

Towards an Information Technology Based Supply Chain Management System For Ghanaian Oil Marketing Companies



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ABSTRACT

This study set out to propose an optimal supply chain management system for Ghanaian Oil Marketing companies. The research approach combined an inductive and deductive approach as a basis for designing the proposed system. This was based on data collected from the Oil Marketing Companies, review of literature, documents and the mode of companies' operation. An optimal information technology based solution is then proposed to automate their processes for how people, activities, information, and resources are involved in moving oil products and services from supplier to consumer. A number of modular systems have been proposed, these include a Purchase Order System, GPS Fleet Tracking System, Credit Reference System and Fore Court Operations management system. It is expected that a comprehensive integration of these modules would significantly make the operations of Ghanaian oil marketing companies systems more efficient and effective.



Introduction

Fundamental to the optimal operation of any oil marketing company is the need for an efficient and effective monitoring and management of the supply chain of the oil products. Based on regulation, there is a mode of operation for all Oil Marketing Companies (OMCs) and those in Ghana are not exempted. The Ghanaian regulations however provide a peculiar mode of operation that requires optimal customization for industry's requirement. Supply chain has been defined by different authors for different contexts.

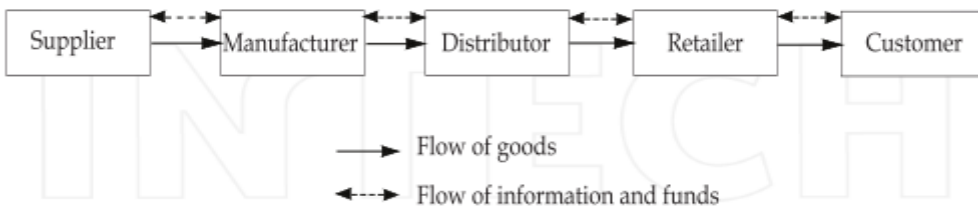
A supply chain is a system of organisations, people, activities, information, and resources involved in moving a product or service from supplier to customer. Supply chain activities involve the transformation of natural resources, raw materials, and components into a finished product that is delivered to the end customer (Kozlenkova & Irina, 2016). In sophisticated supply chain systems, used products may re-enter the supply chain at any point where residual value is recyclable. Supply chain is also known as the flow of materials,

information, funds, and services from raw material suppliers through factories and warehouses to the end customers (Turban et al., 2008). IT can support supply chain in many ways.

Supply Chain Management (SCM) refers to “the practice of incorporating a company's social, environmental and economic goals into the coordination of inter-business process to improve the long-term economic performance of the individual company and its supply chains” (Schonsleben,2011, p.8). In doing so, a company connects with its suppliers upstream and with its distributors downstream in order to maximize customer service at the minimum cost (Christopher, 2011).

According to Christopher (1994), a supply chain is “a network of organisations that are involved, through upstream and downstream linkages, in the different processes and activities that produce value in the form of products and services in the hands of the ultimate customer.”

Figure 1: The basic supply chain (Chopra and Meindl, 2001)



Literature Review

Information technology (IT) is concerned with the use of hardware and software for capturing, storing, analyzing and sending information. Due to the fact that supply chain management involves a network of organisations, information technology is an asset

in the sense that it provides information flow to increase the efficiency of the supply chain (Manuputty & Wijaya, 2013). As a result of IT, there are now more opportunities for coordinating activities across oil and gas supply chains (Abubakar, 2014).

The use of technology in supply chain management has the potential to improve a firm's competitiveness. Supply chain capability is as important to a company's overall strategy as overall product strategy. Supply chain management encourages management of processes across departments. By linking supply chain objectives to company strategy, decisions can be made between competing demands on the supply chain. Improvements in performance are driven by externally-based targets rather than by internal department objectives (Lummus & Vokurka, 1999). Tracking of product movement is a critical component of supply chain management, tracking of a company's vehicles can be achieved through the collection of operational data such as vehicle position. This is accumulated through transit vehicles equipped with positioning devices and data transmitted to a central server. Real-time tracking of transit vehicles is useful for transit operators for the application of proactive control strategies such as bus holding and expressing, after detecting schedule/headway deviations in the system (Shalaby & Farhan, 2004). The ideal ways for a company to keep track of its transit fleet and

goods in the supply chain process in real-time is to provide effective tools and technology.

