



**ASSESSING THE DETERMINANTS OF PRIVATE WASTE COLLECTORS' OPERATIONAL EFFICIENCY AND ITS EFFECT ON REVENUE: A CASE STUDY OF LAGOS WASTE MANAGEMENT SECTOR**

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**Abstract**

*Private waste collection firms play vital role in the realization of waste-related environmental goals of achieving clean environment and reduced solid waste pollution. However, little is known on such firms' efficiency and its effect on firms' revenue. Empirical research on the role of such firms' operational efficiency in boosting financial performance is sparse in waste management logistic operations literature. This study analyzes the factors determining the efficiency of such private firms and its effect on their financial performance. Using secondary data obtained from the Lagos Waste Management Authority (LAWMA) for 260 Private Sector Participants (PSPs), Structural Equation Modeling (SEM) procedure was adopted to analyze the theoretically justified model specified. Relying on SEM's capacity to address endogeneity in cross-section data, the study avoided the possibility of repeating the confounding effects in previous studies, lending more reliability to estimated parameters and conclusions. The analysis reveals that trip frequency, firm capacity, and firm experience significantly influence operational efficiency. The model's diagnostics indicate the model has high explanatory power, lending more reliability to the estimated parameters. The study concludes that operational efficiency, achievable through enhancing trip frequency, firms' capacity, and firms' experience are sine qua non to enhancing the revenue generation of private waste logistics firms in the waste management sector. Thus, the study recommends the government and regulatory authorities to target policies that would aid firms' expansion, and workers' trainings to bridge experience gaps in the industry.*

**Keywords:** PSP (H54, L32, D02), LAWMA (Q53, H83, O18), SEM (C38, C83, C10), Efficiency (D24, L25, Q12), Trip Frequency (R41, R40, L91).

**INTRODUCTION**

The relationship between population density and volume of solid waste generation as well as the resultant increase in cost has been pervasively examined around the world. Various studies have shown that densely populated urban centers produce higher volume of waste, posing greater management challenges relative to sparsely populated areas (Mapunda et al., 2023; Dahiya, 2015; Omololu & Lawal, 2013; Kawai & Tasaki, 2016; Matsunaga et al., 2001; UNESCAP, 2020). Thus, the attention on solid waste issue in Lagos state is therefore both timely and policy-relevant. According to the United Nation's World Urbanization Prospects, Lagos State is adjudged one of the largest urban centers in Africa and the only megacity in sub-Saharan Africa (UN, 2018). Hence, the lingering concern on the management of solid waste in Lagos State is not unexpected. Due to the large volume of waste generated on daily basis, the city faces significant challenges in solid waste management due to rapid urbanization and industrialization, accounting for daily waste

generation in excess of 13,000 metric tons (Adebayo et al., 2020). In response, the Lagos Waste Management Authority (LAWMA) has established partnerships with Private Sector Participants (PSPs) to manage waste collection, transportation, and disposal.

However, the performances of these PSPs vary widely, raising critical questions about the factors influencing their efficiency and how this efficiency impacts their financial performance, specifically their revenue generation. Guerrero et al., (2013), Zhang et al. (2018) and Lai and Vong (2020) noted that the efficiency of waste collection and hauling companies varies significantly across firms. While such is evident in the case of PSPs in Lagos State as shown in Figure 1, no known study has attempted examining the factors influencing their efficiency and how this efficiency impacts their financial performance.

