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The Impact of Using Waiting Lines on Logistics Services at Port Sudan Port: A Theoretical Study

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Abstract

The topic of waiting lines and its impact on logistics services at Port Sudan Port was addressed after the researchers noticed the size of the congestion of goods and the suffering of customers due to the delay in receiving their various shipments, as well as the long wait of ships until they are unloaded at Port Sudan South Port. The research aimed to provide an explanation of how waiting times affect the efficiency of logistics operations at the port. The research was based on the hypothesis of examining the expected effects of the average waiting time. The research relied on interviews, observation and surveys as a method of collecting information. The study reached a set of results, perhaps the most prominent of which is: The length of the waiting period was higher than its normal rates prevailing in various regional ports in neighboring countries, not to mention the global ones that are characterized by high operational efficiency. This indicates the importance of this study being followed by more studies that should be concerned with analyzing the reasons for this significant delay in handling compared to regional ports around Sudan. As previously mentioned, the study recommends conducting research and analytical studies in this regard by working on developing a quantitative model that helps port officials manage logistics services better, which will contribute to solving many problems related to logistics management as well as achieving more customer satisfaction, especially if we know that this port can be a window for a number of neighboring countries that suffer from the lack of an outlet to the sea, such as (South Sudan, Ethiopia and Chad).

Keywords: *Waiting Lines, Logistics Services, Port Sudan Port, Logistics Management, Quantitative Methods.*

Introduction

Various economic indicators intertwine the operational performance of ports and their logistical efficiency, serving as crucial benchmarks for international trade competitiveness. When assessing port performance, it can be divided into several fundamental aspects: port performance metrics and additional performance criteria such as land connectivity, maritime connectivity, and air connectivity. Many scholars have agreed that ports play a pivotal role in global trade, a fact reflected in their classification. The management and performance of ports are focal points in numerous research endeavors. The three primary performance variables for ports are wait times for service, loading and unloading durations, and the turnaround time for vessel berthing, which is influenced by the length of the queue for these three services. Queueing poses a prevalent challenge for port service management in the logistics realm. When transitioning to the port-hopper approach, delays can manifest in both port mirrors. Typically, port management utilizes the free port system to oversee the waiting area for logistics services for multiple carriers. The goal is to discern the potential impact of these delays, which can be substantial. Efforts will be made to accurately forecast these outcomes. Smaller operational spaces are not taken into account, under the assumption that they are solely reserved for priority operations. Any diminutive operational space will be considered a scenario in which wait times surpass the carrier's tolerance threshold, and it is assumed that a shift in operational behavior will transpire under extreme circumstances. The primary aim was to compute the number of vessels awaiting service. Additional considerations will encompass delays in service reception and their associated impediments. This theoretical study was presented on the impact of waiting lines on logistics services at Port Sudan port, in an attempt to initially form a conceptual framework for this important topic. Then, work in the future on preparing survey and analytical studies that address the results that will be reached in this study.

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Background and Rationale

The efficiency of port services plays a crucial role in the global trade landscape, particularly in the realm of maritime trade. The intricacy of shipping logistics, involving various components such as ships, ports, terminals, roadways, and rail networks, sets it apart from other logistical operations. Yet, the operational effectiveness of ports holds immense importance. Port Sudan, serving as the primary marine gateway for Sudan, stands to be profoundly influenced by the growth and progress of neighboring nations, particularly South Sudan. The current state of Port Sudan and its infrastructure is characterized by underdevelopment, with extended wait times significantly impacting port services. Consequently, the waiting line emerges as one of the most pressing challenges confronting the port. The potential reduction of wait times stands to yield a substantial impact on the port's provision of logistics services.

Contemporary scholars have approached the analysis of waiting lines from two distinct angles. The initial faction of theorists has delved into the mechanics of waiting lines with the objective of uncovering their inherent properties and characteristics. Identified and researched features of waiting lines include line structure, wait times, population mean wait time, random service times, infinite population, and the prevalence of queuing systems. These systems give rise to stationary multiple input processes, service order systems, and waiting line models. The second faction of scholars has aimed to examine the impact of waiting lines on operations. Some have endeavored to demonstrate the correlation between customer experience and operational performance, highlighting the influence of operational efficiency on customer experiences, both positively and negatively. Evaluation of the lack of service operating strength followed this process. Holdup in operating systems can be referred to as several theoretical specialties. Waiting lines are an unexpected reality for operating organizations. Waiting lines were permitted to refer to limited-service strength by a group of theorists in operational understanding theory. Even though waiting periods have declined over time, it was noted that the loss of waiting lines is another practical recommendation. In other words, it was suggested that it is smart business to operate off a number of theoretical waiting lines that rely on operating characteristics to take effect while awaiting this line with shoppers. In practical explanation for this theory, the establishment of successful access and service configurations to establish the lines keeps consumers moving very quickly. Additionally, waiting lines are special real-world attributes that have a significant influence on both how consumers take advantage of a firm's assets and a firm's performance. It is related to the sciences of the foundation. It includes a rational strategy and a framework that can assist professionals in reducing these conditions while establishing effective process programs. Providing waiting lines must be demonstrated to assist customers while increasing company profitability. Each of these perspectives offers ways in which waiting lines can be seen. This may also be a reference for practical understanding. This theory shows that waiting lines just appear as a natural attribute of guests.

Research Objectives

The primary objective of this study is to provide a fundamental explanation of how wait times impact the efficiency and effectiveness of logistics operations at Port Sudan. The research goals, derived from the study's hypothesis, include: 1. Examining the anticipated practical effects of the average wait time in the shed at Port Sudan on the total shipping time of coarse coffee using solely logical reasoning. 2. Evaluating the expected practical effects of the wait time in the shed at Port Sudan on the average total shipping time of coarse coffee from the perspective of a hull officer. 3. Assessing the anticipated practical effects of the multiple divisive effects, independent of these effects, of the wait time at the shed at Port Sudan and the accessibility of the coffee areas on the average total shipping time of coarse coffee. These objectives aim to establish the logical basis for understanding the influence of time (wait time) on the efficiency of port operations (logistics activities). The objectives will be validated prior to data collection and analysis to ensure alignment with the analysis procedures. It is important to note that the selected study objectives do not encompass practical application, as the aim is not to directly impact the management of Port Sudan. However, the results of this research may be valuable in terms of the potential capital costs associated with expediting handling at the port. The practical significance of the research results lies in the possibility of delays at the berth when the handling operation is postponed at the port, which could impact the management of Port Sudan in terms of the responsible mechanisms.

