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STATISTICAL REANALYSIS OF PUBLISHED EVIDENCE FROM DELTA STATE, NIGERIA ON OWNERSHIP, INCENTIVES, AND TRACTOR SERVICEABILITY

Onuorah, C. M.[1], Umobi, C. O.[1], Nwakaire, C. O.[1] and Alaribe, V. O.[2]

[1]*Department of Agricultural and Bioresources Engineering, Faculty of Engineering, Nnamdi Azikiwe University, Awka, Anambra State, Nigeria*

[2]*Department of Agricultural and Bioresources Engineering, Federal Polytechnic Oko, Anambra State, Nigeria*

**Corresponding Author's E-mail: mc.onuorah@unizik.edu.ng*

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ABSTRACT

This study assessed the association between tractor ownership type and serviceability in agricultural tractor fleets in Delta State, Nigeria. Published aggregate data comprising 89 tractors from 16 agricultural locations, including 60 state-owned and 29 privately owned tractors, were reanalysed using a 2 × 2 contingency table. A Pearson chi-square test of independence was used to determine whether ownership type was significantly associated with tractor serviceability, while the odds ratio with a 95% confidence interval and Cramér's V were used to quantify the magnitude and strength of the association. The analysis showed a statistically significant association between ownership type and tractor serviceability ($\chi^2 = 22.40$, df = 1, $p < 0.001$). Privately owned tractors were 10.33 times more likely to be serviceable than state-owned tractors (95% CI: 3.65–29.21), with a Cramér's V of 0.50, indicating a large effect. Private tractors also recorded higher mean annual working hours (572.6 h/year) than state-owned tractors (189.0 h/year), yet exhibited substantially higher serviceability. The findings indicate that ownership type is strongly associated with tractor serviceability in the assessed fleet and suggest that differences in maintenance incentives and institutional accountability may contribute to the observed disparity. The study concludes that improving accountability and maintenance management in state-operated tractor fleets may be important for enhancing tractor availability and serviceability.

Keywords: Tractor Serviceability; Chi-Square Test; Odds Ratio; Ownership Structure; Farm Machinery Management

1.0 INTRODUCTION

In Delta State, Nigeria, Nkakini and Etenero (2019) surveyed 89 tractors in 16 government and private farm locations. They found that only 40.45% of the fleet was serviceable, with a significant difference between state-owned tractors (23.33%) and privately owned tractors (75.86%). In this context, a tractor is classed as 'serviceable' when it is maintained, operational and fit for field use at the time of survey; a non-serviceable tractor is broken down, under repair, or otherwise unavailable for work, a distinction with direct implications for the timeliness of farm operations and for mechanization output. However, the original analysis was restricted to descriptive statistics, a Spearman rank correlation between serviceable tractors and work output, a t-test comparing mean annual working hours between the two ownership groups, and a regression coefficient connecting serviceable to total tractor counts per location (a relationship that is partially definitional, since the number serviceable cannot exceed the total number). Notably, the original

study never directly tested the statistical significance of the ownership-serviceability association, despite the fact that it was the single most striking pattern in their own reported data. This is a significant gap, and, as the review below shows, it is not an isolated one: Nigerian tractor mechanization research has repeatedly observed that public and private tractor provision differ in performance, without consistently subjecting that observation to formal statistical testing at the individual dataset level. If the relationship between ownership and serviceability is simply due to fleet-scale artefacts or sample noise, ownership-based policy interventions will be poorly targeted; if, on the other hand, the correlation is statistically significant, it supports a particular and actionable claim within Nigeria's mechanization policy debate, which has been ongoing for over four decades.

Nigerian tractor repair-and-maintenance (R&M) research has primarily followed a cost-regression approach, with accumulated R&M costs calculated as a function of working hours or tractor age. Abubakar *et al.* (2013) used such a model to group 75 MF375 tractors in Kano Metropolis into 25 age-based cohorts; Dankyarana and Umar (2020) compared five regression forms (linear, logarithmic, polynomial, power, exponential) for two tractor brands operated by the Tractor Owners and Hiring Facilities Association of Nigeria (TOHFAN) in Northern Nigeria; and Dauda *et al.* (2010) investigated tractor ownership and off-season utilization patterns in Ogun State. This tradition has produced consistent evidence that R&M costs escalate with cumulative use, but has rarely progressed beyond cost-curve fitting to test discrete categorical outcomes, such as serviceability status, against explanatory factors like ownership structure using formal inferential statistics. Nkakini and Etenero's (2019) Delta State study stands out in this literature because it reports serviceability as a binary/categorical outcome (serviceable vs. not) rather than a continuous cost curve, and it disaggregates by ownership type, but, as previously stated, it does not formally test that disaggregation. A recent study of Nigerian tractor-hiring service sustainability (Kefas *et al.*, 2024) similarly concludes that unplanned breakdowns and reactive maintenance practice persistently undermine tractor-hiring profitability nationally, while recent survey evidence from Anambra State (Nwanna *et al.*, 2026) links weak institutional and cultural support for preventive maintenance specifically to poor mechanization sustainability outcomes, a pattern consistent with, though not a formal test of, the ownership effect examined here. The dispute over whether publicly or privately operated tractor services perform better is not new in Nigerian agricultural engineering and economics research; it has been ongoing since at least the 1980s, when government tractor-