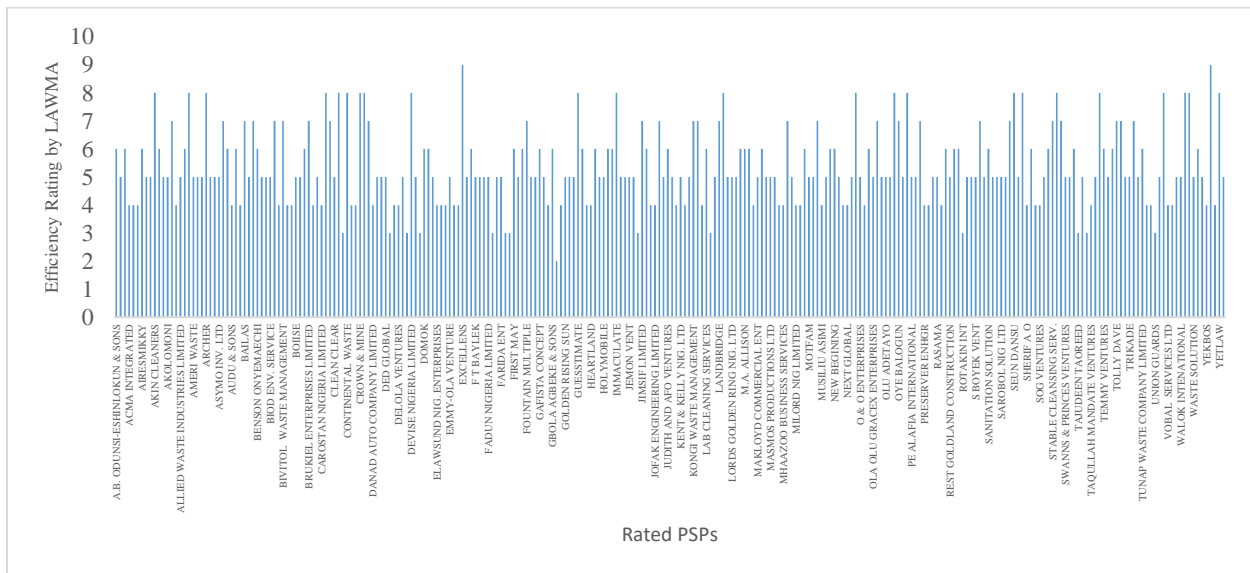


Figure 1: waste collection and hauling companies' (PSPs) Efficiency Rating by LAWMA  
Source: Constructed based on data obtained from LAWMA

Empirical literature abounds on the effects of firms capacity (size of firm), trip count (frequency of trips), and firms' experience on operator's efficiency. These include Wambalaba and Zambetti (2003), Tseng & Yue (2005), Lu & Yang (2010), Jeon et al., (2013), Lalendle et al. (2021). Meanwhile, Markovic et al., (2015) and Wong et al., (2023) examine the effect of efficiency in logistic operations on financial performance of firms. This implies that a group of studies have examined the antecedents to efficiency in logistic operations while the other group studied efficiency itself as antecedent to transporting and hauling companies' financial performance. None of these studies have attempted assessing these two levels of relationship in a model simultaneously. This has the technical implication of causing omitted variable bias, exposing the model to endogeneity arising from the omission of a variable that is correlated both with the dependent and independent variables (Kennedy, 2008; Hill et al., 2021).

Hence, the objective of this study is to analyze the determinants of operational efficiency and the effect of efficiency on financial performance within the realm of a Structural Equation Model (SEM). This simultaneous procedure contrasts previous studies, which have consistently examined these relationships separately, thereby not addressing the exposure of estimated parameters to

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endogeneity which could create inconsistent and biased estimates, generating misleading conclusions. This study is imperative since no previous study has attempted using the rich data on PSPs performance indicator compiled by LAWMA or any other waste-transporting sector in Nigeria to empirically gain insight on the determinants of operational efficiency.

The remainder of the study is structured as follows; section 2 discusses waste collection in Lagos State and the study's theoretical framework. Section 3 presents the methodology adopted in the research, why section 4 presents results and discussion and finally, the conclusion and recommendations from the study are contained in section 5.

### ***Waste Collection in Lagos State***

LAWMA, which is responsible for managing wastes of all kinds, including municipal waste, industrial and commercial waste, is historically a transformation of the Lagos Refuse Disposal Board, established in 1977. The board was charged with the task of collecting domestic waste and cleaning drains in Lagos metropolis (Adam, 2014). In 1981, the organization's responsibility was expanded to include the collection and disposal of commercial waste, industrial waste, Scraps and abandoned vehicles. As a reflection of the expanded roles of the organization, its name was changed to Lagos State Waste Disposal Board (Adepitan, 2010). In similar vein, following the commercialization of the organization's services to both the state and local governments, its name was in accordance to Edict N0 55 of the Lagos State Government, changed to LAWMA in 1999. Since then, LAWMA has been tasked with coordinating the management of solid waste and disposal in the state.

However, key regulatory and enforcement responsibilities still rest with the ministry of environment (Olugbenga, 2010). Between 1996 and 1998, the Ministry of Environment in Lagos played the pioneer role of introducing public-private partnership (PPP) in the state's waste management industry. The private waste collection firms which came to be known as private sector participants (PSPs) in the industry increased in number following the success of an earlier pilot project with just 22 companies (Adepitan, 2010). They operate as private waste collection firms in the capacity of franchisees while LAWMA assumes the role of franchisor. This was deemed necessary as a remedy to the abundance of uncollected waste which resulted from government's budgetary constraints.

## **LITERATURE REVIEW**

### ***LAWMA Performance Indicator Variables***

LAWMA periodically collects data on the operations of private waste collectors in Lagos State. The database used for this study, named PSPs Performance Evaluation Matrix sourced in 2022 include the operational efficiency index, firm capacity index, trip count and firm experience. Each of the variables are conceptually defined below.

