PEER EFFECTS IN SMALLHOLDER AGRICULTURAL PRODUCTION IN KENYA

Kamau Gathiaka, PhD

School of Economics, University of Nairobi

Abstract:

Peer relationships affect production behavior of smallholder farmers, particularly in developing countries where farming is both an economic and a social activity. These interlinked aspects of farming are either treated lightly or completely ignored in the existing literatures on smallholder agriculture in Africa. In the empirical analysis, econometric methods are applied to primary data collected from Nyeri, a rural county in Kenya to estimate peer effects both on demand for farm inputs and on farm outputs. Since data on peer variables are not available, these variables are proxied by cluster level means of relevant covariates. The findings show that peer effects have positive effects on demand for farm inputs and farm outputs. Thus, ignoring peer effects can substantially bias the estimated behavioral parameters.

Keywords: Peer effect, input demand, agricultural production, farm output, smallholder farmers

1.0 Introduction[1]

Peer effect is a situation where an agent takes an action on the basis of dominant opinions and behaviors in his social environment (Kohler, Behrman and Watkins, 2001; Argys and Rees, 2008; Borelli, 2009; Bobonis and Finan, 2009; DeGiorgi, Pellizzari and Redaelli, 2009; Eisenkopf, 2010). In farming, a farmer may copy production behavior of neighbors in order to conform to prevailing opinions. Such copying may be as a result of peer influence (Foster and Rosenzweig, 1996).

[1] The author acknowledges with gratitude financial assistance from the University of Nairobi, and from the International Development Research Centre (IDRC) and African Economic Research Consortium (AERC). However, the views expressed in this paper are solely of the author.

Peer farmers are neighbors that a particular farmer interacts with. Peer effects only relate to members of a defined group or network. The group is a point of reference in transmission of peer effects. A reference group is a set of other farmers whose behavior affects the behavior of the focal farmer of interest. At a micro level, a reference group could be a neighborhood or a village (Ellison and Fudenburg, 1995).

Persons have a propensity to behave in some way that varies positively with the prevalent behavior in their group (Manski, 2000; Banerjee, 1992). This phenomenon is variously referred to in the literature as peer influence, peer effect, neighborhood effect, social norm effect, conformity effect, and imitation or herd behavior, among other terms.

Decision of one farmer is influenced by peer farmers' average decision. However, this one farmer could also be shaping group decision in one way or the other through his actions or characteristics. As such, the individual farmer makes an input in the average decision of peers, and this average decision in turn influences his decision. This is the reflection problem identified by Manski (1993). Individual and group decisions are simultaneously determined. Identifying peer effect is therefore confronted by the problem of simultaneity bias.

Farmers forming a group may behave in the same ways because of some exogenous characteristics common to all group members. For instance, group members may have similar family backgrounds (e.g., parents with same farming history) and this may drive them to behave in similar ways. The social influence from such similarity is referred to as contextual effect (Manski, 1993).

Peer farmers may exhibit similar behavior because of similar individual characteristics or sharing of a similar institutional environment, e.g., a rural village. The social outcome associated with such external factors is referred to as correlated effects (Manski, 1993). That is behavior is correlated with some external factor, e.g., norms in the village.

Farmers are decision-makers endowed with the ability to express preferences, form expectations and operate amidst constraints. They interact through actions that each farmer chooses. One farmer's action may affect the constraints, expectations, or preferences of other farmers, thus influencing the actions that the other farmers choose (Manski, 1993). In other words, actions of farmers in a network have cross-effects (Lalive and Cattanco, 2009).

Preferences find formal expression through utility functions; expectations through subjective probability distributions; and constraints through choice sets (Manski, 2000). In instances when a farmer has to make a decision without full information, he forms expectations of the outcomes that would follow from choosing different actions.

As an economic agent forming expectations, a farmer may seek to draw lessons from observing actions chosen by other farmers and their outcomes. Such observations generate expectations. Observations reveal private information of other farmers that the observing farmer uses to form rational expectations of his own.

According to Hogset and Barret (2008), a farmer may monitor the actions of a population of other farmers and acquire general and imprecise information about farming. This may happen when a farmer draws conclusions on a population behavior, say, adoption of a new technology, on the basis of population adoption rate. Such conclusions are based on social influence. The farmer lacks details of the new technology, and his conclusions are based on general perceptions.

