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Determinants of innovation behaviour among pig farmers in Northern Uganda

J. MUGONYA,[1*] S.W. KALULE [1] and E. K. NDYOMUGYENYI [2]
[1]Department of Rural Development and Agribusiness, Gulu University, P. O. Box 166, Gulu, Uganda
[2]Department of Animal Production and Range Management, Gulu University, P. O. Box 166, Gulu, Uganda
***Corresponding Author:** mugonyajohn@gmail.com

ABSTRACT
Attributable to poor market linkages, Ugandan pig farmers are taken advantage of by middlemen who pay low prices, recline the weight of pigs and default on payments. Farmer innovation can remedy the situation; however, the factors influencing pig farmers' innovation behaviour are not fully known. Further, extant studies on the subject tend to report findings on innovation behaviour as a composite variable other than its decomposed phases of exploration, experimentation, adaptation and modification of farming practices. This study therefore aimed at examining the influence of socio-economic factors on the phases of innovation behaviour among pig farmers in Northern Uganda. A cross sectional survey of 239 respondents was carried out and primary data were collected using pre-tested, semi-structured questionnaires between the month of October and November 2018. Tobit regression was employed for data analysis. The results revealed that personal selling affects all phases of innovation behaviour. In addition, i) exploration of new practices was affected by stock size, educational level and gender; ii) experimentation of new practices also depended on educational level; iii) adaptation of new practices was predicted by farming experience, extension service, access credit, non-farm employment, distance to town market and pork selling, and lastly iv) modification of existing practices was contingent on farming experience, access to extension service, access to credit, price negotiation ability, selling pigs to peer farmers and selling pork. Therefore, pig farmers operating in poorly developed value chains should as much as possible do personal selling of their pigs and pig products through informing their community members about the availability of piglets for sale on their farms, taking their pigs to the market or slaughtering pigs to sell pork instead of live pigs.

Keywords: Innovation phases, middlemen, pig production, pig value chain, Uganda

RÉSUMÉ
Les éleveurs de porcs ougandais profitent des médiocres liens du marché avec des intermédiaires qui paient des prix bas, inclinent le poids des porcs et font défaut de paiement. L'innovation paysanne peut remédier à la situation; cependant, les facteurs qui influencent le comportement d'innovation des éleveurs de porcs ne sont pas entièrement connus. De plus, les études existantes sur le sujet ont tendance à rapporter les résultats sur le comportement d'innovation en tant que variable composite autre que ses phases décomposées d'exploration, d'expérimentation, d'adaptation et de modification des pratiques agricoles. Cette étude visait donc à examiner l'influence des facteurs socio-

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économiques sur les phases du comportement d'innovation chez les éleveurs de porcs du nord de l'Ouganda. Une enquête transversale auprès de 239 répondants a été réalisée et les données primaires ont été collectées à l'aide de questionnaires semi-structurés pré-testés entre le mois d'octobre et novembre 2018. La régression Tobit a été utilisée pour l'analyse des données. Les résultats ont révélé que la vente personnelle affecte toutes les phases du comportement d'innovation. De plus, i) l'exploration de nouvelles pratiques a été affectée par la taille du stock, le niveau d'éducation et le sexe; ii) l'expérimentation de nouvelles pratiques dépendait également du niveau d'éducation; iii) l'adaptation des nouvelles pratiques était prédite par l'expérience agricole, le service de vulgarisation, le crédit d'accès, l'emploi non agricole, la distance au marché de la ville et la vente de porc, et enfin iv) la modification des pratiques existantes dépendait de l'expérience agricole, de l'accès au service de vulgarisation, accès au crédit, capacité de négociation des prix, vente de porcs à des pairs agriculteurs et vente de porc. Par conséquent, les éleveurs de porcs opérant dans des chaînes de valeur peu développées devraient autant que possible vendre personnellement leurs porcs et leurs produits en informant les membres de leur communauté de la disponibilité des porcelets à vendre dans leurs exploitations, en amenant leurs porcs au marché ou en abattant vendre du porc au lieu de porcs vivants.

