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Production Scale and Dung/Manure Management of Pig Farmers in Ifo Local Government Area of Ogun State

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Abstract: Over the years, structural changes in pig production has led to obvious increase in scale of production through the establishment of medium to large industrial sized pig farms. This has given rise to monumental increase in pig dung with attendant waste management challenges that need to be addressed. This paper seek to analyze the impact of structural changes in pig production and how they affect manure management practices. Data were collected from three hundred pig farmers in Ifo local Government Area through the use of questionnaire. These data were analysed using mean, standard deviation and multinomial logit regression. The results showed that the scale of pig production has an important impact on the pattern of pig manure management. Moreover, the results from descriptive statistics and multinomial estimation suggest that smaller pig producers are more likely to apply pig manure to their own lands, while larger pig producers are more likely to sell the manure or find other ways to dispose of it. It was recommended among others that environmental policies that encourage greater manure treatment should be encouraged.

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1. Introduction

Historically, many rural households in Southern part of Nigeria raised between one to five pigs, typically on a free range. One pig typically provides enough pork for a rural household of four, so long as the meat can be stored to last, but often households would trade pork/pig for other products when pigs were slaughtered to provide meat. Thus, the pork from these operations was typically consumed and sold in the market. However, as markets expanded, more households expanded production and sold their pigs outside the village. These small scale yet very commercial operations became one of the major activities in the agricultural sector and a major source of income for many farmers, especially poor farmers, in rural areas.

Today, the world population of pigs runs into billions. For example, in the United States of America alone where one farmer rears as much as 4,000 to 5,000 sows, more than ten million pigs are slaughtered each year (Bruno *et al.,* 2008). Similarly, in Vietnam with a human population of 80 million, pig population, has shot up to a recognizable 19 million pigs within a decade (Gerd'de and Tondeur, 2001). In Nigeria, the population of Pigs is estimated to be 7.1million as at 2016. There is commensurate increase in pork demand over the years, and continuous expansion is expected via increasing number of pigs per farm.

Throughout the country, especially in many southern states, the challenge of handling pig dung is recognized as a major issue in sustaining the growth of the industry (Okoli *et al.,* 2006). The environmental and health concerns in all pig production businesses therefore, have to do with the waste management problems. Besides foul odor, the hydrogen sulphide, ammonia and other gases emitted by stored pig manure can diminish air quality (Spence *et al.,* 2008). The disagreeable odor can also lead to tension between pig producers and their neighbours, which can evoke litigations and risk of possible shut down of production (Oseghale, 2010). Another serious concern is the unscrupulous behavior of some pig farmers who would indiscriminately dump faecal matter into nearby natural water supplies, thus making them unsuitable for human consumption. Furthermore, manure generates heat as it decomposes, and can in fact ignite spontaneously should it be stored in a massive pile, (State News, 2007). Once such a large pile of manure starts burning, it fouls the air over a very large area and requires considerable effort to extinguish, thus polluting the air with attendant greenhouse gas effect. This calls for effective measures to contend systematically, the accumulation of pig dung from large feedlots, as there is no risk of spontaneous combustion in smaller operations.

Another important reason behind the heated discussion regarding pig manure disposal and pollution is the transition in pig manure management, led by the structural change in pig production. Traditionally, pig producers in Nigeria are small-scale backyard producers. At this scale, pig manure, as well as other livestock and poultry manure, is easily utilized as fertilizers by the producers on their own land. However, manure management practices of larger, more commercial pig producers are significantly different from those of backyard producers. Rather than applying pig manure to their own land, larger pig producers must find other means by which to dispose of the manure produced by their operations.

With the recent favourable policy environment and various lending programmes of central bank to farmers such as anchor borrowing scheme and Nigerian Risk-Sharing System of Agricultural Lending (NIRSAL), Nigeria's pig production is experiencing a rapid transition from small-scale backyard production to larger-scale commercial production. Since manure management practices of backyard and commercial pig producers are significantly different, these structural changes have generated concern over the environmental effects of pig manure management with increasingly large operations. To the best of our knowledge, no empirical study investigates the impact of structural changes in pig production on manure management and the environment in Nigeria. Previous studies either just documented these changes, or concentrated on the identification of factors affecting the evolution. This study aim at addressing the manure management implications of increasing concentration in pig production and the impact on the rural environment. Specifically, the study seek to first, document the pig manure management practices of pig producers at the study area, looking mostly at how size affects management practices; second, to estimate the net impact of further consolidation in pig production on manure management; and third, to discuss the environmental impact of the consolidation of pig production at the study area.