It is worth mentioning that the evolution of buyers requesting suppliers to comply with IT systems can be observed in the overall evolution of IT adoption in the extended supply chain

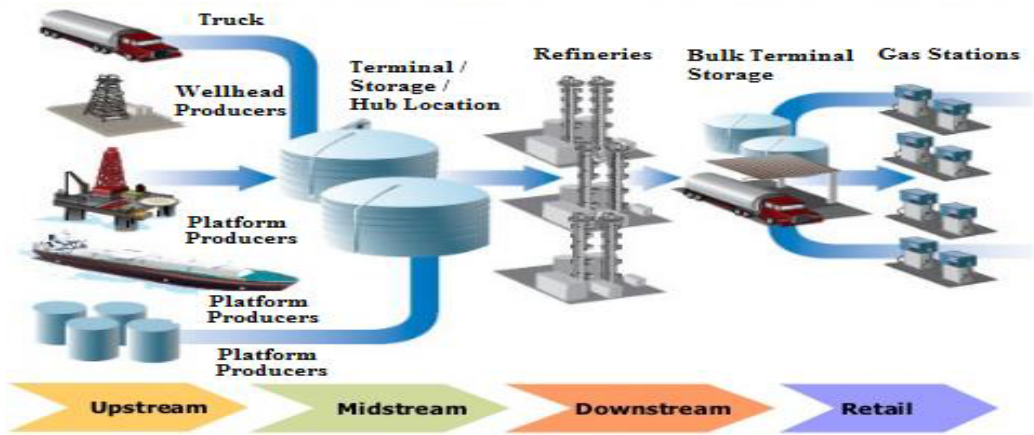
(Vanpoucke, Vereecke & Muylle, 2017). (Tarafdar & Qrunfleh, 2017) were relatively more instructive . by theoretically explaining and empirically demonstrating how Supply Chain practices and Information System capability for agility act together to effect a positive relationship between Agile Supply Chain strategy and supply chain performance.

Further studies on supply chain system concluded that the use of technology is an important support tool for sustainable supply chain management practices since it brings benefits to the organisation, suppliers, and customers. Emphasis is laid on how technology positively influences the operational, financial, and environmental performance of the organisation (Fiorini & Jabbour, 2017).

The Ghanaian Context

Ghanaian regulations require that Oil Marketing Companies procure and sell refined petroleum products to bulk consumers and the general public through retail outlets (i.e. fuel/gas stations). Bulk Distribution Companies (BDCs), on the other hand, supply petroleum products to OMCs to retail nationwide (Amponsah & Opei, 2014). Below is a diagram showing the value chain;

Figure 2: Ghana Petroleum Industry Value Chain



Source: Amponsah and Opei, 2014.

As indicated earlier, the Ghanaian Oil Marketing Companies are mandated to procure and sell refined petroleum products to bulk consumers and the general public through retail outlets (i.e. fuel/gas stations). The Ghanaian OMCs have an association which represents the collective interests of the companies involved in the oil marketing and petroleum products in Ghana, coordinating with the major Stakeholders in the Industry which include: Ministry of Petroleum, Ministry of Finance & Economic Planning, Bank of Ghana, National Petroleum Authority (NPA), The Energy Commission, Environmental Protection Agency (EPA), Tema Oil Refinery (TOR), Revenue Agencies Governing Board (RAGB), Ghana Standard Board, Ghana Fire Service, Customs Exercise and Preventive Service (CEPS), Internal Revenue Service (IRS) and Bulk Oil Storage and Transportation Co. Ltd (BOST)

This implies that OMCs in Ghana are restricted to the downstream of the entire oil supply chain, they tend to focus on buying from bulk distributors and selling at their outlets to end consumers.