### ***Operational efficiency***

In logistics services *operational efficiency* describes the ability of a service provider to strategically manage logistics processes, resources and trips targeted at maximizing productivity while simultaneously minimizing operational costs. Such cost to be minimized include time and resource employment, while meeting customer demands sustainably without service quality compromised

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(Fabbes-Costes & Jahre, 2008; Christopher, 2016; Rodrigue, 2020). Generally, the main dimensions of operational efficiency in logistics services are;

1. **Optimal Resource Use:** Cost effective and maximal use of tools and equipment, human resources, vehicles and maximizing fleet capacities such as trip count, truck loads and routes planning (route optimization) to reduce idle times and consumption of fuel (Lai et al., 2008; McKinnon, 2015).
2. **Technology Utilization:** Technology integration is top-notch in transport service. Software are being deployed to meet customers' preferences, achieve route optimization, as well as availing real-time tracking by both customers and service providers. These enhance decision-making, timeliness and maintaining accuracy, thereby helping firms to build clients' trust and perceived reliable (Lai et al., 2008; Slack, 2015).
3. **Reliability and Quality of Service:** Trust, timeliness and reliability are bait for attracting customers in logistics service provision. Thus, scheduling trips to consistently meet clients' expectations is crucial. This is achieved through timeliness and maintaining accuracy in deliveries to establish trust and reliability (Bowersox et al., 2013; Christopher, 2016).
4. **Cost Efficiency:** This involves the adoption of cost-saving strategies while maintaining service quality in fleet management. This include strategically minimizing fuel consumption, cost-effective maintenance costs and optimal employment of workers while achieving timeliness and reliability in service delivery (Fabbes-Costes & Jahre, 2008; Slack, 2015).
5. **Time Management:** In logistics services time lost is money lost. Thus, the reduction of unproductive time such as the minimization of the time committed to loading and unloading and optimal routes planning. The optimization of routes planning includes avoiding idle times and peak traffic deliveries to improve lead times and ultimately, customers' satisfaction (Bowersox et al., 2013; Rodrigue, 2020).

### ***Firm Capacity***

The capacity of a firm in transport logistics, including waste collection companies, describes its scale of operations, which encompasses the number of workers, truck fleet size and other equipment the company deploys in services delivery. Firms with higher capacity can easily deploy the requisite resources to conduct more frequent trips, cover larger service areas and achieve timeliness in service provision by processing larger quantity of waste (Moya et., 2017).

### ***Trip Count (Frequency of Trips to Dumpsites)***

Trip count refers to the number of times a waste logistics firm transport collected waste from either the source of generation or transfer-loading station to dumpsites. This variable is important because it affects service quality and firms cost of operation. This is because high trip frequency, although desirable by reducing waste accumulation which leads to cleaner environments, it is achieved at higher cost of operation if not well managed through strategic route optimization (Ming et al., 2016; Ghanbari & Yigitbasioglu, 2020).

### ***Firm Experience***

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Experience is an important determinant of firms' performance. It describes the expertise earned through repeated routines in the industry and the knowledge accumulated in that process. Such experience gained over time influences company's adaptations to the downsides of the industry, enhancing operational efficiency and profitability (Lai, Cheng, & Yeung, 2004). Experienced firms already have established relationships with both clients and regulators in the industry and can easily refine operational procedures, reducing inefficiencies (Larsen et al., 2017; Agwu et al., 2019).

**Firm revenue (Financial Performance)**

Profitability is the goal of most businesses. Solid waste transportation and haulage companies are not exceptions. Like every other business, attractive turnovers (either gross revenue or net profit) motivate new entrants while incentivizing existing firms to expand by increasing their capacity in the form of increased truck fleet, human resources as well as investments in advanced technology. The drive for profit is justified by the huge investment required to setup such logistic firms. While recent data on Nigeria is not available, the 2024 average cost of setting-up waste management company in the United States range from \$324,000 to \$456,000 equivalent to ₦529,092,000 to ₦744,648,000. Such investment cost cover licenses and permits, furniture and fixtures, insurance policy premium, rent, utilities, marketing, other miscellaneous expenses as well as purchase of trucks which constitute as much as much as 80% of the total investment (Remi, August, 2024). This is as shown in Figure 2.

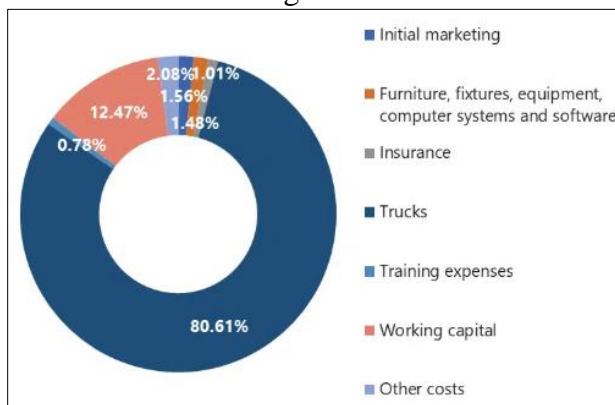


Figure 2: upfront investment cost structure for SWM companies  
Source: Remi (2024)

Despite the huge investment required, operators are motivated to invest in SWM companies since its profitable (Adam et., 2015; Remi, 2024). Thus, understanding the determinants of such firms' financial performance is imperative.

**Theoretical Framework**

A sizeable number of theories have been advanced to understand the relationship between firm capacity (size), trip frequency and experience on firms' operational efficiency, including the effect of efficiency on financial performance. Some of the theories include, the Resource-Based View (Barney, 1991), the Dynamic Capabilities theory (Teece et al., 1997), efficiency wage theory (Akerlof & Yellen, 1986), and production theory (Chambers, 1988; Varian, 1992). However, both efficiency wage theory and production theory are adopted in this study on account of their correspondence and explicit explanation to the proposed relationships.

