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Influence of Trade Liberalization and its Related Policies on the Adoption of Mechanized Ploughing in Yam Cultivation in Kpandai District in Northern Region, Ghana.

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Abstract

This paper analyses the trade potential factors that influence the adoption of mechanized ploughing in Kpandai District in Northern Ghana. The paper estimate a logic model with data from 510 sampled yam farm households. It was identified that producer price, farm size, competition among farmers, export, integration into market economy, market proximity were found to show strong significant influence on adoption of tractor ploughing technology. It is therefore recommended that these factors should seriously be underscored and incorporated in policy formulation and implementation of adoption of plough mechanization for the farm households in the district. Moreover, establishment of tractor plant pool in yam cultivating districts would help to reduce the difficulties farmers face in hiring the services of tractors in peak demand periods.

Keywords: tractor, mechanisation, ploughing, adoption, trade potential factors

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INTRODUCTION

The yam subsector of Ghana has changed over the past three decades partially due to government policies such trade liberalization and its related policies. Trade liberalisation and its related policies in the form of export and import liberalisation, tariff adjustments, artificial barriers removal, price liberalisation, foreign exchange liberalisation and removal of subsidies on inputs has altered the general operation, structure, conduct, and performance of the subsector. Export, artificial barriers removal, price liberalisation and foreign exchange liberalisation are some of the key components of trade liberalization and its related policies that have had a direct influence on the yam subsector. These key components associated with trade liberalization and its related policies over the years have increased the demand, producer price, competition among yam farmers and market size of yam. These in tend have affected production levels, farm sizes, and production operations (such as tillage practice). Tillage operations such as ploughing have been affected in this era of trade liberalization and its related policies, which is partly due to increase in farm sizes. The promotion of mechanized ploughing (the use of animal-drawn ploughs or tractor- mounted ploughs) has increased in this era.

Before yam seeds are sown, the land is prepared by loosen the soil so that the tubers can grow deep in the soil; water percolation and aeration would be enhance; turn organic matter under into the soil; control the growth of weeds; enhance the shaping of seedbed (into ridges, beds, or mounds). Ploughing is one of the most important land preparation activities in yam production. Ploughing means turning over the top soil and burying all the weeds and organic matter. The depth of ploughing depends on the type of traction available and the way the plough is adjusted. Ploughing should always be deep enough to loosen the soil where the roots will develop. Mechanisation of tillage operations will minimize the drudgery associated with yam cultivation and encourage more youth into yam production. Land preparation by ploughing and harrowing will eliminate the need for under-digging under the yams. This will greatly enhance yam cultivation and reduce the cost of production. For instance, the study result of Odjugo (2008) pointed out that zero tillage reduced yield when compared with ploughing. Mechanized ploughing can be achieved either by animal-drawn ploughs or tractor- mounted ploughs, as is commonly practiced in the Guinea savanna agro-ecology of Ghana (Ennin *et al*, 2009). After ploughing, the land is usually harrowed.

In spite of the advantages of mechanized ploughing, zero and manual tillage techniques are the commonest land preparation system among yam growers in most yam cultivation areas in West Africa including Ghana. This practice has always made yam cultivation very labour intensive and unattractive to the youth. Nonetheless, zero-tillage soils have high moisture content that might partly be due to the increase in soil organic matter content (Ojeniyi *et al*, 2006) which helps tuber development.It is therefore, important to assess the factors that affect the adoption of mechanized ploughing in yam production especially in the era of trade liberalization and its related policies. This era has resulted in a changed in the general operations, structure, conduct, and performance of the yam subsector in Ghana. For example liberalisation of trade and its

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related policies has affected market size, farm sizes, prices, preferences and specifications of consumers (Amanor, 2005; Otoo 2005). The paper therefore, focuses on trade related factors that affects the adoption of mechanised ploughing among yam farm households. Identification of these factors would facilitate the promotion of mechanised ploughingand other improved mechanisation technologies that would be developed in the near future.