The OMC population consists of 88 registered OMCs in Ghana, the regulation required every registered OMC to have a minimum of five outlets for sale of

their products. The largest OMC in Ghana operates about 320 outlets country wide.

Research Motivation

Monczka and Morgan(1997) focused on the importance of process integration in supply chain management. The gap identified in the literature review is a comprehensive definition of the processes that constitute supply chain management in Ghanaian OMCs together with the required technological interventions to optimize the supply chain. How can companies achieve supply chain integration if there is not a common understanding of the key business processes? The introduction of technology into supply chain management is a quest to remove supply channel costs, streamline channel communications, and link customers to the value-added resources found along the supply chain continuum (Ross, 2016).

This is the basis for setting out to obtain knowledge of what constitutes the supply chain management processes within the oil marketing sector in Ghana with an eye towards modeling a customized information technology system to address the supply chain management lapses within the oil marketing sector.

Methodology

The research approach combined an inductive and deductive approach as a basis for designing the proposed system, the deductive involved reviewing literature and documents made available at the various companies whereas the inductive on the other hand was based on empirical data obtained from the data collection.

Forty Two out of the 88 OMCs were used in this research. A total of 91 individuals were interviewed and observed, these ranged from chief executive officers, operations managers, marketing managers, information technology officers, forecourt attendants at stations, station supervisors, liaison officers, truck drivers and regulators. Specific numbers are provided below;

No	Rank	Quantity
1	Chief Executive Officers	3
2	Operations Managers	9
3	Marketing Managers	10
4	IT Officers	8
5	Forecourt Attendants	31
6	Station Supervisors	17
7	Liaison Officers	4
8	Drivers	7
9	Regulators	2

The study employed a predominantly qualitative approach to data collection in order to establish the accurate behaviour and requirements of the Oil Marketing Companies and the industry. Behavioural sciences require empirical data to investigate the decision processes and communication strategies within and between organisms in a social system(Leady & Ormrod,

2010). An attempt to determine requirements for an efficient and effective model for oil marketing supply chain systems required the collection and abstraction of as much empirical data as possible to be used for analysis. The choice of subjects and instrumentation therefore required utmost credibility to ensure data collected was credible.

Given the chosen subjects of managers, field workers and regulators, more than one method was used to collect data from the same source at any point in time to ensure reliability. Specifically interviews, observations and review of regulatory documents were used. A predominantly qualitative approach is also used in the analysis as that is essential to determine more accurate first hand information on operations. Peshkin (1993) explains that qualitative research approach is used for the purposes of description, interpretation, verification and evaluation. This therefore makes it ideal for the obtaining real patterns in OMC operations and supply chain activities.

The problem identified for research is how to proactively and optimally monitor and manage the supply of oil marketing products for OMCs in Ghana. The research employed the use of exploratory methods, given specific objective of ultimately modeling a system for its development and implementation, this invariably drove this research approach to use a combination of inductive and deductive approach.