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Research Problem

The researchers noted that Port Sudan port suffers from a number of problems, the most important of which is the long waiting periods suffered by both parties (customers to receive their goods, and ships to unload their cargo). As a result of this problem, many other problems emerged, such as (increased operating costs, customer dissatisfaction, damaged goods, increased fees paid as a result of loading and unloading problems, and other problems). For all this, we began to address this topic from its theoretical perspective, hoping that the points that could help in conducting analytical studies that could contribute to solving these problems suffered by the port would be revealed to us.

Scope and Limitations

The research will focus on the Port Sudan port in Sudan, specifically examining the logistics services provided. This will include analyzing the volume of transactions for trucks and various logistics services, as well as investigating the reasons for variations in customer arrivals and service provision times. It is worth noting that we have identified certain bottlenecks in the logistics transport services, and freight forwarders have observed multiple causes behind these issues. The study will specifically address three of these problems.

The exploration will center on three components of queuing theory: 1. Variability in customer arrival lines 2. Diverse service times causing fluctuations in service provision 3. Documentation of departure lines and the total volume of goods transported through different modes such as cartons, tons, and shipping containers. This includes the handling and servicing of items at various locations, as well as any delays and the packing of goods by the crew. Furthermore, due to these factors, it becomes challenging to ascertain the varying service times for different quantities of goods. Additionally, there may be subsequent services provided. It is important to note that the research findings, being specific to the Port of Port Sudan, cannot be generalized to all ports worldwide. Furthermore, there were challenges in gathering the necessary data for this study, and the information collected may be influenced by the external staff's nature and working conditions. Therefore, it is difficult to ensure the accuracy of the information provided, as it is largely based on the experiences of long-term employees known to the management. It is also possible that errors in judgment may lead to frequent service delays.

Literature Review

The theory of queuing is the examination of waiting lines, with a wide range of uses in making decisions about the effectiveness of systems such as banks and airports. Waiting or queuing lines are present in almost all logistical services, where the term "queue" signifies the state of customers waiting to receive service. The existence of waiting lines has a negative impact on operational and customer handling efficiency – a well-known issue in the operational environment of ports, particularly in the area of container terminals. Additionally, port facilities are expected to offer prompt and effective services; otherwise, a variety of drawbacks, such as the loss of incoming vessels, a reduction in transit times, and a decline in the appeal of the port or the region, can arise. As a result, it is crucial to minimize the waiting time in port logistical services in order to satisfy the needs of customers.

One of the primary concerns for port authorities and government agencies is the issue of congestion at port terminals. As the size of ships continues to increase, so does the surge of cargo with each ship arrival, leading to longer waiting times for ships at the port. The presence of waiting lines not only incurs significant costs and service disruptions but also causes intangible frustrations for those waiting, potentially resulting in a loss of customer loyalty. Port congestion can also result in customer dissatisfaction and adversely affect the economic advantages of the terminal. Consequently, port authorities are increasingly focused on implementing measures to prevent congestion, particularly in light of the growing capacity of vessels. Moreover, the characteristics of vessels are evolving in tandem with the increasing capacity and size of ships. The examination of waiting lines has progressed beyond theoretical analyses, now encompassing empirical research, thereby introducing a high level of complexity to these studies. It is essential to consider the main factors of heterogeneity and uncertainty before applying queuing theory to the port environment.

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Identifying the distribution type of ship arrival and service times stands as one of the most critical aspects of these inquiries.

Conceptual Framework of Waiting Lines in Logistics Services

The concept of queuing behavior is widely acknowledged in the field of operations research and supply chain management, where waiting lines are formed in service settings. In these scenarios, waiting lines are quite evident and clear, and their significance far surpasses their seemingly straightforward manifestation. Our focus on waiting lines is confined to the operational context, also referred to as the DIY department, where logistics services support the six main businesses represented at these ports and act as a consumer gateway. Certainly, certain services entail waiting lines, such as those of aircraft, railway, traffic signals, snack shops, and so on, but these are also constrained by capacity and the queuing of customers who do not request services. According to the general definition, a "queuing system" is a service designed to serve customers by one or more servers and known for waiting in line.

Referred to as "waiting lines," queuing systems are also known as "queue length," and the probability of finding a system "busy" or "occupied" are all waiting times in the system.

Previous Studies on Waiting Lines in Ports

Numerous inquiries have delved into the ramifications of queues in port settings, exploring facets concerning their organization, administration, and operation. Empirical studies have posited that the utilization of waiting lines yields various consequences, such as detrimental impacts on operational efficacy, a diminishment in the capacity to oversee service operations, a requirement for extended overall time allotments for incoming or outgoing goods, and potential adverse feedback cycles between queueing conduct and stakeholder choices, among additional factors. Simultaneously, alternative scholars have ascertained that an augmentation in container handling systems can invigorate the efficiency of the port facility.

Various methodologies are employed by authors to model waiting lines, encompassing deterministic, stochastic, and combined models. Within the realm of port operations, simulation models executed through specialized software are the prevailing approach, with the remainder being predominantly case studies utilizing observational data. Certain researchers have leveraged both the II and MM principles to maximize information acquisition, validate model assumptions, and optimize the recording of service times. It is important to note, however, that the findings and implications of these studies do not directly translate to Sudanese ports. A more targeted investigation, specifically examining Sudanese ports, is imperative to gain a deeper understanding of the ramifications of waiting lines on logistics services. Sudan is home to two primary ports, namely Port Sudan and Suaken. This study will concentrate on Port Sudan harbor, which accounts for approximately 95% of domestic exports and perishable goods. Since 2012, roughly 70% of Sudan's imports have been channeled through this harbor. The data for this study is sourced from the Port Sudan port, the principal seaport in the country. Notably, petroleum products, machinery, livestock, automobiles, and livestock constituted the majority of the solid cargo at this seaport. Additionally, nearly 29.36% of Sudan's exports and intercontinental cargo traffic traverse through this port, underscoring its strategic importance and value.