Mots-clés: phases d'innovation, intermédiaires, production porcine, chaîne de valeur porcine

INTRODUCTION

Pig rearing is an important economic activity worldwide (FAO, 2011). The production and consumption of pig products such as pork have been on the rise in recent decades (Thornton, 2010). Pork production increased by factor 3.5 from 24.7 to 86.6 million metric tonnes between the year 1961 and 2002 in response to a comparable increase in demand (Speedy, 2003; Hartog, 2004; Ngapo *et al*., 2004), and this trend is unlikely to change in the near future. For instance, the Food and Agriculture Organisation of the United Nations (FAO) along with the International Food Policy Research Institute (IFPRI) and the International Livestock Research Institute (ILRI) projected an increase in meat production and consumption from 233 to 300 million metric tonnes between the year 2000 and 2020 (Delgado *et al*., 1999). Such projection statistics coupled with the fact that pork exports are said to be four times more profitable compared to the export of grains (Hartog, 2004), shed light of a bright future on the narrative of the market outcomes for pig and pork marketing.

The importance of pig production and consumption is not any different in Sub Saharan Africa (SSA), and specifically, Uganda as a country. While emphasizing the importance of pigs, IFPRI pig production report shows that Uganda is ranked third in SSA producing about 12% of the region's pig meat following Nigeria and South Africa (Guo, 2015). That aside, at an annual consumption rate of 3.4 kg per person, Uganda has the highest per capita pork consumption in SSA (Ballantyne, 2012).

Unquestionably, pork is a good source of high-quality proteins and so responds to both the nutritional and food security needs of many households (Mutetiika and Nabasirye, 2010; Eliakunda and Milan, 2017). For this reason Tatwangire (2013) and Mulindwa (2016) contended that pig production could accelerate Uganda's economic development through improving livelihoods of smallholder farmers and provision of employment. Moreover,

many smallholder farmers have a desire to rear pigs due to their unique characteristics. These include i) faster growth rates; ii) ability to be kept on a small piece of land; iii) high rate of multiplication; iv) ability to be fed on many different crops and animal products and by-products; v) high feed conversion efficiency; and vi) early maturity and short generation interval (Muhanguz*i et al*., 2012; Ndyomugyenyi and Kyasimire, 2015).

The massive opportunities and benefits that pig rearing offers to smallholder farmers and to the economy notwithstanding, production and marketing in Uganda is still limited by inadequate pork processing facilities and practices; parasites and diseases; derisory access to market information; inadequate access to inputs, extension services, financial services and insurance; poor market linkages; absence of institutional frameworks for marketing and low levels of export of pigs and pig products (Ouma *et al*., 2013; Tatwangire, 2013; Birungi *et al*., 2015; Mulindwa, 2016). Such constraints hinder the development of the pig value chain in the country.

Many scholars have suggested that the key to pig value chain development is nurturing farmers' capacity for innovation. This in the long run results in improved competitiveness of the pig-based farms. In turn, this contributes to the redistribution of value added benefits across the value chain actors, and most particularly, the smallholder farmers (Johan and Alm, 2014; Chopeva *et al*., 2015; Makosa, 2015).

Notably, innovation behaviours among pig farmers are important for value chain upgrading and overall agribusiness. However, farmers have hardly engaged in innovations that would guarantee higher gains from the value chain, for instance, in slaughtering and processing of pig products or making off-farm efforts of searching for the best market (Tatwangire, 2013; Access, 2017). As a result farmers are reduced to only 'price takers' since they are taken advantage of by middlemen who purportedly pay low prices for the pigs, recline the live weight of animals and often do not pay on time (Muhanguzi *et al*., 2012; Riedel *et al*., 2012; Etwire *et al*., 2017; Kamaghe *et al*., 2017).

