

Extending the Learning Community: Rural Radio, Social Learning and Farm Productivity in Ghana

Olumide Taiwo[1*] and Emmanuel Ekow Asmah[2]

1. Centre for the Study of the Economies of Africa. 4 Dep Street off Danube Street, Maitama Abuja FCT Nigeria.
2. Department of Economics, University of Cape Coast, University Post Office, Cape Coast Ghana, Ghana.

* E-mail of the corresponding author: eeasmah@mail.com

Abstract

This paper examines the potential role of indigenous knowledge sharing through rural FM radios in Ghanaian agriculture. To identify social learning effects, we examine crop productivity trends and their association with participation in radio programs, and compare the strength of these associations before and after emergence of rural radio. Our analysis shows stronger conditional correlations between participation intensity and non-cash crop yields, consistent with expectation that non-cash crop farmers will more likely adjust farming practice as a result of social learning. The results suggest potentials for agricultural research to impact farming effectively by taking advantage of rural FM stations.

Keywords: Rural radio, farm productivity, social learning, OLS regression model

1. Introduction

Agricultural productivity remains a crucial factor in poverty reduction and rural transformation in Africa. After a long period of decline and stagnation there have recently been reports of improved performance of the agricultural sector in many if not all countries in the continent. Mugera and Ojede (2011) provide a good survey of the literature on this subject and show that a variety of changes have made this progress possible. The studies cited in the survey emphasize the impact of remarkable changes in farm inputs such as crop varieties, fertilizer, pesticides and water resources (rainfall and irrigation), and the infrastructural changes that have made those gains possible such as market reforms and extension services. However, whereas changes in inputs and markets are well captured, changes in extension services are muted in these reports to the effect that credit is given to effectiveness of orthodox agricultural extension[1]. To the contrary, a survey of attitudes to and experiences with orthodox extension services shows that farmers have largely been abandoning those services since the beginning of the last decade.

The implication is that credit given to extension services is largely misplaced, and the analyses omit a crucial *change* in the form of knowledge that farmers are adapting to and the ways in which that knowledge is disseminated. The literature on knowledge systems distinguishes clearly between formal or explicit knowledge that is based on scientific evidence, and informal or tacit knowledge that is experimental in nature and is acquired after a given practice has proved fruitful (Roling 1992). Whereas orthodox extension services focus on application of the former, there is evidence that farmers are instead shifting to the latter. In a survey of farmers' perspectives on agricultural extension in the East-Akim district of Ghana reported by Boateng (2006), two-thirds of farmers surveyed expressed dissatisfaction with orthodox extension services. Among the dis-satisfied majority, the main reasons cited were unreliability of the service (47%) and the enormous costs of applying the new techniques (47%). In their responses to other questions in the survey, the farmers unanimously declared extension service as unreliable because 'they were not involved in the development of technologies passed on to them by the experts' (Boateng, 2006, p. 24). This attitude toward orthodox extension services is not a 'new millennium' experience. Udry and Conley (2010) found from a survey conducted between 1996 and 1998 among pineapple farmers in three villages in southern Ghana that only one in three farmers took advice from an extension agent from the Ghanaian Ministry of Food and Agriculture. They found from their data that average fertilizer use is less than one-tenth of the 400kg/hectare recommended by extension officers. Their analysis and findings show that farmers adjust fertilizer use not after the recommendations of the extension officers but following the experiences of other farmers in their neighborhood[2].

Recent developments in communication and socialization infrastructure have extended the sphere of social learning beyond village borders. In the Ghanaian context, the rural radio phenomenon has successfully moved the borders of social learning from the village to the range of radio broadcast. Rural radios, used interchangeably with community radios, are FM radio stations established with the aim to broadcast to a rural audience that are predominantly engaged in agriculture. These new stations are not mere extension of national

FM radio stations to rural areas but new FM stations that are owned and situated in rural areas. As noted by Girard (2001, p. 6), 'In 1985 the term rural radio usually referred to a division within the national broadcaster that produced programs in the capital and broadcast them to the countryside. Now rural radio is local radio.' A study by Chapman et al. (2003) suggests that the community element of rural radio encourages active participation of the audience, engagement of intellectual resources of the community as well as community ownership of the radio station. In particular, community radios are set up with the aim to 'enable marginalized communities and groups to generate and share their knowledge and experience' (Quarmyne, 2001)[3]. In terms of their programs, they focus on livelihood and development issues, transmit most of their events in local dialects and cater strongly to occupational segments such as farmers and fishermen.[4] The main advantage is that the uneducated rural population in those communities can and do participate in those programs. The first community radio in Ghana, Radio Ada, started operations in February 1998 shortly after the liberalization of Ghanaian airwaves in 1996.[5] At the end of 2005, there were seven operational community radio stations with broadcast range covering large swaths of seven of the ten regions of the country. It is estimated that community radios reached between a quarter to two-fifths of the country's area as of that time (Whaites, 2005).