Theoretical Framework

The interplay between queues and logistics services in Sudanese ports is explored through the lens of queuing theory. Logistics services play a vital role in supply chain systems, particularly in the context of port logistics systems. These systems have been designed to facilitate swift and efficient responses to import and export activities, with the aim of reducing costs associated with the transportation of national products and materials. Access to the materials earmarked for retrieval and transportation is facilitated through the use of specialized service codes. The exchange service provided by the shipping industry within the port encompasses various freight service modalities, with operations being categorized as either entry or exit services. The rapid expansion of the service infrastructure has led to an increase in workload, resulting in

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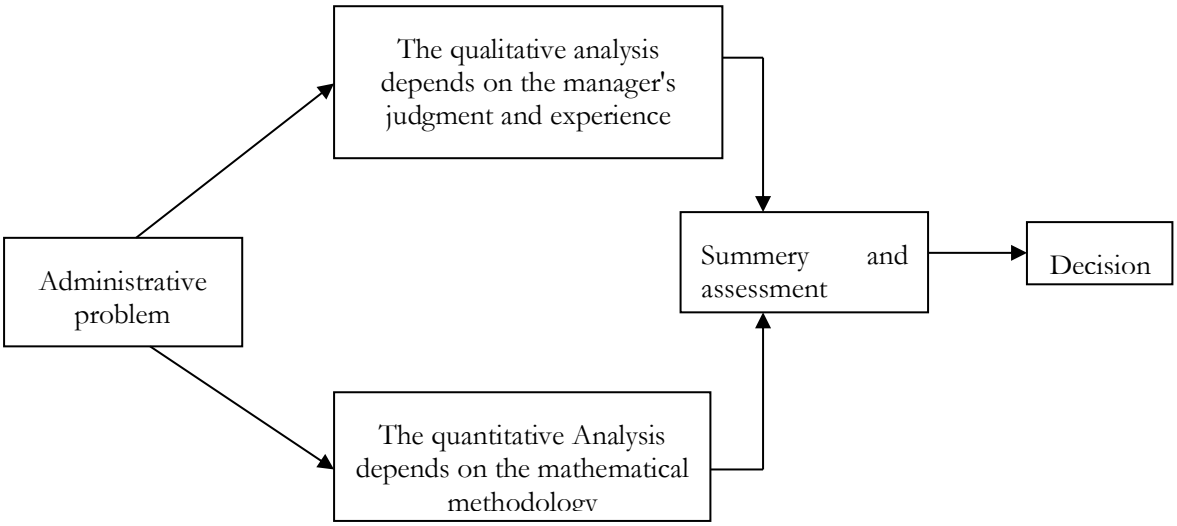
longer queues and delays in customs clearance services, thus impacting customer satisfaction. Consequently, the queuing system service within the port's logistics holds significant importance.

A mathematical framework for studying various queuing systems elucidates the service processes within a queuing model's service system. These models serve to explicate essential concepts necessary for characterizing customer behavior, impacts, and waiting line attributes within arrival systems. They encompass a suite of services comprising one or more immediately responsive servers tending to these entities without delay. The queuing model operates on the basis of independent, uncomplicated, first-come decisions, assuming first-served servers to establish the waiting line with an infinite population and ensuring servers are independent, dynamic, and service time is allocated based on the parameter distributions of standard random variables. While the system within the server component is infinite, the population is finite. Nonetheless, to gain a deeper comprehension of queue system operations, it is feasible to model scenarios pertinent to discerning the logistical service management's behaviors that interface with drivers' movements between port terminals. This framework underscores the significance of understanding the logistical system among the seaport's divisions to address potential waiting lines that could result in delays or hinder the port's seamless operation. Formally, this theoretical construct posits an assumption rooted in the presence of a service rate equivalent to the customer's arrival rate, thereby obviating waiting times.

Quantitative Analysis

Where qualitative analysis depends on the judgment of the director and his personal experience, and then it can be described as an art rather than a science. The roots of this approach go back to the old administrative schools that used trial and error method. If the manager has little experience or is not aware of the problem in question, then the manager in this case must rely on quantitative analysis and on the data and facts accompanying the problem in preparation for developing a mathematical expression to describe the goals, constraints and relationships involved in the problem. The following is a figure showing the relationship between decision-making and quantitative and qualitative analysis:

Figure (1). The Relationship Between Decision-Making and Quantitative and Descriptive Analysis



Source: Anderson, David R, Sweeney, Dennis j, A. Williams., Quantitative Methods For Business, Second Edition, U.S.A, West Publishing Co, 1983, P: 2

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Different Definitions of Operations Research

The Operations Research Society in the United Kingdom defined it as (the application of scientific methods to the complex problems that arise when directing and managing large systems of people, equipment, materials, and funds in the field of industry, commerce, government, and defense, and the distinctive approach is to prepare a scientific model of the system that includes a measure of factors According to this model, the returns of the various alternative decisions and strategies can be predicted and compared with the aim of assisting the administration in determining its policy and procedures in a scientific manner).

As for Dantzing, he defined it as (management science), meaning the science of making and implementing decisions.