A farmer's preference ordering over alternatives in his choice set may get influenced by actions or preferences chosen by other farmers. Studies show that a farmer's initial decision to adopt a new technology is influenced by decisions taken by others in his or her social network of relatives, friends and neighbors (Foster and Rosenzweig, 1995; Conley and Udry, 2003; Munshi, 2004; and Bandiera and Rasul, 2006). These are the individuals with whom a farmer holds strong ties with, and thus likely to influence his decision. The influence is referred to in the literature as social or peer effect (Munshi, 2004).

Bandiera and Rasul (2006) in a study of social networks and sunflower (an exotic crop) adoption in Zambezia province of Northern Mozambique find an inverted-U relationship in social effects. When adopters in a network are few, social effects are positive and when the adopters are many, the social effects are negative.

Social effects are also strong among farmers that lack adequate information about a new crop or new technology for that matter. Farmers with better information are insensitive to adoption choices of others (Bandiera and Rasul, 2006).

In a study of how farmers in the eastern region of Ghana learnt about appropriate use of fertilizer in a new farming system of pineapples for export, Conley and Udry (2001) finds that information regarding farming flows through relatively sparse social networks rather than being freely available in a village. The networks are based on geographic proximity and other factors. Bandiera and Rasul (2006) identify religion to be one of the factors determining social networks.

Through peer effects, farmers acquire relative information regarding other farmers' actions. For instance, a farmer gets to know if the other farmer harvested more or less output than the village average or than himself (Conley and Udry, 2001). Peer effects therefore provide incomplete information of broad facts i.e., general information from all farmers, without specific details.

To apply information gathered through peer influence, a farmer needs additional information. This may come from inferences drawn from reviewing histories of actions and outcomes of everyone the farmer interacts with (Conley and Udry, 2001) or from own private information.

Previous studies in Kenya, as in many other places, have not taken into account the peer effects in smallholder agricultural production. There is need to investigate how input demand and farm output behave in the presence of peer influence because this social phenomena is common in small farm environment. In particular, demand for fertilizer and crop production function has previously not been estimated accounting for peer effects. The same is the case with demand for animal feeds and livestock output. This study addresses this research gap using cross sectional data from Nyeri, a rural county in Kenya.

The study builds on available literature by focusing on smallholder farms with regard to input demands and farm output while paying due attention to peer effects. It estimates parameters of input demand functions controlling for peer influence. Peer effects in inputs demand are proxied by average neighborhood usage of fertilizer and animal feeds. In respect of farm output, peer effects are proxied by average neighborhood output of crops and livestock products. Each of the neighborhood variables excludes the observation of farmer of interest.

The rest of the paper is organized as follows: The section that follows discusses the analytical issues essential for understanding peer effects in smallholder agriculture. The section also informs on data site, sampling procedure and offers some descriptive statistics. The third section presents econometric results and discussion on demand for farm inputs and the associated farm output controlling for peer effects. The fourth section summarizes the paper and draws some conclusions.

2.0 Materials and methods

2.1 Analytical issues

The linear-in-means model can be modified to show the behavior of farmer *i* in village *s* in crop production to be as follows:

$$Y_{is} = a_0 + a_1 X_i + a_2 \bar{Y}_{is} + a_4 F_i + a_4 W_i + a_5 V_s + \square_i \text{.........................} (1)$$

where Y_{is} = crop output of farmer i in village s; X_i = endogenous input used by farmer i (e.g., fertilizer); $\overline{Y}_{is}$ = mean crop output of farmer i's peers in village s when farmer i's output is excluded; F_i = vector of farmer i's observable characteristics or observed heterogeneity; W_i = vector of other covariates of inputs demanded by farmer i; V_s = village s fixed effects; a_i= parameters (i=0,1,…); ε_i = error term (see Halliday and Kwak, 2007; Gaviria and Raphael, 2001; Fletcher, 2010).

