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The Effect of Weigh Bridge on Logistic Timeliness The Case of Dar Es Salaam - Tunduma Route

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Abstract:- This study investigates the effect of weighbridges on logistics timeliness along the Dar es Salaam-Tunduma route, focusing on three key factors: weighbridge capacity, operations, and the number of weighbridges. By employing a combination of quantitative regression analysis and qualitative insights from logistics professionals, summary tables for the analysis of the data, results revealed that weighbridge capacity and operations significantly impact logistics timeliness. Specifically, increasing weighbridge capacity is positively associated with improved logistics timeliness, reducing congestion and long queue delays. Conversely, inefficiencies in weighbridge operations, such as slow documentation handling and technical issues, negatively affect logistics timeliness. The study underlines the importance of enhancing weighbridge capacity and optimizing operational efficiency to mitigate delays and improve logistics performance. Moreover, in contrast, the number of weighbridges encountered shows a weak negative correlation with logistics timeliness, which is not statistically significant. This suggests that while additional weighbridges may contribute to delays, their impact is less critical than capacity and operational efficiency. The qualitative insights from logistics professionals support these findings, highlighting the need for improvements in weighbridge capacity and operations to streamline the logistics process and reduce delays. The study's findings hold practical implications for logistics operators, policymakers, and infrastructure planners. This research contributes to a deeper understanding of weighbridge-related factors and their impact on logistics timeliness, offering actionable recommendations for improving transportation networks.

I. INTRODUCTION

In Tanzania, road transport dominates the logistics landscape, carrying over 90% of passengers and more than 75% of freight traffic. However, the road network is plagued by congestion, particularly at weighbridge stations along key routes like Dar es Salaam to Tunduma. This 919-kilometer route, managed by TANROADS, features multiple weighbridges and police checkpoints that exacerbate delays. Research indicates that these weighbridge stations that are critical for maintaining road safety, often disrupt the flow of traffic, negatively impacting logistic timeliness (ISCOS, 2022).

Road transport infrastructure is vital for the economic development and competitiveness of nations, serving as a backbone for trade and logistics. Efficient road networks facilitate the swift and cost-effective movement of goods, thereby boosting economic activities and enhancing trade competitiveness (Stokes, 2019). In recent years, initiatives within the East African Community have focused on improving customs clearance and cargo handling at ports and terminals, resulting in notable advancements in regional trade dynamics However, these positive developments within the East African Community still face significant challenges that hinder the flow of goods.

En-route delays caused by weighbridges, slow border-crossing processes, and police roadblocks have substantially increased transit times for cargo, nearly doubling the expected duration of transport. This phenomenon indicates a failure to maintain logistic timeliness, which encompasses the scheduling and operational efficiency of the entire transport network. Logistic timeliness involves the coordination of shipments, cargo, and passengers, ensuring that all movements from the point of entry into the network to the point of delivery are seamless (Pečený et al., 2020).

Maintaining logistics timeliness is crucial for ensuring traffic safety and fluidity in road transport. It requires a proactive approach to managing road conditions, particularly in response to the increasing volume of vehicles that contribute to road degradation. Implementing statutory weight limits for vehicles is essential to prevent overloaded trucks from causing excessive damage to road surfaces (Naukowe et al., 2017). Effective enforcement of these weight limits relies on a combination of legislative measures and advanced technical devices, such as static and dynamic weighing systems, which allow for efficient monitoring of vehicle weights.

This study explored the effects of weigh bridges and their characteristics in the logistic timeliness with a focus on the Dar es Salaam Tunduma route which is part of the central corridor in Tanzania and is responsible for distribution along the central Southern and eastern parts of Africa. This study used the optimization theory to explain the ways the weighbridges can be used efficiently and avoid delays.

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II. METHODOLOGY

➢ *Research Design and Data Sources*

To conduct this study, a researcher applied a descriptive research design. Descriptive research design is instrumental in providing a comprehensive understanding of various phenomena or situations. Descriptive research is used because it facilitates informed decision-making processes. Descriptive design provided objective understanding of variables that is weighbridges and logistic timeliness.