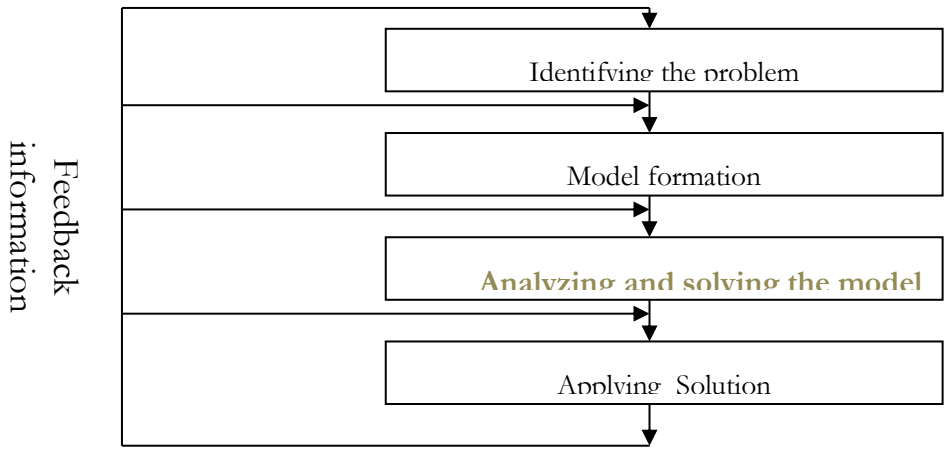
(Wagner) defined it as "the science approach used to solve problems encountered by top management).

The researcher reached the following definition of operations research through the previous definitions: (It is the science that uses quantitative and digital means and mathematical models to reach the optimal decision that helps the organization to solve problems and confront environmental variables in light of the available human and material resources).

General Steps to Operations Research Methods

Despite the multiplicity of tools and methods used in operations research applications, they all agree on the main elements that make up the common general set of steps for operations research methods. The following figure shows these steps:

Figure (2). General Steps of Operations Research Methods



Source: Farid Abd Alfatah zain Alabdeen:"Resources of operations and their application in problems resolution and decision making" Vol.1,Cairo,1997, p.13-In Arabic

In the previous section, we dealt with the methods of operations research, and below we will deal with the queue models in some detail.

Waiting Queue Models

The queues theory addresses the problems faced by different service systems, the most important of which is determining the number of service providers (servers) and the number of service centers (service lines) in order to reduce the percentage of customers who leave service centers due to congestion (the large

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number of service seekers). It is natural that the average service time decreases with the increase in the number Service providers, but here the cost component overlaps, so the increase in the number of service providers leads to an increase in the operating costs of the facility and the small number of its providers, which results in customer dissatisfaction from the length of waiting and here it is necessary for the facility management to search for the optimal balance that achieves what it seeks This is what is trying to address the theory and models of waiting lines, while at the same time ensuring customer satisfaction.

The Emergence and Beginning of Queues

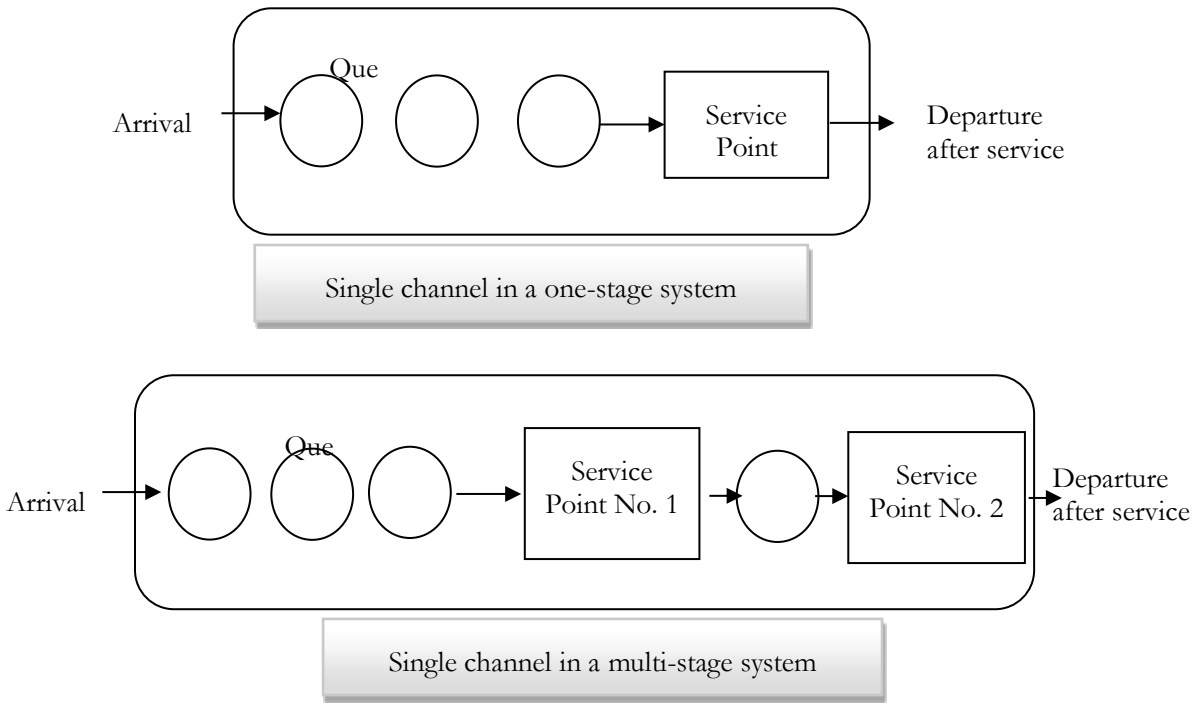
The pioneer of this theory is the scientist, an engineer who worked in the field of telephone line movement and was working on trying to reduce the waiting time for telephone calls. After the end of World War II, his interest in solving these problems shifted at the level of business organizations. Waiting lines can be defined as the accumulation of individuals or machines in a waiting state in order to be provided with a specific service.

