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Effect of rural transportation system on agricultural productivity in Oyo State, Nigeria

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Abstract

Food farming in Oyo North, Nigeria is characterised by an increasing use of Intermediary Mode of Transportation (IMT) to ease inputs and outputs mobility and farm access. To assess the influence on food farmer's productivity, a random sample of 230 respondents was selected and data collected on their socio-economic and farm specific characteristics. Descriptive statistics, Herfindhal Index and Technical Efficiency Approach were used to analyse the data. The results indicate that majority of food farmers were in their middle age with mean age of 50 years and most of them used one plot at a location between 5 and 10 km to their village of residence. They acquired land by inheritance and practiced intensive crop diversification as risk management strategy. The transportation modes used in addition to walking include bicycle, motorcycle, and car with increasing trend in the use of motorcycle. The mean Technical Efficiency (TE) of food farmers was 0.82 with significant inefficiency effects. The inefficiency analysis indicates positive effect of distance, crop diversification and un-tarred type of road on farmer's productivity, while poor level of education among farmers, use of bicycle; trekking and weekly working time negatively affect farmer's efficiency. The negative effect of trekking and use of bicycle and the excess working time suggest the adoption of more IMT of motorized type to optimize farming time and increase farmer's productivity.

Keywords: Food farming, IMT, Farm access road, Technical Efficiency, Nigeria

1 Introduction

Food farming is an important business in Nigeria as about 70 % of the population use it to sustain their livelihoods. But Agriculture is characterised by increasing farming population putting more pressure on farm resources and the mobility of resource-poor food farmers. Food farming, mostly rain-fed with predominance of small scale systems using traditional techniques of production could be said to be at a typical Mellor's stage II of Agricultural Development with more hardship and low productivity (Mellor, 1966). The traditional systems of land management and the high pressure on land resulted in a decline of soil fertility and led to shifting cultivation and an increase in farm distances from the village or community primary location. In view of this, agricultural intensification and the adoption of improved production techniques became necessary. But confronted with growing rainfall uncertainty, farmers also adopt crop and land location diversifications to minimise farming risk. The combined effects are increased hardship and daily long distances trekking/motoring to getting to farm.

Different mobility systems, full/part-time farming are first-hand strategies used to reduce hardship and maxi-

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mize farming time utility. It could be noted that in a constant effort at reducing distance effect and the associated weak productivity, food farmers generally devise strategies to quail the negative effect of long distances ranging from adoption of adequate transportation modes, relocating to farm, to periodic absenteeism from farm activities.

Roads and transportation are essential for the sustainability of agricultural production in Sub-Saharan Africa as it impacts positively factors such as mobility (John & Carapetis, 1991), the adoption of high yielding varieties, high productivity crops and bigger farm size (Sieber, 1999).

A transportation mode is the means of mobility used to carry goods and persons from one place to another in this case from village/market to farm and vice versa. Rural transportation mostly include animal traction, car, truck, train and other intermediary means of transport (IMT) such as motorcycle, bicycle, boat and canoe mostly adapted for local transport problems with low and medium loads (Sieber, 1999). Intermediary modes of transportation (IMT) are crucial to farmers' timely access to farm, markets and agro-services though the level of adoption may not be unconnected with availability of quality road (Oyatoye, 1994).

Research concerns would be to address policy issues susceptible to improve farmer's mobility and rural accessibility while enhancing farm livelihood assets and reducing rural poverty (Davis, 2000). Starkey (2001) noted a low adoption of IMT in rural Africa compared to the rest of the developing world and sees this as a constraint to rural development. (Ahmed & Rustagi, 1987) further noted that crops remain un-harvested or become spoilt once harvested because of unavailability of vehicles during harvesting.