### ***Efficiency Wage Theory***

Traditionally, the Efficiency Wage Theory espouses the notion that offering wage rates higher than prevailing market wages incentivizes workers to work efficiently. More recent research has expanded this notion to include organizational investments that increase productivity (Härtel & Fujimoto, 2021; Yao et al., 2021; Basak & Panda, 2022). Following such extended notion, Efficiency Wage Theory espouses improvement in firms' productivity not only through the payment of higher-than-market wages but by providing an enabling work environment through investment in resources such as work enhancement aids, tools and exposure to capacity-building training, among others, all of which empower employees to perform better.

Current studies highlight that investing in non-wage factors, like scheduling systems or operational resources, can also drive productivity gains (Yao et al., 2021; Basak & Panda, 2022). In logistics such as waste-transporting and hauling services, such investments in operational improvements like capacity expansion (increased firm size) or attractive wages motivate employees to maximize performance, altogether - increasing trip count, enhancing experience and ultimately increasing financial performances (Adam, 2024). This aligns with the findings of Yao et al. (2021) which shows that transportation and logistics service providers' investments in technologies upgrade improved workers' performance and enhances cost savings. Basak and Panda (2022) noted that such outcomes enhance operational efficiency, thereby improving firms' financial performance.

### ***Production Theory***

The theory of Production examines the functional relationship between input efficiency and output. It particularly espouses that the attainment of optimal output is determined by input use and input combination maximization. Recent studies extend this theory to show that input optimization in logistics resources, such as fleet capacity, workforce experience and operational frequency directly influence productivity (Nangpiire et al., 2025). Thus, by maximizing the allocation and use of such logistics resources, waste collection firms could attain higher productivity levels. It could thus be concluded that in the logistics industry – such as solid waste collection and haulage sector, production theory espouses that the efficient use of resources like fleet capacity and trip frequency (trip count) enhances work flow and reduces costs, thereby increasing financial performance.

This theoretical exposition conforms to Holguín-Veras (2006) which found that by adjusting trip count and optimizing capacity utilization, logistics firms achieved substantial cost reductions and enhanced performance. Similarly, Mateli (2023) found that by optimizing the use of input resources, logistics firms operate efficiency and record financial success. Hence the theory of production provides theoretical framework on how logistics inputs such as firm's fleet capacity, trip frequency (count), experience and operational efficiency determine output - financial performance (Varian, 1992; Nangpiire et al., 2025; Mateli, 2023).

## **METHODOLOGY**

### ***Research Design***

This study adopts quantitative cross-section research design, using an unexplored secondary data collected by LAWMA to analyze the relationship between waste management firm-level variables including, revenue generation, firm capacity/size, operational efficiency, workforce experience, and trip frequency. The use of cross-sectional approach is deemed appropriate since the data, focuses on 2022, representing the performance of firms during that period.

### ***Data and Data Source***

This study used secondary data on PSPs performance indicators, sourced from LAWMA in September 2022. The data captures several variables collected by LAWMA on the operations of PSPs in Lagos state. The data for all variables are ratio scale and cross-section data for 261 logistic waste transporting private firms, all of which are registered as franchisees under LAWMA. Data was collected on variables including operational efficiency, trucks trip count, PSPs revenue, firms' capacity (size) and firms experience in waste collection. The data for all variables were measured by LAWMA on a ratio scale of "0" to "10" where "0" is assigned for the least score and "10" assigned to the highest score. Although more than 300 companies were in operation when the data was collected, only 261 firms were sampled for data collection by LAWMA. Meanwhile from the sample of 261 firms initially obtained, only 260 was analyzed as a result of missing data observed for one of the companies. Below is a brief description of the variables.

### ***Variables Description and Measurement***

The variables used in this study are categorized into exogenously independent, endogenously independent and dependent variables. Further descriptions of the variables are already provided in section 2. They include:

1. Dependent Variable:
  - Revenue: This variable measures the financial performance of waste collection companies in Lagos. For the purpose of the analysis in this study, it is conceptualized as a dependent variable since based on the framework adopted in subsection 3.3, it is determined within the system.
2. Endogenously Independent Variable:
  - Operational Efficiency: This variable evaluates waste management company's ability to optimize operations and the use of resources, detailed description is provided in section 2. It is endogenously independent since as obvious in equations (3) and (4), the variable is both a dependent and independent variable within the SEM procedure adopted.
3. Exogenously Independent Variables: This refers to variables that are independent variables and not determined within the adopted SEM equations. They refer to the following;
  - Firm Capacity/Size: This variable as presented in section 2 measures firm's scale of operation covering machinery, fleet size and human resources.
  - Trip Frequency: This variable is measures trip count which describe the number of trips waste collection vehicles travel from service areas to dumpsite.
  - Company Experience: This variable measures firms' experience in the industry since such influences their competence in managing waste collection more optimally.