hire programmes were first adopted as a mechanization policy instrument. Akinola's (1987) early review of government tractor hire-service schemes across Africa, drawing heavily on Nigerian experience, identified defective management, cumbersome decision-making, and poor enforcement of maintenance policy as recurring weaknesses of publicly administered tractor-hire units, an institutional diagnosis that foreshadows, at a qualitative level, the statistical finding produced by this reanalysis four decades on. Subsequent empirical studies have established similar outcomes using different approaches and settings. Takeshima *et al.* (2015) used a nationally structured survey of Nigerian tractor owner-operators to characterize private-sector tractor service provision, and found that market-sourced (private) tractor owners operated more extensively across both peak and off-peak seasons than government-sourced provision. In a related synthesis, Takeshima and Lawal (2018) found, after studying the trajectory of agricultural mechanization in Nigeria, that when demand for tractor services is adequate, the private sector has emerged over time as a more efficient service provider than the government sector. Kabir's (2019) study of issues affecting tractor-hiring services in Nigeria identifies poor maintenance, insufficient record-keeping, and ineffective technical management as recurring public-sector obstacles. This reanalysis thus fits within an established line of Nigerian mechanization literature that has long noted a qualitative or quantitative performance disparity between the public and private sectors; its distinct contribution is to use a formal statistical test (chi-square, odds ratio) to directly quantify the strength and significance of this association in a single published dataset, rather than inferring it from descriptive patterns or utilization-rate comparisons alone.

The idea that ownership structure influences asset-maintenance incentives has a long theoretical basis in economics. Shleifer's (1998) influential analysis of state versus private ownership contends that private ownership typically gives stronger incentives for cost-cutting and quality-enhancing investment, including maintenance, because residual claimants directly capture the returns on such investment, whereas state-owned entities' managers face weaker, more diffuse accountability for asset condition. This theoretical prediction, however, has not held consistently across sectors and contexts. A 2023 analysis of hospital ownership in Sichuan Province, China, for example, found that private hospitals were associated with higher, not lower, in-hospital mortality for pneumonia (adjusted OR 1.67–1.69) despite comparable or higher costs (Xue *et al.*, 2023), showing that the direction of an ownership-performance effect depends on sector-specific incentive and regulatory structures rather than following a fixed rule. This balance of evidence

matters for interpreting the current reanalysis: the large, statistically significant private-ownership advantage found here for Delta State tractor serviceability should be read as a specific empirical finding for this sector and context, consistent with the Nigerian tractor literature's qualitative consensus (Akinola, 1987; Takeshima *et al.*, 2015; Takeshima and Lawal, 2018; Kabir, 2019), and not as evidence that private ownership universally outperforms public ownership in asset maintenance across all sectors.

At the time of this reanalysis, the public-private tractor performance issue remained very much alive in Nigerian policy circles. Nigerian mechanization stakeholders reported in 2025 that tractor-hiring rates more than doubled between 2023 and 2025, from approximately ₦80,000 to ₦205,000 per day, driven by rising maintenance and spare-parts costs (Daily Trust, 2026); the country's mechanization density nonetheless remains far below the FAO-recommended minimum (The Guardian, 2025). Separately, a Federal Government initiative to deploy 2,000 tractors and associated implements, procured through an international agreement, experienced significant delivery and deployment delays, with legislative oversight bodies formally investigating the non-delivery in December 2024 (Nigerian Eye Newspaper, 2024), and reports as of mid-2026 indicate that a substantial share of delivered government tractors remained idle at storage premises rather than in active service. These developments show that the ownership-serviceability issue raised here is not a historical curiosity but an active constraint on Nigerian agricultural mechanization policy today.

The goal of this study is to determine the effect of ownership type on tractor serviceability, using the published Delta State tractor data. Specifically, the study: (i) formally tests, using a chi-square test of independence, whether ownership type (private vs. state) is significantly associated with tractor serviceability status; (ii) quantifies the strength of this association using an odds ratio with a 95% confidence interval and Cramér's V effect size, where, as a general guide, a Cramér's V above 0.3 is conventionally regarded as a large effect for a 2×2 table; and (iii) interprets the finding alongside the utilization-intensity data reported in the original study (mean annual hours, coefficient of variation) to assess whether the ownership effect on serviceability is consistent with the Nigeria-specific and theoretical literature reviewed above.