Tracey-White (2005) noted also that mobility in rural areas could be hampered by the lack of transportation facilities and unavailability of good roads. He canvasses the need to study how transport systems affect the marketing channels and therefore the long term agricultural productivity. He noted that the mode of transportation used, length and time of the journey and the costs of transport all affect the efficiency of marketing system and therefore farm output. He listed benefits attached to improved transport as: (i) that agricultural surplus reach collection centres and markets timely; (ii) a reduction of time burden for family members and (iii) a reduction in transportation damages to perishable crops. Additionally, an improved transport reduces operating costs to vehicle users and provides more direct and cost-effective access to public utilities. Classifying bicycle and motorcycle as Intermediary Mode of Transports (IMT) the author predicted the prevalence of motorcycle taxis increase in rural areas as a result of falling prices. The adoption of IMT may have the following effects on agricultural production and marketing: (a) cultivation of large farm areas, (b) utilization of more fertile remote soils and heavier crops production, (c) increased utilization of fertilizer and manure, (d) reduction in effort and drudgery and spill-over effects if animals are used for ploughing and transport enabling farmers respond better to markets signals (Hine & Ellis, 2001). These authors also found that African farmers receive only 30-50 % of final market price against 70-85 % to Asian farmers with most of the difference due to high transport costs. They observed that a reduction in transport cost by 20 % rise farm gate price by 6 %. It was noted that though road investment plays an important role in reducing transport costs, improving feeder roads may have little impact if "no change in transport mode occurs", that is "upgrading 5 km of feeder road from earth to gravel might only increase farm gate price by about 10 % only, while bringing motor vehicle access 5 km closer to farms would increase farm gate price by over 100 % as much". Transportation cost is not also unconnected with road roughness and seasonality. Ninnin (1997) found in Madagascar that wet season fares were 70 % higher than dry season fares while in Tanzania an increase in road roughness by 50 % raises the truck charges by 16 % and pickup charges by a little below 100 % and (Starkey, 2001) empirically found an estimated cost/ton/km of $0.60, $1.30 and $0.70 for bicycle, motorcycle and pickup. (Oyatoye, 1994) in Nigeria found that if road quality improves, farmers have lower marketing costs and gain access to wider markets. They experience little or no delay in moving their produce and hence undergo fewer losses. They also receive better market prices for their products as the realization of a new road always attracts more of transportation systems and eases access to farm.

Productive efficiency is a measure of productivity that assesses output by unit of total input. It is the translation into money costs of production technical efficiency. A production process is technically efficient if it produces the largest possible output of a good from a given set of inputs (Powell, 1989).

An effective demand for transportation arises also from the presence of markets and the use of Intermediary Mode of Transport (IMT) would be viable only if distances are not too lengthy, while a multimodal system could be the best approach to rural transportation challenges. With the increasing adoption of IMT among food farmers in Nigeria, this study assesses the effects of intermediary modes of transport and other road infrastructure on the technical efficiency of food farmers in Oyo State.

2 Materials and methods

2.1 Study area

The study was carried out in Oyo North, Oyo State, Nigeria. The area is located within the guinea savannah agro-climatic zone of Nigeria with an average annual rainfall of 800 mm spanning March/April to October with temperature varying between 25 and 35 °C and the relative humidity is 91 %. Food farming is the major activity of the people in the area. Other activities include rearing livestock, handicraft and other small businesses. Traditional techniques of production and a relative paucity of transportation characterize the area while farmers are gradually incorporating IMTs into their farming systems. Crops mainly cultivated in the area include tubers (yam, cassava and sweet-potatoes), cereals (maize, guinea corn), fruits (e.g. cashew) and small ruminants such as goat, sheep and guinea fowl.

2.2 Sampling and sample size

A Multistage sampling technique was adopted to select food farmers. The first stage was the purposive selection of three local government areas (LGAs) namely Orelope, Atisbo and Olorunsogo. The second stage was the random selection of farmers in proportion to each LGA farming population size. The third stage was a random selection of food farmers in each LGA. The sample includes 130 food farmers from Orelope, 50 food farmers from Atisbo and 50 from Olorunsogo LGA, making a total of 230 farmers for the study.

