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Edited Book

McDowell, L. & Sharp, J. P. (Eds.) (1999). *A feminist glossary of human geography*. New York, NY: Oxford University Press.

Book Chapter

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Journal Articles

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Bayer, J. (2010). Customer segmentation in the telecommunications industry. *Journal of Database Marketing & Customer Strategy Management, 17*,247 – 256. doi: 10.1057/dbm.2010.21

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IMPACT OF TRACTOR SERVICE ADOPTION ON PROFIT MARGIN DIFFERENCE BETWEEN ADOPTER AND NON-ADOPTER IRRIGATED RICE FARMERS IN NORTH-WESTERN NIGERIA

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ABSTRACT

The North-western region of Nigeria is distinguished by a high density of small-scale farmers who predominantly depend on manual labour for agricultural activities. This study estimated impact of tractor service on profit margin of adopter and non-adopter irrigated rice farmers in the North-western Nigeria. The study employed cross-sectional survey design and utilized multi-stage sampling technique to collect data from 564 farmers cultivating rice under irrigation across Kaduna, Jigawa and Kano States. The Endogenous Switching Regression (ESR) model and Endogenous Treatment Effect model (ETM) were used as analytical tools to address the potential selectivity and treatment. The results of the ESR indicates that adoption of tractor services has probability of increasing the profit margins by approximately 2.232 for adopters, compared to only 0.610 for non-adopters. The profit margin difference between adopters and non-adopters of tractor services is about 1.622 (₦1.6 million). Based on these results, it is concluded that adoption of tractor service has a positive and significant correlation on the farmers' profit margin. The study recommends promoting tractor services adoption among the non-adopters by making tractors available for hire to farmers through government subsidies.

Keywords: Adopters and non-adopters; Irrigated rice farmers; Profit margin difference; Small-scale farmers; Nigeria

Introduction

Profit has been identified as an important indicator of successful business in the modern economy. It motivates businesses to innovate and improve their products, attracts additional investors, creates jobs, rewards risk-taking, promotes sustainability, enhances reputation, and ultimately drives economic growth. Agriculture, particularly rice farming, is not exempt from these benefits. As an essential crop in the modern economy, more than half of the world's population relies on rice as a main source of food energy. However, due to the natural scarcity of economic resources, the volume of rice supplyhas not been sufficient to meet the world's rising demand (GEMS4, 2019). Rice is a staple food crop in Nigeria, and small-scale rice farmers play an important role inensuring food security in the country (Adeola & Oluwafemi, 2024; Ezedimma, 2019). However, these farmers face many challenges, including limited access to mechanized

farming technologies, which hinders their productivity and profitability (Adhikari, Mishra, & Chintawar, 2019; Ahmad & Bakhsh, 2010). Tractor services have been identified as a key factor in improving agricultural productivity and efficiency. This study aims to investigate the impact of tractor service adoption on profit margin difference between adopt and non-adopter irrigated rice farmers in North Western Nigeria. The North-western region of Nigeria is distinguished by a high density of small-scale farmers who predominantly depend on manual labour for agricultural activities (GEMS2, 2019). The use of tractors and other mechanized farming equipment is limited in the region due to various constraints, including high costs, lack of access to credit facilities, and limited technical knowhow (Houssou & Chapoto, 2015). As a result, rice farmers in the region face significant challenges in land preparation, planting, and harvesting, which of course negatively impact their yield, income and profitability (Takahashi, Muraoka & Otsuka, 2019).

The introduction of tractor services in this region has the potential to transform the agricultural sector by increasing yields, reducing labour costs, boosting income and enhancing efficiency. Though empirical studies such as Obayelu, Adeoti and Dontsop (2017) and Owoeye (2017); have made significant efforts to investigate the adoption of improved agricultural technology on different socio-economic aspects, however, there is limited research on the impact of tractor service on farm profit among small scaleirrigated rice farmers in North Western Nigeria based on Endogenous Switching framework. This study aims to address this knowledge gap by examining the effects of tractor services on farm profit of adopters and non-adopters including their respective treatment effects due to selectivity bias.

By investigating the impact of tractor services on farm profit among small scale irrigated rice farmers in North Western Nigeria, this study contributes to the existing body of knowledge on agricultural mechanization and its potential to improve the livelihood of small-scale irrigated rice farmers. The findings of this study will provide valuable insights for policymakers, agricultural extension agents, and other stakeholders seeking topromote agricultural development and improve food security in Nigeria. The research is organized as follows: Section one introduces the study; section two presents the literature review; section three outlines the methodology; section four offers an analysis and discussion of the results; and section five concludes with the conclusions and policy recommendations.

