

# Optimization of E-commerce Logistics Network in African Countries

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**Abstract:** The purpose of this research is to assist the Central African's logistics network authorities in making, evaluating, and realizing their decisions in regard to the development and management of e-commerce logistics network of companies. This article evaluated and used mathematical models which provided a descriptive analysis on the current situation of its' logistics network while applying the e-commerce logistics network optimization method in dealing with common issues of the logistics network in Central Africa, especially Chad. The suggested network in this study would promote the "from plant-to-from DC" ratio of 83% to 17% which conforms to the companies' objective in progressing towards direct plant shipments. In regard to that, it was proved that direct plant shipments could reduce the distribution costs from 12% to 3% of the net sales (approximately \$135,000 in monthly savings).

**Keywords:** Central Africa; Logistic network; Optimization; E-commerce

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## 1. Introduction and Problem Statement

The development of e-commerce has acquired great importance in contemporary business. It has helped business organizations, businessmen, and end-users to overcome the hindrance of time and distance in buying and selling as well as to fulfil other business transactions across the globe. The shipping in Chad has been greatly deregulated and many African countries are trapped in a vicious cycle of high tariffs which discourages traffics and increases the costs. According to the International Road Federation, less than a quarter of roads in Central African (Chad) have been paved. Electricity supply and postal services are also unreliable in many parts of Africa. These infrastructure issues affect the people's access to online platforms and the timely delivery of goods to clients.

In addition to the poor inland links in Chad (lack of an integrated land distribution system particularly for transit which impedes container traffic), inefficient administration and management as well as costly goods accentuate this problematic situation.<sup>[10]</sup> Several countries in Central Africa suffer from low capacities particularly in terms of storage terminal, maintenance, and dredging capabilities. Moreover, many companies are poorly equipped with inefficient operations. The decision for optimization is the highest level in decision-makings. These decisions are made based on long-term objectives because they would need a substantial amount of time in addition to large investments.

In this research, optimization decisions involve the launching of distribution centers (DC) (e.g., DC locations and sizes) and the shift in focus of the clients towards independent distributors.<sup>[12]</sup> Therefore, it is important to have a coordinated logistics network for companies' optimization and reduction of Central Africa's (CA) cost while serving as a vivid platform for cooperation, information sharing, and the exchange of practices and knowledge with the common goal of improving and developing the port logistics sector.<sup>[10]</sup>

A strategic development is therefore required since there is a high chance that the economy of Central

Africa as well as their foreign traders (allies and clients) would be affected. In this way, there would be a boost in the economy of the entire nation with poverty eradication and solving unemployment issues of most countries in Central Africa. Many Central African countries have been experiencing ramshackle of some of their key export goods (cocoa, coffee, rubber, oil, etc.) from the entire region.

Furthermore, the issue of long dwell time is another huge constraint which hinders the development of Central African ports and has brought about negative effects on their supply chains and logistics network services.<sup>[10]</sup>

With these in mind, this article intended to provide answers to the following questions related to Central Africa's logistic network development as far as port logistics and transportations are concerned.

- 1) What is the impact of Central Africa's logistics network modernization under the influence of globalization on the development of their economy?
- 2) Which issues of logistics network impact the Central African ports the most?
- 3) Which of these issues are the most critical and what is the effect from tackling them?
- 4) Does the elimination of these critical issues improve logistics network optimization under the influence of globalization?

The development of country-oriented systems includes the full cycle of tasks, such as collection and analysis of data, the definition of the requirements, designing, implementation, introducing, testing, and maintenance of the system.<sup>[11]</sup> The features required for approaching the design of this system are formulated as follows: fundamental analysis of countries' businesses to devise solutions corresponding to the goals and issues faced by clients; detailed explanation and coordination with the customers at all stages of the project development; controlled points and required resources; convenience in the maintenance, modifications, and extensions of the system; openness, mobility, and sociability of the system.