2.3 Data collection

Primary data were collected with the use of a pre-tested open–ended questionnaire which was administered during the farming season through interview. The data collected include farmers' age, level of education, records keeping, farming group, mode of land acquisition, mode of transport used, farm-home distance, type of farm access road, number of farmlands cultivated and size, trekking time, working hours on the farm, types of food crops and business enterprises adopted, quantity of inputs used, outputs harvested and market prices.

2.4 Data analysis

Descriptive statistics, Herfindahl Index and Technical Efficiency Estimation were used to analyze the data. An one-step estimation of both technical efficiency (TE) and inefficiency models was adopted and technical efficiency ranges described.

Formally the stochastic production function is as follows:

$$Y_i = f(X_i;\beta) + \varepsilon_i$$

$$\varepsilon_i = \varepsilon_{ia} - \varepsilon_{ib} = v_i - u_i \text{ and } \sigma^2 = \sigma_a^2 + \sigma_b^2$$

Where, Y_i = level of output of i^{th} firm, X_i = vector of inputs used by firm i, ε_{ia}: Normally distributed random variables and ε_{ib}: Non-negative term representing the firm's inefficiency component.

The technical efficiency is therefore derived as follows:

$$\mathrm{TE}_i = Y_i/Y_i^0 = \exp(-\varepsilon_{ib})$$

With $\gamma = \sigma_a^2 / \sigma_{\varepsilon_i}^2$ to be used to capture food farmer's TE.

The empirical model to be estimated is as follows:

$$\ln Y_i = \ln\beta_0 + \beta_1 \ln X_{1i} + \beta_2 \ln X_{2i} + ... + \beta_5 X_{5i} + v_i - u_i$$

Where, Y_i = Farm output in value ($) comprising all crops grown on the farms and their market prices,
X_1 = Planting materials ($),
X_2 = Labour costs including land preparation, planting, weeding, fertilisers/chemicals application and harvesting ($),
X_3 = Costs of fertilisers ($),
X_4 = cost of chemicals ($),
X_5 = Household size,
$\beta_0 ... \beta_5$ = Stochastic production Frontier parameters.

The inefficiency model was specified as follows:

$$\mu = \delta_0 + \delta_1 Z_1 + \ldots + \delta_n Z_n$$

μ = Technical inefficiency score
δ_0 = constant, and
Z_n= farmer's socio-economic characteristics (see *S1*, Supporting Information);
$\delta_1 \ldots \delta_n$ = inefficiency parameters

2.5 Measure of Agricultural Diversification Index

Crop diversification is one of the strategies used by food farmers to minimize agricultural risk and stabilize income from a combination of enterprises. It is therefore interesting to assess how this strategy affects farmer's technical efficiency. Crop diversification is captured using Herfindahl-index presented as follows.

$$H_i = \sum (s_{(ji)}/S_i)^2 \text{ with } i = 1 ... n;\ j = 1 ... m$$

H_i = Diversification index of farmer i; $s_{(ji)}$ = size of enterprise j adopted by farmer i; S_i = total farm size used by farmer i.

3 Results

3.1 Farmers' socio-economic characteristics

Most farmers were in their middle age between 30 and 60 years, with no or primary education only (Table 1). This indicates a low level of education of farmers. But almost half of farmers keep records of their farms probably with the assistance of their children as we now have an increasing number of educated youth in the area. The majority of farmers do not participate in a farming association or agricultural cooperative probably because the benefits of membership are not enough compared to resulting costs. Most food farmers acquired theirs lands by inheritance with 70 % followed by lease system, 29 % and purchase, 1 %. This also indicates a low level of purchase that is lack of a formal land market in the area. Most farmers owned one plot denoting poor plot diversification strategy probably because of the high level of management involved especially cost associated to distances. Food farmers exploited less than 30 acres with a crop diversification index of less than 0.5. The home–farm distance seems to be evenly distributed up to ten kilometers but most farms are within two and ten kilometers that is sometimes beyond walking distance. A good number of farmers, 39 %, trek to get to their farms on daily basis but there is a growing trend in the use of IMT systems such as bicycle and motorcycle.