➢ *Sampling Method*

This study used non-probability (purposive) sampling was strategically implemented to target specific individuals who possessed expert knowledge and direct experience relevant to the research focus. These individuals included professionals involved in road transport, exporters, and those engaged in weighbridge operations. By deliberately selecting these key informants, the study was able to gather in-depth insights and detailed information that may not have been captured through random sampling alone. This approach allowed the researcher to delve into specialized areas of the subject matter, enriching the overall analysis and ensuring that the findings were both robust and nuanced.

III. DATA COLLECTION AND ANALYSIS

➢ *Personal Interview Method*

Semi-structured interviews were conducted with key informants identified through purposive sampling (Wang, 2022). These interviews were delved into their understanding and experiences where the respondents with suitable knowledge were accessed and able to give their thoughts about the topic of study. The study also gave flexibility to the respondents (interviewers) based on the list of standardized and predetermined questions. Such respondents involved Truck operators (both drivers and conductors), road users (pedestrian and motorists) and business operators/residents around the weighbridge station.

➢ *Questionnaire*

About 150 questionnaires were disseminated for gathering data because they are capable of cover many respondents of the sample size for a short time and easy to administer. More questionnaires were distributed compared to the required number of respondents because of response rate of associated with the use of questionnaires. The questions were prepared in a logical sequence to address the research objectives and some questions were open ended which allowed the respondents to give a wider view about their understanding of the study problem. The method was used because it targets a wider group of respondents, and it eliminates bias.

➢ *Data Analysis*

This study used mixed methods (qualitative and quantitative data analysis) these include descriptive, inferential and narrative data analysis techniques. Descriptive and inferential data analysis was used to reflect the relationship that exists between the independent and dependent variables. The multiple linear regression was used to explain this relationship. Thematic analysis offered a deeper understanding of individuals' lived experiences and perspectives. By focusing the themes shared by stakeholders involved in logistics operations, thematic analysis uncovers the subjective meanings and interpretations attributed to the presence of weigh bridges.

➢ *Validity and Reliability*

To ascertain and generalize the validity of the data, this study triangulated findings and compare them across the three data collection methods used. Results were compared from the documentary review, observation and interview performed on the stakeholders. Reliability, research instrument that can provide similar results when used repeatedly under similar conditions is said to be reliable (Kumar, 2018). In this study, a research instrument was used to test reliability through accuracy, stability, and predictability. Hence the reliability of the study was checked by comparing the analysis of the same data from several pieces of literature.

➢ *Ethical Consideration*

Before data collection, informed consent was obtained from all participants, ensuring they understood the purpose of the research, their voluntary participation, and their right to withdraw at any time. Confidentiality and anonymity were upheld throughout the study. Participant identities were not disclosed in any reports or publications, and data were securely stored. Measures were taken to minimize potential harm or discomfort to participants. Sensitive questions were addressed with care, and participants were informed of available resources in case of distress during the research process. The research adhered to principles of honesty, integrity, and transparency. Data were reported accurately, and any potential conflicts of interest were disclosed. The research findings were shared with participants and relevant stakeholders, respecting their feedback and interpretations. Finally, the study contributed to a broader understanding of weighbridge characteristics and their impact on logistics timeliness, benefiting both the public and academic communities in Tanzania.

IV. FINDINGS AND DISCUSSIONS

Distribution of occupation among the respondents come from transport officers, followed by logistics coordinators and weighbridge operators. This distribution is significant in the context of the study, as it highlights the predominant roles within the transportation and logistics sectors that are being examined.

- Transport officers, ensure compliance with legal, safety, and environmental regulations while optimizing costs by controlling fuel consumption and negotiating with suppliers. They implement safety protocols, maintain records of transport activities, and prepare reports.
- Road Safety Ambassadors, are individuals or groups dedicated to promoting road safety awareness and responsible driving practices. They work to educate the

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public, advocate for safer road policies, and engage in campaigns to reduce road accidents, often collaborating with government bodies, schools, and local communities.