2. Methodology

2.1 Study Area

Ifo Local Government Area (LGA) of Ogun State has the headquarters in Ifo town with total area of 521km^2 and a population of 524,837 according to 2006 census. It is the home to Oke-Aro Farm settlement which has the largest concentration of pig farmers in Nigeria spanning an area of 30 hectares and has patronage from as far as Republic of Benin.

2.2 Data

Purposive sampling technique was used to gather information from pig farmer as pig farming is a popular enterprise in Ifo local government area. Thus, Ifo LGA was selected due to rising status of pig farming enterprise in the area. Three Hundred (300) Farmers were interviewed regarding the inventory of pigs in different size categories of operations. Socio-economic information such as the number of pigs and feeding processors and infrastructure were collected. By doing so, we were able to gather information regarding small-scale, medium-scale, and large scale producers in the study area. Information were elicited about each sample farmer with respect to the basic household characteristics (e.g. the family size, labor endowments, farm size, and total asset value), the demographic information such as gender, age, education, and marital status of each farmer was gathered and recorded. Specifically, questions about whether each pig farmer had off-farm employment and how much time they spent engaged in off-farm work were asked.

In addition to the basic characteristics of the farmers' household and labor, the interview elicited information on total number of pigs that the farmer raised in 2015 and detailed information regarding their methods of handling pig manure. On the basis of this, pig manure management is classified into four categories: self-use (pig manure is either applied to farmer's land directly or used to produce biogas first); sale; feed (mainly for fish); and discard.

2.3 Analytical Technique

Estimation Model

To isolate the impact of pig production scale and other factors on pig manure management multinomial logit regression model was used. The advantage of the multinomial logit is that it permits the analysis of decision across more than two categories, allowing the determination of choice probabilities for different manure management. if we run single-equation models using ordinary least squares (OLS) for self-use, sale, feed, and discard, individually, we run into seemingly unrelated bias (Zellner, 1962). In this approach, these four independent equations are estimated separately by OLS and the estimated parameters are used to predict the proportions of self-use, sale, feed, and discard. However, this assumption of independence is not supported, since if a factor has a positive impact on the share of self-use of pig manure, then it must have a negative impact on the share (s) of other methods of pig manure management. As the proportions of the different pig manure management methods are correlated, it is expected that the equations for predicting these will be interrelated. Thus, we can expect that the single-equation approach will be inefficient from a statistical point of view (e.g. Judge et al., 1988), the multinomial logit is adopted as it shows superior features to any other model in that it was able to give contemporaneous correlations among the variable categories. Multinomial logit has S possible states or categories that is S=1, 2, 3…….,S that are exclusive and exhaustive (Nkamleu and Coulibaly, 2000). In this analysis, the probability of a pig farmer manure management is characterised as a polychotomous choice between four mutually exclusive alternatives. Let U_{ij} denotes the utility that the farmer derive by choosing one of the four outcomes and $U_{ij} = {}_{\gamma j} X_{ij} + eij$ Where: γj varies and X_{ij} remains constant across alternatives; and eij is a random error term reflecting intrinsically random choice behaviour, measurement or specification error and unobserved attributes of the alternative outcomes. Let also P_{ij} (j = 0, 1, 2, 3) denotes the probability associated with the four categories, where j=0 is the probability of self-use, j=1 is the probability of sale and j=2 feed, and j=3, discard as form of manure management. Because the multinomial logit model does not treat these categories in any continuous order, it is different from ordered or sequential logit/probit models (Ameniya, 1981).