Table (1). Examples of Waiting Lines

Site	Inputs	Outputs
Bank	Arrival of clients	Clients " Service
Blood Bank	Arrival of blood givers	Blood receive by ill people
Basin of ships repair	Ships back from the sea ,and sent to repair	Ships repaired and sent back to sea

Source: Waynel. Winstom, Operation research: Application and Algorithms, 4th, Canada, Thomson Learning, 2004, p1052

Figure 3. Four Models of Queue System



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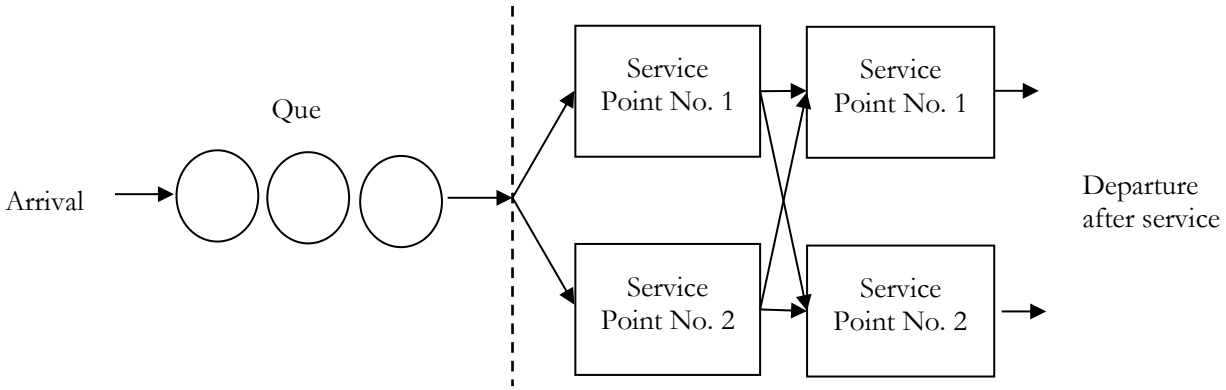


Multiple channels in a multi-stage system

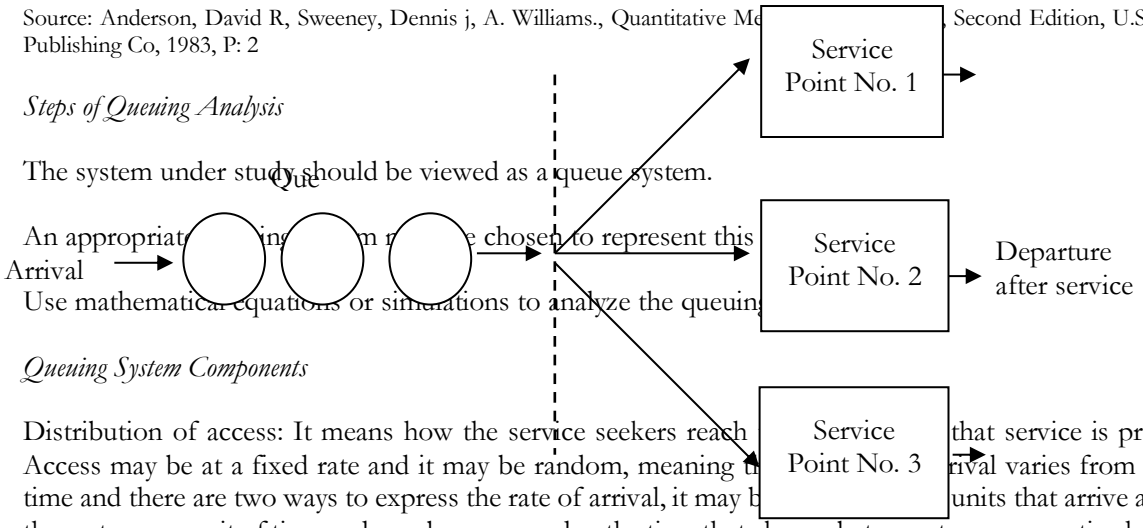
Source: Anderson, David R, Sweeney, Dennis j, A. Williams., Quantitative Me , Second Edition, U.S.A, West Publishing Co, 1983, P: 2

Steps of Queuing Analysis

The system under study should be viewed as a queue system.

An appropriat ing m e chosen to represent this

Use mathematical equations or simulations to analyze the queuin



Queuing System Components

Distribution of access: It means how the service seekers reach that service is provided. Access may be at a fixed rate and it may be random, meaning t rival varies from time to time and there are two ways to express the rate of arrival, it may b units that arrive and join the system per unit of time and may be expressed as the time that elapses between two consecutive hyphens.

Multiple channels in a one-stage system

Service distribution: means th ther the service is provided consistently or randomly, and e in the form of the number of units for which the service is provided per unit time, and it may be in the form of the required time To provide service to a customer.

The method of providing the service: it may be that the one who arrives first is the one to whom the service is provided first, and the customer who arrives may be the one to whom the service is provided first, and there is another system called precedence where the service is provided to those seeking it according to their urgent need for it, as happens in hospitals in critical cases.

Service Provision Center: It depends on the number of service providers in the system, as there may be one service provider and there may be more than one service provider.

Number of service seekers: The number of service seekers varies, as their number may be limited, and their number may be infinite.

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System energy: It is defined as the largest number of units the system allows to enter, and this number may be limited and may not be final.

Other features of the queuing system: Some customers may reach the queue but not join it because there is a large number of people waiting for service the moment they arrive, and the second feature is that some customers may join the queue for a certain period and then leave it before they get the service they were waiting for. And the third feature is that some customers may join a certain queue and then leave it to join another queue in which the same service is provided because it is less in number than the first queue they were in.

Mathematical models used in addition to the most important mathematical symbols:

(n): The number of units in the system (in queue + for which the service is provided).

(pη): the probability of having (n) units in the system in equilibrium.

(λ): The average number of units that arrive and join the queue in one time unit.

(μ): The average number of units that are served per unit of time by one service provider.

(L): The expected number of units in the system.

(Lq): expected number of units in queue.

(ω): The time expected to be spent by one unit in the system.

(ωg): The time one unit is expected to spend in line.

(e): [usage factor] the probability that the service provider is busy.