- Logistics Coordinators, Professionals responsible for planning, organizing, and overseeing the efficient movement of goods within a supply chain. Stakeholders refer to any individuals, groups, or organizations with an interest or investment in a particular project, company, or initiative.
- Weighbridge operators, who are involved in monitoring and recording the weights of vehicles, contribute valuable information regarding weight compliance and operational efficiency. The concentration of respondents in these key roles ensures that the study captures a comprehensive view of the operational dynamics and regulatory impacts within the transport and logistics sectors.

A. Descriptive Statistics

Descriptive statistics was performed as it importantly provides information on the characteristics of data observed or used in the study (Mokatsanyane, 2016). Such statistical measure provides information on how variables are distributed from the mean for meaningfulness of such data (Kumar, 2019). To provide an overview on data used, mean, and standard deviations, maximum and minimum were performed per each with and between variable.

➢ *Number of Weighbridges*

The survey conducted aimed to assess how frequently respondents transport goods using trucks. The results revealed a range of frequencies, with some respondents not transporting goods at all (minimum frequency of 0), while others transported goods as many as 15 times (maximum frequency). This indicates that delays are a common challenge, with the majority of respondents facing them frequently. The survey data further highlighted the importance of addressing congestion at weighbridges to improve logistical efficiency. The descriptive analysis provided insight into the number of weighbridges encountered as an independent variable, further supporting the understanding of logistics operations in this context.

➢ *Weighbridge Operations*

The survey conducted aimed to provide a comprehensive evaluation of different facets of weighbridge operations, focusing on critical elements such as personnel availability and readiness, efficiency in handling documentation, accuracy of weight readings, timely resolution of technical issues, and the adequacy of communication signage. In terms of personnel availability and readiness, the survey results revealed that the majority of respondents perceived the weighbridge personnel as generally available and prepared to carry out weighing operations promptly. However, the standard deviation signifies a notable degree of variability in the respondents' experiences. While some found the personnel consistently ready and accessible, others experienced occasional lapses in availability or readiness.

➢ *Weighbridge Capacity*

The survey investigated the operational capacity of weighbridges by examining the frequency with which respondents encounter both long and short dwell times; results implies that shorter wait times are less frequent and exhibit more variability in their occurrence. The variation indicates that while short dwell times do occur, their consistency and frequency are less predictable compared to longer dwell times.

B. Correlation Analysis

Correlation is used to measure extent and direction to which variables depend on or influence each other (Mokatsanyane, 2016; Nga & Nguyen, 2020). The extent and direction to which variables are linearly associated. Correlation ranges from -1 to +1 where, association with negative value closer to one is regarded as strong dependence between observed variables (Mokatsanyane, 2016). Correlation with positive value closer to one, indicates existence of strong positive dependence between variables (Mokatsanyane, 2016). Strength of association between variables decreases as correlation value gets closer to zero. Hence weak linear association exist between variable if correlation value is closer to zero (Nga & Nguyen, 2020).

➢ *Logistics Timeliness and Weighbridge Capacity*

There is a correlation that positively suggests that as weighbridge capacity improves, logistics timeliness also improves, results indicates a moderate relationship, meaning that higher capacity at weighbridges, which likely reduces waiting times and congestion, contributes to more timely logistics operations. This finding underscores the importance of enhancing weighbridge capacity to facilitate smoother and faster logistics processes.

➢ *Logistics Timeliness and Weighbridge Operations*

Results indicate that better weighbridge operations are associated with fewer delays. Efficient weighbridge operations, such as timely availability of personnel, clear instructions, and prompt handling of documentation, can help minimize delays in logistics operations. Despite the weak correlation, the negative direction aligns with the expectation that improvements in weighbridge operations can positively impact logistics timeliness by reducing operational inefficiencies.

➢ *Logistics Timeliness and Number of Weighbridges*

There is a weak negative correlation that suggests an increased number of weighbridges is slightly associated with increased delays in logistics timeliness. Although the correlation is not strong, it implies that encountering more weighbridges may contribute to longer transit times due to the cumulative effect of stopping at multiple points, potentially leading to delays. This finding highlights the need for strategies to streamline weighbridge processes or reduce the number of weighbridges to enhance logistics efficiency.

