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The Application of Shortest Path Model in the Efficiency of the Downstream Distribution: A Case Study of ALIMENS GAS COMPANY (Part A: From Tarkwa to SAMREBOI)

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Abstract

The main purpose of this study was to redesign a shortest path route for ALIMENS Gas Company which is situated in Tarkwa, to one of their distribution centers which is in SAMREBOI. The results depict the shortest path from **TARKWA ALIMENS GAS COMPANY to SAMREBOI** is **TK-PT-TB-ES-WA-AK-SB**. In addition, if the shortest path model strategy is implemented on this distribution channel, there would be a total reduction of 34 km which will help reduce the total distance thereby reducing fuel cost. Based on the findings, there is a need for ALIMENS GAS COMPANY to adopt shortest path model strategy, since they are facing problems with their lead time. In this case, products will be distributed on time whilst cutting down cost.

Keywords

TARKWA ALIMENS GAS Company, Customer Satisfaction, Lead Time, Shortest Path Model, SAMREBOI

1. Introduction

In today's globalized and extremely competitive business era, organizations and firms have begun to realize that in order to gain and sustain the competitive advantage, they have to deliver the best customer value at the lowest possible cost (Coyle et al., 2009). The customer is extremely becoming highly competitive with respect to faster response time, shorter product cycle time, customized products and services. With the growing importance of supply chain management, transportation has assumed an increasingly pivotal role (Gudonaviciene & Alijosiene, 2008).

A channel of distribution or trade channel is the path or route along which goods move from producers to ultimate consumers or industrial users. In other words, it is the distribution network through which a producer puts his product in the hands of actual users (Coughlan, 2006). Distribution serves as a key driver of the total or entire profitability of an organization, because it directly impacts both supply chain cost and customer satisfaction. Distribution represents all the logistics activities involved in delivering an organization's product to the right location, at the right time, at the right price or cost (Obaji, 2011).

ALIMENS Commercial Limited, commonly known as ALIMENS gas, is gas filling company located in the active town of Tarkwa, Abontiakoon to be precise. The company is owned and financed by Mr. Victor Essilifie. The company was established or founded in the year 2007. The company initially started with fifteen workers including drivers, watchmen, cashier tickets, secretary and a manager. ALIMENS GAS Company incurs a lot of costs due to their supply and distribution challenges they have been facing. As a result, demand is not met since lead times are longer and hence the company loses revenue. This paper seeks to redesign the shortest path or route from TARKWA ALIMENS GAS Company to one of their distribution centers (SAMREBOI) using the best means and mode of distribution at the downstream level in order to meet customer requirement and demand.

2. Literature Review

2.1. Customer Service

Customer service includes all sub-processes of the distribution, which add value to the product from the customer's viewpoint and mirror the speed and accuracy with which the order of a customer is delivered to him (Kartika et al., 2020). The main objectives of customer service in terms of logistics are:

- Reasonable formulation and service programming.
- Preserving and retaining satisfied customers in the direction of strengthening the occupied market share of the company.
- Enhancing the distribution time in regards of the processing of the orders.
- Ease of placing orders.
- The capacity to create quality control procedures of the supplied product, within the framework of the delivery.

The above objectives entirely and completely describe the prime or principal elements of customer service in relation to logistics: on time delivery, order-fill rate, product state or condition, correct and precise documentation (Gupta & Singh, 2015). Efficient and consistent customer service can assist and provide significantly in building long lasting and trustworthy relationships with customers through the increase of customers' loyalty (Mathong et al., 2020). High levels of customer service can also help to increase or shoot up demand and to retain a competitive advantage. Notwithstanding the importance of customer service, we must bear in mind that high levels of customer service come at high levels of cost. Hence, it is important to know precisely the desirable levels of customer service of our cus-

tomers and the cost of each level (Gandhi et al., 2019).

