Journal of Agriculture and Environment for International Development - JAEID 2014, 108 (1): 29 - 42
DOI: 10.12895/jaeid.20141.186

Trade Potential Determinants of the Adoption of Seed Yam Innovations in Ghana

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Submitted on 2013, 28 September; accepted on 2014, 19 February. Section: Research Paper

Abstract: This paper analyses the factors that influence the adoption of seed yam innovations in Kpandai District in Northern Ghana. In contrast to most empirical studies on innovation adoption in which a specific technology is analyzed, this study covers several seed yam technologies (such as minisett, milked seeds, small setts, traditional setts). The paper estimate a logit model with data from 510 sampled yam farm households. It was identified that households' ability and willingness to address consumer complaints, export, and integration into market economy positively and significantly influence the adoption of seed yam innovation. However, farm size and cost of transportation significantly influences the adoption of seed yam innovation negatively. The results therefore call for policies aimed at ensuring means to promote integration of households into local and international markets by bridging the gap of trust between farmers and yam exporters or middlemen.

Keywords: minisett, milked seeds, small setts, traditional setts

Introduction

Yam is an important food and cash crop in Ghana both at the local and international markets. The crop occupies 11.61% of the total cropped area of Ghana and annual output estimated to be 5.7 million metric tons in 2009 (MoFA, 2010). Yam contributes about 17% of agricultural gross domestic product (GDP) and forms an integral part of in household food security with more than 2 million tons harvested yearly (Kenyon and Fowler, 2000). Not only is yam very important in Ghana it is also well noted in West Africa in general with production levels varying from 90 to 95% of the world production level (FAO, 2009).

The aforementioned statistics of yam in Ghanaian economy and West Africa regions is partly due to trade liberalization and its related policies. With the growing demand and associated supply, yams have assumed great importance both in domestic and international market. However, yam is becoming more expensive and relatively unaffordable in urban areas as production has not kept pace with population growth leading to demand exceeding supply. Moreover, the cost of production is continuously hitting the roof, chiefly due to inadequate seed yam supply. As if the cost of seed yam is not a problem, liberalization of trade has also changed the face of technologies adopted by farm households because suppliers want to meet consumer demands and specifications. Farmers that are market oriented or are involved in trade are therefore, compelled to practice various seed yam technologies and modifications to meet consumer preferences. Thus farmers in the environment of liberalized trade are confronted with certain factors that affect the type of technologies they adopt. The paper therefore describe these factors (drivers or barriers) affecting farmers technology or innovation adoption in the environment of trade liberalization as trade potential factors. These factors include yam export, market integration, farmers' willingness to address consumers' complaints, outlet of sales, market proximity, competition among farmers, producer price, time of marketing, farm Size, and cost of transportation. Seed yam technologies such as minisetts, milked seeds, small setts cuttings, big setts cuttings, and small whole seeds are the various technologies available to farmers. Though leaf cuttings and vine multiplication (Asante *et al.*, 2011) also exists but not widely known by most farmers. Big setts cuttings are a seed yam technology where yam tubers are sliced into sizes ranging from 100g to 200g for planting. This method result in large tuber size however, this method is expensive and result in a low multiplication ratio. Therefore, the use of small setts (60-100g) and minisett (15-50g) are alternatives for farm households were big setts use is a problem. Among seed yam technologies used in Ghana, milked seeds have gain a lot patronage over the last three decades because farmers have less difficulties in adopting the technology. Though the technology has been in existing for long but it has gained prominence and attention in the era of trade liberalization and its related policies. Milked seeds are yam obtained by cutting off tubers of growing yam plant after five or six months of planting and allowing the remaining portion of the yam in the soil to form setts, which is used for planting in the next season. The study defined seed yam innovations as seed yam technologies that have been developed, modified or gain special attention or consideration due to the change trade liberalisation has brought to the yam subsector. The use of minisetts, small setts and milked seeds were considered as seed yam innovation based on the definition above. Nonetheless large setts cuttings and small whole tubers were the non seed yam innovations.