## 2. Literature Review

The logistics network optimization in the long-term strategic development of Central Africa can be defined as logistics that would open a "new world" with unparalleled locations as the gateway to boost the economy of Africa in which these logistic optimizations do not only serve the landlocked countries around their neighborhood but also, the coastal countries in other parts of Africa (north, east, south), as well as the global economy in general.

In line with this definition, most supply chain models include either a single objective (minimize cost) or two objectives (minimize cost while maximizing service level) in their models. However, researchers have showed that other objectives (customer response time, retailers' credit performance, etc.) are also important when optimizing the supply chain. Some of the major optimization models used in the supply chain are for production and inventory.

The mission for low costs in Central Africa can be realized as companies assist carriers to deliver customers' products to their destinations. The four operational functions associated with the logistics network are ship operation, transfer operation,<sup>[7][10]</sup> storage operation, and gate operation. In order to maintain continuous growth and development, short-term and long-term decision-makings are required for the survival of businesses. Once a strategy is set up and implemented, effective and efficient managements are still required because a generally accepted strategy does not necessarily mean a successful one.

To recognize if such a strategy is indeed the right or best strategy, the following characteristics can be observed:

- The strategy should guarantee little or negligible uncertainties.
- It is available and suitable for application in various situations.
- Unforeseen circumstances should have a rescue or backup measure.
- It should be possible to implement the strategy with the available resources in the organization.

- Profitability is guaranteed (via excellent hinterland connections among different countries).
- Competitiveness: examining the companies' weaknesses and using them as strengths, converting threats into opportunities, forecasting the future, and dynamically adapt to changes in managements.<sup>[1]</sup>

### 3. Methodology and Model Building

The problem in formulating the model is the assumption that only one option may be selected per client per plant. As the model will only be used to make tactical decisions, it would identify potential clients or distributors for direct shipments and the arrangement of clients among existing distributors.<sup>[8]</sup> Set,  $N_j$  was introduced to each client which included all the independent distributors that could supply to the client,  $j$ . The constraints of the first set introduced was that only one option can be selected per client per plant.

In Central Africa, companies are continuously looking for ways to improve their performance and remain competitive in the market. Ambrosiano and Grazer mentioned that “all companies that aim to be competitive in the market should pay attention to the entire organization of the supply chain.”<sup>[9]</sup> A large number of optimization models and algorithms have been developed to contribute to the decision-making process along the supply chain. Most of the recent research suggested models that would make decisions for only one function of the supply chain (e.g., production scheduling, facilities planning, inventory policies, etc.) at a time.

In order to answer the questions of Central Africa logistics network optimization, the use of multiple mathematical models is required. These models assisted in the correlation analysis of the relationship between CA's logistics network determinants and Chad's e-commerce values.<sup>[3]</sup> In simpler terms, the different models examined the critical issues of Central African logistics network separately. The multiple regression model suggested that there were critical issues that affected the landlocked e-commerce logistics under the influence of globalization. The following shows a few main equations:

#### Maximize profit

$$\begin{aligned}
& + \sum_{s \in S} \sum_{i \in I} \left[ VCM_{si} \beta_{si} + \sum_{j \in J} VCM_{sj} m_{sij} \right] - \sum_{k \in K} \sum_{j \in J} LTCC_{kj} Y_{kj} \\
& - \sum_{s \in S} \sum_{j \in J} TCC_{sj} t_{sj} - \sum_{k \in K} \sum_{i \in I} LTCD_{ki} \delta_{ki} - \sum_{s \in S} \sum_{i \in I} TCD_s IC_{si} - STC \\
& \left( \sum_{j \in J} \lambda_j + n_j \right) - \sum_{s \in S} \sum_{j \in J} HCC_{sj} y_{sj} - \sum_{s \in S} \sum_{i \in I} \left[ HCD_{si} (1 - \beta_{si}) \sum_{j \in J} cd_{sj} x_{sij} \right]
\end{aligned} \tag{1}$$