Research on pig value chain (production and marketing) in Uganda is very rich. For example, the International Livestock Research Institute (ILRI) highlights opportunities and limitations in the pig value chain (Access, 2017). There are also breeding studies done by Makerere University in which Mutetiika *et al*. (2010) and Noce *et al*. (2015) have suggested that artificial insemination is an appropriate technology which when embraced by farmers could enhance disease control. Other studies have also given attention to feed conservation technologies (Asindu *et al*., 2017; CIP, 2017). Yet again, Tatwangire (2013) and Mulindwa (2016) articulated that the Government of Uganda has been supplying piglets to farmers through several development interventions such as National Agricultural Advisory Services (NAADS) and "Bona-bagaggawale" (prosperity for all) programmes. However, studies that examine the innovation behaviour of smallholder pig producers, that would guarantee improvement and/or development of the pig value chain, are limited in research literature.

Previous research has tended to rely on socio-economic factors (for instance education, age, and sex) to explain farmer innovation behaviour (Tirfe, 2014; Chopeva *et al*., 2015). Nevertheless, there is hardly any research that attempts to analyze the effect of these socio-economic factors on the phases of innovation behaviour (exploration, experimentation, adaptation and modification of farm practices) in agribusiness. Even then, such reseach has largely been in the context of seed and crop production systems which present perspectives differing from those in the pig value chain (Tirfe, 2014).

Therefore, this study sought to determine the influence of socio-economic factors on the

phases of innovation behaviour among pig farmers in Northern Uganda. The results will inform how the interventions to improve the pig value chain should be tackled using the innovation phases' approach.

METHODOLOGY

Description of the study area. The study was conducted in communities of Acholi Sub-region in Paicho sub-county, Gulu district and Koro sub-county, Omoro district, Northern Uganda. The geographical coordinates are 2.8186 N, 32.4467 E and 2.7152 N, 32.4920 E for Gulu and Omoro, respectively. The region has fertile soils, a hot dry climate with two rainy seasons, and an altitude that ranges between 600 and 1,200 m above the sea (JICA, 2011). Agriculture in the study area is largely rain-fed with a mixed crop-livestock system in which annual crops such as soybean, sunflower, sesame, sweet potatoes, finger millet, beans, cassava, groundnuts, maize and vegetables are grown alongside rearing of animals such as pigs, goats, sheep and cattle (FAO, 2018).

Gulu has two constituencies, Aswa county and Gulu Municipality. Paicho sub-county is situated in Aswa county and has a total land area of 457.8 square kilometers (UBOS, 2013a). On the other hand, Omoro district is made up of two counties and seven sub-counties. Koro sub-county is located in Tochi county and has a total area of 215.5 square kilometers with a total population of 28,611 (UBOS, 2017b). The two districts were selected because they were rated among the lowest pig producing districts in Uganda (Tatwangire, 2014). It was expected that Omoro district would give the study perspective on events in the rural markets while Gulu district would give the outlook of urban/ terminal markets.

Sampling. The study employed a cross sectional design where data were collected from smallholder producers of pigs between October and November 2018. The design was chosen because it is a one-time research approach and thus it is cost effective in terms of time and financial resources (Levin, 2006). It was also appropriate for collecting data for achieving objectives and hypothesized relationship in the conceptual framework of this study.

A multi-stage sampling technique was employed to select study participants. Firstly, the two districts, Gulu and Omoro, were selected purposively because pigs in these districts have been reported to have a lucrative market and high turnover (Ikwap *et al*., 2014), yet farmers hardly exploit existing opportunities for own gain. Secondly, Paicho sub-county in Gulu and Koro sub-county in Omoro district were also selected purposively since they have the highest number of pig rearing households in the two districts (UBOS, 2017a, 2017b). Thirdly, a list of all pig-rearing households which had benefited from the National Agricultural Advisory Services (NAADS) program was obtained from the respective sub-county headquarters. The list had 393 farmers from Paicho and 201 from Omoro bringing the sampling frame to 594 farmers. Systematic random sampling was done to obtain a study sample of 239 respondents using a skip interval of eight. The sample size was arrived at based on Slovin's formula (Yamane, 1967) as shown below;

$n=N/1+Ne^{2}$, $n=594/1+594^{2}$, $n = 239$. Where; N = population, n = Sample size, e = Degree of confidence level at 95%.

The enumerators interviewed 96 pig farmers from Omoro and 143 pig farmers from Gulu district. This is because Gulu contained 1.49 times more pig farmers than Omoro (UBOS, 2013b).