The adoption of any technology is affected by plethora of factors; mostly the attention of many studies is limited to socio economic, demographic, and farmer or

farm household factors. However, this paper focuses on trade potential factors (such as yam export, market integration , farmers willingness to address consumers complaints , outlet of sales, market proximity, competition among farmers, producer price, time of marketing, farm Size; cost of transportation) affecting the adoption of seed yam innovations among yam farm households. Knowing the effect of these factors would enable policy analyst, makers, researchers, development partners, stakeholders and prospective investors to appreciate these factors, and their influence on farm households. Moreover, identification of these determinants would facilitate the promotion of seed yam innovation adoption and other improved technology 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). 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:

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

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

$$Z = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_n X_n + \varepsilon_i$$

Where β_0 is the intercept
$\beta_1, \beta_2 \ldots \beta_n$ are the estimated coefficients of the corresponding variables
$X_1, X_2 \ldots X_n$ $X_1, X_2 \ldots X_n$ are independent variables specifying innovation.
The error term is represented by ε_i

Empirical Model of the study

The study was conducted in the Kpandai District of Northern Region of 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. Moreover, more than 50% of the farm households in the district were engaged in yam production. The district consists of four major Agricultural Zones namely; Kpandai, Katiejieli, Jamboi and Ekumidi. In the fourth stage, the study included all the zones in the survey in order to get representative sample from each zone in the district. In the third stage, within each Agricultural zone four (4) communities were randomly sampled except Katiejieli where five communities were randomly sampled because of the higher number of communities in the zone. The total number of communities that were sampled was seventeen (17). A random sampling technique was again employed in stage five to select thirty (30) farm households within each selected communities. In all 510 farm households were selected and interviewed using structured 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 equally used. The model used is implicitly stated as:

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

$$Y_i = \beta_0 + \beta_1 X_i + \beta_2 I_i + \beta_3 C_i + \beta_4 O_i + \beta_5 D_i + \beta_6 Q_i + \beta_7 P_i + \beta_8 T_i + \beta_9 S_i + \beta_9 R_i + \varepsilon_i$$

Where:

$$Y_{si} = \begin{cases} 1 \text{ if household is using minisetts / milked seeds / small setts cuttings} \\ 0 \text{ if household is using traditional setts} \end{cases}$$

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 ($\beta_{1.....9}$) Error term (ε_i).

Result and Discussion

Description of the farm household 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 for a tuber of yam while that of a "bunch of yam" was GH₵50 to GH₵400. The mean selling price of a group of 100 tubers of yam (bunch of yam) of the sample household was GH₵141.63 with standard deviation of 57.80.

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	+
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 if 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	-

Source: Field survey data

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). It is easy to justify that the sampled households are mostly commercial and business oriented since most of their produce are sold.

Export

Furthermore, 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%). Though farm households in the study area where commercial

producers nevertheless their produce were mostly sold in the local market other than the international market.

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). The justification of the statistics above are not far from the fact most farm households sell their produce in the urban market due to the high producer price it attracts hence they would prefer to bypass local collectors and other middlemen in the process.

Market Proximity

Farmers that sold their produce in the urban market spent between 10hrs to 26hrs on roads with an average time of 17hrs and standard deviation of 4.78. Most farm households knowing very well how much local collectors and other middlemen sold gathered produce from farm gate and village markets in the urban markets normally felt cheated. Therefore most producers would prefer to travel long hours to the urban market to sell their produce.

Competition among yam farm households

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

Time of marketing

Shifting the direction of the discussion to Table 2, 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

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 bunch 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: Field survey data

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 "bunch 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 of them were willing and have the ability to address the needs and complaints of customers. Out of the many complaints received during the survey, most of the households received complaints that yam tubers were too big (that may account for the reason why few of the produce were exported since smaller tubers are often preferred by yam exporters) however very few of the households received complaints on the variety of yam produced. The revelation is unsurprising because farmers use seed yam technologies that yield bigger tubers. Households wanting to address this complaint would be forced to adopt improved technology such as minisetts, small setts and milked seeds. Only few farm households received complaints on the variety of yam produced because most of the farm households in the study area were producing white yam varieties.

Trade potential factors influencing the adoption of seed yam innovation

Prior to running, the logit model all the hypothesized explanatory variables were checked for the existence of multicollinearity problem using Variance Inflation Factor (VIF) to exclude the highly correlated explanatory variables. The highest VIF value for variables included in the model was 1.54 and the least was 1.28. The VIF values of the included independents variables of the model showed the model has no serious multicollinearity problem since none of the included variables has a VIF value equal to or greater than 10.