METHODOLOGY

Theoretical Model

For the sake of mathematical simplicity, the logit model is employed within the framework of this analysis (Field, 2000; Nnadi & Akwiwu, 2007, Greene, 2008, Maliki *et al*, 2009, Seidu, 2013). This model makes it possible to predict the decision to adopt seed yam innovation and not to adopt. Thus the decision to adopt lies between zero (0) and one (1). The model also caters for the problem of heteroscedasticity. The model can be presented by the following equation:

$$E(y_i) = P(y_i) = \frac{1}{1+e^{-z}} \qquad (1)$$

Where,

$P(y_i)$ is the probability for a household i for adopting an seed yam innovation;

$P(y_i)$ = 1 if technology is adopted and 0 if technology is not adopted.

e is an exponential function

$$Z = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + ... + \beta_n X_n + \varepsilon_i \qquad (1.1)$$

Where β_0 is the intercept

$\beta_1, \beta_2 ... \beta_n$ are the estimated coefficients of the corresponding variables $X_1, X_2 ... X_n$,

$X_1, X_2 ... X_n$ are independent variables specifying innovation.

The error term is represented by ε_i

Empirical Model of the study

The study was conducted in Kpandai District of Northern Ghana in 2012. Multistage sampling was employed in the study. The first and second stages were purposive selection of the region (Northern) and the district (Kpandai) because of their respective massive yam production relative to other regions and districts. Also, more than 50% of the farms households in the district are engage in yam production. The district consists of four major Agricultural Zones namely; Kpandai, Katiejieli, Jamboi and Ekumidi. In the third stage, the study included all the zones in the survey in order to get representative sample from each zone in the district. In the fourth stage, within each Agricultural zone four (4) communities were randomly sampled except Katiejieli where five communities were randomly sampled because the number of communities engaged in yam production in the zone was many relative to the other zones. The total number of communities that were sampled was seventeen (17). The random sampling technique was again employed in stage five to select thirty (30) farm households within each selected community. In all 510 farm households were selected and interviewed using structured

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questionnaires. The data collected include seed yam innovations and characteristics of farmers towards trade liberalisation and its related policies. The data collected were analysed using both the descriptive statistics such as mean, percentage, frequency distribution and standard deviation. The econometric tool such as the binary logit regression analysis was used. The model used is implicitly presented as:

$$Y = f\left(X, I, C, O, D, Q, P, T, S, R\right) \qquad (2.0)$$

$$\ln\left(\frac{P}{1-P}\right) = \beta_0 + \beta_1 X_i + \beta_2 I_i + \beta_3 C_i + \beta_4 O_i + \beta_5 D_i + \beta_6 Q_i + \beta_7 P_i + \beta_8 T_i + \beta_9 S_i + \beta_{10} R_i + \varepsilon_i \qquad (2.1)$$

$$Y_i = \beta_0 + \beta_1 X_i + \beta_2 I_i + \beta_3 C_i + \beta_4 O_i + \beta_5 D_i + \beta_6 Q_i + \beta_7 P_i + \beta_8 T_i + \beta_9 S_i + \beta_{10} R_i + \varepsilon_i \qquad (2.2)$$

From (2.1) and (2.2) $\ln\left(\frac{P}{1-P}\right) = Y_i$

Where:

P isthe probability of a household ploughing the land during land preparation
*1-P*is the probability of a household not ploughing the land during land preparation

$$Y_i = \begin{cases} 1 \text{ if household ploughs the land during land preparation and} \\ 0 \text{ if household does not plough the land during land preparation} \end{cases}$$

Export (X), Market integration (I), Consumers complains (C), Outlet of sales (O), Market Proximity (D), Competition (Q), Producer Price (P), Time of Marketing (T), Farm Size (S); Cost of Transportation (R_i), Intercept (β_0), Estimated parameters ($\beta_{1...10}$) Error term (ε_i).