Literature Review

Conceptual Clarification

Tractor service adoption is defined by Schultz (2024) as the use of mechanized tractor services by farmers to improve agricultural productivity and Efficiency. Rogers (2022) perceives tractor service as the process by which farmers adopt and utilize tractor technology to enhance the farming operations. It can also be defined as the diffusion of tractor technology among farmers, influenced by factors such as perceived benefits, compatibility and observability (Rogers, 2012). The major weakness of the aforementioned definitions is their inability to conceptualize the term is more specific manner that facilitates measurement. Here, tractor services adoption is operationalized as an effort to incur costs for hiring a tractor services. It is measured as a dummy variable, with a value of 1 if a farmer has incurred costs for hiring a tractor services, and 0 otherwise.

Profit margin difference refers to the variation in competitive advantage among firms, resulting in differing levels of profitability (Porter, 2018). To Rumelt (2014), profit margin difference represents the differing level of profitability among firms, arising from distinct resources, capabilities, and strategies. Hall (2008) defines profit margin difference as the disparities in costs and revenues among firms, driven by factors like efficiency, innovation, and pricing strategies. The major weakness of the aforementioned definitions is the vagueness of their conceptualizations, which makes them difficult to understand. In this study, profit margin difference is operationalized as a gap in net income between a farmer and others following the adoption of tractor services. It is measured in naira per hectare cultivated.

Theoretical Framework

Expected Utility theory is also known as Standard Rational Choice theory. Expected Utility Theory was initially introduced by Daniel Bernoulli in 1738 in his paper *Exposition of a New Theory on the Measurement of Risk*. His work introduced theconcept of utility to explain decision-making under risk. The formalization and development of the theory were further advanced by John von Neumann and Oskar Morgenstern in their 1944 book *Theory of Games and Economic Behavior*, which expanded upon Bernoulli's ideas and integrated them into game theory. The theoryhypothesized that under certain assumptions, an individual's preferences towards riskscan be represented as a linear function of the utility of each option multiplied by the probabilities associated with those options (Ogu, 2013). The selection of this theory asthe framework is grounded in the fact that farmer's decision-making processes regarding the adoption of agricultural technology reflect choices made under conditions of uncertainty or risk. This necessitates ranking their technological options according to their expected utility.

Review of Empirical Literature

In their effort to investigate the empirical linkage between tractor service adoption and profit margin of adopter and non-adopter irrigated rice farmers in North Western Nigeria, the study of Bidzakin et al. (2019) examined the impact of contract farming on rice farm performance using Endogenous Switching Regression and Propensity Score Matching. The study found that contract farming significantly increases yield and gross margins. The study of Bidzakin et al. (2019) is limited by being not based in Nigeria. In another efforts, Adhikari, Mishra and Chintawar (2019) examined the adoption of technology andits impact on profitability of young and beginning farmers using 2004-2006 Agricultural Resource Management Survey (ARMS) data and Quantile regression model. The study found that the adoption of improved crop (GM) among young beginning cotton farmers increased farm profitability but decreased farm profitability among corn farmers. The major weakness of this research was its use of faulty methodology that could not account for selectivity bias. Though it employed Endogenous Switching Regression (ESR), whichis the most suitable technique of data analysis, the study of Michler et al. (2018), investigated the role of yields and profits in agricultural technology adoption in Ethiopia using survey data. The study is also limited by being situated in some selected districts of Ethiopia.

Studies have consistently shown that the adoption of agricultural technology significantly improves profit margin of farmers. For instance, a study by Nguyen, Cheng and Findlay (2019) found that the adoption of precision agricultural technology increased profits margins by 20% of farmers in China. Similarly, Michler et al. (2018) found that the

adoption of drought-tolerant maize in Africa increased profit margins by 15% for adopting farmers. A study of Muhaimin et al. (2020) found that the adoption of mobile- based agricultural advisory services increased profit margins by 12% for farmers. Additionally, Mishra et al. (2016) found that the adoption of solar-powered irrigation systems in Africa increased profit margins by 10% for adopter farmers. In contrast, non-adopters of agricultural technologies often have lower profit margins. Forexample, a study by Nguyen, Cheng and Findlay (2019) found that non-adopters of precision agricultural technology in the China had an average profit of 5%, compared to 15% for adopters. Similarly, Michler et al. (2018) found that non-adopters of drought- tolerant maize in Africa had an average profit margins of 3% compared to 12% for adopters. These findings suggest that the adoption of agricultural technologies can significantly improve profit margins for adopting farmers, while non-adoption can result in lower profit margins.