2.2. Channel Strategy

There are three types of market coverage:

- Intensive
- Selective
- Exclusive

Intensive distribution means that as many available outlets as possible hold this product, e.g. chocolate, newspapers, bread, etc. Intensive distribution will mean convenience to the customer and multiply or increase customer satisfaction. The sale of groceries in petrol and service stations is an example of how intensive distribution has grown. (Coyle et al., 2009).

Key characteristics comprise:

- Lower prices or cost
- Highest number of outlets covered to maximize availability
- Target outlets in as many geographical regions as possible
- Consumer convenience products
- High purchase frequency
- Impulsive purchase
- High number of purchasers

Selective distribution is different in that some products are only available from some outlets, e.g. electrical appliances, certain brands of clothes and fashion products (Gandhi et al., 2019).

Key characteristics include:

- Medium level of customers—but likely to be significant
- Less intensive distribution of outlets
- Retailers may require specialist knowledge
- Shopping based products
- Medium number of shoppers
- Purchase is occasional
- Purchase is more likely to be planned
- Medium price

Exclusive distribution is where possibly only one outlet in a certain geographic area supplies a product. This method of distribution usually relates to specialty products, e.g. special cars, special clothing, etc. Often exclusive distribution is relevant to niche products (Coyle et al., 2009).

Key characteristics include:

- Relatively few customers
- Limited retail outlets
- Close retailer/customer relationship
- Special products
- Infrequent purchase
- High involvement and planned purchase
- High price

2.3. Channel Decision

There are six basic channel decisions to make. These are:

- **Whether to distribute direct to the customer or indirectly through middlemen**. The benefits of going direct are that it enables or enhances firms to exercise more control over marketing activities and it reduces the amount of time spent in the channel. The disadvantages are that it is cumbersome to acquire or obtain widespread distribution, and more resources are required to maintain distribution. Going direct is the method widely used by industrial goods producers. In the case of consumer goods, examples of going directly to the customer are to be found in marketing cosmetics and encyclopedias (Obaji, 2011).
- **Whether to adopt single or multiple channels of distribution**. The advantages of using a single channel are that it guarantees a minimum level of sales and the exclusivity of using a single channel guarantees attention to the product. In the first case, intermediaries can be asked to accept a minimum non-returnable order quantity. In the second case, the fact that a product is only available from very specific outlets suggests that it is difficult to obtain because it is exclusive. The harder it is to get; the more people will want to know about it—or so the argument goes. On the other hand, the disadvantage of using exclusivity is that it does limit sales.

In contrast, the use of multiple channels should lead to increased or multiplying sales and a potential for wider distribution. It must be argued that the more establishments put the product on view, the more likely it is that sales will be substantial. Restricting the number of channels through which the product is sold, restricts the number of people who can come into contact with the product. On the other hand, there are disadvantages with using multiple channels. First, greater investment, more salespeople in the field, more marketing effort in general and more administration are required (Obaji, 2011).

- **How long should the channel of distribution be**? In determining the best channel length to adopt, the following factors have to be considered:

a) The financial strength of the producers in a strong position can carry out the functions provided by intermediaries.

b) Size and completeness of the product line—the costs of carrying out the distribution function can be spread across the various items in the product line. The more items, the more economical it might be to consider a shorter distribution channel.

c) The average order size—large orders may be distributed directly to customers.

d) The geographical concentration of customers—geographically dispersed customers merit a longer distribution channel since servicing them requires substantial investment of resources.

e) The distance of the distributor from the market—geographical distance makes it less attractive for the producer to want to supply direct (Coyle et al., 2009).

3. Methodology

3.1. Illustration of Shortest Path Model

The formula for the shortest path model is Min Σ Xij Dij. The purpose of the shortest path model is to minimize the distance between two main points. With this a matrix is formulated and solved. The solver in EXCEL is used to find the shortest path or route from **node A** to **node D**. The points in the network are called nodes (A, B, C, E, F, G, H, and D as shown in Figure 1 below) whilst the lines in the network are the arcs. The model has two major parts. The main parts of the model are:

- The network structure and flow (as shown in Figure 2)
- The flow balance constraints (as shown in Figure 2)

The network structure and flow comprise of the product source (the origin), the destination, the distance and route.