The multinomial logit model (Babcock et al., 1995), is given by

$$P_{ij} = \frac{\exp(\gamma j Xi)}{4}$$

$$1 + \sum_{j=1} \exp(\gamma j Xi), \quad \text{for j=1,2,3,4 (1)}$$

P_{ij} is the probability of being in each of the groups 1, 2 and 3.

$$P_{i0} = \frac{1}{4}$$

$$1 + \sum_{j=1} \exp(\gamma j Xi), \quad \text{for j=0 (2)}$$

P_{io} is the probability of being in the reference group or group 0.

In practice, when estimating the model, the coefficients of the reference group are normalized to zero (Maddala, 1990; Greene, 1993; Kimhi, 1994). This was because the probabilities for all the choices must sum up to unity (Greene, 1993). Hence, for 4 choices only (4-1) distinct sets of parameters can be identified and estimated.

The natural logarithms of the odd ratio of equations (1) and (2) give the estimating equation (Greene, 1993) as

$$\text{In} \frac{\lfloor P_{ij} \rfloor}{[P_{i0}]} = \gamma j X_i \quad (3)$$

This denotes the relative probability of each of group 1, 2 and 3 to the probability of the reference group. The estimated coefficients for each choice therefore reflect the effects of Xi`s on the likelihood of the pig farmer adopting sale, feed, and discard manure management relative to the reference group. However, following Hill (1983), the coefficients of the reference group may be recovered by using the formula γ3 = -(γ1 + γ2). For each explanatory variable, the negative of the sum of its parameters for groups 1, 2 and 3 is the parameter for the reference group. This however was not generated in this study.

Dependent Variable:

Y_1= probability of sale as manure management

Y_2= probability of using manure as feed,

Y_3= probability of discard as manure management

Y_4= probability of Self-use of manure

In this analysis, the fourth category (self-use), is the "reference state"

Independent Variables:

The independent variables which are the economic and demographic variables that influence the choice of manure management following Huang, Qiao, Liu, Jia, Lohmar, (2016) include:

X_i= Wealth

X_j = Household Characteristics variables, and

X_k =Pig farmer characteristics

X_L = Geographical variables

Wealth

X_1 = per capita asset value

Household characteristics

X_2= Household size

X_3 = Farm size (Ha)

X_4= No. of labourer

X_5= off-farm work (1= yes, o otherwise)

Pig farmer characteristics

X_6 = Age of Pig farmer

X_7 = Age^2

X_8= Gender (male=1, 0 otherwise)

X_9= Education (years)

Geographical Variable

X_{10} = Distance of Pig farm to the main road

X_{11} = Nearness to fish pond (1= Near, O otherwise)

Dummy Variable

X_{12}= Medium Scale dummy

X_{13}= Large Scale dummy

3. Results and Discussion

3.1 Descriptive Analysis

A simple summary of the main variables used in this study is shown in Table I. As could be seen, more than 70 percent of the pig producers treat pig manure as discard while two methods, namely, sale and feed shares similar values (about 10 percent each) and self-use is indicated as the least method (8.98 percent). The mean family size was about 5 while average farm size was 0.65 hectares. On average, about 23 percent of pig farmers engaged in off-farm work. Majority of the pig farmers are male (mean=0.96) with mean age of about 48 years. Their mean income per capita was ₦4,477.4.

Table 1: Summary of Main Variables

	Mean	SD
Characteristics of households		
Number of pigs produced (100 heads)	3.61	10.99
Household size	5.27	1.53
Farm size (Ha)	0.65	0.47
Percentage of labors with off-farm work	23.16	23.88
Asset value per capita (₦10,000)	8.74	25.27
Percentage of manure methods		
Self-use	8.98	26.24
Sale	9.76	27.31
Feed	10.91	30.00
Discard	70.35	42.05
Characteristics of Pig Farmer		
Gender	0.96	0.19
Age (years)	48.08	9.73
Education (years)	7.98	2.95
Geographical Variables		
Fish Pond	0.36	0.16
Distance from main road (km)	1.55	3.02
Average income per capita	4477.34	1939.45

Sources: Authors' 2017 survey. Total sample size is 300

In order to show the effect of different factors on pig manure management, we attempt to link them individually with pig manure management, as shown in Table 2. First, we chart the relationship between pig production scale and pig manure management. There are various definitions of small, medium-scale, and large-scale pig producers. We first define pig producers as follows: small-scale pig producers have inventories of up to 45 head, medium-scale pig producers have pig inventories greater than 45, but less than 200; and large-scale pig producers have inventories of 200 or greater. As shown in Table 2, there is a significant difference in manure management practices between different scales of pig producers.