#### Minimize response time

$$\begin{aligned}
& + \sum_{j \in J} HCD_{sji} X_{sj} - CPP \\
& \left[ \sum_{s \in S} \sum_{j \in J} cd_{sj} y_{sj} + \sum_{s \in S} \sum_{i \in I} \left( dd_{si} (1 - \beta_{si}) + \sum_{j \in J} cd_{si} x_{sij} \right) \right]
\end{aligned} \tag{2}$$

#### Maximize power

$$\begin{aligned}
& DCLT \sum_{s \in S} \sum_{j \in J} y_{sj} + \sum_{s \in S} \sum_{j \in J} SLT_s t_{sj} \\
& + DLT \left( \sum_{s \in S} \sum_{i \in I} \sum_{j \in J} x_{sij} + \sum_{s \in S} \sum_{i \in I} m \right)
\end{aligned} \tag{3}$$

#### Credit performance

$$\sum_{j \in J} P_j x_{j+} + \sum_{j \in J} (10 - P_j) \lambda_j \tag{4}$$

#### Maximize distributors' reputations

$$\sum_{s \in S} \sum_{i \in I} \sum_{j \in J} R_i x_{sij} + \sum_{s \in S} \sum_{i \in I} \sum_{j \in J} R_i m_{sij} \tag{5}$$

## 4. Experiment and Results Analysis

The network that the client owns includes three warehouses and three distribution centers. Figure 1 shows the complete network locations of the warehouses and the distribution centers.

### 4.1. Data description

#### 4.1.1. Required amount to be shipped out

From each warehouse, JDGL is required to transport out a certain number of powdered drinks. For example, out of Libya, exactly 20 tons should be transported out. An illustration of the amount that is required to be shipped out is shown in Table 1 in which 15 tons should be transported out of Nigeria, 20 tons out of Libya, and 30 tons out of Sudan.

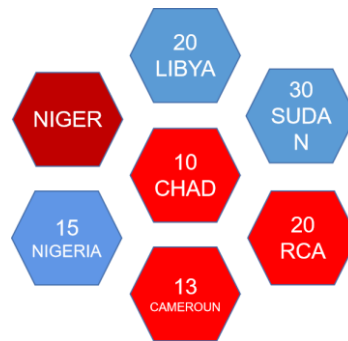


Figure 1. Complete network

Table 1. Amount to be shipped

Warehouse	To be shipped out (tons)
Nigeria	15
Libya	20
Sudan	30

#### 4.1.2. Minimum requirements to be received by DCs

Each distribution center has a minimum requirement for the amount it should receive. For example, at least 10 tons of the goods should be shipped into Chad's DC. In regard to the minimum quantity that must be shipped out of the warehouses, JDGL may ship more to these DCs than the required quantities to ensure that all 65 tons of the goods have been removed from the warehouse.

Table 2. Minimum requirements

DC	Minimum amount to be shipped
Chad	10
Cameroun	13
RCA	20

#### 4.1.3. Shipping costs

Transportation costs (in \$ per ton) are incurred to ship goods between each warehouse and DC. For example, to ship 10 tons from Sudan City to Cameroon, it would cost \$132 for each ton, hence, the total cost would be \$1,320. The cost incurred by JDGL for shipping one ton of powdered drink from each warehouse to each distribution center are shown in Table 3.

**Table 3.** Shipping costs

From \ To	Chad	Cameroun	RCA
Nigeria	\$105	\$135	\$153
Libya	\$110	\$140	\$137
Sudan	\$130	\$132	\$115

#### 4.2. Objective function

The objective function has three contributions from shipments originating from Nigeria, Libya, and Sudan each.