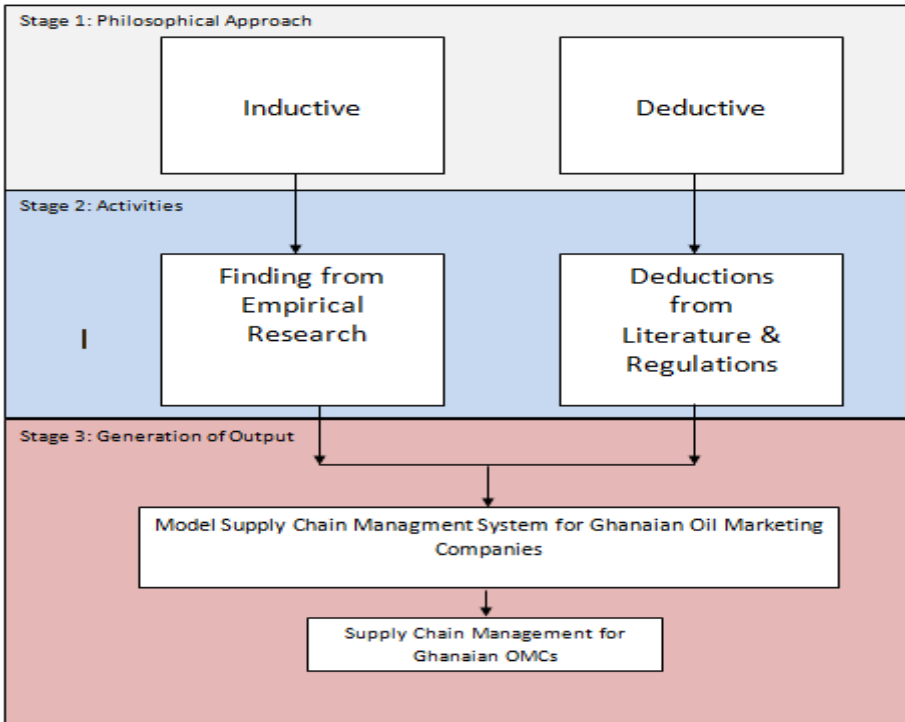
The methodology was validated by presenting to peers for scrutiny before subsequently adopting it, reliability of findings was ensured by demonstrating the model at all stages to the subjects for confirmation.

The deductive approach was used by reviewing literature and documents made available at the various companies, the inductive on the other hand was based empirical data obtained from the data collection. These were subsequently analyzed and

the outcome was the model of the supply chain management system for Ghanaian OMCs.

Below is a diagram depicting the research approach and outcome.

Figure 2



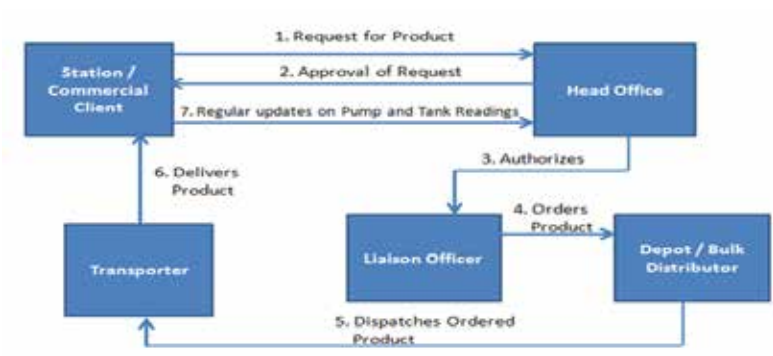
Results and Analysis : *Mode of Operation at Ghanaian OMCs*

The main elements involved are the stations, commercial clients, the head office, liaison officers, sealers the depots, bulk distribution companies, transporters and drivers. Below is a table showing the functions of each of the actors.

Table 2 : Various Roles within a Ghanaian OMC

No	Actor	Location	Function
1	Marketing Manager/Operations Manager	Head Office	<ul style="list-style-type: none"> Approves orders Verifies Lodgements Generates reports
2	Liaison Officer	Depot	<ul style="list-style-type: none"> Orders from Bulk Distribution Companies Loads product from Depot on to Truck
3	Sealers	Depot	<ul style="list-style-type: none"> Seal compartments of trucks
4	Bulk Distribution Companies	Depot	<ul style="list-style-type: none"> Sell products to OMC
5	Transporters	Depot	<ul style="list-style-type: none"> Lift and transport products to fuel stations/outlets
6	Drivers	Depot	Drive product delivery trucks
7	Station Manager/Supervisor	Fuel Station	<ul style="list-style-type: none"> Receives products Monitor and update head office regularly with: <ul style="list-style-type: none"> - Pump readings - Tank readings - Bank lodgments - Return to tank entries - Credit sales - Expenses

Figure 3



The typical operations in the Ghanaian OMC supply chain is shown in the diagram below and subsequently explained.