Livestock output function can similarly be formulated. In equation (1), Y_{is} is output of farmer i in village s while $\overline{Y}_{is}$ is a neighborhood variable whose coefficient shows the effect of neighbors average production decisions on farmer i. X_i is an endogenous input, say fertilizer or animal feed. To estimate equation (1) without the problem of endogeneity, X_i has to be instrumented (see Greene, 1997; Wooldridge, 2002). Instrumentation entails predicting the demands for the endogenous inputs and substituting those endogenous inputs with their predicted demands in the estimation of the crop production equation (1) (see Gathiaka, 2010, 2012a, 2012b).

2.2 Data

The data for this study were collected from Nyeri County in Central Province of Kenya. The county is in the eastern highlands of Kenya. The dominant activities in this part include growing of cash and subsistence crops as well as dairy farming.

A majority of the residents engage in small scale farming and the activity occupies 80% of the county's total land area (Republic of Kenya, 1997). Household incomes are mainly derived from agriculture (53%) and to a lesser extent from wage employment (20%) and rural self employment (10%).

Smallholder farmers in Nyeri rear a variety of animals, the main ones being dairy cattle, sheep, goats and chicken. While most livestock farmers practice zero-grazing, a combination of zero-grazing with open grazing is widespread. The farmers adjacent to forests practice open grazing. Virtually every rural household in the county keeps at least one livestock type especially the small stocks to cater for household needs (Republic of Kenya, 1997, 2002) with chicken being the most common livestock.

The unit of analysis was the household and the data was collected in face-to-face interviews with farmers between July and September 2007. Sample selection was guided by the National Population and Household Survey framework of the Kenya National Bureau of Statistics (KNBS) (Republic of Kenya, 2007). The sample size was 423 households.

On average the household heads were literate, with at least primary school education and their main occupation was farming. Most households undertook farming without any training in agriculture.

Maize and beans were the most widely grown crops. Maize was grown by 91% of the farmers while beans were grown by 81%. The two crops were found to be inter-cropped and they constituted the staple foods in the county. Potatoes were also widely grown (56%) and consumed. In cash crops, coffee was the most widely grown, but by only 41% of the farmers. However, its prevalence exceeded by a wide margin that of horticultural crops and tea each of which was grown by 15% of farmers.

Most households were found to be far from cooperative societies and tarmac roads. This aspect coupled with poor road maintenance denied many households participation in market activities. Table 1 shows sample statistics for some variables in the study area.

Table 1: Sample statistics for some variables in Nyeri County

Variable	*Mean*	*Std. Dev.*	*Min.*	*Max.*
Log crop output	9.2	0.64	4.28	12
Log livestock output	2.6	3.42	0	8.9
Capital*10^{-3}	0. 2	1.86	-2.76	22.07
Labor	216.7	183.31	8	1002
Land	2.6	3.14	.12	23
Fertilizer	45.9	72.57	0	600
Animal Feeds	11785.2	15979.64	0	94900
Age of household head	51.3	13.90	16	90
Education level of household head (0=none, 1=primary,..)	1.3	0.78	0	4
Average fertilizer usage by neighbors within a cluster	46.0	27.45	2.31	130.06
Average animal feeds usage by neighbors within a cluster	14043.2	11217.02	1273.25	57823.63
Distance to the nearest cooperative	5.4	7.62	.01	60
Distance to the nearest market	3.0	2.44	.01	16
Sample size	423	423	423	423

3.0 Results and discussion

This section analyzes demand for farm inputs together with the associated farm output, first with reference to crop output and then with reference to livestock output in the presence of peer effects. The basic factor inputs and characteristics of the household head were the controls. The factor inputs of capital, labor and land were entered separately in order to net out any multicollinearity among them. The coefficients of village level variables showed peer effects.

The parameters of demand for fertilizer are presented in Table 2 columns 2, 4 and 6. The mean fertilizer usage by neighbors was the variable of peer effect in fertilizer demand. Distance to the nearest cooperative society was used as an instrument for fertilizer usage in a farm. The effect of distance on fertilizer demand was assumed to be non-linear, which was the reason for inclusion of the square of distance in demand equation (see Thori and Mehlum, 2010).