Table 2: Production Scale, Manure Management and Selected Household Characteristics Linkages

Category variable	Pig manure use					
Observation	Mean	Self-use	Sale	Feed	Discard	
Scale of pig production (Inventory)		(head)		(%)		
Small (1-45)	174	30	88.65	1.06	2.76	5.53
Medium (45-199)	76	135	64.98	10.89	12.72	11.41
Large (200~)	50	712	15.25	29.50	27.54	27.71
Asset value per capita			(₦10,000) (%)			
Low (bottom one-third)	136	0.76	79.93	2.57	9.49	8.01
Middle	137	3.28	77.01	5.43	8.39	9.16
High (top one-third)	135	22.32	53.95	21.38	14.89	9.78
Farm size (Ha) (%)						
More than 1 Ha	264	4.77	67.30	8.78	13.83	10.09
0.5~0.99 Ha	112	17.34	75.16	13.05	5.00	6.79
0.1~ 0.49Ha	32	57.18	78.75	6.25	7.50	7.50

As shown in Table 2, small scale pig producers reported the highest self-use of their pig dung (about 89%) followed by medium scale pig producers (64.98%) while the large scale producers of pig are the least self-user of their pig dung (15.25%). Only 1 percent of small scale producers reported selling their pig dung with about 3 percent using it as pig dung and more than 5 percent indicated they discard it. Of the medium scale pig producers who did not report self-use of pig dung, most of them either uses it as feed (13%), discard (12%) or sold them (11%). Similar pattern was observed with the large scale pig producers; most of those who did not report self-use, either sold them (30%) discard (28%) or use them as feed (28%). Thus, most commercial pig producers use very small quantity of their pig manure while the largest proportion is discarded if there is no market for it.

Table 2 also shows that farmers' wealth and land/farm size work are also potential variables that affect their manure management practices. As shown in the Table, low-income farmers are more likely to apply pig manure to their own lands, while higher income farmers are more likely to sell their pig manure or use it as feed than the lower income farmers, although the relationship is not as strong as it is for operation size. Income does not seem to have a strong impact on whether farmers discard their manure, with 8 percent of low-income farmers reporting that they discard their manure, 9.2 percent of the middle income farms, and 9.8 of the high income farms reporting they discard manure. While the percent of farmers reporting they discard manure rises with income, the increase is quite minimal, and household wealth may be highly correlated with the size of their swine operation, thus the descriptive statistics for wealth may just be indicative of the scale effect on manure management practices. Contrary to expectation, the size of a household's land holdings is not correlated with how they manage manure. *Apriori*, households with larger land holdings are expected to use more manure on their own land than households with smaller land holdings. For household with more than 1 hectare 67.3 percent of them reported using manure on their own land, but the share using manure on their own land rises to 78.8 percent for households with less than half hectare of land. As the table indicate, farmers with more land asset aren't any different from their counterparts with smaller land asset with respect to other manure management practice. The quantity reported for sale, used as feed or discarded were proportional to the size of their land asset or farm use.