The following are examples of how to handle queue problems:

Average number of clients per Queue:

$$Lq = \frac{\lambda^2}{\mu(\mu-\lambda)}$$

Average number of clients per system

$$L \quad \frac{\lambda}{\mu-\lambda}$$

Average number of clients per system

$$Wg \quad \frac{\lambda}{\mu(\mu-\lambda)}$$

Average number of clients per system

$$W \quad \frac{1}{\mu-\lambda}$$

Queue Models

There are a number of models of waiting lines in which some mathematical formulas can be derived using the birth and death processes of the row, and these models include the following:

One-Channel Case Model for Service Provision

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This model assumes that there is one channel or one person who provides the service to the units that request the service and this model is referred to by the expression and the components of this model are the following:

System power is infinite.

The number of service seekers is not final.

The arrival distribution follows the Poisson distribution, with a rate of capacity per unit time.

The service distribution follows an exponential distribution with a rate of amount per λ Unit time.

The access rate is less than the service rate, that is

The method of providing the service is: For the one who comes first, the service is provided to him first.

There is only one channel to provide the service.

Queuing Theory and Its Applications in Logistics Services

Queuing Theory Queuing theory, a statistical approach, delves into the dynamics of waiting lines, enabling the examination of customer wait times. Queuing systems encompass customers, waiting lines, ticket counters, waiting areas, ATMs, and other service stations. Key features of queuing problems include service mechanisms, customer arrival patterns, and system capacities. Within the realm of logistics, queuing problems are categorized into single-server and multi-server queuing models. From a pragmatic standpoint, modeling waiting lines in a logistics operation is crucial for assessing an organization's logistics system and providing guidance for decisions regarding location, equipment capacity planning and design, configuration of logistics systems, and service level management to enhance logistics performance. In the port environment, various studies have applied queuing theory to diverse port operations. For example, one study sought to determine the required number of straddle carriers at a container terminal by developing an arrival model and average service time. Additionally, another study employed the queuing model as a design tool in optimizing queuing systems. Queuing theory was subsequently utilized as a benchmark in efficiency ratio analysis, where priority queuing enables certain vessels to bypass the queue, thereby reducing waiting time. Other case studies have applied queuing theory to analyze vessel waiting times at seaports, employing graphical rotation to create a queuing framework. To address high uncertainty, these studies assumed uniform inter-arrival times in their models. In the realm of transportation, queuing theory has been predominantly applied to infrastructure such as roads and railways. Numerous models have also utilized queuing theory in ports, border stations, and other transit stations. However, the exploration of port models is crucial, as there have been few attempts to apply queuing theory to ports. Some studies and practices have focused on reducing service time by increasing the number of service facilities to optimize capacity and decrease average waiting time. The theoretical application of queuing theory is instrumental in optimizing waiting line management and lowering service standards to an acceptable level. Additionally, queuing problems are influenced by various factors, which have posed constraints on the use of queuing theory models in logistics service systems. These influencing factors will be elucidated in the subsequent discussion.

Methodology

This section introduces the framework and methodologies utilized in conducting the present study on traffic lane waiting times at Port Sudan Port. The framework elucidates the systematic approach employed to procure the empirical findings. Initially, the research design utilized is expounded upon, whether qualitative, quantitative, or a combination of both, contingent on the rationale for undertaking the study, thus proposing the research design. Additionally, this section encompasses the data to be gathered, as well as the strengths and constraints of the methodologies employed.

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Research Design

A research design serves as a blueprint to guide the researcher in crafting a study that facilitates the achievement of predetermined goals. It outlines the study's process, initially proposed in the introduction and subsequently refined with the integration of new knowledge. Additionally, it delineates the methodology employed to gather essential data and present the resultant information as substantiation to address the research query. Consequently, research designs may be qualitative, quantitative, or a fusion of both. Depending on the aim or objectives, the research question can be addressed through qualitative or quantitative research. In this study, a descriptive approach is favored, as the investigation centers on the impact of shipment waiting times on the provision of assurance supply chain services along the logistics corridor from the port to the customer. This approach also seeks to ascertain the individuals affected by waiting times in the current infrastructure and to explore potential measures for mitigating these effects in the future, thereby reducing the cost impact of goods delivery.

The next phase of the study will involve in-depth semi-structured interviews with stakeholders from Djibouti, Ethiopia, and Sudan along the study corridor. A diverse group of 6-10 interviewees will be selected, including male and female officers/managers from the Ministry of Finance, Ministry of Physical Infrastructure, and their respective road/transport agencies. Additionally, the Heads of Customs and Immigration from the three countries, as well as the director and deputy of the Port Authority, will be considered suitable candidates for interviews. It is important to also include support staff from NGOs and CBOs in the interview study. Prior to this, a pilot study was carried out to validate the chosen method and questionnaire, demonstrating its suitability for gathering the required data. If necessary, the study can be expanded to explore further impacts on the broader supply chain using alternative methods. The structured questionnaire, designed to measure waiting time and its impact on business competitiveness in the region, was developed by mapping out the questions on a flow chart of the entire supply chain from the ship to the border post. The survey questions are formulated in a manner that ensures the collected data can be directly measured or calculated, aligning with the study's objectives. It is essential to note that while this approach has its limitations, it provides a unique insight into how waiting time affects business competitiveness in the region, particularly within the context of Sudan.

Data Collection Methods

The primary emphasis of this research question was to thoroughly understand the research problem, for which surveys, interviews, and analysis served as the primary methods for data collection. Surveys and interviews were conducted with individuals from Umm Al-Gura, companies oriented towards Port Sudan, and port specialists at the Port of Sudan, as well as informal interviews. Furthermore, direct observation of container waiting areas using carts was carried out and verified with the port's existing documents.

Surveying Surveys require flexibility, precision, and access to individuals' attitudes and opinions, leading to a deeper understanding of potential controversies within a research issue. The knowledge acquired from the surveys has been instrumental in addressing the concerns of this study. 4.2.2. Conversations The primary objective of the interviews was to verify the reliability of the surveys. In this regard, employing an exploratory approach to explore this issue, delving into different perspectives proved highly beneficial in achieving the study's objectives. The majority of the research data was obtained from the surveys, with occasional consultations with affiliated organizations, particularly regarding the direct delivery of over 100 containers in the waiting area, and similar matters. 4.2.3. Observational Analysis The purpose of the observational analysis was to confirm the accuracy of the survey data. It also aided in the selection of the research site and the collection of relevant data. This method facilitated the identification of containers in the waiting area and was particularly valuable when inquiring about customer-related delays.