$105 * X_{NC}$  = cost to shipped  $X_{NC}$  from Nigeria to Chad

$135 * X_{NK}$  = cost to shipped  $X_{NK}$  from Nigeria to Cameroon

$153 * X_{NR}$  = cost to shipped  $X_{NR}$  from Nigeria to RCA

Total shipping costs to be minimized:

$105 * X_{NC} + 135 * X_{NK} + 153 * X_{NR} =$  Shipping cost from Nigeria to Chad +  $110 * X_{LC} + 140 * X_{LK} + 135 * X_{LR} =$  Shipping cost from Libya to Cameroun +  $130 * X_{SC} + 132 * X_{SK} + 115 * X_{SR} =$

#### 4.3. Demand constraints

JDGL needs to ship exact amounts from each warehouse. For example, all shipments from Nigeria’s warehouse either to Chad, RCA, or Cameroon, need to add up to 15 tons. In the same way, all shipments from Libya and Sudan must add up to 20 tons and 30 tons, respectively. From that, it can be understood that there are supply constraints for all three; Nigeria, Libya, and Sudan.

Starting with Chad’s DC, it needs to receive at least ten tons then, Cameroon center, at least 13 tons and finally, RCA needs to receive at least 20 tons.

$X_{NC} + X_{LC} + X_{SC} \geq 10$  (Minimum demand of Chad)

$X_{NK} + X_{LC} + X_{SC} \geq 13$  (Minimum demand of Cameroon)

$X_{NR} + X_{LR} + X_{SR} \geq 20$  (Minimum demand of RCA)

#### 4.4. Model formulation for JDGL

The summary of demand constraints is as follows. One for Chad, one for Cameroon, and one for RCA DCs. Putting all together, there would be an algebraic model with nine variables. The objective function and total shipping costs were expressed in terms of these nine variables. The respective expressions of the supply and demand constraints were also formulated.

The shipping quantities did not require any restrictions to integer values only since it is possible to ship fractional amounts. For example, 12.5 tons. Shipping quantities were also made certain that there were no negative values.

$105 * X_{NC} + 135 * X_{NK} + 153 * X_{NR} + 110 * X_{LC} + 140 * X_{LK} + 135 * X_{LR} + 130 * X_{SC} + 132 * X_{SK} + 115 * X_{SR}$

$X_{NC} + X_{NK} + X_{NR} = 15$  (Nigeria supply)

$X_{LC} + X_{LK} + X_{LR} = 13$  (Libya supply)

$X_{SC} + X_{SK} + X_{SR} = 20$  (Sudan supply)

$X_{NC} + X_{LC} + X_{SC} \geq 10$  (Minimum demand of Chad)

$X_{NK} + X_{LC} + X_{SC} \geq 13$  (Minimum demand of Cameroon)

$X_{NR} + X_{LR} + X_{SR} \geq 20$  (Minimum demand of RCA)

$X_{NC} \dots \dots X_{SR} \geq 0$  (Non-negative)

An algebraic model for JDGL was formulated. Excel was then used to create a spreadsheet formulation and the optimal shipping plan was determined using a solver. A template (JDGL) was provided.

#### 4.5. Results of the single objective and the multi-objective model

**Table 4.** Results of the single objective model

JDGL		JDGL Issue					
Operation analytics						Total cost (\$)	<b>7485</b>
Shipping cost (\$)							
From\To	Chad	Cameroun	Rca				
<b>Nigeria</b>	105	135	153				
<b>Libya</b>	110	140	137				
<b>Sudan</b>	130	132	115				
Shipping quantity / ton							
From\To	Chad	Cameroun	Rca	Total Shipped		Supply	
<b>Nigeria</b>	15	0	0	15		15	
<b>Libya</b>	17	3	0	20		20	
<b>Sudan</b>	0	10	20	30		30	
<b>Total</b>	32	13	20				
<b>Minimum demand</b>	10	13	20				

#### 4.6. Results Discussion

The results in regard to the questions are to stipulate that the current challenges may become opportunities in the long run. These developments should be examined over time so that more efficient logistics network and transport operations can be designed. This in turn would significantly decrease transport costs for CA's logistics network optimization.

**RQ1:** What is the impact of Central Africa's logistics network modernization under the influence of globalization on the development of their economy? African nations are living in poverty because of the unstable politics and economy. Central Africa in the attempt to fight this strangulation is determined to modernize their logistics network infrastructures to improve their economic standards.