The development of rural radio has brought about a change in the content of radio transmission that is accessible to rural audience. McKay (2003), in his qualitative study of radio participation in a fishing community, cited a fishmonger's account:

> *'The first {radio we bought] was 16 years ago. Back then we tuned to the radio a little but we mainly played cassettes. My husband is educated so he liked tuning to where they spoke English but if my husband was not in the house then we put the cassette in the tape player and played gospel songs. Now we listen to Radio Ada, because of the Dangme being spoken.'(p. 4)*

Whereas learning from neighbors are confined to members of the same village, rural radios enable individuals to learn from more distant counterparts. McKay (2003) cited a fisherman who was knowledgeable of the development occurring among fishmongers in his Anyakpor community as saying:

> *'Anyakpor women, when they've finished smoking, use a certain grass named* lale *giving colour to the fish here. With a programme from another community along the coast here I learned that there's another grass which is called* zue *which is used in giving the fish colour and it is better than the* lale *the Anyakpor fishmongers are using. So the women here are changing to use* zue*.'* (p. 3)

In Ghana, rural radio has been used to promote adoption of a high-yield rice seed named New Rice for Africa (NERICA). The impact of the promotion, as documented by the Bill and Melinda Gates Foundation (2010), is a doubling of demand for the seed among farmers between 2008 and 2009. However, the report shows that adoption of the seed variety is made possible by having farmers talk to themselves on radio. Citing a 46-year old female rural rice farmer, Faustina, who experienced a turnaround on her rice farm, the report makes the case that it is often more convincing to learn about a new yield-improving technology from a farmer than from an extension agent. 'Hearing about the rice from other farmers made it more convincing,' says Faustina.

In this paper, we attempt to evaluate the impact of social learning through rural radio on crop yield in Ghana. We lay the theoretical foundation and examine the literature in the next section and follow with a section describing our identification strategy and examining the data. We then present descriptive statistics and our results. We thereafter discuss the results and conclude.

2. Background and Literature

Leading theories of economic growth and productivity are founded on production functions that combine human capital with other kinds of capital. While human capital could be defined to include other components such as health, knowledge possessed by workers remains a very important component. In the neoclassical setting, economic efficiency is driven by two distinct forms of knowledge namely cutting-edge (or frontier) production practices and market conditions. The idea is that farmers would be more productive when they have access to knowledge about the technology frontier. Holding inputs constant, adoption of superior technology leads to higher productivity. In addition, farmers will be more productive when they are knowledgeable about agricultural produce and factor markets, and consequently are able to allocate input factors more efficiently. The neoclassical models assume that new knowledge diffuses instantly and is 'under competition available to all' (Borts and Stein, 1964, p.8). In other words, all production systems are automatically on the frontier.

The assumption of immediate diffusion of knowledge is perhaps the most unrealistic among the many that implicitly underlie the neoclassical theory. The reality of spatial barriers to knowledge diffusion informed the need for deliberate efforts to connect locations of invention or innovation with the rest of the world. Extension services are the bedrock of such efforts in agricultural settings whereby well-trained agents carry the findings in one setting to another or transmit the findings in laboratory experiments to producers on their farms.

Beginning in the early 1960s, independent African countries vigorously pursued a strategy of extension based on the premise that technology existed elsewhere and only needed to be brought home. Thus, additional extension agents were only needed to persuade farmers to adopt better technologies. In pursuance of this objective, Eicher and Rukuni (2003) note that African countries expanded agricultural extension by additional 36,000 agents between 1959 and 1980.

Agricultural extension has yielded very little benefit to African farmers due to a host of factors. According to Cleaver (1993) the most common problems associated with extension are

> *‘ (a) extension staff are poorly trained and know little more than the farmers know; (b) extension staff are poorly paid and have little motivation to share whatever knowledge they do have with farmers; (c) management systems are poor, so that there is little pressure on staff or their managers to seek new knowledge or to serve farmers; (d) farmers are treated as ignorant recipients of information, rather than knowledgeable partners in technology transfer; (e) extension agents are not accountable to farmers; and (f) in some cases, operating facilities, vehicles and bicycles are so rare that the few motivated and knowledgeable extension staff cannot visit farmers regularly.’ (p.65)*

Out of the enumerated criticisms, the treatment of farmers as ‘ignorant recipients’ of information rather than ‘knowledgeable partners’ is perhaps the most compelling explanation for dismal utility of extension services at least in the Ghanaian context. An evaluation of mud silos promotion (a common crop storage facility) in Northern Ghana by Bediako et al. (2005) led to the conclusion that extension officers may to a large extent contribute to technology non-adoption by resource-poor farmers. Eicher and Rukuni (2003) reported that despite expansion of agricultural extension by 36,000 agents from 1959 to 1980, food production only grew at half the rate of population growth from 1970 to 1985.