Difficulties Encountered In conducting the surveys, it proved to be quite challenging to acquire all the required information. This was primarily due to the fact that the waiting areas contained specific details such as quantity, destination, contents within the containers, the age of the containers, and so forth. The majority of the information gathered during the survey was obtained from the individual responsible for the transshipment. Ethical Considerations It is imperative to take into account the sensitivities involved in

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the data collection process. In many instances, samples from customs and transshipment agents were only obtained after sending a direct explanatory letter. Data Analysis All the information gathered from the surveys, interviews, and observational analysis was compiled into a single comprehensive document, both for validation and examination. The majority of the data collected manifested in the form of a singular record resource.

Analysis and Findings

Waiting Lines and Logistics Performance has been the subject of numerous studies, delving into the intricacies of queuing within the realm of logistics performance. It is widely acknowledged that queuing phenomena exert a significant impact on both domains. Extensive discussions have centered around the influence of queue length on customer wait time, illuminating a positive correlation between waiting time and the average number of customers in the queue. This correlation has been utilized to analyze operational performance. However, scant attention has been devoted to exploring how waiting lines could potentially enhance the effectiveness and efficiency of their relationship to procedure partitions behind the queuing desk. As a result, this study endeavors to derive insights from the construction of multiple waiting lines.

TUThe issue of waiting lines in service organizations cannot be ignored, as they lead to poor services, customer dissatisfaction, increased hidden costs, ineffective systems, and inefficient resource utilization. Prolonged waiting times have a detrimental impact on the effectiveness of logistics services. At the Port of Sudan, there are clear indications of delays, with data showing the extent of the delays, including the presence of ships of up to 464 meters in the anchorage area despite a maximum allowable vessel size of 280 meters and a waiting time of up to 29 days. Furthermore, the management of Port Sudan has expressed concern about the delays at the port. It is essential to recognize that these delays are not caused by a single factor, but are influenced by on-site service inefficiencies, insufficient capacity in logistics areas, and alleged issues such as poor scheduling, equipment shortages, indirect control of yards and gates, and significant daily fluctuations, among others.

From a theoretical standpoint, the impact of delays on the overall efficiency of logistics operations has garnered extensive attention from numerous scholars, with a predominant reliance on queuing theory. Queuing theory offers a valuable approach for analyzing and structuring essential components of customer flow. Initially utilized in the emergency room as a strategic planning tool in healthcare operations since the early 1950s, it has been adapted and extended for evaluating port operations. A comprehensive set of strategies provides a detailed guide for enhancing port performance utilizing various queuing-based frameworks, employing threshold indicators such as waiting times to assess queuing behavior, determining suitable policies to be enacted, and addressing other operational decision points. Diverse analyses have connected such assessments to metrics for waiting lines (queues) that are pivotal to service systems, encompassing line lengths and average waiting times, priorities, lost calls or turned away customers due to space or time constraints, balking, reneging, and jockeying behaviors, the requisite number of servers or operators, or the average useful service rate, and per unit arrival service rate, among others. These analyses yield valuable decision-making information, including whether to expand service operations to mitigate delays, overall operational assessments, or aggregate resource needs, among other considerations. The primary focus lies in the waiting time line (or queue) rather than the specific operational element or the individual patient or customer in question. As per the findings in the literature, policies should be implemented through standardizing vessel calling patterns, bolstering port transit systems that support existing underdeveloped facilities, or further developing those in existence, and managing the anchorage area.

Discussion

The exploration uncovers the predominant system of queuing regulations utilized in docks and harbors. Comprehending this information is crucial in grasping the implications of managing existing wait lines at ports. The implementation of queues at ports has a detrimental impact on clients' perception of the services offered. Lengthy wait times, ranging from mere minutes to several days due to high customer volume, result

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in discontent with the services rendered. Prolonged wait times also escalate service costs. Consequently, queues at ports diminish the appeal of the port, ultimately leading to decreased maritime traffic. The duration of wait times is pivotal, as it is determined by the theoretical and practical significance of wait line analysis. The foundation of all theoretical findings pertaining to wait lines is a set of assumptions. Hence, the primary findings are economic in nature. Therefore, it does not encompass a discussion of the study's limitations or empirical results.

In maritime transport systems, waiting lines play a crucial role, serving a multitude of ports and companies. As such, new empirical data has the potential to reshape theoretical concepts and alter the dynamics of waiting lines. Presently, there are emerging trends in waiting line management, including congestion pricing, underscoring the ongoing interplay between theory and practical application. Furthermore, the services offered by a port, along with the size and attributes of the vessels, are not the sole determinants of port clientele. Other factors, such as vessel handling methods, can impact port operations and service durations, potentially leading to congestion. In fact, unloading strategies can negatively impact loading times and contribute to congestion. Expanding empirical research in this area holds great promise. The management of conflicts inherent in berth waiting lines holds broader implications for the governance of terminals and ports. Our aim is to further develop our theoretical discourse in a manner that aligns with the managerial challenges encountered in future research. While we have endeavored to evaluate the operational benefits of waiting lines, we are mindful of the methodological limitations inherent in theoretical analysis. Both empirical data and the errors observed in sought-after tests, as perceived by decision-makers in the realm of waiting lines, serve as a catalyst for future research endeavors.