3.2 Multinomial Analysis

Besides providing descriptive statistics (as shown above), in this section, we report the results of the multinomial analysis of the impact of pig production scale and other factors on pig manure management. This is done because it is possible that the descriptive results in the previous section are misleading, since we did not exclude the impact of other factors that simultaneously affect pig manure management. Table 3 shows the regression coefficients, standard error, estimated marginal effects. The log-likelihood value for the model is -2375.654. The likelihood ratio index p2 value is 0.2621confirmed that all explanatory variables are collectively significant in explaining the probability of a household producing migrant and receiving remittance. In literature, Rahji, Fakayode and Sanni (2008) obtained p2 value of 0.3145 while Zepeda (1990) reported p2 value of 0.25 as representing a relatively good- fit for a multinomial logit model. Hence, the p2 value of 0.300 in this study is indicative of good-fit for the estimated model. Evidence from the model as contained in Table 3 shows that the set of significant explanatory variables varies across the groups in terms of the levels of significance and signs. Several of the outcomes are unexpected. For all sets of pig manure management (sale, feed and discard), most of the household characteristics variables are statistically insignificant. However, for sale as pig manure management, Medium-scale dummy, Large-scale dummy and Asset value per capita are positive and significantly associated with sale of pig manure. Likewise for feed; Household size, Farm size, Distance from main road and Nearness to fish pond are positive and significantly associated with using pig manure as feed. Similarly, for Discard; Medium-scale dummy, Large-scale dummy, Farm size, Number of labourer and Nearness to fish pond are positive and significantly associated with discard as pig manure management. This suggest that for sale as pig manure management, as scale of pig production increases, for instance from medium to large scale, farmers will sell more of the pig manure as dung management technique. The positive asset value suggest that rich farmers (i.e. the higher the per capita asset value) are more likely to sell pig. Likewise for feed as pig manure management, farmers with large household size and farm size are more likely to use pig manure as livestock or fish feed. Positive sign of distance from fish pond is quite surprising as it implies the farther the feed ponds the more likely that pig manure will be sue as feed. The contrary is expected in this scenario. For Discard as pig manure management, as scale of production increases, the more likely the pig manure would be discarded perhaps because the quantity of pig dungs exceeded the quantities that be exhausted through other management practices. Positive Farm size suggest that as farm size increases, pig farmers are more likely to discard pig manure. Increase in number of labour is more likely to cause pig farmer to discard pig manure /dung manure. Similarly, positive nearness to fish pond suggest that the farther the pig farm to fish pond, the more likely the pig farmer would discard the pig manure. This outcome is plausible. Over all, the positive sign implies that the probability of the pig farmers to adopt sale, feed or discard as pig manure management relative to the reference group increases as these explanatory variables increase.

	Sale	Feed	Discard
Medium-scale dummy(herd size: 45-199)	10.95 (4.00)***	3.21 (1.24)	5.71 (1.94)*
Large-scale dummy(herd size:>200)	26.86 (6.56)***	2.96 (0.76)	-2.48(5.30***)
Asset value per capita	0.16 (3.20)***	-0.10 (-2.09)**	-0.02 (-0.30)
Household size	0.98(1.15)	-1.77 (-2.18)**	0.61 (0.66)
Off farm Work	-0.06 (-1.17)	-0.04 (-0.76)	0.08 (1.42)
Farm size	-0.02 (-0.28)	-0.11(-2.12)**	-0.12(-2.01)**
Gender of household head	4.25 (0.70)	-3.33 (-0.58)	7.11 (1.08)
Age of household head	0.63 (0.74)	-0.55 (-0.69)	-1.00 (-1.09)
Age square	-0.01 (-0.89)	0.00 (0.63)	0.01 (1.16)
Education of household head	-0.30 (-0.67)	-0.35 (-0.82)	0.71 (1.06)
No. of Labourer	2.36 (0.63)	3.49 (0.98)	-7.56 (-1.87)*
Distance from main road	-0.93 (-2.36) **	0.70 (1.87)*	0.69 (1.17)
Nearness to Fish pond area	-2.32 (-2.10) **	3.30 (3.16)***	2.46 (2.07)**
Constant	60.31 (1.76)*	26.37 (1.22)	26.68 (1.08)
Observations 300	300	300	
Pseudo R^2	0.300		
Log likelihood	-2375.654		
Restricted log likelihood	-5014.412		
Chi-squared (30)	504.31		
Significance level	0.0000		

Notes: z-statistics in parentheses. *po=0.1; **po=0.05; ***po=0.01

Distance from main road and nearness to fish pond are negative and significantly associated with sales of pig manure. Likewise Asset value per capita, Household size and farm size are negative and significantly associated with using pig manure as feed. Similarly, Large-scale dummy, farm size and number of labour are negative and significantly associated with discard as pig manure management. The negative and significant parameters mean that the probability of being classified in the three groups is lower relative to the probability of being placed in the reference group.