Five variables significantly influenced adoption of seed yam innovation as depicted in Table 3. Surprisingly, the indicators for outlet of sales (sales at the farm gate and village market) in this study did not have a significant relationship with adoption of seed yam innovations. This could indicate that at least at this stage and scale, outlet of sales does not affect the adoption of seed yam innovation. Even more puzzling is the non-significant effect of producer price given that seed yam innovation is labour-

intensive, which require high funding to cater for the task. This is probably because, demand for labour in the study area might also be low making the cost of labour for that matter also low hence farmers are not sensitive to producer price.

From Table 3 below, the Wald tests show that five factors were significant in explaining adoption of innovation in seed yam. Overall, the estimated model of

Table 3 - Determinants of seed yam innovation adoption.

VARIABLES	SEED YAM INNOVATION		
	LOG ODDS	ODD RATIO	MARGINAL EFFECT
Producer Price	-0.004	0.996	-0.000
	(0.168)	(0.168)	(0.165)
Addressing Complaints (yes)	1.579***	4.850***	0.200***
	(0.000)	(0.000)	(0.000)
Farm Size	-0.022**	0.978**	-0.002**
	(0.020)	(0.020)	(0.019)
Market Proximity	0.020	1.021	0.002
	(0.576)	(0.576)	(0.576)
Time of marketing (during)	0.003	1.003	0.000
	(0.494)	(0.494)	(0.494)
Competition	-0.004	0.996	-0.000
	(0.892)	(0.892)	(0.892)
Outlet of sales (farm gate)	0.006	1.006	0.001
	(0.376)	(0.376)	(0.374)
Outlet of sales (village market)	-0.007	0.993	-0.001
	(0.275)	(0.275)	(0.274)
Export	0.055***	1.056***	0.005***
	(0.001)	(0.001)	(0.001)
Market Integration	0.031***	1.031***	0.003***
	(0.002)	(0.002)	(0.002)
Transportation cost	-0.249***	0.780***	-0.024***
	(0.000)	(0.000)	(0.000)
Constant	4.320***	75.158***	
	(0.000)	(0.000)	
Observations	510	510	510
Deg freedom	11	11	
log likelihood	-160.667	-160.667	
Mc Fadden R^2	0.539	0.539	
LR test	375.478***	375.478***	
Classification	85.88%	85.88%	

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 data*

sample size 510 has a strong explanatory power, as the included variables correctly predict 85.88% of the observations. The model chi-square of 375.478 is significant at a probability level of 1% with a degree of freedom of 11. This shows that variables in the model other than the intercept term were useful in explaining the adoption of seed yam innovation.

Addressing of Consumer complaints

A positive and strongly significant (at $P<0.01$) factor in the likelihood to adopt seed yam innovations was famer's ability and willingness to address consumer complaints (Complaints) [see Table 4]. The result was consistent with the assertions of Liu *et al*, (2002); Bear & Frese, (2002); Calontone *et al*, (2002) and Sabri (2006). Farmers who were able to addressed consumer complaints and still willing to address any further complaints were found to be better adopters. Thus, farmers' ability to address consumer complaints increased their likelihood of adopting new seed yam strategies. A one-person increase in the ability to address consumer complaints increases the odds of adopting seed yam innovation by 4.850 (which is a 20% increase in the likelihood of adoption). This is mainly because farmers that addressed consumer complaints had access to detailed information about the interest, specifications, and standards of a customer or consumer, which intends increase consumers acceptance. Hence, producers having the ability to address the complaints of consumers would employ improved seed yam innovation in the shape of minisetts, small setts and milked seeds.