From the foregoing, although existing literature has made significant efforts to establish a link between improved technology adoption and farming performance among different farmers in Nigeria and beyond, using various techniques such as Propensity Score Matching (PSM), Tobit model, Ordinary Least Squares (OLS), Quantile Regression, and Conditional Random Effect (CRE), only studies conducted outside Nigeria address selectivity issue by applying Endogenous Switching Regression (ESR) as an analytical tool. Additionally, this study used costs of tractor services as a measure of tractor services adoption, assigning a value of 1 if a farmer has incurred the costs and 0 if otherwise which makes the current study unique. Therefore, this study applied ESR model to estimate impact of tractor service adoption on the profit margin difference betweenadopter and non-adopter irrigated rice farmers in North Western Nigeria. Additionally, access to technological information is adopted as the instrumental variable, based on the works of Chen et al. (2022), Zegeye et al. (2022) and Wu (2022).

Methodology

Description of the Study Area

North Western Nigeria is among the six geopolitical areas of the nation that make up the country (Accret, 2023). The North West is the largest zone in country, making about 59% of the entire landmass of Nigeria (Almu, Adesina & Kanmodi, 2019). It is located on Latitude $8^0$14’60” N to $14^0$30’0’’N and Longitude $3^0$30’0’’E to $10^0$24’0’’E (Isaac, 2021; Bosola, 2020). The zone lies in the Sub-Saharan Sudan belt of the West Africa in zone of Savannah-type vegetation. Rainfall averaging about 30 inches annually occurs chiefly in a wet season which lasts from May to October, with a prolonged dry season extending from October to April usually dominated by dusty harmattan winds from the Northeast (USGS, 1973). Moreover, rice production in North Western part is dominated by rainfed farming (GEMS4, 2019).

Sources of Data

This study is a cross-sectional survey that focuses on the responses of irrigated rice farmers in North-western Nigeria. The population of the study comprises all registered irrigated rice farmers from Kaduna, Jigawa and Kano States. The sample size for this study is determined based on Yamane (1967). Thus;

Hence, $$n = \frac{N}{1+N(e)^2} = \frac{542{,}206}{1+542{,}206(0.05)^2} = 400$$ 3.1

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Additionally, non-response error or bias is addressed using the formula proposed by Fox, Hunn and Mathers (2009), who recommended dividing the initial sample size by the response rate to obtain representative sample.

$\therefore n_2 = \frac{400}{0.7} = 571$ irrigated rice farmers.

Regarding the sampling technique, multi-stage sampling was used to select the irrigated rice farmers across the study areas. In the first stage, the seven rice producing states were stratified into high, medium and low size of land mass from which Kaduna (high); Jigawa (medium) and Kano (low) were selected. In the second stage, to provide equal opportunity to larger and smaller rice-producing local governments, the local governments were stratified based on the number of irrigated rice farmers-classified as high, medium and low. Therefore, Makarfi, Ringim and Kura (high); Soba, Hadejia and Doguwa (medium) and Kudan, Gwiwa and Bunkure (low) were chosen from Kaduna, Jigawa and Kano States respectively. In the third stage, villages or clusters within each selected local government area were enumerated systematically, starting with a common random start of 1 across the local governments. Skip intervals of 3, 5 and 3 were then applied for Kaduna, Jigawa and Kano respectively. Therefore, Makarfi, Soba and Hunkuyi were selected from Makarfi, Soba and Kudan Local Governments of Kaduna State; Gujaba, S/Garu and Wailare were selected from Ringim, Hadejia and Gwiwa LocalGovernments of Jigawa State; and Kura and Bagau, Doka Sati and Zangon Buhari were selected from Kura, Doguwa and Bunkure Local Governments of Kano State. Finally, in the fourth stage, a sampling of 571 individual irrigated rice farmers was selected from the list of enumerated villages based on the availability of farmers in each village as described by Obayelu et al. (2017). The distribution of the sample farmers shown in Table
3.1 below:

Table 1. Distribution of the Research Sample: Irrigated Rice Farmers

S/N	Name of Strata	Local Government	Selected Villages (Clusters) Tech. Adopters	Tech. Non-Adopters	Number of Respondents
1	Kaduna	Makarfi L.G.A.	Makarfi (49)	Makarfi (30)	79
		Soba L.G.A.	Soba (35)	Soba (20)	55
		Kudan L.G.A.	Hunkuyi (55)	Hunkuyi (35)	90
	Sub-total				**224**
2	Jigawa	Ringim L.G.A.	Gujaba (24)	Gujaba (24)	48
		Hadejia L.G.A.	Sabon Garu (29)	Sabon Garu (28)	57
		Gwiwa L.G.A.	Wailare (10)	Wailare (7)	17
	Sub-total				**122**
3	Kano	Kura L.G.A.	Kura (63)	Kura (42)	105
			Bagau 10)	Bagau (4)	14
		Doguwa L.G.A.	Doka Sati (37)	Doka Sati (18)	55
		Bunkure L.G.A.	Z/Buhari (35)	Z/Buhari (16)	51
	Sub-total				**225**
4	**Grand Total**				**571**

Source: Author's Computation, (2024).
Note: Figure in parenthesis represents the number of sampled irrigated rice farmers.