The supply chain process in an OMC commences with a fuel station's request for a product from the head office, the products range from petrol, diesel, kerosene, aviation turbine kerosene, liquefied petroleum gas, marine gas oil, premix to residual fuel oil. The stations request for these products via phone calls to their respective head offices for all companies contacted in this research. Upon receipt of the request by the head office, the credit worthiness of the station is checked and approval is given or otherwise to load the product from the depot. If approved, a bulk distribution company is selected for purchase at the depot and a transporter is selected, subsequently, the liaison officer who is resident at the depot is instructed to load the product onto the selected transporter's track and dispatched. The liaison officers are usually notified of approved orders via phone calls, 7 companies out of 42 however had an information technology solution for this notification. In the process of dispatching, the product is loaded onto the tracks in compartments that have top and bottom seals. These seals are installed by designated licensed sealers, they verify products' volume, density, hatch and coupling height of trucks. Upon satisfying all the listed requirements, the product is dispatched

to the station. The station acknowledges receipt by observing the seals, measuring the products' volume, density, hatch and coupling height of truck. The station manager confirms the above to ensure the products' integrity is not compromised. If any aspect of the delivery check is inconsistent with the loading details, the relevant authorities are notified for investigations and reconciliation. 4 out of the 42 companies had some technology related approach to storing this data at the station and transmitting to the head office.

On a daily basis, the head office must be updated by the stations on the opening stock and reading of their various storage tanks and pump/nozzle for all products respectively. The purpose is to track the product sale at the stations and to have an overview of the entire supply chain of their products. The head office must also be notified of any credit sales, expenses, money lodgment to the banks and any products returned to tanks for any peculiar reasons. It was observed that 4 companies out of the 42 used in this research had some information technology solution for storing and notifying the head office about these developments.

Table 3 : The State of Information Technology Use in Ghanaian OMCs

No	Process / Stage	Number of Companies using IT	Number of Companies not using IT	Total Number of Companies	Percentage Using IT
1	Product Request	0	42	42	0 %
2	Approval	0	42	42	0 %
3	Notification / Authorization	0	42	42	0 %
4	Product Order	7	35	42	16.7 %
5	Product Dispatch	7	35	42	16.7 %
6	Receipt Acknowledgement	2	40	42	4.8 %
7	Update on Forecourt Operations	3	39	42	7.14%
8	End to End Integration	0	42	42	0 %

Data collected revealed from 42 oil marketing companies showed that some Ghanaian OMCs employ the use of technology partially whereas others do not use any form of technology. It was observed that there were no companies that had successfully employed end to end technology use in its supply chain management. Investigations pointed to two major reasons namely;

1. High cost of implementation and operation
2. Inadequate fully customized technology solution to suite the requirements for operation.

Most OMCs had an accounting application software whereas some had improvised with Microsoft Excel, a significant number had no enterprise application for managing its routine operations hence a lot of daily activities were carried out manually. Some companies used applications like JD Edwards, SAGE and SAP whereas others used applications such as ACCPAC, TAS Books and Tally. The monitoring of product movement and sale was significantly delayed as records and documents were manually transferred via transportation to responsible officers for monitoring.

A striking lapse was the revelation that no company had an integrated solution for their stations, forecourt operations and the tracking of product orders and delivery. The forecourt operations consist of tracking opening stock and reading of their various storage tanks and pump/nozzle for all products respectively, tracking product sales at the stations, credit sales, expenses, daily lodgment to the banks and any products returned to tanks.

This lapse created inconsistencies and delayed reporting in having a full overview and reconciliation for products supplies, sales, revenue and losses experienced. Some general concerns that were expressed showed that product diversion, dilution and theft were experienced occasionally though not often.

On the basis of the mode of operation of the oil marketing companies, a comprehensive information technology based supply chain management system is proposed to address the concerns and lapses in the supply chain management of Ghanaian oil marketing companies.

Metrics for Analysis and System Design

Given the observations made and information gathered from the interviews, it was imperative that a structure is set to situate the existing challenge with supply chain management in oil marketing companies. The primary objective of the metrics is to ensure the management and communication issues are addressed at all stages of the supply chain.

On that basis, an information technology solution is proposed at each stage of the supply chain process with an eye towards making it most optimal.