Data collection. Before starting data collection, the study was approved by Gulu University Research Ethics Committee (GUREC) under application number GUREC-094-18 and an informed consent was sought from every respondent prior to commencing the interview.

Face to face interviews were employed to collect primary quantitaive data using pre-tested, semi-structured questionnaires which allowed for clarification of ambiguous answers and completion of all questions in the tool (Opdenakker, 2006; Akidi, 2016). Pre-testing was done on 10 pig farmers in Unyama sub-county because the sub-county had many pig farmers and yet it was not one of the sub-counties under study. Additionally, it was also not far away from the study area. After the pretest, some amendments were made in the questionnaire such as re-wording and re-ordering some questions to ensure clarity, logical question sequence and instruction adequacy. The questionnaires were administered by research assistants recruited and trained from the study area for purposes of conducting the interview in the local dialect.

The questionnaire comprised of closed and Likert scale questions in which participants were requested to rate various items so as to ensure clarity of the questions to the respondents for easy answering. Some questions were multi-choice requiring respondents to choose one or more items from a list of choices which resulted in a faster processing speed because the study participants did not have to answer in wordy statements.

The data collection tool consisted of two parts. Part one captured socio-economic information which included age of the household head, education level, sex, household size, marital status, non-farm employment and group membership. The second section gathered data on pig production, marketing and access to institutions and institutional services. The variables included; farming experience (years), current pig stock size (number of pigs), pork selling (1=yes, 0=no), price negotiator (1 = yes, 0 = no), distance to the nearest market (km), access to extension services (1 = yes, 0 = no) and access to credit (1 = yes, 0 = no).

Farmer innovation behaviour was captured under the four phases of the innovation process namely :i) exploration, ii) experimentation, iii) adaptation of new pig rearing techniques/ practices, and iv) modification of existing farm practices as adapted from previous research (Ho and Wu, 2011; Aubert *et al*., 2012; Wilson *et al*., 2014; Coussy, 2015; Björklund, 2018; Tunde *et al*., 2018). A total of 12 items were used to collected data on innovation behaviour. Each item was rated on a five point Likert scale where 1 = not at all and 5 = always to ensure a high response rate. A sample item on innovation behaviour from the domain of exploration of new farming practices reads as follows: "I am very curious about learning how to appropriately feed pigs".

Data analysis. Previous research has shown that the innovation process of the farmers involves four phases namely exploration of new practices, experimentation of new practices, adaptation of new practices and modification of existing practices (Tidd *et al*., 2001; Khorakian, 2011). Accordingly, this study constructed the dependent variable based on these four indicators of the innovation process. Likert scale data were used to compute the indices for the dimensions of the innovation behaviour as shown in equation

$$X_{i,k} = \sum_{j=1}^{j=n} a \Big/ b \quad \text{.....(1)}$$

where;

X = index for the phase of innovation behaviour

$i = i^{th}$ sampled pig producer

$k = k^{th}$ phase of the innovation behaviour which includes exploration, experimentation, and adaptation of new pig rearing practices; and modification of the existing farm rearing practices

j = number of items for a given phase of innovation behaviour

a = individual score for a specific item by i^{th} sampled farmer involved in pig production

b = the sum of ratings of the i^{th} respondent for the k^{th} phase of innovation behaviour

All items were rated on 1-5 point Likert scale with 1 (not all) being the lowest score and 5 (always) being the highest score.

A sample item for exploration is "I like to learn new ways of housing pigs"; that of experimentation is "among my peers, I am usually the first to try out new pig rearing practices". For adaptation, the sample item is "I alter new pig feeding practices to fit my situation" and lastly for modification of existing pig rearing practices "I use new knowledge to modify existing pig feeding practices on the farm". In this study, and based on research literature, innovation behaviour was postulated to be a function of socio-economic factors. Thus, the factors that influence innovation behaviour among pig producers were analysed as

$$Inno\_Behaviour_{i,k} = \beta_0 + \beta_i[Soc.Econ]_i + \varepsilon_i$$

.....(2) where;