Failure of orthodox agricultural extension has stimulated a shift toward successful tacit knowledge[6]. Farmers can learn from their own experiences with a technology (learning by doing), from other farmers in the same locality, or from the media. Using relatively elaborate models, Foster and Rosenzweig (1995) and Munshi (2004) examining data from the Indian Green revolution, and Udry and Conley (2010) examining data from Southern Ghana found evidence of social learning among farmers in village settings. They observed that farmers adjust their production techniques based on the experiences of their neighbors.

However, social learning through rural radio enlarges the learning community beyond the village by allowing farmers to learn from other farmers in distant villages and communities. Studies examining the impact of learning through radio on farm productivity are rare. Indeed, existing studies of social learning through the media have focused mainly on deliberate attempts by development agencies to disseminate knowledge to rural farmers rather than evaluating the effects of farmers learning from one another through organized media (for example see Ray, 1978 and Sangare, 2000). This paper makes a first attempt to fill this void in the literature.

Two major issues arise in connection with enlarged information networks that are associated with rural radio transmission. First, by widening the sphere of social learning, virtual links between farmers in participating communities are more complex compared with neighborhood learning. Second, the possibility that farmers adopt a cutting-edge practice is more likely through radio than through person-to-person learning. By learning about many other farmers’ experiences on radio, a farmer is likely to be able to pick the best practice rather than merely adopting the neighbor’s practice.

Intuitively, we expect that the shift from scientific to tacit knowledge in transforming agriculture will be more pronounced and beneficial for non-tree crops cultivation than tree crops farming for two reasons. First, there is a marked difference between tree and non-tree crops in terms of investments and fruit-bearing lifetime. Risk-averse farmers may be less willing to adopt tacit knowledge in tree-cropping than non-tree cropping, and the set of technological changes that can be applied on a tree crop when it is already fully grown is relatively limited. Second, more advanced research systems exist for tree-crops than non-tree crops in Ghana. An examination of agricultural research institutes and extension services providers in Ghana reveals that formal extension services are focused on tree crops – mainly oil palm, rubber and cocoa – and much more recently on livestock. This biased focus dates back to the colonial era. Eicher and Rukuni (2003) note that most colonial governments devoted agricultural research efforts primarily to export crops while food crops and livestock were treated as secondary. As part of efforts to promote agricultural productivity, government and donor organizations have provided increasing amounts of funding and, in effect, intensified tree-crop research and extension. On the other hand, non-tree crop farmers intensively engage in social learning.

3. Methodology

An appropriate model to evaluate the learning effect of radio transmission would be very complicated and is beyond the scope of this paper. In the present effort, we adopt a simple model that relies on variation in intensity of learning through radio within local areas in identifying social learning effects. We measure learning intensity by averaging over a given locality the frequency with which individuals in households listen to radio. Our main assumption is that the likelihood that a farmer selects the best practice is positively and linearly related to the intensity of participation in rural radio in the given locality.

Knowledge socialization on radio started in 1998. We use data from surveys conducted before and after the commencement of rural radio to estimate the potential effect of change in rural radio content on productivity. We proceed by estimating the effect of radio listenership intensity on crop yield in the 1991 and 2006 datasets, and compare the change in estimated effect on non-cocoa crop yield with change in estimated effect on cocoa yield over the 15-year period. The rationale for this comparison is the expectation for the shift to have little or no effect on cocoa yield, so that unobserved changes that might be correlated with the estimates are isolated using the non-cocoa minus cocoa estimates, leaving us with the differential effect on non-cocoa crops. For robustness checks, we estimate similar models using participation intensity of other forms of media and compare the results.