However, the ineffectiveness of CA's logistics network or in general, their supply chain has been on constant alert. Following the research on the issues that affect the growth of e-commerce in CA, one would say that the ineffectiveness of CA's logistics network is substantial, but it is modernized under globalization with good strategic plans and frameworks.

**RQ2:** Which issues of logistics network impact the West and Central African ports the most? As far as the West and Central Africa's logistics network are concerned, there are many issues in relation to ineffectiveness such as poor hinterland links, outdated machineries, poor infrastructures, inadequate shipping services, benchmarking, low maintenance of port areas, port officials' corruptions, high custom fees, slow logistic performances, containerizations which linger low despite revival efforts, low capacity, and undeveloped technologies.<sup>[6]</sup>

**RQ3:** Which of these issues are the most significant and what is the effect from tackling them? According to research and other evaluations, the most significant or critical issues in Chad's logistics among others are poor hinterland links, outdated machineries, poor technologies, and the belt road capacity.<sup>[2]</sup>

However, the highest bid issue is the transportation rates which is persistent despite stabilizing efforts. This issue represents a tree that branches out with more problems such as long cargo dwell time and turnaround time of ships, congestions in transportation facilities, etc. For example, from 2008 to 2009, container traffic dismayed among WCA developing ports in which Cote d'Ivoire was at -5.13%, Senegal at -4.72%, and Cameroon at -10.00%.<sup>[5]</sup> Therefore, to tackle this problem, there is a necessity for a solid

strategic plan followed by frameworks in order to propose solutions for the defect.

In addition to that, the issue of underdeveloped technologies has destroyed all hope. Without adequate machineries and technologies, a proper port would be unable to keep up with the global trend. For example, the Douala port and Abidjan port have only two gantry cranes to move the containers up onto the docking ships. Hence, the time required is long and eventually, this would cause congestions at warehouses, DCs, and the companies' areas. As a subsequent effect, the cost for shipping would increase as shipping lines lengthen. Decisions on transshipment centers in CA would require a wider range of business considerations including the capacity of the ports, capabilities of warehouses or DCs to handle the significant increase in traffic, infrastructures, productivity to minimize turnaround time, and the country's stability.

**RQ4:** Does the elimination of these critical issues improve logistics network optimization under the influence of globalization? From the results of the analysis as well as the facts from the strategic formation and implementation of logistics network optimization, a substantial amount of information have been put forth to improve Central Africa's logistics network under the influence of globalization.

However, the eradication of all these issues in CA is not able to affirm the newly developed e-commerce logistics network as a whole in order to contribute to a boom in their economy. Nevertheless, there would be substantial improvements internally (logistic premises) and globally (in respect to CA countries and other countries outside CA) whereby clients and collaborators from all around the world would return for businesses. This reflects that the current challenges may become opportunities in the long run and these developments should be examined over time to ensure efficient ports and transport operations. Hence, the transportation costs would significantly reduce for the growth of Central African economies.

## 5. Conclusion

A mathematical model was developed to assist with tactical decisions in the design of a supply chain distribution network. The model proposed an ideal arrangement of distributors and customers in the supply chain network according to multiple objectives such as profit, clients' response time, power, credit performance, and distributors' reputation.

In this article, data from small landlocked regions of an anonymous consumer goods company were used. The model was solved with the general algebraic modeling system (GAMS) for each of the 12 months analyzed. The results showed a proposed network whereby 3 countries would directly receive from three warehouses, three clients would directly receive from only two of the plants, 24 clients would receive from only one plant, three clients would be supplied by a distributor, and the other 39 clients would receive from the DC.

This suggested network would ensure that the "from plant-to-from DC" ratio is 83% to 17% which conforms to the company's objective of moving towards direct plant shipments. It was proved that direct plant shipments could reduce distribution costs from 12% to 3% of the net sales (approximately \$135,000 in monthly savings).

## Disclosure statement

The author declares no conflict of interest.

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