Table 2: Parameter estimates of fertilizer demand and crop production functions controlling for peer effects (*t*-statistics in parentheses)

Variables	*Crop output function (1)*		*Crop output function (2)*		*Crop output function (3)*	
	First stage regression: Fertilizer demand in log kg.	Second stage regression: Crop output in log kg.	First stage regression: Fertilizer demand in log kg.	Second stage regression: Crop output in log kg.	First stage regression: Fertilizer demand in log kg.	Second stage regression: Crop output in log kg.
Factor inputs and farmer characteristics						
Log fertilizer	-	.096(0.97)	-	.108(1.12)	-	.094(0.90)
Log capital, index	.501(3.65)	.067(1.11)	-	-	-	-
Log labor	-	-	.253(2.71)	.042(1.28)	-	-
Log land	-	-	-	-	0.096(1.01)	.022(0.83)
Log age	-.331(1.03)	.173(1.92)	-.346(1.06)	.169(1.85)	-.283(0.85)	.171(1.88)
Education, level	.139(1.18)	.011(0.31)	.190 (1.64)	.014(0.37)	.207(1.77)	.019(0.48)

Neighborhood Characteristics						
Log mean crop output of neighbors	-.141 (0.78)	.982 (19.82)	-.125 (0.69)	.985 (19.80)	-.132 (0.71)	.980 (19.57)
Log mean fertilizer used by neighbors	.727 (6.68)	-.088 (1.11)	.708 (6.47)	-.098 (1.29)	.670 (6.21)	-.088 (1.09)
Exclusion Restrictions						
Distance to a cooperative society, km.	-.065 (2.67)	-	-.068 (2.77)	-	-.061 (2.50)	-
Distance to a cooperative society squared, km^2	.001 (2.21)	-	.001 (2.32)	-	.001 (2.13)	-
Constant	2.138(0.99)	-.587(1.00)	1.260(0.57)	-.742(1.27)	2.278(1.01)	-.516(0.85)
R^2	0.142	0.491	0.130	0.476	0.117	0.490
F-statistic	9.84	73.04	8.88	70.64	7.86	71.54
p-value	0.000	0.000	0.000	0.000	0.000	0.000
Root MSE	1.722	.459	1.734	.466	1.747	.459
Observations	423	423	423	423	423	423

The estimates in Table 2 indicated that labor usage in a farm, capital endowment in a household and peer effects associated with fertilizer usage were the main determinants of fertilizer demand. The estimates indicated that a unit increase in capital endowment in a household increased fertilizer usage in a farm by 0.5 kilograms. Likewise, one person-day increase in labor usage at the farm was associated with an increase in fertilizer application on a plot by 0.253 kilograms.

The social effect of fertilizer usage was positive. When mean fertilizer usage at the village level increased by one kilogram, an observing farmer within the village increased his own fertilizer usage by 0.7 kilograms. This finding was suggestive of positive peer influence among farmers within the village in fertilizer usage.

An increase in distance to the nearest cooperative society was found to reduce demand for fertilizer. For every kilometer increase in distance to a cooperative society, a farmer reduced his annual demand for fertilizer by 0.06 kilograms. Long distances to cooperative societies discouraged fertilizer usage.

The parameters of crop output are presented in Table 2 columns 3, 5 and 7. The mean crop output by neighbors was the variable of peer effect in crop production. The estimates in Table 2 indicated that when mean crop output at the village level increased by one kilogram, an observing farmer within the village also increased his own crop output by nearly 1 kilogram. This finding was suggestive of further positive peer influence and social learning among farmers within a village in crop production.

The parameters of demand for animal feeds are presented in Table 3 columns 2, 4 and 6. The mean animal feeds usage by neighbors was the variable of peer effect in animal feeds demand. Distance to the nearest cooperative society and its square were used as the instrument for animal feeds usage in a farm.

Table 3 Parameter estimates of demand for animal feeds and livestock output functions controlling for peer effects (*t*-statistics in parentheses)

Variables	*Livestock output function (1)*		*Livestock output function (2)*		*Livestock output function (3)*	
	First stage regression: Demand for animal feeds in kg.	Second stage regression: Livestock output in log kg.	First Stage Regression: Demand for Animal Feeds in Kg.	Second stage regression: Livestock output in log kg.	First stage regression: Demand for animal feeds in kg	Second stage regression: Livestock output in log kg.
Factor inputs and farmer characteristics						
Animal feeds $*10^{-3}$, kg	-	.030 (1.22)	-	.031 (1.27)	-	.031 (1.21)
Log capital, index	7861.36 (3.84)	.859 (2.62)	-	-	-	
Log labor	-	-	3468.98 (2.46)	.615 (3.18)	-	-
Log land	-	-	-	-	4059.664	.343