Inno_Behaviour = level of innovation behaviour of the pig producers
$i = i^{th}$ sampled pig producer
$k = k^{th}$ phase of the innovation behaviour and includes exploration, experimentation, and adaptation of new pig rearing practices; and modification of the existing farm rearing practices
β_o = constant
β_i = various parameters to be estimated
Soc.Econ = social economic factors (described in Table 1)
ε = the error term
Since the dependent variable comprised of indices that ranged between zero (0) and one (1), it meant that ordinary least squares methods would not be an appropriate estimator. Accordingly, the Tobit model that efficiently analyses data censored between 0 and 1 was preferred to analyse the effect of the independent variables which included farming experience, gender, stock size, access to extension services and access to credit on the phases of farmer innovation behaviour using STATA 13.0. The predictors in the model were first tested for multicollinearity using the Variance Inflation Factor (VIF). All predictors had VIF below 4.0 and the mean VIF was 1.4 indicating that the explanatory variables were not associated with each other in the model. Table 1 shows the variables used in the data analysis.

RESULTS AND DISCUSSION

Characterization of pig farmers in the study area. Results in Table 2 revealed that a large number of pig farmers (73.6%) were males probably because the activity has quick financial returns and males still dominate ownership, access and control of key production resources such as land and finance in many households in SSA and thus find it easy to invest in pig rearing (Njuki *et al*., 2011). This is in agreement with the finding of Mwanyumba (2010) who reported that women farmers were less likely to have control let alone ownership over these resources which possibly hinders their engagement in many agricultural enterprises.

The majority of the farmers (52.3%) were aged between 30 and 50 years old with the mean age of the dataset standing at 37.732 years which is similar to the findings of Chindime *et al*. (2017) among dairy farmers in Malawi. Oladee bo and Oladeebo (2008) asserted that this age bracket of farmers is able to explore and make sound decisions which may result in innovation.

All farmers in the sample had at least received some form of formal education and it was only the level attained that differed amongst them. The mean number of complete years spent in school was 7.209. This may be attributed to the effect of Universal Primary Education (UPE) which was introduced by the Government of Uganda in 1997 to enable all children to attain at least primary education (Bategeka and Okurut, 2006). Predictably, there were more farmers with primary education compared to those with secondary and post-secondary education.

Table 1. Description of explanatory variables

Independent Variable	Description	A priori sign expectation and source
Farming experience (years)	Continuous	+ (Ndambiri *et al*., 2012; Ndunda and Mungatana, 2013; Tirfe, 2014)
Stock size (number of pigs)	Continuous	+(Garcна-Martнnez *et al*., 2016)
Access to extension	Dummy 1 if yes, 0 no	+ (Ndunda and Mungatana, 2013)
Access to credit	Dummy 1 if yes, 0 no	+(Ndunda and Mungatana, 2013)
Non-farm employment	Dummy 1 if yes, 0 no	+ (Tirfe, 2014)
Price negotiation ability	Dummy 1 if yes, 0 no	+/-
Personal selling (indices)	Continuous	+ (Chindime *et al*., 2017)
Group membership	Dummy, 1 if yes, 0 no	+ (Tirfe, 2014)
Distance to market (km)	Continuous	+ (Chopeva *et al*., 2015; Chindime *et al*., 2017)
Age (years)	Continuous	+/- (Chopeva *et al*., 2015; Tirfe, 2014)
Education level (years)	Continuous	+ (Chindime *et al*., 2017; Chopeva *et al*., 2015; Tirfe, 2014)
Gender	Dummy 1 if male, 0 female	+/- (Chindime *et al*., 2017; Chopeva *et al*., 2015; Tirfe, 2014)
Sell pigs to peer farmers	Dummy 1 if yes, 0 no	+/-
Sell pork	Dummy 1 if yes, 0 no	+ (Tatwangire, 2013)

The number of pig farmers with access to credit and extension services was below 40% which points to the need for a boost in efforts geared towards agricultural extension services and financial sector deepening in the country. Further, 42.30% of the respondents participated in some form of non-farm employment; 16 % of these were involved in running small retail shops in trading centers while others earned from the provision of labor to other farms, riding boda boda (passenger service motorcycles), and running pork joints, burning charcoal and brewing alcohol, among others.