The interviews are analyzed based on the stages of the supply chain as outlined in table, an attempt

is made to determine if there is any evidence an existing solution and whether it is the most optimal for the respective stage. Specific questions are asked and deductions are made from responses as well as an additional method of confirming responses, this may be through observation of related processes, activities, documents or regulations.

The specific metric involves as follows;

1. Noting the stage and if the technical solution in question is available in any OMC.
2. Determining if the response indicates evidence of influence. Positive evidence is

- depicted by «√» whereas negative evidence as in absence of evidence is depicted by «x».
3. Observing or confirming via additional means such as documentation.
 4. A positive influence obtained or deduced from response and a positive observation or conformation implies presence of full evidence of existence of optimal technology.
 5. A negative influence obtained or deduced from response and a negative observation or conformation implies absence of full evidence an optimal technical solution.
 6. A positive influence obtained or deduced

- from response and a negative observation or confirmation implies partial presence of an information technology solution.
7. A negative influence obtained or deduced from response and a positive observation or confirmation implies partial presence of a technology solution.
8. A full evidence is depicted by «yes», a partial evidence is depicted by «partial» and the absence of evidence is depicted by «no»

The metrics is illustrated with a summary of data collected from the 42 OMCs used in this research.

Table 4: Deduced Conclusions from Interviews and Observations

No	Stage/Process	Response	Observation	Confirmation	Outcome
1	Product Request	X	X	X	No
2	Approval	X	X	X	No
3	Notification / Authorization	X	X	X	No
4	Product Order	√	X	X	Partial
5	Product Dispatch	X	X	X	No
6	Receipt Acknowledgement	√	√	√	Yes
7	Update on Forecourt Operations	√	√	√	Yes
8	End to End Integration	X	X	X	No

Proposed System Components and Functionality

1. Centralized Server in Cloud with Replication: This system serves as the hub where all information about the supply chain of the OMC is stored. This runs the Supply Chain Management System of the organisation. The system must be replicated for redundancy.
2. Automated Tank Gauging with Virtual Private Network connection to server: An installed sensor in the product tanks that automatically read tank levels and updates the server.
3. Automated Meter Reading with Virtual Private Network(VPN) connection to server: An installed sensor in the product pumps that automatically read product quantities sold through nozzels and updates the server in the cloud via the VPN.
4. Smart Cell Phones at all Outlets or Computers: This is required with Internet connectivity and a mobile application on the phones to enable station managers and supervisors regularly

perform the under listed functions while interacting cloud server. The computers only require browsers.

- Product Request: This functionality enables stations to order for products via the system to their respective head offices for approval
 - Product Receipt / Delivery Comments: This functionality enables the station acknowledge receipt of the product and record critical information like product volume received, product quality or density, evidence of trucks compartment status upon delivery etc.
 - Credit Sales: In the event some credit sales are made at the station for customers, this functionality provides the opportunity to record in the system
 - Expenses: This functionality makes it possible to keep record of any expenses made at the station.
 - Pump Entries: In the event of a failed automatic flow meter reading sensor, the station manager can update the system with opening and closing meter readings.
 - Tank Entries: In the event of a failed automatic flow meter reading sensor, the station manager can update the system with opening and closing stock levels of tanks.
 - Bank Lodgments: This functionality enables station managers to update the system with lodgments made to the bank and possibly upload images of payment slips into the system.
 - Return to Tank Entries: In the event some dispensed fuel is returned to the tanks, this functionality makes it possible to update the system as such.
5. Head Office reliable and secured internet connectivity that provides connection to server in cloud.
6. Seals on trucks and the transporters trucks must be tagged/digitized with GPS traceable strips/devices to ensure the products can be tracked at all times to know the location.
7. Integration: The data from orders to bulk distribution companies, transporters, daily records from stations must all be integrated to efficiently and effectively generate prompt coordinated reports.
8. Proposed Relevant Default Reporting
- The supply chain management server is required to functionally provide the following reports;
- Station / Commercial Clients: This report is generated to show all supplies to a station or site of products over any specified period.
 - Orders: This report is generated to show all details of an order based on the order ID.
 - Lifting from Bulk Distribution Companies / Depots: This report is generated to show all listings from a particular BDC over any specified period.
 - Automated UPPF Updates: This report is generated as required by the National Petroleum Authority for any specified duration and is exportable to Excel for further enhancements.
 - Payments to Head Office: This report is generated to show all payments made by stations to into specified banks over any specified duration.
 - Payments to Bulk Distribution Companies: This report is generated to show all payments made to specific BDCs over any specified duration.
 - Credit Status: This report is generated to show the credit worthiness and duration of any specified station or commercial client.
 - Station Ledger: This report shows all sales, expenses, credit sales and net value.
 - Account transactional reports exportable to excel – this can be uploaded into your account software e.g. Sage, Pastel etc.
 - Sales: This report shows sales made over a period for a station or all stations at a glance
 - Tank Levels: This report shows tank levels at any point in time for a station or all stations at a glance
 - Lodgments: This report shows lodgments made to the bank at any point in time for a station or all stations at a glance