### ***Theoretical Model Specification***

Relying on the theoretical frameworks advanced, the study adapts the empirical model furthered by Mantje et al (2023). The study specified firm's capabilities in the form accumulated knowledge as determinant of efficiency while simultaneously specifying operational efficiency as a determinant of firms' competitiveness. The model is thus specified as;

$$Competitiveness_i = \beta Efficiency_i + \epsilon_{1_i} \quad (1)$$

$$Efficiency_i = \beta Capacity_i + \epsilon_{2_i} \quad (2)$$

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Mantje et al (2023) noted that competitiveness as used, just like profit or revenue, is a measure of firm's performance, which aligns well with this study's objective. Hence, revenue was substituted for competitiveness in equation (1) to obtain equation (3). Similarly, based on the ideas espoused under the theoretical framework, equation (2) was extended based on the justifications under theoretical framework to include Firm Capacity (number of vehicles, trucks and equipment), trip frequency and Firm experience, as evident in equation (4).

$$Revenue_i = \beta Efficiency_i + \epsilon_{1i} \quad (3)$$

$$Efficiency_i = \beta Capacity_i + \alpha trip\ frequency + \delta experience + \epsilon_{2i} \quad (4)$$

where  $\epsilon_{1i}$  and  $\epsilon_{2i}$  represent the error terms associated with each of the equations.

### ***Method and Analytical Procedure***

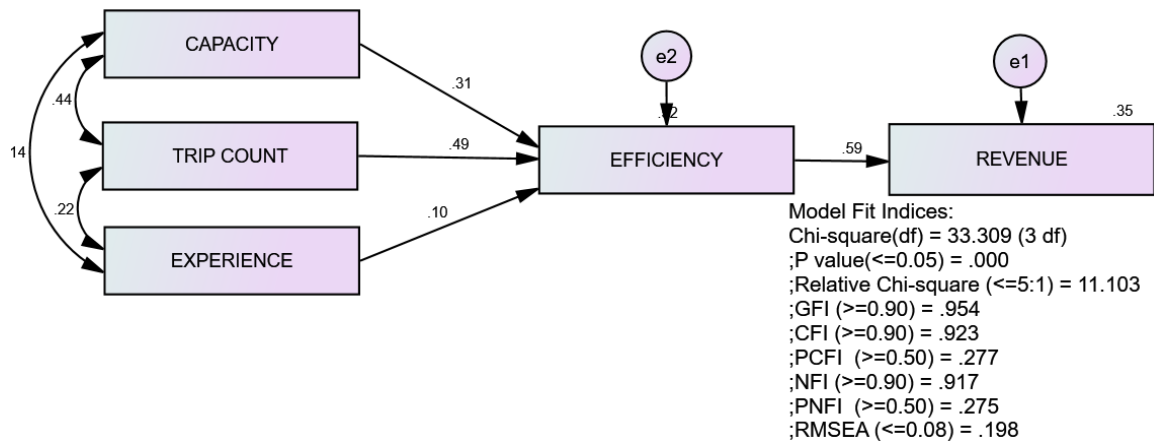
This study uses Structural Equation Modeling (SEM) procedure to estimate the two theoretical models presented in equations (3) and (4). This is because SEM allows the simultaneous estimation of interrelated multiple equations which when combined will present an elaborate equation beyond the traditional regression methods with multiple dependent variables. The suitability of SEM in the context of this study is predicated on its capacity to estimate equations (3) and (4) as one model. This conforms to the study's objective of examining the effect of efficiency on revenue and how firms' capacity, trip frequency, and experience influence efficiency. Such procedure is superior over the traditional regression modeling of estimating the equations separately, thereby avoiding omission bias that may arise when variables are interdependent (Byrne, 2016; Kline, 2016). This is evident in the indirect effects of firms' capacity, trip frequency, and experience on revenue which is intrinsically captured by the SEM specification, allowing for more nuanced interpretation of all hypothesized relationships (Hoyle, 2012).

A unique benefit of adopting SEM in this context is the reliability it accords estimates by separately modeling the unobserved errors  $\epsilon_{1i}$  and  $\epsilon_{2i}$  associated with each equation. This is relevant since in the context of this research, both the revenue and efficiency have their unique measurement errors, which this procedure can address more effectively compared to the traditional single-multiple regression procedures (Hair et al., 2014).