The production function incorporates the knowledge infrastructure available to farmers in addition to traditional farming inputs. The basic theoretical model is given by

$$Q_i = A_i L_i^{\alpha_L} K_i^{\alpha_K} \prod_{j=1}^{J} e^{\delta_j N_j} \qquad (1)$$

where Q_i represents output quantity, A_i represents acres of land, L_i represents labor input, K_i represents capital (or other non-labor) input, N_j represents infrastructure of type j. The coefficients α_L, α_K and $\delta_j, j = 1,2,\ldots,J$ are productivity parameters. We categorize rural radio in the set of infrastructure items. Exponentiation of the infrastructure terms is meant to distinguish the direct physical inputs from indirect non-material inputs. The specification of the production function also implies that production can occur without infrastructure but such production will yield minimal output. For example, a farmer may not have access to motorable roads but may still produce crops. In this case, the production system will be inefficient and output will be lower than otherwise. The presence of motorable road has the effect of expanding his output through the market effect. In logarithm form, the production function is translated into

$$\ln Y_i = \alpha_0 + \alpha_L \ln L_i + \alpha_K \ln K_i + \sum_{j=1}^{J} \delta_j N_j \qquad (2)$$

where $Y_i = Q_i / A_i$ represents crop yield measured in terms of output per acre, and α_0 is a constant term. In estimating the equation, we use data from the Ghana Living Standard Surveys GLSS 3 (1991/1992) and GLSS 5 (2005/2006) and include only sampled households that produce positive quantities of the selected crops. Our crop yield and traditional inputs (labor and capital) are measured at the household level while the infrastructure items are measured at the cluster and regional levels as far as the data allows. We restrict our analysis to six crops: one tree crop (cocoa), and five non-tree crops (beans and peas, groundnut, guinea corn, rice and maize). Together, these crops account for 97 per cent and 91 per cent of crop market values in 1991/1992 and 2005/2006 surveys respectively. We converted crop outputs from different units of measurement reported by households into kilograms. As a caveat, it is not feasible to convert all the reported measures into kilograms. However, our sample accounts for 99 per cent of production of the selected crops in both periods and covers1,469 households from the 1991/1992 survey and 2,386 households from the 2005/2006 survey. The GLSS survey instruments do not cover access to media either at household or community levels. To fill this gap, we use data from the Demographic and Health Surveys (DHS) conducted in 1993 and 2003. The DHS contains geographical markers that include region, district and clusters within each district. But the district and cluster markers cannot be matched with similar markers in the GLSS data. In merging the two datasets, we compute region-level averages of media participation in the DHS and used the region markers to merge the datasets.

There is a possibility that estimated coefficient of infrastructure items inclusive of radio are biased because they may pick up the effect of other important variables that are excluded from the model. It is indeed plausible that the correlation between radio intensity and crop yield captures unmeasured supply-side effects in addition to the knowledge effect. For example, establishment of a rural radio station in a particular place is unlikely to be a random exercise; it is likely correlated with excluded determinants of crop productivity. Radio stations may be selectively established in areas with high population density, and those areas are likely to have more fertile soil than areas with low population density in the same region. In this case, the correlation between radio intensity and crop yield will also capture the simple fact that areas with more productive soil and consequently higher crop yield have more radio coverage. There is also a potential demand-side challenge: the possibility that agricultural knowledge remains unchanged yet increase in income in areas that experience high crop yield enables greater access to radio. In effect, the change in radio intensity is not distinguishable from unmeasured income or wealth effect. To deal with this potential challenge, we include controls for income and population density in the estimation procedures. The complete list of variables in the analysis and their derivation is provided in the Appendix.

4. Descriptive Statistics

We provide the trend of crop production and yield in the GLSS data in Table 1. Average household cocoa output grew by 122 per cent during the 15-year period from 723 kg to 1607 kg. During the same period, average household production of the selected non-cocoa crops rose by 72 per cent from 837 kg to 1439 kg. However, in terms of acres of land devoted to production, mean acres of farmland devoted to cocoa production reduced by 3 per cent whereas farmland acres devoted to the other crops reduced by 42 per cent, perhaps reflecting diversification in the mix of crops that households grow over the period. Apart from diversification, these statistics point to farm intensification during the intervening years. We were unable to separate the labor and non-labor inputs for each crop; therefore, monetary values of those inputs provided in the table are for all crops produced by households. The statistics show that crop production outlays were dominantly labor costs in 1991/1992 where labor costs were about 57 per cent of those costs combined. The picture in 2005/2006 shows that farmers spent more on non-labor input, such as fertilizer and insecticide, so that labor costs reduced to 44 per cent of the combined costs. We attribute this change to transformation in farm technology where crop production has drastically shifted away from a labor intensive system to more technologically driven system that increasingly relies on non-labor inputs. We attribute this shift in production technology to new knowledge that farmers have acquired over the period as well as various agricultural policies relating to farm inputs.