Road is an important transport component that encourages the use of IMT. Access road of most farms is the un-tarred type with 61 % of respondents using it to get to their farm, the remaining being footpath and tarred type of road. Akinola (2003) that found in Ile – Ife Area of Osun State, Nigeria that 28 % of settlements were linked with footpaths and 79 % of farmers trek to their workplace on bad roads.The walking time for most farmers, about 82 %, is within two hours, and farmers often combine other modes of transportation with trekking. The weekly time of work on the farm for most farmers is between 30 and 60 hours for about 60 % of farmers while 35 % are working less than 30 hours a week. These results denote disparate time allocation by food farmers to their farms during cropping season.

3.2 Distribution of food farmers' Technical Efficiency

The analysis reveal food farmers' TE distribution. Seventy-two percent of food farmers had an efficiency of 0.80 and above, while 25 % had an efficiency between 0.50 and 0.70 and only 3 % below 0.4. The lowest value was 0.31 and the highest 0.96. In a large part food distribution is therefore relatively efficient with a TE value of more than 0.80. These findings compared better with Amaza *et al.* (2006) with highest percentages distribution between 0.61 and 0.80 and a mean efficiency of 0.68 only in the Guinea savannah of Borno State with similar

Table 1: *Frequency and percentage of farmer's socio-economic characteristics, n* = 230

Farmer's socio-economic characteristics	*Frequency*	*Percentage*
Age range (in years)		
20 until 35	10	4
36 until 50	115	50
51until 60	68	30
61 and above	37	16
Education		
None	124	54
Primary	60	26
Secondary	23	10
Tertiary	23	10
Records keeping		
No	104	45
Yes	126	55
Group membership		
No	150	65
Yes	80	35
Land acquisition		
Inheritance	161	70
Lease	67	29
Purchase	2	1
Number of farmlands		
1 only	194	84
2 until 3	32	14
4 until 6	4	2
Diversification index		
0 until 0.30	115	50
0.31until 0.50	97	42
0.51until 1.0	18	8
Home-farm distance (in km)		
0.25 to 2.0	52	23
2.1 to 5.0	74	32
5.1to10.0	74	32
10.1to 20.0	30	13
Transportation mode		
Foot	90	39
Bicycle	60	26
Motorcycle	66	29
Car	05	02
Using two of the above	09	04
Farm access road		
Tarred road	42	18
Un-tarred road	140	61
Footpath	32	14
Trekking time to farm (in hours)		
0.2 to 2.0	189	82
2.1 to 3.0	30	13
3.1 to 6.0	11	5
Weekly on farm working time (hours)		
Up to 30	81	35
30.1 to 60.0	138	60
60.1 to 77	11	05

agro-ecology. Technical Efficiency gap could be corrected with adequate measures based on "farmer's specific characteristics".

3.3 Determinants of food farmers' Technical Efficiency

The results of the MLE simultaneous estimation of food farmer's technical efficiency and inefficiency effects indicate a significant intercept meaning significant output is still possible without the stipulated inputs (Table 2). Of all inputs, only planting materials make a significant positive contribution to output while labour shows a negative contribution. But fertilizers, chemicals and household size did not significantly contribute to output. The values of 1.51 and –0.43 for planting materials and labour mean that planting materials are underutilized while labour is overused. Hence, there is a need to optimize the use of these two resources by reducing the cost of labour and increasing the level of planting materials given the current state of technology used by farmers. The LR ratio test (Lambda) accepting H_0 means an appropriate functional form (Cobb-Douglas functional form). The significant sigma squared indicates a goodness of fit for the data while the Gamma indicates a significant technical efficiency value or inefficiency effect among food farmers. The mean TE was 0.82 meaning an inefficiency gap of 18 % needed to be filled by farmers. The value of 1.076 indicates a constant return to scale an indication of optimum scale of production in food farming.