The flow balance constraints comprise of the node, the net outflow and the supply/demand. The net outflow shows the products or demand that should be supplied (as seen in Figure 3).

The following were named in order to make the ranges easier to comprehend as seen in Table 1.

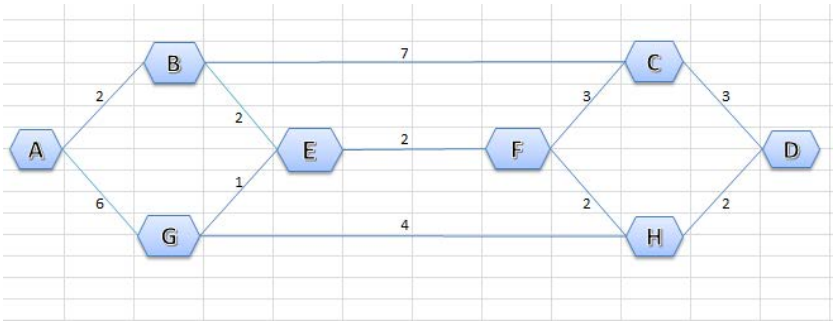

Figure 1. Illustration of shortest path diagram. (Source: Researcher, 2026)

NETWORK STRUCTURE AND FLOW		
FROM	TO	DISTANCE ROUTE
A	B	2
A	G	6
B	E	2
B	C	7
C	D	3
C	F	3
E	B	2
E	G	1
E	F	2
F	C	3
F	H	2
G	E	1
G	H	4
H	F	2
H	D	2
F	E	2

FLOW BALANCE CONSTRAINTS			
NODE	NET OUTFLOW	=	SUPPLY/DEMAND
A		=	1
B		=	0
C		=	0
E		=	0
F		=	0
G		=	0
H		=	0
D		=	-1

Figure 2. Illustrations of excel spread sheet. (Source: Researcher, 2026)

Table 1. Illustration of shortest path ranges. (Source: Researcher, 2026)

From	A4:A19
To	B4:B19
Distance	C4:C19
Net flow	J4:J11
Supply Demand	L4:L11
Total Distance	C21

3.2. Ideal Solution

NETWORK STRUCTURE AND FLOW			
FROM	TO	DISTANCE	ROUTE
A	B	2	1
A	G	6	0
B	E	2	1
B	C	7	0
C	D	3	0
C	F	3	0
E	B	2	0
E	G	1	0
E	F	2	1
F	C	3	0
F	H	2	1
G	E	1	0
G	H	4	0
H	F	2	0
H	D	2	1
F	E	2	0

FLOW BALANCE CONSTRAINTS			
NODE	NET OUTFLOW	=	SUPPLY/DEMAND
A	1	=	1
B	0	=	0
C	0	=	0
E	0	=	0
F	0	=	0
G	0	=	0
H	0	=	0
D	−1	=	−1

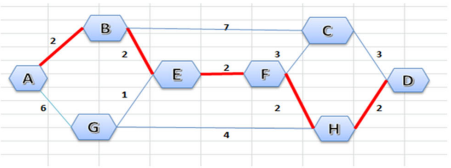

Figure 3. Illustrations of excel spread sheet. (Source: Researcher, 2026)