As regards the effect of socio-economic factors on phases of innovation behaviour, the Tobit regression results (Table 3) revealed that all the four specified models were highly significant at P≤0.01. Interestingly, the findings show fewer significant socio-economic factors that affect the farmer innovation behaviour for the first two phases of the innovation process compared to the latter two phases of the same process. Promotional activities for pigs and pig products using personal selling had a positive significant effect across the four phases of farmer innovation process. For exploration of new pig rearing practices, this explanatory variable was statistically significant at P≤ 0.1 and at P≤ 0.01 for all the other phases of innovation behaviour. Farmers who do personal selling, for instance by informing peer farmers about the availability of piglets for sale on the farm, and taking pigs to the market or trading center were found to be 16.6% more explorative, 30.5% more experimental, 42.4% more adaptive and 47.4% more able to improve existing pig rearing techniques. This could be attributable to the fact that through personal selling farmers interact with different people which enables them to access knowledge, markets, and finance (Chindime *et al*., 2017). This information access through appropriate market searches is likely to offer farmers knowledge of the market outlook prompting them to innovate suitable ways of staying afloat.

It was detected from the results that stock size has a negative significant effect on the exploration index of farmers (P≤ 0.05). A unit percentage increase in the number of pigs leads to a 0.003 decrease in exploration index of the farmer. This result suggests that the bigger the size of the pig stock kept by a farmer, the less the level of exploration of new pig rearing practices. Farmers

with many pigs tend to have a greater experience about pig husbandry than those with few pigs. On the other hand, farmers with fewer numbers of pigs were largely new in the pig farming business and thus needed to explore to learn and gain knowledge and skills required for them to succeed in their new venture.

Education status significantly affected farmers' exploration and experimentation of new pig production and marketing techniques ($P \leq 0.05$). An additional year of schooling increased both exploration and experimentation indices by 0.009 and 0.010, respectively. More educated farmers tend to have a better attitude towards innovation which enhances their potential to acquire, analyze and utilize information (Tirfe, 2014; Chopeva *et al*., 2015; Chindime *et al*., 2017). Additionally, formal education exposes farmers to experiments while in school which makes them appreciate the value of testing something new to know its demands and actual benefits before taking it up.

Gender only significantly affected the level of exploration of the farmer ($P \leq 0.05$). Males were found to be 7.7% less explorative than females. This could be attributable to the fact that males do rarely attend agricultural extension meetings and trainings compared to the females (Anandajayasekeram *et al*., 2008). Further, Tirfe (2014) articulated that women have specific socio-economic challenges which hinder implementation of their ideas such as the burden of household care and less endowment with capital assets such as land. This may prompt them to inspect their surroundings in the quest for a lasting solution to these challenges which limit their pig production and marketing potential.

The results provided statistically significant evidence that farming experience predicts the adaptation of new practices and the modification of existing practices by farmers ($P \leq 0.05$). A unit percentage increase in farming experience increases the farmers' adaptation index by 0.005 and their modification index increases by 0.007.

Table 2. Respondents' socio-economic profile (n=239)

Profile	Category	Frequency	Percentage (%)	Mean	SD
Gender	Male	176	73.6	-	-
	Female	63	26.4		
Non-farm employment	Yes	101	42.3	-	-
	No	138	57.7		
Access to credit	Yes	82	34.3	-	-
	No	157	65.7		
Price negotiator	Yes	185	77.4	-	-
	No	54	22.6		
Pork seller	Yes	29	12.1	-	-
	No	210	87.9		
Sells pigs to peer farmers	Yes	118	49.4	-	-
	No	121	50.6		
Access to extension services	Yes	86	36.0	-	-
	No	153	64.0		
Personal selling (indices)				0.713	0.419
Education (years in school)				7.209	3.452
Age (years)				37.732	13.364
Stock size (Number of pigs)				5.782	6.491
Farming experience (years)				16.933	13.692
Distance to town market (km)				0.611	2.949

Ndambiri *et al*. (2012), Ndunda and Mungatana (2013) and Tirfe (2014) asserted that experience gives farmers more knowledge about their agricultural system and the requirements to develop an ability to skillfully assess features of new farming techniques so as to make informed decisions. These firm choices may be related to resource deployment and may be backed up by deliberate efforts of adaptation through information search to understand consumer needs so as to devise cost-effective means of meeting these needs (Hofer and Schendel, 1978; Perez *et al*., 2010). This could be the basis for adaptation and modification of pig rearing practices.