Table 1: Description of variables used in the Empirical model

Variable	Definition and Measurement of Variables	Hypotheses
Export (X_i)	Quantity of direct sales to export agents and/or to middle men who also sell to export agents	+
Market integration (I_i)	Quantity of yam sold in the production season	+
Consumers complaints (C_i)	Ability and willingness to address consumer complains. 1, if Yes and 0 otherwise	+
Outlet of sales (O_i)		
farm gate (O_f),	Quantity of yam sold at farm gate	+
village market (O_v)	Quantity of yam sold at village market	-
urban market (O_u)	Quantity of yam sold at urban market	+

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Market Proximity		
urban market (D_i)	The time (hours) taken to transport yam from the farm to the urban market using lorry	-
Competition (Q_i **)**	Number of yam suppliers in the area	+
Producer Price (P_i)	The average price of hundred tubers of yam	+
Farm size (S_i)	The acreage of yam farm under cultivation	+/-
Time of Marketing		
Sales before market season (T_b)	Quantity of yam tubers sold before market season	+
Sales during market season (T_d)	Quantity of yam tubers sold during market season	+/-
Sales after market season (T_a)	Quantity of yam tubers sold after market season	+
Producer Price (P_i)	The selling price of hundred tubers of yam	+
Cost of Transport (R_i)	The average cost of transporting hundred tubers of yam	-

RESULT AND DISCUSSION

Description of the farm house hold based on trade potential characteristics

Producer Price*:* As indicated in Table 2 producer price of yam of the sample respondents ranged from GH₵ 0.50 to GH₵ 4.00 for a tuber of yam while that of a "batch of yam" (a group of 100 tubers of yam) was GH₵50 to GH₵400.00 The mean selling price of batch of yam of the sample household was GH₵141.63 with standard deviation of GH₵57.80.

Degree of Integration into market economy*:* From Table 2 it can be depicted that, the total number of yam sold by sample households vary from 100 to 75000 tubers. Moreover, the average degree of integration of sampled farmers into the market economy was 13721 (76.01%) tubers of yam with a standard deviation of 13067 (15.96%).

Table 2: Distribution of farm households according to trade potential characteristics

Trade potential characteristics	Mean	SD	Min	Max
Producer Price of yam				
A tuber of yam (GH₵)	1.39	0.59	0.5	4
A batch of yam (100 tubers of yam) [GH₵]	141.63	57.8	50	400
Market integration				
Tubers of yam sold (number of tubers)	13721	13067	100	75000
Tubers of yam sold (%)	76.01	15.96	10.26	100
Quantity of yam for export				
Total yam exported (No. of tubers)	1404	3056	0	20000
Total yam exported (%)	7.5	13.26	0	70.18
Outlet of Sales				
Tubers of yam sold at farm gate	3353	7548	0	53000
Tubers of yam sold at farm gate (%)	16.03	25.73	0	100
Tubers of yam sold at village market	1216	2567	0	19000
Tubers of yam sold at village market (%)	16.45	29.88	0	100
Tubers of yam sold at urban market	9154	8747	0	50000
Tubers of yam sold at urban market (%)	67.52	33.45	0	100
Competition among yam suppliers	10	6	1	40
Time of marketing				
Tubers of yam sold before market season	1922	5376	0	52000
Tubers of yam sold before market season (%)	10.4	19.84	0	100
Tubers of yam sold during market season	8090	7652	0	48500
Tubers of yam sold during market season (%)	67.19	35.66	0	100
Tubers of yam sold after market season	3715	7544	0	47200
Tubers of yam sold after market season (%)	22.42	32.41	0	100
cost of transportation	27.46	6.94	17	45

Source: generated from field survey data

Export: The quantity of yam exported by sampled households ranges from 0 (0%) to 20000 (70.18%) tubers with mean of 1404 (7.50%) and a standard deviation of 3056 (13.6%).

Outlet of Sales: The quantity of yam sold at the farm gate ranges from zero to 53000 tubers, with a mean number of tubers of 3353 (16.03%) and a standard deviation of 7548 (25.73). Likewise, the quantity of yam sold at village markets ranges from zero to 19000 tubers, with an average number of tubers of 1216 (16.45%) and a standard deviation of 2567 (29.88%). Similarly, the number of yam sold at urban markets varies from zero to 50000 tubers, with an average number of tubers of 9154 (67.52%) and a standard deviation of 8747 (33.45%).