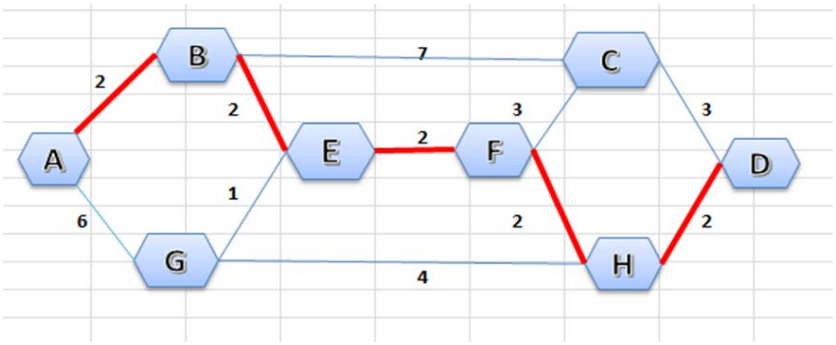

Figure 4. Illustrations of excel spread sheet. (Source: Researchers, 2026)

From Figure 4 above, it can be clearly seen that shortest path is A-B-E-F-H-D, which is the best and most efficient route for distribution.

4. Data Presentation and Analysis

ALIMENS GAS Company distributes liquefied petroleum gas to all its customers all over Tarkwa. Below are three separate samples showing the shortest path model from ALIMENS GAS Company to its customers in Tarkwa.

4.1. Finding the Shortest Path from TARKWA ALIMENS GAS COMPANY to SAMREBOI

And the original route used by ALIMENS GAS COMPANY TO SAMREBOI is from: **Tarkwa** to B**ogoso**, then from **Bogoso to Hiawa**, from **Hiawa** to **Manso Amenfi** and then to **Samreboi** (TK-BG-HW-MA-SB) which is 83 km as seen in Figure 5 and Figure 6.

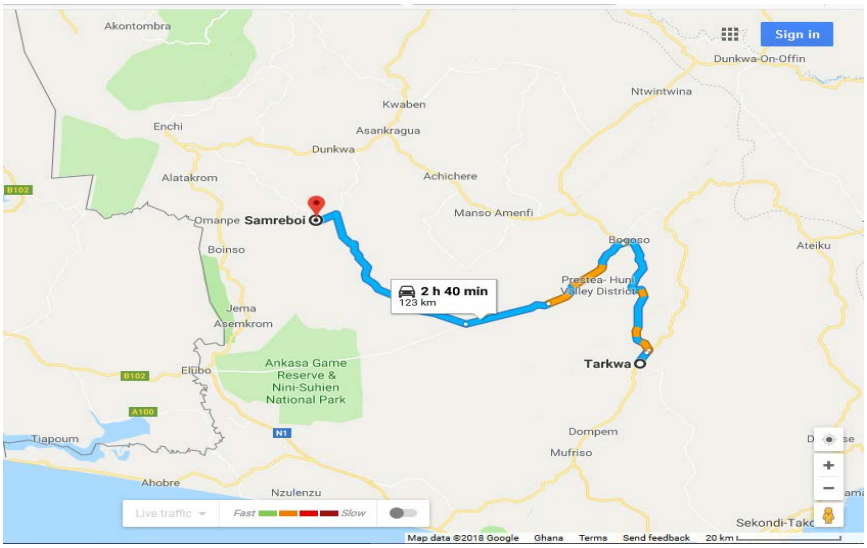

Figure 5. Map showing the various routes from Tarkwa ALIMENS GAS Company to SAMREBOI. (Source: Researcher, 2026)