Access to extension services had a positive significant effect on adaptation of new practices (P≤ 0.05) and modification of existing pig production and marketing practices (P≤ 0.10). Farmers who had access to extension services were found to be 7.6% more adaptive and 6.6% more able to modify existing practices than those who did not have access to extension services. This is because extension services avail farmers with information and knowledge required to adjust their pig rearing practices to suit their unique farming situations (Kibwika, 2013; Läpple *et al*., 2015). This result corroborates with that of Ndunda and Mungatana (2013) in which access to agricultural extension was found to significantly impact the farmers' use of innovative approaches for risk reduction in water irrigated farming. Additionally, agricultural extension through demonstrations and farmer field schools enables peer learning and adaptation of tools and techniques to fit individual farmer's conditions (Hermans *et al*., 2015). This particular finding is of paramount importance to the farmers and the State because

Table 3. Tobit results of socio-economic factors affecting innovation behaviour

Predictor	Farmer Innovation behaviour			
	Exploration of new practices	Experimentation of new practices	Adaptation of new practices	Modification of existing practices
	β (SE)	β (SE)	β (SE)	β (SE)
Farming experience	-0.002 (0.002)	0.002 (0.002)	0.005 (0.002)**	0.007 (0.003)**
Stock size	-0.003 (0.001)**	-0.000 (0.002)	0.002 (0.002)	0.002 (0.003)
Access to extension	0.018 (0.026)	0.034 (0.028)	0.076 (0.030)**	0.066 (0.040)*
Access to credit	-0.044 (0.030)	0.010 (0.034)	0.075 (0.032)**	0.092 (0.043)**
Non-farm employment	-0.043 (0.027)	0.033 (0.029)	0.061 (0.030)**	0.061 (0.038)
Price negotiation ability	-0.027 (0.032)	0.046 (0.035)	0.048 (0.034)	0.116 (0.044)***
Personal selling	0.166 (0.094)*	0.305 (0.107)***	0.424 (0.112)***	0.474 (0.130)***
Group membership	-0.011 (0.028)	0.022 (0.034)	0.004 (0.032)	-0.024 (0.043)
Distance to the market	0.003 (0.003)	-0.003 (0.003)	-0.007 (0.003)*	0.002 (0.007)
Age of household head	0.001 (0.002)	-0.001 (0.002)	0.000 (0.002)	-0.002 (0.002)
Education level	0.009 (0.004)**	0.010 (0.005)**	0.007 (0.005)	0.005 (0.006)
Gender	-0.077 (0.034)**	0.002 (0.037)	-0.022 (0.035)	0.047 (0.044)
Sell pigs to peer farmers	0.031 (0.027)	0.047 (0.030)	0.040 (0.029)	0.123 (0.038)***
Sell pork	-0.038 (0.371)	0.060 (0.040)	0.168 (0.043)***	0.194 (0.065)***
Constant	0.974 (0.102)***	0.421 (0.106)***	0.133 (0.100)	-0.067 (0.120)
Log likelihood	-42.369	-19.686	-5.570	-56.416
F (15, 224)	2.57	2.42	7.54	10.06
Prob > F0.002	0.004	0.000	0.000	
Pseudo R^2	0.2395	0.4421	0.8846	0.4338

*****Significant at P ≤ 0.01, **Significant at P ≤ 0.05, *Significant at P ≤ 0.1**

it alludes to the fact that reinforcement and promotion of an effective agricultural extension system could yield better innovation performance by farmers and thus better household food and nutrition security and income.