Implications for Port Operations

The findings and analysis of this study suggest that the number of vessels anchored in the Gulf of El Gaba is likely to increase in the coming decade. Without the implementation of a waiting line, the cost of waiting times for ships is expected to rise. Prolonged waiting times may dissuade carriers from visiting Port Sudan, particularly given the subpar quality of port services. Delays in accessing terminal berths directly impact stevedores due to late ship arrivals and financial losses if ships must depart before loading or unloading is completed. The heightened stress caused by heavy workloads and frequent thefts prompts stakeholders to reconsider their strategies for port transactions, possibly involving increased hiring of temporary or permanent staff, or seeking assistance from foreign partners experienced in port operations. The financial burden of these delays directly affects stakeholders, leading to increased depreciation costs and operational expenses for machinery maintenance due to excessive use. Delays also elevate the company's managerial costs, as shipments arrive at the port and the expected loading ship arrives, but machines are unavailable and skilled staff struggle with difficult working conditions. Ultimately, these financial setbacks impact the health of the staff. Senior management recognizes the financial risks associated with port performance and regards partner satisfaction as a crucial asset to monitor. Adjusting the approach to waiting times in different port sections can reduce operational costs and enhance customer satisfaction. The survey indicates that improved operational efficiency at the port will lead to greater satisfaction. Tailoring training programs to the needs of professionals should decrease anticipated waiting times. Lastly, the implementation of a call planning program with operational control of loading and unloading operations should help alleviate delays. The study highlights the strong correlation between waiting, port performance, and customer satisfaction at the port.

Conclusion and Future Research

In this examination, we offer a comprehensive overview of various concepts and characteristics of queue theory as it is applied across diverse domains, situating our model within the realm of port operations at Port Sudan. Following an identification of the correlation between this study and prior research, we present an assessment of the influence of various model parameters on the logistical services at the port. With respect to the operational dynamics of liners, there remain unresolved matters warranting further investigation. Our model is streamlined by excluding other shipping lines, as this falls beyond the scope of our work. The primary elements of our waiting line model encompass the additional lines or truck

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cooperatives, which may be fashioned based on our waiting line simplifications. Enriching our work is conceivable by applying the developed propositions in the field to address exceptional cases. Furthermore, the investigation reveals that the quantity of waiting lines exerts a significant impact on the wait time. Consequently, operating more than one berth diminishes the waiting time and uncertainty, thereby heightening the efficacy of the logistics operations in accommodating incoming vessels. Significantly, the findings of the study furnish valuable insights for stakeholders, shedding light on the influential parameters governing the operational conduct of the shipping lines for the Sudanese commercial ports. Additionally, in summation, the objective of this research was partially fulfilled. In future inquiries, it is imperative to devise strategies for the situational management of waiting lines at the port of Sudan to meet the demands and regulate the performance of the port as a hub for imports and exports. The proposed models fortify the logistics strategy of the interplay between shipping and its logistical repercussions. This interplay necessitates an iterative, integrative, and strategic framework to address the waiting lines at transportation terminals. It may also encompass strategic considerations such as slow steaming, high demand, and port risk management, carrying implications for forthcoming studies.

Summary of Findings

The realm of maritime transportation plays a crucial role in global trade, accounting for approximately 90% of the overall trade volume. Port Sudan, a prominent and bustling port in Sudan, is equipped with cutting-edge facilities to meet the demands of the growing international trade. The objective of this study is to assess the impact of introducing queuing logistics services at Port Sudan on waiting times.

The study's results reveal that waiting lines can have a detrimental effect on logistics services at the port. It was observed that clients of the port express dissatisfaction with the prolonged waiting times at Port Sudan. The test outcomes also led to the conclusion that the overall quantity of service resources can lead to interventions as perceived through trip records, as opposed to the actual number of interventions recorded by clients at the port over the past five years. The proposed model's objective was found to align with the results obtained from the semi-structured interview and survey data. The study's findings also proposed practical implications and solutions for port management to improve the quality-of-service delivery at the port. Queuing theory can aid in reducing investment costs, increasing operational and port security levels, and improving workforce education and training. It plays a crucial role in forecasting and planning logistics services at the port and in devising strategies for business advancement.

This paper delves into the exploration of queuing systems in the context of logistics services at ports. With limited resources, managing waiting lines has become increasingly crucial. The findings of a new model for real field research revealed that the client satisfaction level at Port Sudan does not align with the theoretical model operations. In order to meet the desired delivery standards, it is imperative for management to improve the logistics service at the port. The port may incur minimal expenses for hiring new staff or implementing advanced technology as compared to alternative 1. Financial decline and client contentment at the same operational levels are potential outcomes. The cost of hiring new personnel or acquiring high-tech equipment to optimize the logistics service distribution level at the port may be estimated.

Recommendations for Future Research

Based on the preceding theoretical examination, it is suggested that further investigation be undertaken to enhance the efficiency of logistics services waiting lines and to put forward solutions that more effectively assist in patient and logistics service waiting. It would be beneficial for researchers to carry out on-site studies to validate the movement of trucks, as well as to evaluate strategies for streamlining procedures in a manner that expedites the unloading or loading of ships. Furthermore, researchers could conduct on-site studies to identify the technologies currently employed or that have the potential to be utilized for managing queue and wait time services, in order to ascertain the extent to which management can capitalize on technological solutions. Additionally, researchers could assess the application of statistical methods for delineating and analyzing queue operations.

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Ultimately, the analysis of ship and truck movements at the New Port can be approached through the application of statistical models due to the substantial variability in the time needed for the completion of arrival and departure operations for both ships and trucks. This study culminates with the necessity for further research to address the specific challenges highlighted in this domain. Consequently, the management of waiting lines must be carried out utilizing cutting-edge technology, dock-handling equipment, and a transient workforce of dockers. Procedures need to be reassessed and innovated in order to optimize the turnover of vessels and the subsequent release of trucks from the waiting lines. Collaboration with other ports, comprehensive research, and interdisciplinary approaches could serve as a crucial step in identifying the future areas of focus for subsequent studies. Furthermore, future research endeavors should center on both the theoretical and practical applications of queuing. Additionally, researchers should persist in proposing the most effective tools and techniques to operate within the theoretical framework and study case studies from all logistical service centers to gather substantial primary data and validate the outcomes of the theory. Given the subjective nature of the services, they are subject to change and thus necessitate ongoing research in practice to address the real issues posited in the theoretical proposition.

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