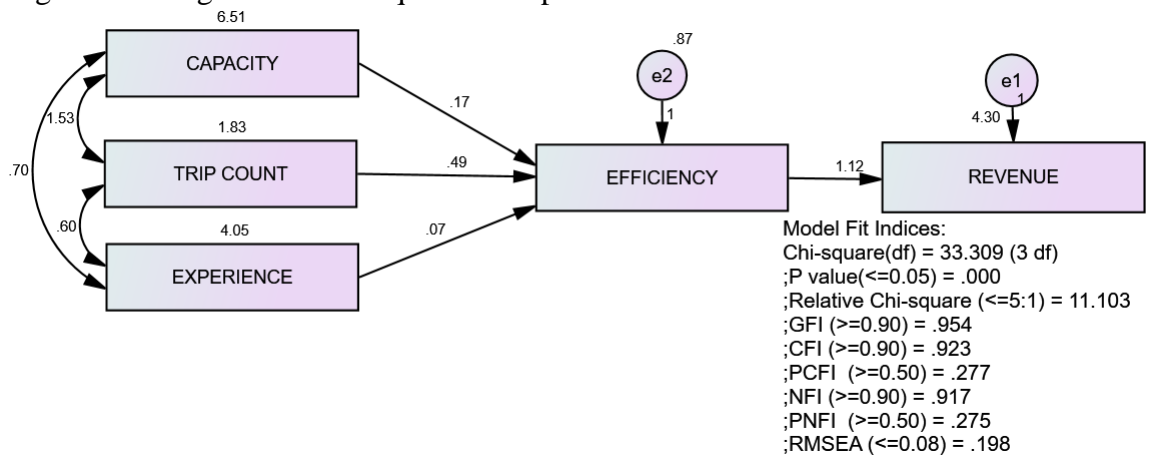
## **RESULTS AND DISCUSSIONS**

### ***Estimated Exogenous SEM Model***

The theoretical models in equations (3) and (4) were estimated as one SEM equation and in conformity with the attributes of the data, totally aggregated SEM was estimated, using AMOS 23 software. The estimated SEM models the relationships between trip frequency, firms' experience, as well as firms' capacity on the efficiency of franchised private waste collectors, and simultaneously, the effect of their efficiency on revenues. As evident in in Figures 2 and 3, both the standardized and unstandardized regressors were estimated, detailing the significance levels (see Table 1) and relative effect of each independent variable.



Figures 2: Exogenous SEM Equation Graphics with Standardized Estimates



Figures 3: SEM Equation Graphics with Unstandardized Estimates

Table 1: Estimated SEM Equation with Standardized and Unstandardized Estimates

		Coefficients					
		Unstandardized	Standardized	S.E.	C.R.	P	
Efficiency	<---	Trip count	0.487	0.49	0.049	9.995	0.0000
Efficiency	<---	Capacity	0.166	0.315	0.025	6.514	0.0000
Efficiency	<---	Experience	0.066	0.099	0.03	2.224	0.0260
Revenue	<---	Efficiency	1.125	0.589	0.096	11.735	0.0000
<i>Correlation/Covariance</i>							
Tripcount	<-->	Capacity	1.532	0.443	0.235	6.524	0.0000
Capacity	<-->	Experience	0.702	0.137	0.322	2.181	0.0290
Tripcount	<-->	Experience	0.6	0.22	0.173	3.461	0.0000
Revenue	<-->	Efficiency	-	0.589			
<i>Model Diagnostics</i>							
R-Squared							
(R <sup>2</sup> )		Efficiency	0.516				
		Revenue	0.347				

### ***Evaluation of the Estimated Exogenous SEM Model***

Prior to interpretation of estimated parameters, the evaluation of SEM models are assessed using Model Fit Indices (Hair et al., 201; Kline, 2015). In SEM, such fit indices specify a group of diagnostics where certain minimum thresholds must be reached before estimated coefficients are deemed reliable and unbiased. They are broadly categorized into three. Firstly, the Absolute Fit Indices which assess the extent to which the model fits the data (including, Chi-Square ( $\chi^2$ ) Test, Root Mean Square Error of Approximation (RMSEA), Standardized Root Mean Square Residual (SRMR), Goodness-of-Fit Index (GFI), R-Square for endogenous variables).

Secondly, the Incremental Fit Indices which examines the improvement in the fitness of an estimated model relative to a baseline (null) model. The indices under this category include, Comparative Fit Index (CFI), Tucker-Lewis Index (TLI), Normed Fit Index (NFI), Relative Fit Index (RFI), and Incremental Fit Index (IFI). Thirdly, the Parsimony-Adjusted Fit Indices. These measures discredit complex models while favoring simpler and easily interpretable models by adjusting the values of either absolute or incremental fit indices. They include, Parsimonious Normed Fit Index (PNFI), Chi-Square/Degrees of Freedom Ratio ( $\chi^2/df$ ), Parsimonious Comparative Fit Index (PCFI): Adjusts CFI for model complexity.

As a guiding rule, at least, one indicator is to be evaluated in each of the dimensions of model fit to ascertain the validity of estimates (Hu & Bentler, 1999; Schreiber et al., 2006; Hair et al., 2019). Based on the guiding rule, the assessment of the exogenous SEM results in Figures 2 and 3 as well as Table 1 is deemed unacceptable. This is because even though the Absolute Fit Indices (based on GFI) and the Incremental Fit Indices (based on CFI and NFI), are met, the Parsimony-Adjusted Fit Indices are not met since both the PNFI and PCFI are less than 0.5 threshold and the Relative Chi-Square value of 11.103 is higher than the required maximum range of  $\leq 5$ , indicating poor fit.