The existence of a significant inefficiency effect means that food farmers without increasing the quantity of factor input could still improve on the use of non specific farm inputs to increase total output at latitude up

Table 2: *MLE of the Stochastic production frontier and inefficiency model estimation (n = 230)*

Variable	*Parameter*	*Coefficient*	*Standard error*	*t-statistic*
Intercept	β_0	5.33 ***	0.394	13.5
Planting materials	β_1	1.51 ***	0.025	58.61
Labour	β_2	-0.43 ***	0.042	-10.14
Fertilizers	β_3	0.01 ^{NS}	0.0066	1.63
Chemicals	β_4	0.0070 ^{NS}	0.0077	0.90
Household size	β_5	-0.079 ^{NS}	0.071	-1.11
Inefficiency model				
Constant	δ_0	-0.49 ^{NS}	0.47	-1.05
Age (in year)	δ_1	-0.0113 ^{NS}	0.0104	-1.08
Education	δ_2	0.197 **	0.074	2.64
Records keeping (Yes/No)	δ_3	0.104 ^{NS}	0.152	0.68
Group membership (Yes/No)	δ_4	-0.0068 ^{NS}	0.127	-0.05
Crop diversification index	δ_5	1.46 ***	0.34	4.30
Distance home – farm (km)	δ_6	-0.150 ***	0.042	-3.5
Un-tarred road (Yes, No)	δ_7	-0.539 **	0.186	-2.8
Bicycle (Yes, No)	δ_8	0.313 **	0.141	2.21
Motorcycle (Yes, No)	δ_9	-0.127 ^{NS}	0.203	-0.62
Walking time (hours)	δ_{10}	0.391 ***	0.147	2.66
Hours of work per week	δ_{11}	0.0142 **	0.0071	1.99
Diagnostic statistics/Estimations				
Sigma squared	σ^2	0.17 ***	0.039	4.32
Gamma	γ	0.497 ***	0.166	2.98
Log likelihood function = -76.06				
Lambda (One sided error) = $\lambda = 63.7 < \lambda_t = 124$ (H_0 accepted)				
Mean efficiency = 0.82				
Returns to scale = 1.076				

***; **; *: 1 %; 5 % and 10 % level of significance respectively.
^{NS}: not significant

to 18 % gap to the production frontier. The results indicate that level of education, crop diversification, home-farm distance, un-tarred type of road, use of bicycle, walking time and hours of work per week had a significant effect on food farmer's technical efficiency. While food farmer's TE significantly increases with the crop diversification (as lower value means higher diversification), distance of the farm and the un-tarred type of road, the technical efficiency decreases with level of education, use of bicycle, walking time and the weekly hours of work on the farm. But age of the farmer, records keeping, group membership and the use of motorcycle did not show significant effects on food farmer's technical efficiency. As expected the walking time reduces farmer's productivity, which stems the need to encourage adoption of transportation means among food farmers. But the weekly hours of work seem to reduce farmer's productivity. This would indicate that an excess weekly working hours on the farm is reducing food farmer's productivity. Part of his working time could therefore be reallocated to other related and non-farm activities as shedding the excess would increase not only food farming productivity but the overall farmer's productivity. The positive effect of crop diversification as risk management strategy makes it also a productivity enhancing strategy among food farmers. Age of farmer, records keeping, group membership and motorcycle usage show no significant effect on food farmer's productivity.