Market Proximity: Farmers that sold their produce in the urban market spent between 10hrs to 26hrs on roads with an average time of 17 hrs and standard deviation of 4.78 hrs.

Competition among yam farm households*:* From Table 2, it was observed that competition among farmers ranges from 1 to 40 farmers with mean competition of 10 farmers and a standard deviation of 6. The impression deduced was that for every farmer in the study area there were ten (10) farmers surrounding him or her that were equally involved in the supply of yam. This put a lot of pressure on a farmer to produce to meet the needs and specifications of consumers in order not to lose customers to the other ten (10) farmers.

Time of marketing: Table 2 also shows that, the quantity of yam sold before the main market season varies from zero to 52000 tubers, with a mean number of tubers of 1922 (10.40%) and a standard deviation of 5376 (19.84). Similarly, the quantity of yam sold during the main market season ranges from zero to 48500 tubers, with an average number of tubers of 8090 (67.19%) and a standard deviation of 7652 (35.66). What's more, the number of yam sold after the main market season varies from zero to 57400 tubers, with an average number of tubers of 3715 (22.42%) and a standard deviation of 7544 (32.41). Households selling their produce before and after the main market season constitute farmers selling in the lean season.

Cost of Transportation*:* As shown in Table 2, the cost of transporting a "batch of yam" ranged from GH₵ 17.00 to GH₵ 45.00 with an average cost of transportation of GH₵27.46 and a standard deviation of 6.94. It is worthy to note that the cost transportation is a function of yam size.

Addressing Consumers complaints*:* Among the sampled households, 493 (96.67%) of them received complaints on their produce nonetheless only 274 (53.73%) of them were willing and have the ability to address the needs and complaints of customers (see Table 3).

Table 3: Distribution of households in relation to consumers/ customer complaints

Handling consumer complaints	Freq	% (N=510)
Households that received/heard complaints on the quality of yam	493	96.67
Households with the ability and are willing to address complaints	274	53.73

Source*:* generated from field survey data

Factors affecting Tractor Ploughing Technology

A multicollinearity test was run prior to the logit regression modeling. VIF (variance inflation factor) was used for testing the association between the hypothesized continuous variables. The problem of multicollinearity was avoided by excluding the variables with high VIF value equal or greater than ten (10). Therefore, variables that showed high VIF value more than ten (10) were dropped. Moreover, predictors not significant and does not have the expected sign were dropped from the models. The VIF values depicted in Table 4 show that all the continuous explanatory variables considered in the model have no serious multicollinearity problem.

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Table 4 Multicollinearity test result for continuous variables (N=510)

Variables	Collinearity Statistics		
	VIF	Tolerance	R^2
Producer Price	1.47	0.6806	0.3194
Farm Size	1.38	0.7268	0.2732
Market Proximity (urban)	1.29	0.7731	0.2269
Sales during main market season	1.29	0.7744	0.2256
Competition among producers	1.54	0.6488	0.3512
Sales at farm gate	1.43	0.7009	0.2991
Sales at the village market	1.47	0.6797	0.3203
Export	1.26	0.7964	0.2036
Integration into market economy	1.35	0.7380	0.2620
Cost of transportation	1.28	0.7817	0.2183

Source*:* generated from field survey data

Considering the maximum likelihood regression results captured in Table 5, the likelihood ratio test indicates that the null hypothesis that the model contains only a constant (intercept) is decisively rejected at (P<0.01). The measure of the goodness-of-fit shows a likelihood ratio chi square of 222.644, Log likelihood value of -235.883 and a Mc Fadden R^2 of 0.321. The model classifies 78.43% of the farm households correctly, which shows that the strength of the model in explain the adoption of mechanisation in the study area was high. Eleven explanatory variables were included in the econometric model out of which six variables were found to influence adoption of tractor ploughing significantly. Addressing of Consumer complaints,sales during main market season (time of marketing [during]) and outlet of sales (Farm gate and village market) were found to be insignificant.