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C. Findings from Thematic Analysis

The findings focus on specific objectives, such as the effect of the number of weighbridges, operational inefficiencies, dwell time, capacity constraints, and the need for technological improvements. Through this approach, the study provided a comprehensive understanding of the factors impacting logistics timeliness.

➢ *Delays and Increased Transit Time*

The analysis reveals a strong correlation between the number of weighbridges encountered and the overall transit time for logistics operations. This relationship is primarily due to the cumulative delays caused by stopping at each weighbridge for inspection and weighing. As one respondent highlighted, *"Yes, the operations differ from one location to another, resulting in delays,"* it becomes clear that not only the presence of weighbridges but also the variability in their operational efficiency contributes to extended transit times. This variability can arise from differences in technology, staffing, or procedural adherence, all of which affect how quickly vehicles can be processed.

➢ *Operational Inefficiencies*

A recurring theme in the data is the inefficiency of weighbridge operations, which is a significant contributor to delays. Respondents frequently mentioned outdated technology and inconsistent procedures as key issues. One comment noted, *"Wind loading is likely to cause errors also weighing can be lengthy,"* suggesting that even environmental factors, such as wind, can interfere with accurate and timely weighing. This points to a broader issue of inadequate technology that may not be well-suited to handle various operational challenges, leading to errors and further delays. The inconsistency in procedures across different weighbridges also means that drivers and logistics companies cannot predict the time it will take to pass through these points, complicating logistics planning and scheduling.

➢ *Dwell Time*

The time vehicles spend waiting at weighbridges, known as dwell time, emerged as a crucial factor impacting logistics timeliness. Longer dwell times are particularly detrimental because they add to the overall delay without any compensatory gain in efficiency or accuracy. A respondent stated, *"Those with longer dwell times impact the timeliness more significantly,"* emphasizing that reducing dwell time should be a priority. This suggests that even small improvements in the speed and efficiency of weighbridge operations can lead to significant gains in overall logistics performance.

➢ *Capacity Constraints*

Capacity issues at weighbridges, particularly during peak traffic periods, are another critical concern. Limited capacity can lead to bottlenecks, where the number of vehicles arriving exceeds the weighbridge's ability to process them efficiently. This is often exacerbated by inadequate infrastructure, such as a lack of sufficient lanes or outdated equipment. One participant noted, *"Capacity issues at weighbridges can cause significant delays, particularly during busy times,"* indicating that these problems are not just isolated incidents but systemic issues that can disrupt logistics operations during critical periods. The bottleneck effect caused by capacity constraints can lead to a cascade of delays that affect the entire supply chain.

➢ *Technology and Efficiency*

There is a strong consensus among respondents on the need for technological upgrades and improvements in infrastructure at weighbridges. As one respondent pointed out, *"Lack of proper signs and signals, flexibility, and technology slows down the process."* This comment underscores the multifaceted nature of the problem, where both physical infrastructure (such as signs and signals) and technological capabilities (such as automated systems for weighing and documentation) are lacking. Investing in modernizing these systems could lead to substantial improvements in processing speed and accuracy, thereby enhancing the overall efficiency of logistics operations. For instance, implementing automated weighing systems could reduce the need for manual intervention, minimizing errors and speeding up the process. Additionally, improved communication systems could better manage the flow of vehicles, reducing congestion and waiting times.

D. Regression Analysis

To quantify the impact of weighbridge capacity, weighbridge operations, and the number of weighbridges on logistics timeliness, a multiple regression analysis was conducted. The regression model used logistics timeliness as the dependent variable weighbridge capacity, weighbridge operations, and the number of weighbridges as independent variables.

➢ *Weighbridge Capacity and Logistics Timeliness*

Results indicate a positive relationship between weighbridge capacity and logistics timeliness. This means that improvements in weighbridge capacity are associated with better logistics timeliness. Specifically, as the capacity of weighbridges increases, delays in logistics operations decrease. These results suggest that enhancing weighbridge capacity, such as increasing the number of lanes or improving equipment, can significantly reduce delays and improve the efficiency of logistics operations.