2.0 MATERIALS AND METHODS

2.1 Source Data

The aggregate, location-level tractor counts surveyed by Nkakini and Etenero (2019) were used in this study. The survey covered the Delta North, Delta Central and Delta South senatorial districts of Delta State, Nigeria, with the 16 sampled locations spanning approximately. For each of the 16 studied farm locations, the number of tractors present and the number deemed serviceable were grouped by ownership type (private or state). Across the 16 locations there were 60 state-owned tractors (14 serviceable) and 29 privately owned tractors (22 serviceable), for a total of 89 tractors (36 serviceable) (Table 1). Only these location- and ownership-level aggregate counts, as published in the original study, were used; no individual tractor-level records were available or used. This reanalysis is accordingly limited to re-examining the ownership-serviceability association within this single published dataset, using statistical techniques (chi-square, odds ratio) that were not applied in the original study; it does not reconstruct individual tractor records, failure timestamps, or degradation curves, none of which are available from the published source.

2.2 Chi-Square Test of Independence

A 2 × 2 contingency table was constructed, cross-classifying ownership type (state, private) against serviceability status (serviceable, not serviceable), summed across all 16 locations (Table 1). Pearson's chi-square statistic was computed using eqn.1 as:

$$X^2 \frac{\Sigma(0-E)^2}{E} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \textit{eqn. 1}$$

Summed over all four cells, where O is the observed count and E is the count expected under the null hypothesis of independence between ownership and serviceability. The test was conducted without Yates' continuity correction, appropriate given the cell sizes involved, at the 5% significance level.

2.3 Odds Ratio and Effect Size

The odds ratio (OR) of serviceability for privately owned versus state-owned tractors was computed as:

$$OR = \frac{(a\ x\ d)}{(b\ x\ c)} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \textit{eqn. 2}$$

where a and b are the serviceable and non-serviceable counts for privately owned tractors, and c and d are the corresponding counts for state-owned tractors. A 95% confidence interval for the odds ratio was constructed using the standard log-odds approximation. Cramér's V was computed as $V = \sqrt{(\chi^2/n)}$, where n is the total sample size (89), to express the strength of the ownership-serviceability association independent of sample size.

3.0 RESULTS AND DISCUSSION

3.1 Ownership-Serviceability Contingency Table

Table 1: Ownership × serviceability contingency table, reconstructed from location-level counts in Nkakini and Etenero (2019). ***Source: Nkakini and Etenero (2019).***

Ownership	Serviceable	Not Serviceable	Total
State	14	46	60
Private	22	7	29
Total	36	53	89

3.2 Chi-Square Test of Independence

The null hypothesis that ownership and serviceability status are independent was decisively rejected by the chi-square test of independence, which yielded $\chi^2 = 22.40$ ($df = 1$, $p < 0.001$). The expected cell counts under independence (24.27 and 35.73 for state serviceable/not-serviceable; 11.73 and 17.27 for private serviceable/not-serviceable) differed substantially from the observed counts in each cell, indicating that neither chance nor the difference in fleet size between the two ownership groups could account for the ownership-serviceability disparity reported descriptively in the original study.

3.3 Odds Ratio and Effect Size

Privately owned tractors were 10.33 times more likely to be serviceable than state-owned tractors (95% CI: 3.65–29.21) Table. 2. This confidence interval lies entirely above 1, indicating a strong and significant effect. Cramér's V of 0.50 further supports a large effect size by standard benchmarks ($V > 0.3$ is conventionally regarded as large for a 2×2 table), suggesting that ownership type explains a substantial share of the variation in serviceability status across this fleet, rather than a statistically detectable but practically small effect.

Table 2: Summary of chi-square, odds-ratio, and effect-size statistics for the ownership-serviceability association.