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Data Estimation Strategy

Endogenous Switching Regression (ESR) Model

Irrigated rice farmers' decision to adopt tractor service may be self-selected which may result into a potential self-selectivity bias (Zegeye et al., 2022; Chen et al., 2022). In order to address this bias, the Endogenous Switching Regression, consisting of treatment equation and two outcome equations are widely used in economic literature (Chen et al., 2022) and this study will adapt Chen et al. (2022) with possible modifications.

3.1 Model Specification

In this study, expected utility framework is adopted to analyse the irrigated farmer's decision to adopt tractor service based on the work of Chen et al. (2022) with little modifications. Here, D_i^* indicates the difference in the utility between adoption of tractor service and non-adoption. An irrigated rice farmer would adopt the tractor service if $D_i^* > 0$, and not adopt the tractor service when $D_i^* \leq 0$. Hence, the irrigated rice farmers' decision to adopt tractor service (measured in the cost of tractor service, 1 if a factor incurred costs but 0 otherwise) is modeled as:

$$D_i^* = X_i\beta + \varepsilon_i, D_i = \begin{cases} 1 \; if \; D_i^* > 0 \\ 0 \; if \; D_i^* \leq 0 \end{cases} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (3.2)$$

Where D_i is a dummy variable that is equal to 1 if an irrigated rice farmer adopts tractor service and zero otherwise; X_i are factors influencing the farmers' decision to adopts improved agricultural technology (age, household's size, year of formal education, accessto credit, farm size, farming experience, frequency of extension of contact, year ofcooperative membership); βs are coefficients to be estimated; and is a random error term with a zero mean. The ESR will help to compare the expected profit margin of the irrigated rice farmers that adopted tractor and those who did not adopt.

Empirically;

$$D_i^* = AGE_i\beta_1 + HSZ_i\beta_2 + YEDU_i\beta_3 + AOL_i\beta_4 + FSZ_i\beta_5 + FEX_i\beta_6 + FEC_i\beta_7 + COM_i\beta_8 + \varepsilon_i \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (3.3)$$

Given that irrigated rice farmers choose to either adopt or not to adopt tractor service, the observed benefits take the following values:

$$Regime\ 0\ (NYtservice): Y_{iNtservice} = X_i\beta_{Ntservice} + U_{iNtservice} \; if \; D_j = 0 \dots\dots\dots\dots (3.4)$$

$$Regime\ 1\ (Ytservice): Y_{itservice} = X_i\beta_{tservice} + U_{itservice} \; if \; D_j = 1 \dots\dots\dots\dots\dots\dots (3.5)$$

Where $Y_{jtservice}$ and $Y_{jNtservice}$ are the outcome variables (profit margin) of irrigated rice farmers for adoption and non-adoption of tractor service respectively, X_i is a vector of explanatory variables (age, household size, level of education, farm size, access to credit, cooperative membership, and extension contact). The vector β in equation 3.4 and 3.5 and in equation are the associated parameters that have to be estimated.

The expected profit margin of an adopter irrigated rice farmer who actually adopted tractor services (Actual):

$$E(Y_{jtservice}|D = 1) = X_i\beta_{jtservices} + \sigma_{tservices}\varepsilon\lambda_{tservice} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (3.6)$$

The expected profit margin of an irrigated rice farmer who did not adopt tractor services

(Actual):

$$E(Y_{jNtservice}|D=0) = X_i\beta_{jNtservice} + \sigma_{Ntservice}\varepsilon\lambda_{Ntservice} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (3.7)$$

The expected profit margin of an irrigated rice farmer who decided not to adopt tractor services (Counterfactual):

$$E(Y_{jNtservice}|D=1) = X_i\beta_{jtservice} + \sigma_{Ntservice}\varepsilon\lambda_{tservice} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (3.8)$$

The expected profit margin of an irrigated rice farmer who decided to adopt tractor services (Counterfactual):

$$E(Y_{jtservice}|D=0) = X_i\beta_{jNtservice} + \sigma_{tservice}\varepsilon\lambda_{Ntservice} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (3.9)$$

Cases 3.6 and 3.7 represent the actual expectations observed in the sample. Cases 3.8 and 3.9 represent the counterfactual expected outcomes. In addition, following Heckman and Vytlacil (2001), ESR can calculate the effect of the treatment on the treated (ATT) as the difference between equation 3.6 and 3.8; Thus:

$$ATT = E\{Y_{itservice}|D=1\} - E\{Y_{iNtservice}|D=1\}$$
$$= X(\beta_{itservice} - \beta_{itservice}) + (\sigma_{tservice}\varepsilon - \sigma_{Ntservice}\varepsilon)\lambda_{tservice} \dots\dots\dots (25)$$