This noted, one of the major shortcomings of previous studies as indicated in the study background in modeling the combined equations (3) and (4) is the omitted variable bias the above model might have suffered by not relaxing the exogeneity assumption. This could be due to the confounding effect of variables that might relate the efficiency equation to the revenue equation as shown by the high correlation of 0.58 between the two dependent variables for both equations. This might have biased estimates (Kennedy, 2008; Hill et al., 2021), leading to poor model fit. Thus, the model is re-estimated by relaxing the exogeneity of the efficiency equation by correlating the error terms for both equations – an acknowledged strength of SEM (Hair et al., 2019). The new results are shown in Figures (4) and (5) and Table 2.

### ***Evaluation of the Estimated Endogenous SEM Model***

Based on the guiding rule presented in section 4.1.1, the assessment of the endogenous SEM results in Figures 4 and 5 as well as Table 2 is deemed acceptable. This is because the Absolute Fit Indices (based on GFI) and the Incremental Fit Indices (based on CFI and NFI), are met. In addition, the Parsimony-Adjusted Fit Index is also since the Relative Chi-Square value of 2.80 is lower than the required maximum range of  $\leq 5$ , indicating good fit.

### ***Estimated Endogenous SEM Model***

Figures (4) and (5) respectively show the standardized and unstandardized estimated results for the endogenous model. The results show that the three specified determinants of firms' efficiency, viz; firms' capacity, trip count/frequency, and firms' experience are empirically proven to influence its variation, albeit at varying intensities and significance. Starting with Trip Frequency,

the variable has an unstandardized coefficient of 0.484 and standardized coefficient of 0.488 and statistically significant at 1%. This shows that trip frequency strongly and positively influences waste collection firms' efficiency. This conforms to the theoretical notion that the more the resources of firms are optimally used, with less redundancy, the more the firms achieve operational efficiency, among others.