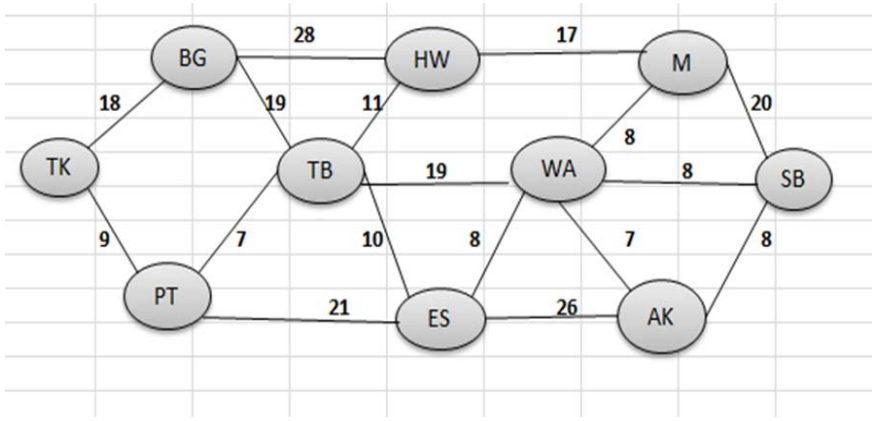

Figure 6. Sketched map showing the various routes from Tarkwa ALIMENS GAS Company to SAMREBOI. (Source: Researcher, 2026)

4.2. Abbreviations (Nodes) Full Names as Shown in Figure 6

TK	Tarkwa Alimens Gas Company
BG	Bogoso
PT	Prestea
HW	Hiawa

Continued

TB	Tarkwa Bremen
MA	Manso Amenfi
WA	Wassa Amenfi
ES	Esiama
AK	Amoaku
SB	Samerboi

NETWORK STRUCTURE AND FLOW		
FROM	TO	DISTANCE
TK	BG	18
TK	PT	9
BG	HW	28
BG	TB	19
PT	TB	7
PT	ES	21
TB	BG	19
TB	HW	11
TB	PT	7
TB	ES	10
TB	WA	19
HW	TB	11
ES	TB	10
HW	MA	17
ES	WA	26
ES	WA	8
MA	WA	20
AK	WA	7
WA	AK	7
AK	SB	8
WA	MA	8
MA	SB	20
WA	SB	8
Total distance	0	

NODE	NET FLOW	=	SUPPLY/DEMAND
TK		=	1
BG		=	0
PT		=	0
HW		=	0
TB		=	0
MA		=	0
WA		=	0
ES		=	0
AK		=	0
SB		=	-1

Figure 7. Shortest path excel spread sheet illustrations. (Source: Researcher, 2026)

At this point of the Excel Spread sheet illustration, the nodes in the Network Structure and Flow column are inserted (as shown in **Figure 2**). Every node which supplies a product to another node is inserted in the" From column, thus from (A3:A25). And every node that received a product or had the product passing through is inserted into the "To" column thus from (B3:B25). This is followed by the insertion of their respective distance units which are from (C3:C25) as seen in **Figure 7**.

From there we move to Flow Balance Constraints. This is where we insert all the names of the places which form the nodes serving as the available routes engaged in product delivery from TARKWA ALIMENS GAS Company to SAMREBOI, thus from (G3:G12). Under the Demand/Supply column, the first node which is the origin should only have an outgoing arc which is represented by 1 in cell column (J3). All the other intermediary nodes or towns are represented by 0 thus from cells (J4:J11). The final node/town which is the final receiving node is represented by the number −1 in cell (J12) as seen in **Figure 7**.

In calculating the Net Flow of each node, for example TARKWA ALIMENS GAS Company (TK), first enter the equal to sign, followed by selecting the sum if function. Afterwards, select all nodes in the "From" column thus from (A3: A25), then select the node (G3), and then highlight all the route columns thus (D3: D25). Thereafter, enter the minus sign, then select the sum if function, followed by highlighting all nodes in the "To" column thus (B3:B25), select the "TK" node again (G3), and then highlight all the route columns (D3:D25), and then close bracket and press enter. This would for the meantime give you zero (0) until the model is run. This is shown in the image below.