Similarly, the model can calculate the impact of the treatment on the untreated for the irrigated rice farmers that actually did not adopt tractor service (ATU) as the difference between equation 3.7 and 3.9; Thus:

$$ATU = E\{Y_{itservice}|D=0\} - E\{Y_{iNtservice}|D=0\}$$
$$= X(\beta_{itservice} - \beta_{iNtservice}) + (\sigma_{tservice}\varepsilon - \sigma_{Ntservice}\varepsilon)\lambda_{Ntservice} \dots\dots (26)$$

Measurement of the Variables

Table 2 Variables of the Model and Their Hypothesized Relationships

Variable Label	Description	Unit of Measurement	Expected Signs (ESR)
1.	Characteristics of Irrigated Rice Farmers		Gross Margin
AGE	Age of the farmer	Years	+
HSZ	Numbers of family	Number	-
EDU	Education level	Years	+
AOL	Access to credit access=1, 0=No access)	Dummy	+
2.	Inputs		
FSZ	Size of farmland	Hectare (ha)	+
HYVs	Quantity of rice seeds	Kilogram (kg)	+
TSER	Service of tractor used	Hour (hr)	+
FERT	Quantity of fertilizers	Kilogram (kg)	+
PEST	Quantity of pesticides	Liter (L)	+
HERB	Quantity of herbicides	Liter (L)	+

HLAB	Quantity of labour	Number	+
3.	Input Prices		
CHYVs	Price of rice seeds	Naira (₦)	-
CTSER	Price of tractor service	Naira (₦)	-
CFERT	Price of fertilizers	Naira (₦)	-
CPEST	Price of pesticides	Naira (₦)	-
CHERB	Price of herbicides	Naira (₦)	-
CHLAB	Labour wages	Naira (₦)	-
4.	Output		
GMargin	Profit Margin/kg	Naira (₦)	

Source: Author's Computation (2024)

Note: The signs; $^{+}$, and $^{-}$ represent positive and negative nature of the preliminary expectations respectively.

Results and Discussion

This section presents the analysis of the study's results, which aimed to investigate the impact of tractor service adoption on the profit margin difference between adopter and non-adopter irrigated rice farmers in North Western Nigeria. The results are presented in two major parts: Descriptive statistics (for the socio-economic characteristics of thesampled irrigated rice farmers) and inferential statistics (for Endogenous Switching Regression and Treatment Effects Results).

Socio-Economic Characteristics of the Sampled Irrigated Rice Farmers

The descriptive statistics presented in Table 3, which shows the mean and standard deviation of profit margin for both adopters and non-adopters.

Table 3. Socio-Economic Characteristics of the Irrigated Rice Farmers

Variables	Non-adoption of Tractor Service	Adoption of Tractor Service	Whole Sample
	Mean	Mean	Mean
AGE	29.39 (6.21)***	43.02 (14.28) ***	37.94 (11.84) ***
HSZ	10.76 (1.06) ***	12.06 (0.64) ***	7.97 (1.52) ***
YED	1.88 (1.10) ***	3.33 (0.63) ***	2.90 (1.06) ***
AOL	0.38 (0.49) ***	0.34 (0.48) ***	0. 37 (0.48) ***

FSZ	2.06 (0.63) ***	1.95 (0.78) ***	1.95 (0.71) ***
FXC	2.30 (1.00) ***	2.97 (0.74) ***	2.44 (0.90) ***
GEN	0.77 (0.43) ***	0.93 (0.25)**	0.86 (0.35)*
DIS	3.43 (0.41) ***	7.70 (1.39) ***	5.60 (1.29) ***
Sample Farmers	n=188	n=376	n=564

Source: Author's Estimation Using Stata 14.

Note: The t-test Mean Comparison is used to compare the mean of explanatory variables between non-adopters and adopters of the tractor service; and the signs *, **and *** represents level of significance @ 10%, 5% and 1% respectively.