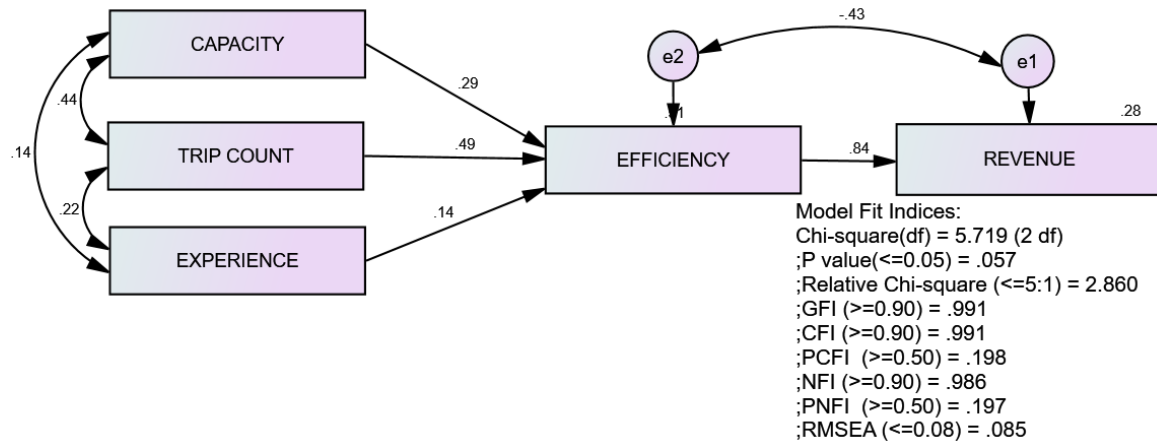


Figure 4: Endogenous SEM Equation Graphics with Standardized Estimates

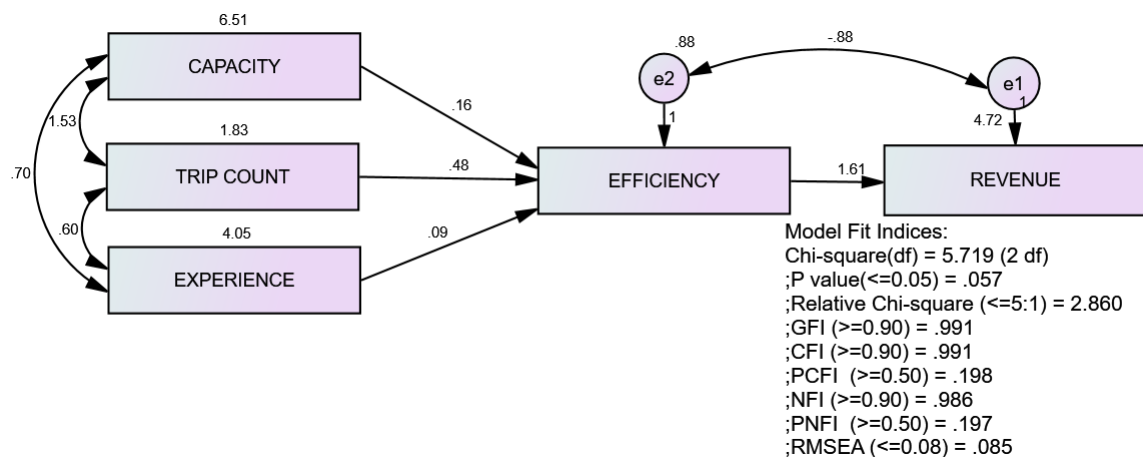


Figure 5: Endogenous SEM Equation Graphics with Unstandardized Estimates

Similarly, firms' Capacity, which describes all forms of resources at the disposal of firms for deployment in the provision of services, is found positive, although with moderate influence in relative terms in determining the efficiency of waste collection firms. The variable has an unstandardized coefficient of 0.155 and standardized coefficient of 0.295 and statistically significant at 1%. This conforms to the theoretical expectation of the dynamic capacities theory and the efficiency wage theory that, the more the resources firms have, the more they are flexible to adjust input combinations to achieve operational efficiency.

Firms experience is a proxy for workforce experience. Meanwhile, the efficiency wage theory, beyond payment of higher wages espouses positive relationship between workforce experience, including on-the-job training enhances efficiency (Yao et al., 2021; Basak & Panda, 2022). This notion conforms to the result obtained as experience was found to have although small but positive and statistically significant effect on efficiency. Particularly, firms experience has an

unstandardized coefficient of 0.094 and standardized coefficient of 0.141 and statistically significant at 5%.

Table 2: Estimated Endogenous SEM Equation with Standardized and Unstandardized Estimates

			Estimated Coefficients		S.E.	C.R.	P-value
			Unstandardized	Standardized			
Efficiency	<---	Tripcount	0.484	0.488	0.046	10.547	0.0000
Efficiency	<---	Capacity	0.155	0.295	0.024	6.558	0.0000
Efficiency	<---	Experience	0.094	0.141	0.027	3.48	0.0000
Revenue	<---	Efficiency	1.611	0.844	0.141	11.387	0.0000
<i>Correlation/Covariance</i>							
Tripcount	<-->	Capacity	1.532	0.443	0.235	6.524	0.0000
Capacity	<-->	Experience	0.702	0.137	0.322	2.181	0.0290
Tripcount	<-->	Experience	0.6	0.22	0.173	3.461	0.0000
E1	<-->	E2	-0.877	-0.431	0.188	-4.67	0.0000
<i>Model Diagnostics</i>							
R-Squared (R <sup>2</sup> )		Efficiency	0.514				
		Revenue	0.282				

Meanwhile, on the relationship between efficiency and firms' financial performance (revenue), the production theory espouses improved efficiency to be accompanied by increased revenue or profitability. The findings of this conforms to such theoretical expectation since efficiency was found to have the strongest positive effect on firms' revenue. Firms' efficiency has an unstandardized coefficient of 1.611 and standardized coefficient of 0.844 and statistically significant at 1%. Hence, improvements in firms' operational efficiency directly increase their revenue growth.

These results conform to findings from previous studies, where among others, firms' capacity, experience as well as frequency of service were found to determine the efficiency and eventually the financial performances of waste management services (Ahmed & Ali, 2004). The strong effect of efficiency on revenue aligns with previous studies, indicating that waste logistics firms' investments in operational improvements yield efficiency and ultimately, financial benefits. This empirical evidence further reinforces the critical role efficient operations play in driving revenue in the waste management industry.

Generally, the findings from the SEM model estimated reveals the unique roles of capacity, experience and trip frequency in determining private waste collectors' operational efficiency, which in turn positively determines their revenue. Most importantly, it becomes apparent that service frequency as well as efficient resource use are key movers of profitability in the waste management sector logistics operation, most especially in densely populated urban settlements with high waste generation such as Lagos (Dangi et al., 2011).

## CONCLUSION AND RECOMMENDATIONS

This study examines the determinants of operational efficiency and its effect on improving the financial performances of private waste collection firms in Lagos. Findings from the study reveals salient implications for waste management practices and collection, most especially for highly dense developing urban cities like Lagos. The study finds that the sustainability of revenue for private waste collectors is significantly influenced by their operational efficiency, more importantly through the optimization of firms' capacity of operation as well as increased trip frequency. These results suggest that waste collectors' investment in larger truck fleets, investment in manpower and the availability of collection routes to improve route optimization, are requisites to achieving long-term profitability by waste collectors. Although workers relative firms' capacity and trip frequency, experience was found to have weaker effect on efficiency, it nonetheless exert positive effect. This implies that firms' operational efficiency is enhance where waste collectors have more experienced workforce. This is logical since more experienced workers have better knowledge of clients and likely to have better decision-making competence in addressing waste collection challenges. Thus, the study's findings imply that bridging the experience gap via though workers exposure to training and skill development is important to improve efficiency.

Based on the enumerated findings and implications of the study, the research recommends policy makers and more precisely in the case of Lagos state, bodies such as LAWMA to support private waste collectors in the aforementioned concern areas to improve efficiency. By so doing, waste management practices by the firms will be made more sustainable to achieve attractive environmental and public health goals in the city.

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