					(2.90)	(1.64)
Log age	4495.10	.522	4547.95	.386	3023.30	.444
	(0.93)	(0.87)	(0.92)	(0.64)	(0.60)	(0.73)
Education, level	-2045.96	.134	-1141.64	.208	-1261.102	.231
	(1.16)	(0.62)	(0.65)	(0.99)	(0.72)	(1.08)
Neighborhood characteristics						
Log mean livestock output of neighbors	64.50	.417	206.52	.426	400.015	.451
	(0.08)	(4.28)	(0.26)	(4.38)	(0.50)	(4.55)
Log mean animal feeds used by neighbors	7801.94	.308	7537.65	.224	6808.625	.236
	(3.92)	(0.92)	(3.73)	(0.68)	(3.32)	(0.72)
Exclusion restrictions						
Distance to a cooperative society, km	-257.23	-	-286.71	-	-194.034	-
	(0.70)		(0.77)		(0.52)	
Distance to a cooperative society squared, km^2	23.30	-	24.27	-	22.014	-
	(2.90)		(2.99)		(2.72)	
Constant	-81801.73	-6.15	-91548.59	-7.28	-64768.51	-4.888
	(2.99)	(1.49)	(3.32)	(1.71)	(2.25)	(1.21)
R^2	.156	0.165	0.138	0.167	0.1429	0.1491
F-statistic	10.92	10.81	9.50	10.63	9.88	8.67
p-value	0.000	0.000	0.000	0.000	0.000	0.000
Root MSE	25833	3.143	26099	3.138	26026	3.172
Observations	423	423	423	423	423	423

The parameter estimates of demand for animal feeds accounting for peer effect in animal feeds usage showed that, capital, labor, mean of animal feeds usage by neighbors and mean livestock output of neighbors were the main determinants of demand for animal feeds.

The influence of these variables was found to be largely positive.

The estimates indicated that a unit increase in capital endowment in a household increased animal feeds usage in a farm by nearly 8000 kilograms (or 114 bags of 70 kilogram each) annually. Likewise, one person-day increase in labor usage at the farm was associated with an increase in animal feeds application on a plot by over 3000 kilograms (or 43 bags of 70 kilogram each) per year.

Capital could have been a proxy for household wealth. Wealthier households adopted better animal husbandry practices, including use of animal feeds. They stocked improved breeds of livestock in zero-grazing pens and employed farm hands.

The social effect of animal feeds usage was positive. When mean animal feeds usage at the village level increased by one kilogram, an observing farmer within the village increased his own animal feeds usage by more than 7000 kilograms (or 100 bags of 70 kilogram each) annually. This finding was suggestive of positive peer influence among farmers within the village in animal feeds usage.

Livestock output of neighbors was also found to influence positively the usage of animal feeds at the farm level. When livestock output of neighbors increased by one kilogram, animal feeds usage by an observing farmer within the village increased by 0.4 kilograms annually. This finding was suggestive of positive social interactions among farmers within a village in livestock production.

4.0 Conclusions

Smallholder farming activities in the studied area were found to be conducted in a social context. Using fertilizer and animal feeds as special cases of more general situations, the paper showed that peer effects matter in smallholder agriculture. They directly influenced demand for inputs and had large impacts on farm output at the plot level. The peer effects on individual farmers were found to be largely positive. If peer effects were ignored in estimating parameters of input demands or production functions, the estimated parameters would have been biased.

Through observations, word-of-mouth demonstration effects, and other social interactions with peers, a farmer’s production decision was found to be influenced by peers’ actions in the same regard. Thus, as the output of peers increased, the output of an observing farmer also increased suggesting farming information gathered from peers in farming may have entailed social learning. Social learning is said to occur when peer effects result in increased productivity at the farm level (Foster and Rosenzweig, 1996).

In livestock farming, wealth affected household's adoption of better animal husbandry practices that included higher usage of animal feeds. Such practices were informed by best practices of peer farmers. This underscored the importance of social interactions and particularly peer effects in smallholder agriculture. Thus, any interventions to improve productivity in smallholder agriculture should be approached from a group or social context for it to have wider acceptance and effects.