➢ *Weighbridge Operations and Logistics Timeliness*

The standardized coefficient (Beta) indicates a negative relationship between weighbridge operations and logistics timeliness. This suggests that inefficiencies in weighbridge operations contribute to delays in logistics timeliness. Inefficiencies such as personnel unavailability, slow handling of documentation, and technical issues with weighbridge equipment negatively impact logistics timeliness. Therefore, improving weighbridge operations by ensuring timely availability of personnel, efficient handling of paperwork, and quick resolution of technical problems can lead to significant improvements in logistics timeliness.

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➢ *Number of Weighbridges and Logistics Timeliness*

The standardized coefficient (Beta) indicates a weak negative relationship between the number of weighbridges and logistics timeliness. This implies that an increase in the number of weighbridges encountered slightly contributes to delays in logistics operations. Although the relationship is weak and not statistically significant, it hints at the potential for reducing delays by optimizing the number of weighbridges on a route or improving the efficiency of existing weighbridges to minimize stop times.

V. RECOMMENDATION AND CONCLUSION

➢ *Recommendations*

To improve logistics timeliness, it is recommended that significant investments be made in enhancing weighbridge infrastructure. Increasing the capacity of existing weighbridges by adding more lanes and upgrading technological capabilities can help accommodate higher volumes of traffic more efficiently. This includes implementing automated systems for vehicle weighing and documentation processing, which can reduce the time spent at each weighbridge. Such infrastructure enhancements will help minimize congestion and long queues, thereby reducing delays and improving the overall flow of goods along critical routes like the Dar es Salaam-Tunduma corridor.

Improving the operational efficiency of weighbridge stations is crucial. It is recommended that weighbridge operators undergo regular training to ensure they are well-equipped to manage documentation swiftly and provide clear instructions to drivers. Establishing standard operating procedures across all weighbridge locations can help ensure consistency in operations, reducing the variability in service quality that contributes to delays. Additionally, it is essential to maintain a high level of readiness among personnel and ensure that technical issues with weighbridge equipment are resolved promptly. These measures will enhance the speed and accuracy of weighbridge operations, leading to significant improvements in logistics timeliness.

The integration of advanced technologies at weighbridges can play a pivotal role in enhancing both capacity and operational efficiency. It is recommended to adopt automated weighbridge systems that utilize real-time data analytics and digital documentation processes. These technologies can streamline operations by reducing manual errors and speeding up the weighing and documentation processes. Moreover, the implementation of RFID (Radio Frequency Identification) tags and GPS tracking can provide real-time updates and better manage the flow of vehicles through weighbridges. Investing in such technologies will not only improve the efficiency of weighbridge operations but also provide valuable data for continuous process improvement.

Policymakers should develop comprehensive strategies to support the enhancement of weighbridge infrastructure and operations. This includes allocating resources for the upgrade and maintenance of weighbridge facilities and ensuring that best practices are standardized across all locations. Public-private partnerships should be encouraged to mobilize the necessary expertise and funding. Furthermore, policies that promote the use of advanced technologies and regular training programs for weighbridge personnel should be implemented. By establishing clear guidelines and standards, policymakers can ensure that all weighbridges operate at optimal efficiency, reducing delays and improving the reliability of the logistics network.

➢ *Theoretical and Practical Implications*

The findings of this study contribute to the existing body of literature on logistics and supply chain management by emphasizing the critical role of infrastructure and operational efficiency in determining logistics performance. The strong correlation between weighbridge capacity and logistics timeliness underscores the importance of infrastructure adequacy in facilitating smooth logistics operations. This study extends the theoretical understanding of logistics management by integrating weighbridge efficiency into the broader context of supply chain bottlenecks. It suggests that theories of logistics performance must account for the physical and operational characteristics of critical infrastructure points like weighbridges, which have been relatively underexplored in previous research.