NETWORK STRUCTURE AND FLOW			
FROM	TO	DISTANCE ROUTE	
TK	BG	18	0
TK	PT	9	1
BG	HW	28	0
BG	TB	19	0
PT	TB	7	1
PT	ES	21	0
TB	BG	19	0
TB	HW	11	0
TB	PT	7	0
TB	ES	10	1
TB	WA	19	0
HW	TB	11	0
ES	TB	10	0
HW	MA	17	0
ES	WA	26	0
ES	WA	8	1
MA	WA	20	0
AK	WA	7	0
WA	AK	7	1
AK	SB	8	1
WA	MA	8	0
MA	SB	20	0
WA	SB	8	0
Total distance	=	=	49

BALANCE FLOW CONSTRAINTS			
NODE	NET FLOW	=	SUPPLY/DEMAND
TK	1	=	1
BG	0	=	0
PT	0	=	0
HW	0	=	0
TB	0	=	0
MA	0	=	0
WA	0	=	0
ES	0	=	0
AK	0	=	0
SB	−1	=	−1

Figure 8. Shortest path excel spread sheet. (Source: Researcher, 2026)

Table 2. Route and the distance covered. (Source: Researcher, 2026).

Routes (Path Used For Distribution)	Distance Covered
Original route used by Alimens gas company **(from Alimens gas company to Samreboi)** which is route: **TK-BG-HW-MA-SB**	83 km
Deduced route from the shortest path model which is route: **TK-PT-TB-ES-WA-AK-SB**	49 km
Difference between the two routes	34 km

From Table 2 above, there has been a reduction of 34 km in total distance through the use of shortest path model and a reduction in distance means a decrease in total fuel cost fuel. Hence, If the shortest path model strategy is implemented on this distribution channel, there would be a total reduction of 34 km as

seen in Figure 8 which will help reduce the total distance thereby reducing total fuel cost.

From Figure 8, the shortest path from **TARKWA ALIMENS GAS COMPANY to SAMREBOI**. The deduced shortest path routes are **TK-PT-TB-ES-WA-AK-SB**.

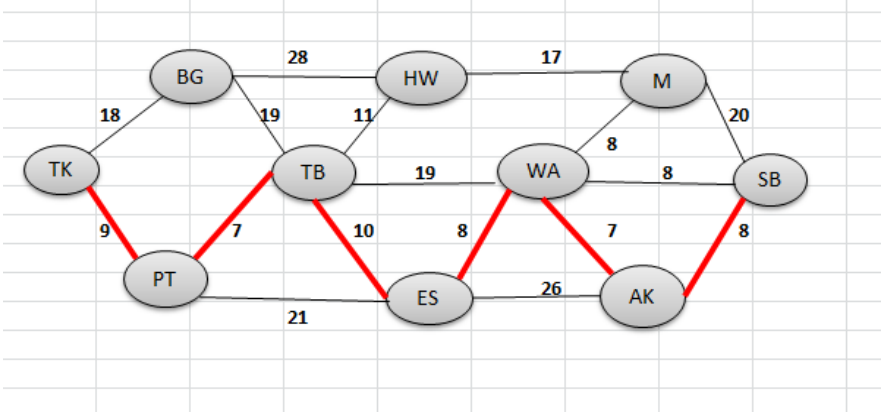

Figure 9. Shortest path route from ALIMENS GAS COMPANY TO SAMREBOI. (Source: Researcher, 2026)

5. Conclusions, Findings and Recommendations

The main purpose of this research is to redesign the shortest path or route for ALIMENS GAS Company at the downstream level using the shortest path transportation model to SAMREBOI. Before we could apply the model, data was taken from ALIMENS GAS Company which helped the researcher in this study. Both structured questionnaire and interview guides were used in retrieving information from the company.

ALIMENS GAS Company could be more effective and efficient, if they had definite or specific road route to their customers (distribution centers). And also total distance (cost) will be brought to a minimum. Shorter lead time plays an important role when it comes to customer satisfaction and shows how proficient a company is. The shortest path model was chosen to help select and redesign the shortest path or route from ALIMENS GAS Company to its customers.

The findings reveal that the shortest path from **TARKWA ALIMENS GAS COMPANY to SAMREBOI** is **TK-PT-TB-ES-WA-AK-SB** as seen in Figure 9. Additionally if the shortest path methodological approach is implemented on this distribution channel, there would be a total reduction of 34 km which will help reduce the total distance thereby reducing costs.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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