References:

Argys L. M. and Rees D. I. (2008). Searching for peer group effects: A test of the contagion hypothesis. The Review of Economics and Statistics, 90(3): 442-458.

Banerjee A.V. (1992). A simple model of herd behaviour. The Quarterly Journal of Economics, 117(3):797-817.

Bandiera O. and Rasul I. (2006). Social networks and technology adoption in Northern Mozambique. Economic Journal, 116(October):869-902.

Bobonis G. J. and Finan F. (2009). Neighborhood peer effects in secondary school enrollment decisions. The Review of Economics and Statistics, 91(4):695-716.

Borelli S. (2009). Social aspects of drug use in Djibouti: The case of the leaf of Allah. Journal of African Economies, 18(4): 555-591.

Conley T. and Udry C. (2001). Social learning through networks: The adoption on new agricultural technologies in Ghana. American Journal of Agricultural Economics, 83(3):668-673.

DeGiorgi G., Pellizzari M. and Redaelli S. (2009). Be as careful of the company you keep as of the books you read: Peer effects in education and on the labor market. NBER Working Paper Series, Working Paper 14948.

Eisenkopf G. (2010). Peer effects, motivation, and learning. Economics of Education Review, 29:364-374.

Ellison G. and Fudenberg D. (1995). Rules of thumb of social learning. Quarterly Journal of Economics, 110:93-125.

Fletcher J. (2010). Social Interactions in Smoking: Evidence using Multiple Student Cohorts, Instrumental Variables, and School Fixed Effects. Health Economics, 19(April):466-484.

Foster A.D. and Rosenzweig M.R. (1995). Learning by doing and learning form others: Human capital and technical change in agriculture. Journal of Political Economy, 103(6):1176-1209.

Gathiaka K. (2010). Social interactions in agriculture. Concepts, measurement and applications, VDM-Verlag Dr. Müller, Saarbrücken, Germany.

Gathiaka K. (2012a). Social interactions and returns to farm inputs in smallholder agriculture in Kenya, European Scientific Journal, 8(15): 180-201.

Gathiaka K. (2012b). Neighbors' soil conservation and crop production in Kenya, European Scientific Journal, 8(19): forthcoming.

Gaviria A. and Raphael S. (2001). School-based peer effects and juvenile behavior. The Review of Economics and Statistics, 83(2):257-268.

Greene W.H. (1997). Econometric analysis. New Delhi: Prentice-Hall Inc.

Halliday T.J. and Kwak S. (2007). Bad apples, goody two shoes and average Joes: The role of peer group definitions in estimation of peer groups. Journal of Economic Literature, I:12-120.

Hogset H. and Barret C. (2008). Social learning, social influence and projection bias: A caution on inferences based on proxy-reporting of peer behavior. Research Paper.

Kohler H., Behrman J.R. and Watkins S.C. (2001). The density of social networks and fertility decisions: Evidence from South Nyanza District, Kenya. Demography, 38(1):43-58.

Lalive R. and Cattaneo A. (2009). Social interactions and schooling decisions. The Review of Economics and Statistics, 91(3): 457-477.

Manski, C. (1993). Identification of endogenous social effects: The reflection problem. Review of Economic Studies, 60(3):531-542.

___________ (2000). Economic analysis of social interactions. Journal of Economic Perspectives 14(3):115-136.

Munshi K. (2004). Social learning in a heterogeneous population: Technology diffusion in the Indian Green Revolution. Journal of Development Economics, 73(2):185-213.

Republic of Kenya (1997). Nyeri district development plan, 1997-2001. Nairobi: Government Printers.

_______________(2002). Nyeri district development plan 2002-08. Nairobi: Government Printers.

_______________(2007). Kenya National Bureau of Statistics. Basic report on well-being in Kenya based on Kenya integrated household budget survey-2005/06. Nairobi: The Regal Press Limited.

Thori L.J. and Mehlum H. (2010). With or without U? The appropriate test for a U-shaped relationship. Oxford Bulletin of Economics and Statistics, 72(1):109-119.

Wooldridge, J. (2002). Econometric analysis of cross sectional and panel data. Cambridge: Massachussets Institute of Technology.