The results as reported in Table 2 show that average comparison indicates some levels of heterogeneity between adopters and non-adopters as well as the whole sample. Themean age for the whole sample is statistically and significantly about 38 years. The mean age of non-adopters of tractor service is statistically and significantly about 29 years; that of adopters of tractor service is statistically and significantly about 43 years with a difference of 14 years. This suggests that older farmers are more likely to adopt tractor service in their irrigated farming. The mean household size for the whole sample is statistically and significantly about 8 persons. The mean household size of non-adopters of tractor service is statistically and significantly about 11 persons; that of adopters of tractor service is statistically and significantly about 12 persons with a difference of 1 person. This suggests that adopters of tractor service possess larger family size than non- adopters of the tractor service. The mean year of formal education for the whole sample is statistically and significantly about 3 years. The mean year of formal education of non- adopters of tractor service is statistically and significantly about 2 years; that of adopters of tractor service is statistically and significantly about 3 years with a difference of 1 year.This suggests that adopters of tractor service possess significant higher formal education than non-adopters. The mean access to credit for the whole sample is statistically and significantly about 0.37, meaning that only the minority (37%) have access to credit. The access to credit for non-adopters of tractor services is statistically significant at approximately 0.38, meaning that only a minority (38%) have access to credit. Foradopters of tractor services, access is statistically significant at approximately 0.34, indicating that only a minority (34%) have access to credit. The mean difference in access to credit shows that adopters of tractor services have significantly lower access compared to non-adopters, with a difference of 1%.

Also, the mean farm size for the whole sample is statistically and significantly about 2 hectares. The farm size of non-adopters of tractor service is statistically and significantly about 2 hectares; that of adopters of tractor service is statistically and significantly about 2 hectares too. This suggests that both adopters and non-adopters have significantly the same farm sizes. The mean frequency of extension contacts for the whole sample is statistically and significantly about 2 days per farming session. The mean frequency of extension contacts of non-adopters of tractor service is statistically and significantly about 3 days per farming session; that of adopters of tractor service is statistically and

significantly about 2 days per farming session, with a difference of 1 day. This suggests that adopters of tractor service have a significant 1 day less extension contacts than non-adopters. The mean gender for the whole sample is statistically and significantly about 0.86, meaning that the majority (86%) are male. The mean gender of non-adopters of tractor service is statistically and significantly about 0.77, meaning that a majority (77%) of the non-adopters are male; that of adopters of tractor service is statistically andsignificantly about 0.93, meaning that the majority (93%) of the adopters are also male, with a difference of 16%. This suggests that adopters of tractor service possess significant higher male farmers than non-adopters. The mean distance to market for the whole sample is statistically and significantly about 6 kilometers. The mean distance to market of non-adopters of tractor service is statistically and significantly about 3 kilometers; that of adopters of tractor service is statistically and significantly about 8 kilometers, with a difference of 5 kilometers. This suggests that adopters of tractor services have a significant 5-kilometer greater distance compared to non-adopters.

3.1 Impact of Tractor Service on Profit Margins of Irrigated Rice Farmers

Table 4: Endogenous Switching Regression Results for Adoption of Tractor Service and Its Impact on Profit Margins of Irrigated Rice Farmers

PROFIT MARGINS				Treatment Effects	
Variable	**Determinants of Adoption of Tractor Service**	**Farmers Adopting Tractor Service**	**Farmers Not Adopting Tractor Service**	**ATT**	**ATU**
AGE	0.032(0.016)**	0.044(0.070)	0.267(0.076)***	2.232 (1.027)**	0.610 (0.138)***
HSZ	-0.013(0.026)	-0.873(0.106)***	-0.118(0.151)		
YED	0.057(0.153)	0.163(0.507)	0.930(0.952)		
AOL	0.077(0.323)	1.669(1.371)	9.448(0.1.504)***		
FSZ	0.078(0.172)	0.986(0.635)	0.853(0.890)		
YFEX	0.017(0.014)	0.153(0.051)***	-0.126(0.090)		
YCOM	0.070(0.070)	0.346(0.338)	2.383(0.376)***		
FEXC	0.121(0.148)	0.201(0.552)	1.989(0.760)***		
Instr.	2.194(0.226)***				
Con.	-0.176(0.708)	-4.836(2.791)*	-8.037(3.737)**		
/Ins0			1.962(0.058)***		
/Ins1		1.262(0.080)***			
/r0			0.065(0.227)		
/r1		-0.358(0.253)			
Sigma_0			7.112(0.414)		

Sigma_1		3.534(0.284)			
rho_0			0.065(0.226)		
rho_1		-0.345(0.223)			
Log Likelihood	-823.91345				
Indep. Eqs. (χ^2)	341.89***				

Source: Author's Estimation Using Stata 14

Note: Robust standard error are in parenthesis; [1],[2], and [3] represent level of significance at 10%, 5% and 1%.