Access to credit had a significant positive effect on farmer adaptation index and modification index (P≤0.05). Farmers with access to credit were 7.5% more adaptive and 9.2% more able to improve existing rearing practices than those who did not have access to credit. This is attributable to the fact that access to credit equips farmers with financial resources to enable them to look for new technology, purchase appropriate farming tools, adapt new practices and modify existing tools and techniques. This result is consistent with the findings of Ndunda and Mungatana (2013) and Chindime *et al*. (2017) in Kenya and Malawi, respectively. Therefore, there is a need for the provision of affordable credit schemes to enable farmers to borrow easily to boost their farm innovation activities for better competitiveness.

Empirical results revealed that non-farm employment had a significant positive effect on adaptation (P≤ 0.05). Farmers engaged in non-farm activities had a 6.1% higher adaptation index than those without non-farm engagement. Non-farm employment tends to expose farmers to other individuals who could share with them new ideas and new ways of doing things through social interaction. Further, the additional non-farm income reduces the liquidity constraint of farmers and may be used to inquire and alter new ways of rearing pigs giving an innovative edge to farmers with non-farm employment. This result is consistent with the findings of Tirfe (2014) among farmers in Ethiopia in which diversification was linked to more capital availability, access, implementation and improvement of new ideas. Therefore to reduce the credit constraint and enhance innovation behaviour of pig farmers, there is a need for them to access off-farm income.

Distance to the town market negatively affected the adaptation index of farmers (P ≤ 0.10). A unit increase in distance to the town market decreased the adaptation index by 0.007. This finding suggests that farmers who live near to the market adapt new farming techniques more than their counterparts who live farther away from the market. This is attributable to the fact that farmers who live near markets tend to easily get information and knowledge of the changing market demands from the town dwellers which enables them to quickly adjust new techniques so as to meet the revealed customer needs. Additionally, transaction costs such as transportation and storage costs involved in accessing the market are low for farmers who live near markets. This may motivate them to innovate so as to capture the market which exists in their proximity.

The sale of pork instead of live pigs was found to have a significant effect on adaptation and modification index (P ≤ 0.01). That is farmers who sold pork were found to be 16.8% and 19.4% more able to adapt new practices and modify existing practices respectively than their peers who sold live pigs. This could be attributed to the fact that selling live pigs is the norm in many pig farming households (Tatwangire, 2013), therefore, selling pork perhaps requires some level exposure, awareness and a disruption of the status quo which likely makes these farmers more innovative.

Price negotiation ability had a positive significant effect on modification index (P≤ 0.05). Farmers who negotiated the selling price with buyers were found to be 11.6% more likely to modify existing pig rearing practices than those who determined the price by other means such as taking the buyers' price or prevailing market price. Farmers who negotiate prices tend to be more inquisitive, confident and determined. These three characteristics could propel them to improve existing pig rearing practices.

The sale of pigs or pig products to peer farmers significantly affected the modification index ($P \leq 0.05$). Farmers who sold their pigs to peer farmers were found to be 12.3% more able to modify existing practices compared to those who sold to others such as butchers and middlemen. This is possibly because peer farmers would easily connect and interact with the seller which favors sharing of experiences while middlemen and butchers, on the other hand, would be interested in keeping as much market information as possible from the selling farmer.

CONCLUSIONS AND RECOMMENDATIONS

This study has shown that personal selling of pigs and pig products by farmers greatly enhances their innovation behaviour which translates into better income from the enterprise. Therefore, it is worth recommending that interventions for improvement of the pig value chain should encourage farmers to actively involve themselves in marketing their pigs so as to earn better prices. Based on the findings of this study, it can be inferred that access to extension and credit services boosts farmers' adaptation and modification of technology thus ensuring competitive and sustainable agriculture. Accordingly, there is need to entrench farmer financial inclusion and the use of well-trained agricultural extension agents to offer agricultural educational programs and trainings to pig farmers for better farmer innovation and gains. On their part, farmers need to attend agricultural extension trainings and utilize the information acquired to improve their pig farming and marketing activities.

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STATEMENT OF NO CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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