Producer Price*:* Producer price was found to be significant at 5% in influencing the likelihood of adoption of tractor ploughing technology. A positive relationship was observed. Specifically, from Table 5, farmers that receive GhȻ1.00 increase in the prices of their produce were likely to plough their farmlands during lands preparation by 0.1%. The result also confirms the conclusion made by Thiele (2002). Farmers receiving high prices for their produce have extra motivation from their household income. The high income earned (because of high producer price) from the sales of yam encourages these households to plough their lands during land preparation. Moreover, it is very understandable for producers receiving lower prices for their yam not to plough their lands during tillage because the operation is not only laborious, but also very expensive. Tractor services were expensive in the study area because the district can boost of only fifteen tractors; this put a lot of stress on the tractor operators during ploughing season. Tractor to farmer ratio in the district for the 2008 cropping season stood at 1:5650. Although other tractors service operators come into the district from other districts to help salvage the situation to some extent during periods of peak demand (May-July).

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Farm Size*:* Increase in the area under cultivation was found to boost the adoption of tractor ploughing mechanisation. The affirmation is obvious from Table 5 where farm size has a positive and a significant coefficient of 0.019 corresponding to p=0.06. The implication is that yam farmers increasing their area under cultivation by one acre increases the likelihood of ploughing by 0.3%. The result is in agreement with the findings of Assefa and Gezahegn (2004) on the adoption of improved technologies in Ethiopia, using probit and logit models, it was reported that farm size had strong and positive effect on the adoption of improved technologies.

Tractor ploughing does not only loosen the soil and destroy soil pest but also reduces the drudgery component associated with tillage practice. This suggests that cultivation of yam on large acreages under plough mechanisation is easier, faster, and less expensive than on manual basis. In certain localities in the study area, it was found out that in seasons where tractor services are very scarce yam production is done on very small scale and in few instances farming was abandoned. Therefore is glaring to observe that large farm sizes increases the likelihood of tractor ploughing during tillage practices.

Market Proximity*:*As shown on Table 5, among many variables that contribute to farmers' likelihood of adopting tractor ploughing, was the proximity of the farmer from the urban market measured by the time taken to transport produce from the farm to urban market. This variable affects the likelihood of adoption negatively and significantly (at P<0.01). Moreover, from the Table an hour increase in the time taken to transport yam from the farm to the urban market decreases the log odds of adoption of tractor ploughing by 0.078. Similarly, the marginal effect shows that, an additional one hour taken to transport yam from the farm to the urban market decreases the probability of being an adopter by 1.2 percent. The study result is consistent with the research report of Mahdi (2005); Mesfin's (2005), Yishak (2005) and Tesfaye (2006) where they reported that market distance is negatively and significantly associated with adoption of crop technologies. Poor transportation network and transports (e.g. vehicles) delay farmers from reaching consumers at the right time and place. Farmers spending more time in transporting their produce lose most of their customers or consumers to producers that spend less time in conveying their yam to the market. Losing customers and consumers is tantamount to losing money that would have been obtained from sales. This affects demand of yam negatively. Therefore farmers that took long time to reach their customers and consumers were likely not able to pay for the services of tractor ploughing because they earn less from the sales of their produce. Urban market proximity is a major obstacle for households in the study area from adopting tractor plough.

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Table 5: Determinants of Tractor Ploughing Mechanisation adoption