Farm size

Farm size was significant at 5% probability level with negative coefficient which is an indication of a negative relationship between farm size and seed yam innovation. This is consistent with the findings of Nnadi and Akwiwu (2007) but however disagree with the study report of Bolarinwa and Oladeji (2009). Considering the marginal effect (in Table 4) shows that, an additional increase in farm size by an acre decreases the likelihood of being an adopter of seed yam innovation by 0.2%. Moreover, the significance and negative influence of farm size on seed yam innovation adoption does not fully support the findings of Sall *et al.* (2000) and Nchinda *et al.* (2010). Sall *et al.* (2000) concluded that farm size has a negative but not significant influence on the adoption of improved rice variety in Senegal while the findings of Nchinda *et al.* (2010) proved similar outcome in the adoption intensity of improved seed yam technology in Cameroon. The negative and significance of the coefficient of farm size might suggest that the availability of land for yam production for most sampled households was high. Therefore adoption of seed yam innovation seemed not to be an option to increase production but rather increase in the acreage under cultivation

was. Moreover, most sampled households could not substitute large farm size cultivation to the risk involve in adopting seed yam innovations (especially minisett technology). Most sampled households perceived seed yam innovations (such as minisetts) as laborious which would end up in producing small tubers to feed mainly the export market and few consumers of the local market. However, the level of communication and trust between farm households and export agent/middlemen involved in gathering of yam for export and local market is very fragile and somewhat non-existing. Hence, farmers prefer to stick to their primitive technologies and increase their acreage under cultivation in order to increase production rather than to practice seed yam innovations.

Export of yam

The test of the null hypothesis that export (farmer's entry into foreign market) coefficient is zero against the alternative hypothesis has a coefficient of 0.055 corresponding to p=0.001, therefore the null hypothesis is rejected in favour of the alternative. The sign of the coefficient for export was as expected (positive). Based on the data set, a one percent increase in export by farm household would result in an increase in the odds of adoption of seed yam innovation by 1.056. Likewise, a percent increase in a household's entry into the foreign market (export) is likely to increase the probability of seed yam innovation (minisett/milk seeds/ small setts cuttings) by 0.5%. This positive role of foreign exposure is consistent with the results obtained by Mairesse and Mohnen (2005) assertions.

Integration into the Market Economy

The degree at which a household integrates itself into the market economy was found to have a positive sign for the coefficient and statistically significant at the 1-percent level indicating higher integration into market economy is associated with higher propensity to adopt seed yam innovation. Thus having an additional one percent increase in sales of yam would increase the probability of seed yam innovation being adopted by 0.3%. 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 in Table 4, it can be deduced that an increase in sales of yam may be translated into increase households' income. Therefore, farmers committing more of their produce to the market have higher income levels and are likely to put more emphasis on seed yam innovations to boost production and productivity.

Cost of Transportation

As can be shown in Table 3 the cost of transportation of yam from the farm to the urban markets affect the likelihood of adoption of seed yam innovation negatively and significantly (at $P<0.01$). Moreover, an increase in the cost of transporting a

"bunch of yam" (hundred tubers of yam) from the farm to the urban market by GhȻ1.00 decreases the log odds of adoption of seed yam innovation by 0.249. Similarly, the marginal effect shows that, an additional GhȻ1.00 spent on transportation decreases the probability of being seed yam innovation adopter by 2.4 percent. The relation established is unsurprising because from the survey it was observed that households pay higher cost for bigger tubers of yam when transporting. Therefore it is normal to find out that farmers paying low transportation fares adopted seed yam innovation (which results in the production of small and medium tuber sizes of yam). Furthermore, the relation also implies that households paying low transportation fares can save enough to pay for the perceived laborious nature of seed yam innovations. Therefore it is convincing for the study to assert that higher transport fares would promotes the adoption of seed yam innovation such as minisett technology.

Conclusion and Recommendation

The aggregate results after performing a logit regression revealed that households' ability and willingness to address consumer complaints, export, and integration into market economy positively and significantly influence the adoption of seed yam innovation. Contrary to this, farm size and cost of transportation significantly influences the adoption of seed yam innovation negatively. Thus five trade potential factors affect the likelihood of seed yam innovation adoption. Hence measures to improve farm households' integration into markets economy and especially foreign market would convincingly promote the likelihood of seed yam innovation adoption. Moreover, means of bridging the gap of trust between farmers and yam exporters or middlemen would also promote effective communication between the two parties which in effect can reduce the risk of seed yam innovation adoption to some extent and thereby promoting its adoption on large scale and elimination of the extra cost of transportation due to relatively large tuber size.

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