Furthermore, the significant negative impact of weighbridge operations on logistics timeliness highlights the importance of human factors and operational procedures in logistics theory. This finding suggests that theories of logistics efficiency should incorporate the role of operational practices and personnel management at critical checkpoints. The negative correlation implies that inefficiencies at these points can substantially degrade overall performance, thus enriching the theoretical frameworks that address the interplay between human factors and logistics outcomes.

For logistics practitioners and policymakers, this study provides actionable insights into improving logistics timeliness through targeted interventions at weighbridges. The positive impact of increased weighbridge capacity on logistics timeliness suggests that investments in expanding and upgrading weighbridge infrastructure can yield significant improvements in logistics performance. Practical measures could include adding more lanes, enhancing technological capabilities, and ensuring that weighbridges are equipped to handle high traffic volumes efficiently. These improvements can help reduce congestion and waiting times, thereby enhancing the overall efficiency of logistics operations.

In addition to infrastructure investments, the study highlights the importance of operational efficiency at weighbridges. Training weighbridge personnel to handle documentation swiftly, provide clear instructions, and resolve technical issues promptly can significantly reduce delays. Logistics companies should consider implementing standard operating procedures and continuous training programs to enhance the efficiency of weighbridge operations. Policymakers might also develop regulations and

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guidelines that promote best practices in weighbridge management, ensuring that these critical points in the supply chain operate smoothly and contribute to overall logistics efficiency.

The study's findings also advocate for the integration of advanced technologies at weighbridges to enhance capacity and operational efficiency. The adoption of automated weighbridge systems, real-time data analytics, and digital documentation processes can streamline operations and reduce human error, leading to faster processing times. Implementing such technologies can help logistics companies achieve more consistent and accurate weigh readings, minimizing disputes and delays. Moreover, leveraging technology can provide valuable data for continuous improvement, enabling logistics managers to identify and address operational bottlenecks proactively.

The practical implications also extend to the need for harmonized standards and practices across different weighbridge locations. The observed variations in weighbridge operations across different sites suggest a lack of uniformity, which can contribute to inefficiencies. Establishing standardized procedures and protocols for weighbridge operations can help ensure consistency and reliability in logistics processes. Logistics companies and regulatory bodies should collaborate to develop and enforce these standards, ensuring that all weighbridges adhere to best practices and operate at optimal efficiency.

On a strategic level, the study calls for comprehensive policy development to support the enhancement of weighbridge infrastructure and operations. Policymakers should consider weighbridges as critical components of the national logistics network and allocate resources accordingly. Strategic investments in infrastructure, combined with policies that promote operational excellence, can significantly improve logistics performance and economic competitiveness. Additionally, fostering public-private partnerships can mobilize the necessary resources and expertise to implement these improvements effectively.

- *Conclusion*

This study investigated the impact of weighbridge capacity, weighbridge operations, and the number of weighbridges on the logistics timeliness of the Dar es Salaam-Tunduma route. Through a combination of quantitative regression analysis and qualitative insights from interviews with logistics professionals, several key findings emerged.

The regression analysis revealed that weighbridge capacity and weighbridge operations are significant predictors of logistics timeliness. Specifically, improvements in weighbridge capacity positively affect logistics timeliness by reducing delays associated with congestion and long queues. Efficient weighbridge operations, characterized by timely availability of personnel, clear instructions, and quick handling of documentation, also significantly reduce logistics delays. Although the number of weighbridges encountered showed a weak negative correlation with logistics timeliness, it was not a statistically significant predictor, indicating that while more weighbridges can contribute to delays, the impact is less pronounced than that of capacity and operational efficiency.

The qualitative insights from logistics professionals corroborate the quantitative findings, emphasizing the critical role of weighbridge efficiency in minimizing delays. Respondents highlighted the need for increased weighbridge capacity and more streamlined operations to enhance the overall logistics process.

The model summary further supports these conclusions, with an R value of 0.769 indicating a strong correlation between the predictors and logistics timeliness. The R Square value of 0.520 and Adjusted R Square value of 0.488 demonstrate that approximately half of the variability in logistics timeliness can be explained by weighbridge capacity, operations, and the number of weighbridges. This substantial explanatory power underscores the importance of focusing on these factors to improve logistics efficiency.

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