VARIABLES	Tractor Ploughing Mechanisation		
	Log odds	Odd ratio	Marginal effect
Producer Price	0.005**	1.005**	0.001**
	(0.023)	(0.023)	(0.020)
Addressing Complaints (yes)	0.393	1.482	0.060
	(0.195)	(0.195)	(0.192)
Farm Size	0.019*	1.019*	0.003*
	(0.060)	(0.060)	(0.057)
Market Proximity	-0.078***	0.925***	-0.012***
	(0.002)	(0.002)	(0.001)
Time of marketing (during)	0.001	1.001	0.000
	(0.800)	(0.800)	(0.800)
Competition	0.120***	1.127***	0.018***
	(0.000)	(0.000)	(0.000)
Outlet of sales (farm gate)	0.001	1.001	0.000
	(0.803)	(0.803)	(0.803)
Outlet of sales (village market)	-0.005	0.995	-0.001
	(0.222)	(0.222)	(0.219)
Export	0.038***	1.039***	0.006***
	(0.002)	(0.002)	(0.001)
Market Integration	0.031***	1.032***	0.005***
	(0.000)	(0.000)	(0.000)
Transportation cost	-0.019	0.982	-0.003
	(0.400)	(0.400)	(0.399)
Constant	-2.713**	0.066**	
	(0.013)	(0.013)	
Observations	510	510	510
Deg freedom	11	11	
log likelihood	-235.883	-235.883	
Mc Fadden R^2	0.321	0.321	
LR test	222.644***	222.644***	
Classification	78.43%	78.43%	

NB: Stars denote significance at 10% (*), 5% (**) & 1% (***) level; p-values for t test in brackets are shown below the coefficients.

Source*:* computed from field survey

Competition*:* Table 5 reveals that, competition was found to have a significant and a positive (at P<0.01) effect on the likelihood to adoption tractor ploughing. A one-person increase in the competitors increases the odds of ploughing yam farm by 1.127 (which is a 1.8% increase in

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likelihood of tractor ploughing). In localities where the number of competitors was high, almost all the household plough their farmlands. The impression was that almost all sampled household heads in the locality did not want the neighbour to get a competitive advantage over him/her. Moreover, in localities where the number of competitors was more, households were motivated to practice technologies that would make their produce to be easily accepted by their customers and consumers.

Export*:* Household entry into foreign market (export) has a coefficient of 0.038 corresponding to p=0.006 therefore the null hypothesis is rejected in favour of the alternative. The sign of the coefficient for export was positive. Thus, a one percent increase in export by farmers would result in an increase in the Log odds of adoption of tractor ploughing technology by 0.038. This implies that a one percent increase in the sales of yam in a foreign market (export) is likely to increase the probability of tractor ploughing by 0.6%. This positive role of foreign market exposure is consistent with the results obtained by Mairesse and Mohnen (2005). Yam export forces households to practice tractor ploughing technology because the foreign consumers' affinity for uniform and smooth yam tubers is very high. Achieving such standards and specification requires soils that are loose and porous; hence farmers would plough their lands to achieve such soil condition in order to help them produce yam tubers preferred by their foreign customers.

Integration into the Market Economy:The positive sign for the coefficient for the variable representing market integration indicates that higher degree of integration into market economy is associated with higher propensity to innovate (adoption of tractor ploughing). The market integration variable is statistically significant at the 1-percent level. Having an additional one percent increase in sales would increase the probability of being an adopter by 0.5 percent (see Table 5). The result of the study is consistent with the reports of Hall and Khan (2003); Stefan (2003) and Boehlje and Erickson (2007). From the results, it can be deduced that an increase in the level of market integration may consist of an increase in the price of yam that are translated into increase farmers' income. Therefore, farmers committing more of their produce to the market have higher income levels and are likely to put more emphasis on tractor ploughing to boost their crop productivity.

CONCLUSION AND RECOMMENDATION

Six factors were found to show a significant relationship with the adoption of tractor ploughing technology. Producer price ($P<0.05$), farm size ($P<0.1$), competition among farmers ($P<0.01$), export ($P<0.01$) and integration into market economy ($P<0.01$) were found to have positive and significant influence on adoption tractor ploughing technology. However, market proximity shown a negative and significant (at $P<0.1$) relationship to adoption of tractor ploughing technology. Therefore, in order to improve on the adoption of this technology emphasizing the above factors in any policy programme on tractor ploughing mechanisation design is potentially advantageous. Moreover, establishment of tractor plant pool in yam cultivating districts would help to reduce the difficulties farmers face in hiring the services of tractors in peak demand periods.

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