More interestingly, the estimation results indicate answer to the main question of this study: pig production scale is shown to have a significant impact on pig manure management. As shown in the first column describing the share of manure sold by the farmer, the estimated coefficients of medium-and large-scale pig producer dummies are both positive and statistically significant. According to our estimation results, compared to small-scale producers, medium-scale pig producers increase the share of sale by near 11 percent, while large-scale pig producers increase the share by 27 percent in reference to self-use. Thus, unlike small-scale pig producers, larger-scale pig producers are more likely to sell pig manure. In fact, the former usually did not sell pig manure (Table 3). This result is as expected, since these larger pig producers usually raise hundreds of pigs and their land endowment is not sufficient for the large amounts of manure generated by their pig inventories. Therefore, they have to find other ways to manage the manure their pigs produce. Since the manure is valuable – it can replace chemical fertilizer and improve soil structure in ways chemical fertilizer cannot – one method is selling the pig manure to other farmers or factories (to produce organic fertilizer). Another method adopted by these commercial producers is dumping pig manure. As shown in the last column of Table 3, the estimated coefficients of medium-and large-scale pig producer dummies are positive and negative respectively and are both statistically significant (rows 1 and 2). The estimation results show that compared to small-scale pig producers, the share of pig manure dumped by medium-scale pig producers increased by nearly 6 percent, while it reduced by about 2 percent for large-scale pig producers. However, as with the descriptive statistics, the largest producers were more likely to sell the manure than to dump it.

4. Conclusions

This study shows that pig production scale significantly affects pig manure management and therefore the rural environment. Compared to more traditional, small-scale pig producers, larger pig producers, owing to land constraints, are less likely to use the manure on their fields and more likely to either sell the manure or discard it without treatment. Technologies to deal with the pollution caused by pig manure are presently non-existent in Nigeria, more demoralising is fact that current efforts by government to boost production does not include waste management. Investment in technologies capable of neutralizing environmental hazards is typically way beyond the means of a rural/small-scale pig producer. Therefore, one cost-saving way for commercial pig producers to deal with pig manure is to simply discard it if they cannot find a willing buyer. Nigeria's pig industry will certainly continue to grow and consolidate. Average per capita pork consumption is still below levels in other more developed economies, and not only is urban per-capita consumption well above rural per-capita consumption in Nigeria, but urban per capita consumption by wealthier households is well above consumption at lower levels of income. Thus, as incomes continue to grow and Nigeria's economy continues to transform, we can expect demand for pork to continue to grow. Moreover, larger operations tend to be far more efficient than smaller operations in terms of feed conversion, sow productivity, and overall mortality and disease control, so we can expect the trend toward larger operations to continue as well. While this study presents initial data on how rural/backyard swine producers manage their manure and shows a clear correlation between size and use on fields, the implications for the environment are not entirely clear. For example, just because smaller producers are more likely to use manure on their own fields, does not mean that they are using it in a way that prevents any runoff. In our fieldwork, we did not find any farmers who actually tested the nutrient content of their manure nor any who had estimated the nutrient demand of the crops they planned to grow. Therefore, the field applications tended to be haphazard and without concern for potential soil nutrient build up or nutrient runoff. In addition to this, most manure was allowed to dry before being applied (or sold) and this likely means a high proportion of the liquid manure was allowed to runoff, even when the farmers used the manure on their own fields. This liquid itself can contain high levels of nitrogen and a significant amount of phosphorous as well, and if this liquid manure found its way into nearby waterways it can contribute significantly to environmental degradation. However, the cost of treating the manure is high, sometimes as much as 15 percent of total production costs, and these costs reduce the overall competitiveness of this sector. Thus, while environmental policies that encourage greater manure treatment and focus on the very large operations may be reducing the untreated manure effluent from these operations, they might also be discouraging further expansion of this segment of the swine industry and thus encouraging more small-scale production where manure management is less regulated.

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