | 2.8 | 2.7 | 2.8 | 3.4 | 4.6 | 0.0 | 7.8 |
| **r_10** | **c_6** | **T** | 1.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 2.9 | 0.0 |
| **r_10** | **c_6** | **p** | 0.0 | 0.0 | 1.7 | 1.6 | 1.4 | 1.2 | 1.2 | 1.3 | 1.5 | 2.1 | 0.0 | 0.0 |