The estimates of Endogenous Switching Regression (ESR) model provides evidence that adoption of tractor service benefits irrigated rice farmers by increasing their profit margin in rice production. Table 4 reports the estimates of the profit margins difference between irrigated rice farmer adopters and non-adopters of tractor service in the North Western Nigeria. The results show that the Wald test statistics is highly significant (341.89), indicating the goodness of fit of the Endogenous Switching Regression (ESR) model and the presence of endogeneity which justifies the use of the ESR model. From the likelihood ratio test results of independence of the selection and the two outcome equations, the results also justify the rejection of the null hypothesis of no correlation between the adoption of tractor service and irrigated rice farmers' profit margins, meaning that adoption of tractor service is positively correlated with the profit margins ofirrigated rice farmers. The validity of the instrument used (access to technological information) was verified using the Hausman falsification test and the result also indicated a significant and positive correlation with adoption of tractor service and therefore, ESR is effectively identified. The negative correlation of rho_0/rho_1 indicatesthe negative selection deviation, meaning that irrigated rice farmers with low technical efficiency are more likely to adopt the tractor service. From the ESR first stage result, it can be seen that age of irrigated rice farmers and the instrument variable (access to technological information) are significant determinants of the irrigated rice farmers'profit margins.

The results of the ESR second stage show significant difference in coefficient estimates between adopters and non-adopters of tractor service. It reveals that the age of an irrigated rice farmer is likely to increase the profit margins of non-adopters of tractor services by about 0.267 percentage points, which is significantly higher than the increase observed for adopters (0.044 percentage points). The variable is fount significant at 1% level. All things being equal, with 1-year increase in the age of an irrigated rice farmer that did not adopt the tractor service; profit margins are likely to increase by about 26.7 percentage points. This is because older farmers are more experienced than their counterparts, and are more likely to adopt new farming methods to achieve higher yields, generate more income, and ultimately obtain larger profit margins. This result contradictsthe findings of Bidzakin et al. (2019). Household size is likely to decrease the profit margins of irrigated rice farmers who adopted tractor services by about 0.873 percentage points, which is higher than the increase observed for non-adopters (0.118 percentage points). The variable is fount significant at 1% level. All things being equal, with an additional family member, an irrigated rice farmer's profit margins are likely to decrease

by about 87.3 percentage points. This is because a larger family size means greater food consumption, leaving less for sale and reducing potential income. This result supports the findings of Bidzakin et al. (2019).

The number of year of formal education for an irrigated rice farmer fails to increase the profit margins of those who adopted tractor services because majority of the sampled irrigated rice farmers have not acquired many years of formal education. According to GEMS4 (2019), irrigated farmers in the North are considered the most efficient farmers in Nigeria who devote most of their lives in the farm without sufficient time to attend school or other supplementary trades. Access to credit of an irrigated rice farmer is likely to increase the profit margins of non-adopter of tractor service by about 9.448 percentage points far greater than the adopters (1.669). The variable is fount significant at 1% level. All things being equal, with 1 more access to credit of an irrigated rice farmer that did not adopt the tractor service; profit margins are likely to increase by about 944.8 percentage points. This is because non-adopters of tractor service among the sampled irrigated rice farmer show a higher tendency of accessing the credit facilities than their adopter counterparts. Farm size of an irrigated rice farmer fails to increase the profit margins of the farmers that adopted tractor service, because majority of the sampled irrigated rice farmers do not have larger hectares of irrigated farm land, which resulted to their credit and financing constraints. According to Muyanga (2015), irrigated farmers in Africa are suffering from small farm sizes, which prevent them from fully accessing credit and subsequently lead to financing difficulties.

Farm size of an irrigated rice farmer fails to increase the profit margins of the farmers that adopted tractor service, because majority of the sampled irrigated rice farmers do not acquire larger hectares of irrigated farm land which resulted to their credit and financing constraints. Farming experience of an irrigated rice farmer is likely to increase the profit margins of the adopters of tractor service by about 0.153 percentage points higher than the non-adopters (0.126). The variable is fount significant at 1% level. All things being equal, with 1-year increase in the farming experience of an irrigated rice farmer that did adopt the tractor service; profit margins are likely to increase by about 15.3 percentage points. This is because irrigated rice farmers with higher experience are more likely to adopt new farming ways to produce higher yields, making more income and ending up with large profit. This result supports the findings of Bidzakin et al. (2019). The number of year of cooperative membership for an irrigated rice farmer is likely to increase the profit margins of the non-adopter of tractor services by about 2.383 percentage points, which is significantly higher than the increase observed for adopters (0.346 percentage points). The variable is fount significant at 1% level. All things being equal, with 1 additional year of cooperative membership by an irrigated rice farmer that did not adopt the tractor service; profit margins are likely to increase by about 238.3 percentage points. This is because non-adopters of tractor services, like their adopter counterparts, benefit from information, training, input supply, market access, risk sharing, social learning and collective action and collaboration as members. This can help them adopt other alternative technologies.