4 Discussion

4.1 Farmers' socio-economic characteristics

Food farming is dominated by middle age farmers in their fifties with an average age of 50 years. Young farmers should therefore be encouraged to take up farming through sensitization, adequate training and the introduction of modern techniques and drudgery relieving farming technologies. This would break the increasing trend of youth not embracing food farming as a profession. The traditional mode of land acquisition is still predominant with little or no evolvement into formal land market system as most lands were acquired by inheritance which proves as rigidity to agricultural modernization. The single farm location of most farmers is an indication of the concern for reducing effort due to distance in addition to the risky nature of farming. The crop diversification index in the first half for about 72 % of farmers is an indication of high level of risk management which is also as a result of traditional farming system. The negative effect of the level of education on food farmer's TE with a coefficient of 0.197 could probably be due to the low rate of educated food farmers than education per se; surprisingly use of bicycle with a coefficient of 0.313 simply means a burden rather than a relief for farmer as this negatively affects his productivity. The equal distribution of the mode of transportation is an indication of increasing demand and use of IMTs in food farming. This reveals the importance of IMTs as these help to alleviate the distance drudgery while making possible farming beyond daily walking distances. The use of IMT should normally be targeting at sustaining farmer's productivity in addition of being a poverty reduction and a supplementary household asset. The type of road mostly used to access farm is the un-tarred one. This is also the most available type of road probably due to cost. Most farmers trek up to two hours daily to get to farm. This waste of energy and time could affect their effective working time and productivity on the farm. It is believed that trekking shorter distances or using IMT would reduce food farmer's walking time and increase productivity (Sieber, 1999).

4.2 Use of IMT and food farmers' Technical Efficiency

The determinants of food farmers' TE transportation related factors include farm distance, quality of farm access road, type of IMT used, the walking time and the numbers of hours of work on the farm, all of which can affect farmer's productivity. Though the results show a non significant direct effect of type of transportation mode on TE except bicycle that implies rather a negative effect, the significant positive effect of the type of road and the negative effect of hours of work per week and trekking time imply a no direct effect of IMT on farmer's productivity as this is a way of reducing trekking time due to distance while improving effective working time on the farm. The positive effect of farming on distant lands with a coefficient of –0.150 and the negative effect of trekking with 0.391 on farmer's productivity implies not only the need for farming on distant lands but also the need to quail the negative effect of distance on farmers as most food farmers trek to their farms. The negative impact of bicycle on farmer's productivity, the non significant effect of motorcycle and the positive impact of road (un-tarred) emphasize the need for more IMT such as motorcycle adoption among food farmers. Since farms located far away from village residence show more productivity and most farmers working on full time reside in the village than on farm during farming (Kassali *et al.*, 2009). Besides most of farmers trek to their farms on daily basis, there is therefore a justification for the growing adoption of IMT among food farmers. But as the use of bicycle implies a negative effect on farmer's TE and the un-tarred type of road a positive effect, while the effect of motorcycle is yet to be positive, there is a need for more motorized IMT such as motorcycle adoption by food farmers. Food farmers already using bicycle can also shift to motorcycle, at least, as a strategy to improve their efficiency. The negative effect of working time also indicates that farmer could reallocate part of excess time from farming to other rural activities without affecting farm productivity. This could be a way of maximizing food farmer's time utility while improving his productivity.

This study exhibits the existence of significant inefficiency effects among food farmers in the Oke – Ogun area of Oyo State. It shows diversity of transport systems used by food farmers with growing trend in the use of motorcycle. Although our results did not show a significant effect of IMT on food farmer's productive efficiency, their adoption contributes significantly to an attenuation of the negative distance-effect and its impact on productivity. Given the negative impact of bicycle on farmer's TE, the high rate of trekking farmers and the relative adoption of IMT with no significant impact on farmer's productivity, there is need to encourage the use of more motorcycles among food farmers. An improvement in road quality up to un-tarred type would also support the use of motorized IMT to sustain productivity and optimize working time on the farm especially among full-time farmers.

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Supporting Information

S1 – Farmer's socio-economic characteristics:

Z_1 = Age of food farmer (years); Z_2 = level of education (years); Z_3 = records keeping (yes= 1/No=0); Z_4 =Group membership (yes =1/No=0); Z_5 = Crop Diversification index; Z_6 = Farm distance (km); Z_7 =use of un-tarred road (yes=1/No=0); Z_8 = use of bicycle (yes=1/No=0); Z_9 = use of motorcycle (yes=1/No=0); Z_{10} =Trekking time to farm (hours); Z_{11} = Weekly working time on the farm (hours).