Statistic	Value	Interpretation
χ^2 ($df = 1$)	22.40, $p < 0.001$	Significant association
Odds ratio (private vs. state)	10.33 (95% CI: 3.65–29.21)	Large effect
Cramér's V	0.50	Large effect size

3.4 Utilization Intensity as an Alternative Explanation

Privately owned tractors showed higher relative variability in annual operating hours (coefficient of variation 0.308 vs. 0.205) and were used significantly more intensively than state-owned tractors (mean 572.6 h/year vs. 189.0 h/year; Nkakini and Etenero, 2019). If heavier use alone caused mechanical wear that reduced serviceability, private tractors, being more extensively utilized, would be expected to show lower, not higher, serviceability than state tractors. The reanalysis shows the opposite: private tractors are both more heavily utilized and more available for work. This is consistent with an institutional or incentive-structure explanation, in which private owner-operators' direct financial stake in tractor uptime drives more responsive maintenance behaviour, regardless of, or perhaps because of, higher utilization, and it argues against a simple usage-wear explanation for the ownership effect. The statistically significant, large-effect association found here confirms that the descriptive gap reported by the original study, that private tractors were more often serviceable than state tractors, reflects a genuine ownership effect and not merely the smaller, more manageable scale of the private holdings (29 tractors across fewer locations); because both the chi-square and odds-ratio tests explicitly account for the differing fleet sizes of the two ownership groups, a pure scale artefact can be ruled out. The most operationally significant outcome of this reanalysis is the counterintuitive utilization finding: private tractors are simultaneously more heavily used and more available. This suggests that the mechanism linking ownership to serviceability in this fleet is unlikely to be passive (private tractors simply sitting idle and staying in better condition); it points instead to active, incentive-driven maintenance behaviour among private owner-operators who depend directly on their tractor's uptime for revenue.

This pattern is consistent with four decades of qualitative and semi-quantitative Nigerian evidence that private tractor provision outperforms public provision on efficiency and utilization grounds (Akinola, 1987; Takeshima *et al.*, 2015; Takeshima and Lawal, 2018; Kabir, 2019), and with the wider Nigerian mechanisation literature's repeated identification of weak institutional accountability and reactive maintenance culture as key drivers of poor fleet performance in state-administered programmes (Abubakar *et al.*, 2013; Dankyarana and Umar, 2020; Kefas *et al.*, 2024; Nwanna *et al.*, 2026). Akinola (1987) and Kabir (2019) in particular attribute weak public-sector maintenance performance to diffuse managerial accountability and cumbersome bureaucratic decision-making rather than to a lack of technical capacity, an institutional rather than resource-

based explanation that matches the pattern found here: the state fleet was both more lightly used and less serviceable, which is difficult to reconcile with a simple staffing or resourcing shortfall alone. This direction of effect is also consistent with the broader cross-sector evidence on ownership and asset performance (Shleifer, 1998; Xue *et al.*, 2023), which finds that ownership shapes maintenance incentives most strongly where the asset holder bears direct, immediate financial consequences for downtime, a condition private tractor owner-operators satisfy far more directly than Nigerian state administrative structures have historically done (Akinola, 1987; Kabir, 2019). For administrators of Nigerian State Agricultural Development Programmes (ADPs) and tractor-hiring schemes, this pattern implies that usage-intensity management alone, for example, imposing caps on the annual hours a tractor may be operated, in order to reduce wear, is unlikely to close the serviceability gap: the state fleet was already used far less intensively than the private fleet and still showed markedly worse serviceability. Institutional interventions that mimic the accountability and incentive structure of private ownership, such as assigning individual operator- or unit-level accountability for machine uptime, or performance-linked maintenance budgeting, are likely to be more effective.

4.0 CONCLUSION

Ownership type is a statistically and practically significant determinant of tractor serviceability in this Delta State dataset ($\chi^2 = 22.40$, df = 1, $p < 0.001$; OR = 10.33, 95% CI: 3.65–29.21; Cramér's V = 0.50), based on a reanalysis of Nkakini and Etenero's (2019) published data using a chi-square test of independence and an odds-ratio framework, methods not applied in the original study. The association cannot be explained by usage-intensity differences alone: private tractors were simultaneously more heavily utilized and more serviceable than state tractors, which points to institutional and incentive-structure differences between the two ownership types rather than differences in workload or wear. Nigerian ADPs and state tractor-hiring programs seeking to close this serviceability gap should prioritize accountability and incentive-structure reforms over utilization-rationing measures.

This reanalysis is deliberately narrow: it re-examines a single association within a single published dataset and does not reconstruct individual tractor records, failure timestamps, or continuous degradation curves, none of which are available from the published source. Future primary-data studies should test whether the ownership-serviceability association reported here replicates in

other Nigerian states and agro-ecological zones, and whether it persists after controlling for tractor make, age, and specific institutional arrangements, such as the presence of a dedicated maintenance officer, staffing levels, or management practices, which were not disaggregated in the original Delta State dataset. Such studies, ideally combining survey data with direct or anecdotal evidence on maintenance and management practice in state- and privately administered fleets, would help establish whether the institutional mechanism proposed here is the primary driver of the ownership effect, or whether it interacts with other factors such as technical staffing levels or operator training.

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