Lastly, frequency of extension contacts by irrigated rice farmer is likely to increase the profit margins of the non-adopter of tractor service by about 1.989 percentage points far higher than the adopters (0.201). The variable is fount significant at 1% level. All things being equal, with 1 additional day of extension contacts by an irrigated rice farmer that did not adopt the tractor service; profit margins are likely to increase by about 198.9 percentage points. This is because non-adopters of tractor service, like their adopter

counterparts, do benefit from knowledge, skills and support needed to adopt other alternative technology from having contacts with their extension agents.

The ESR estimates of Average Treatment of the Treated (ATT) and Average Treatment of Untreated (ATU) account for the selection bias that arises from the fact that adoption and non-adoption of the tractor service may be systematically different. The results indicate that adoption of tractor service significantly increases the profit margins of the adopters with potential of increasing that of the non-adopters if they adopt. Specifically, the causal effect (profit margins-increasing effect) of adopting tractor service for the adopters is about 2.232 representing 20.71% increase in the gross income of the adopters with adoption of the tractor service. Also, the causal effect (profit margins-increasing effect) of adopting the tractor service for non-adopters is about 0.610 representing 10.40% increase in their profit margins if they adopt the tractor service. Therefore, adoption of tractor service has a positive and significant impact on profit margins of adopter irrigated rice farmers and irrigated rice farmers that did not adopt the tractor service will equally experience a less significant increase in their profit margins if they adopt the tractor service. This result is in line to the findings of Zegeye et al. (2022); Adhikari et al. (2019).

Impact of Tractor Service on Profit Margins Difference of Irrigated Rice Farmers

Table 5. Profit Margins Difference between Adopters and Non-adopters of Tractor Service

Farm Outcomes	Adoption Status	Predictions		Treatment Effect	Profit Margin Difference
		Adopters	Non-adopters		
Profit Margin/ha	ATT (Adopters)	13.005	10.774	2.232(1.027)**	1.622
	ATU (Non-adopters)	06.484	05.873	0.610(0.138)***	
	Heterogeneity Effect	06.521	04.901		

Source: Researcher's Estimation Using Stata 14.

Note: Robust standard error are in parenthesis; *,**, and *** represent level of significance at 10%, 5% and 1%.

From Table 5, the profit margins difference between adopters and non-adopters of tractor service among the irrigated rice farmers is determined using the prediction different effect of the predictive values of the adopters and non-adopters of tractor service (Heterogeneity Effect) which is statistically significantly at about 1.622. Therefore, irrigated rice farmers that adopted tractor service have a profit margins or difference of ₦1.6 (₦1622000) above their non-adopter counterparts. This finding is similar with the results of Owoeye (2017), who found positive and significant profit difference between maize farming adopters and non-adopter counterparts.

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Conclusion and Recommendations

Profit is measures success or otherwise of businesses in the modern economy of which rice farming is not exempted. The use of profit margin is intended to measuring the farming performance in its most accurate form. This study estimated the impact of tractorservice on profit margin difference between adopter and non-adopter irrigated rice farmers. The data used in this study were collected using structured questionnaire administered among 571 irrigated rice farmers across Kaduna, Jigawa and Kano States, out of which 564 were successfully retrieved with 98% return rate which is enough to carry out the main estimation and analysis. Endogenous Switching Regression model wasused as a main analytical tool and access to the technological information was adopted from the work of Bidzakin et al. (2019); Chen et al. (2022); Wu (2022); Zegeye et al. (2022); and used as the instrumental variables. From the results of the Endogenous Switching Regression model, it was revealed that adoption of tractor service has positive impact on profit margin of adopter irrigated rice farmers, pointing strong and positive correlation with irrigated rice farmers' profit but the effect on non-adopters due to the existence of self-selectivity is statistically lower. The profit-increasing effect of adopting tractor service for the adopters is higher (2.232). Also, the profit margin difference between adopters and non-adopters of tractor service based on the outcome of treatment effects is about 1.622, implying about ₦1.6 million differences in profit of adopters and non-adopters. Therefore, the empirical results of this study support the view that adoptionof improved agricultural technology will help to improve farm performance of irrigated rice farmers.

Given the statistical significance of the coefficient of tractor service profit-increasing effect in Table 4, and the statistical significance and positive of the profit margin difference in 5, there is a need for redirecting policy aimed at promoting the adoption of tractor service among the irrigated rice farmers by making the service available duringthe optimal harvesting period. Additionally, there is a need to encourage the adoption of tractor services among non-adopter irrigated rice farmers through effective enlightenmentand extension services, and to ease the hiring process so that they can benefit from the potential positive effect of adoption. Additionally, future studies should use larger samplesizes and classify the non-adopters into different categories, and examine the differences in non-adoption across these categories.

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