- Variance: This report compares pump outflows to tank outflows
- Tank Readings: This report is generated to show all dips for opening and closing stock entries for particular tanks/products at the respective stations over any specified duration.
- Pump Readings: This report is generated to show all opening and closing stock entries for particular pumps/nozzles at the respective stations over any specified duration.
- Station Expenses and Credit Sales: This report tracks is used to track all entries made at the respective stations regarding daily credit sales and expenses made.
- Shortages: This report is generated to show all delivery shortages experienced over a specified duration.
- Station Ledger: This report shows all sales, expenses, credit sales and net value.

Table 5: The Information Technology(IT) Interventions in the Supply Chain Process

No	Process / Stage	IT Intervention
1	Product Request	Use of smart mobile phones with customized application or use of application on web interface of computer
2	Approval	Use of smart mobile phones with customized application or use of application on web interface of computer
3	Notification / Authorization	Use of smart mobile phones with customized application or use of application on web interface of computer
4	Product Order	Use of smart mobile phones with customized application or use of application on web interface of computer
5	Product Dispatch	Implementation of traceable trucks and seals on truck compartments containing product
6	Receipt Acknowledgement	Use of smart mobile phones with customized application or use of application on web interface of computer
7	Update on Forecourt Operations	Installation of automated tank sensors with network connectivity for system notification and real time view Installation of automated pump and nozzle sensors with network connectivity for system notification and real time view Use of smart mobile phones with customized application or use of application on web interface of computer for entry of lodgments, return to tank entries, credit sales, expenses, product request, product receipt.
8	End to End Integration	Each stage of process must update the supply chain server

Purchase Order System

The system should also include an automated purchase order system to generate, track and manage purchase orders. In so doing, station or outlets would be able to create purchase

orders to be sent to the head office within the integrated system, the head office, in turn, would be able to forward these purchase orders to its bulk distribution company. Furthermore, the system must match orders with invoices, products received and payments.



GPS Fleet Tracking System

The system should also include a global positioning system (GPS) fleet tracking system which would track the movement of fuel vehicles from the bulk distribution depot to the stations. This would reduce the idle time on delivery and service trucks, product diversions and monitor multiple vehicles across multiple job sites on one screen; track the speed, direction and location of every fuel truck using real-time tracking.

Credit worthiness System

In order to establish the creditworthiness of branches before granting their orders, the system should ensure the cash flows, receivables, payables and the timeliness of payment of each of the branches are stored in a database and readily accessible to the head office.

Conclusion

The proposed IT based supply chain management system for Ghanaian oil marketing companies has been focused on using the optimal processes of any oil marketing company in Ghana as the basis for the system design. Based on regulation and mode of operation the supply chain system has been conceptually computerized, this addresses how people, activities, information, and resources involved in moving oil products and services from supplier to customer. A number of modular systems have been proposed, these include a Purchase Order System, GPS Fleet Tracking System, Credit Reference System and Fore Court Operations management system. A comprehensive integration of these modules should ensure people, activities, information, and resources involved in moving oil products and services from the depots to the consumer operates optimally.

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