The lower panel shows variation in crop yields defined as output per acreage of land. On average, crop yields grew by 87 per cent between the surveys but this growth is more significantly accounted for by non-cocoa crops, which achieved 111 per cent increase in yield, compared to only 20 per cent for cocoa. Further, non-cocoa crop yield grew at a rate of 130 per cent in cocoa regions compared to 87 per cent in non-cocoa regions in a way that seems like non-cocoa crop yields in cocoa areas catching up with yields in non-cocoa regions.

Next, we examine shifts in farmers' sources of knowledge regarding various aspects of farming input and output. These data are derived from two sources. The first source is the community component of the GLSS. The second source of data is the DHS, which is conducted in Ghana every five years beginning from 1988. In order to observe shifts in non-cocoa relative to cocoa production, we provide the statistics for cocoa producing regions and non-cocoa regions. Cocoa production takes place in six of the ten regions: Western, Central, Eastern, Volta, Ashanti and Brong-Ahafo regions.

Table 2 summarizes changes in infrastructure in rural communities over the period disaggregated by region. From the table, the fraction of communities that have access to motorable roads in cocoa regions rose from 83 per cent in 1991/1992 to 91 per cent in 2005/2006 but did not change in the non-cocoa regions. Land markets have not expanded in Ghana because the fraction of communities where land market exists remained virtually consistent with1991/1992 figures. These statistics suggest perhaps that land titling or ownership rights changes are not part of potential explanations for observed changes in Ghanaian agriculture. The fraction of communities where local markets exist decreased significantly from 38 per cent to 30 per cent between 1991/1992 and 2005/2006 in cocoa regions but more significantly from 45 per cent to 26 per cent in non-cocoa regions. There are no dramatic changes in farmers' cooperatives; however, a slight increase of 5 per cent in cocoa regions and slight decrease of 4 per cent in non-cocoa regions is noted. The proportion of communities with cooperatives increased in cocoa areas and decreased in non-cocoa areas; however, these changes are not statistically significant. Nonetheless, a higher proportion of communities reported using insecticide in 2005/2006 than in 1991/1992 in all regions: from 64 per cent to 81 per cent in cocoa regions and from 32 per cent to 44 per cent in non-cocoa regions. Whereas extension services appear to rise slightly in cocoa regions from 23 per cent to 26 per cent, the proportion of communities receiving extension services reduced significantly from 34 per cent to 18 per cent in the non-cocoa regions. The proportion of communities where farmers use fertilizer follows the same pattern; communities reporting fertilizer use increased from 49 to 72 per cent in cocoa regions and decreased from 81 to 60 per cent in non-cocoa regions. Provision of extension services and fertilizer usage are two items that have increased in cocoa areas but declined in non-cocoa areas. Coincidentally, a simple test of difference of means also shows that differences between cocoa and non-cocoa regions are striking only in terms of changes in extension services and fertilizer usage.[7]

We now incorporate the DHS documented changes in electronic and print media sources of knowledge between the 1993 and 2003 surveys. Although the timing of the DHS does not coincide with the GLSS, the ten year interval between the two surveys is entirely contained within the fifteen-year interval between the GLSS surveys and allows us to observe changes in access to media within the interval. At the individual level, the surveys collect information regarding how frequent respondents read newspapers, watch television and listen to radio. From this information, we restrict the sample to rural households and construct a household level dummy that equals one if anyone in the household report a frequency of doing any of these at least once a week and zero if otherwise. For each item, we compute the average of the dummy across households in each cluster to obtain the fraction of households. Figures reported in the lower panel of Table 2 are cluster averages.

From the table, the proportion of households that read newspapers at least once a week increased only slightly from 17 per cent to 20 per cent and in cocoa areas compared to non-cocoa areas where the proportion moved from 8 per cent to 9 per cent. The proportion of households that watch television at least once a week increased significantly by 13 per cent in cocoa regions compared to 2 per cent in non-cocoa regions. The proportion of households that listen to radio at least once a week increased dramatically in all regions from 59 to 93 per cent in cocoa areas and from 48 to 80 per cent in non-cocoa regions. These changes are significant at the 1 per cent level and are in part the result of nationwide expansion of radio transmission during the period between the two surveys. It is possible that these changes are ubiquitous.

We next examine the possibility of differential increase in radio listenership over television viewership[8]. To do this we compute the fraction of households where residents listen to radio only.[9] The figures show that cocoa and non-cocoa regions were not different in the baseline year 1993: one third (33 per cent) of households in both areas had radio-only listeners. However, by 2003, the radio-only proportion had increased by 16 per cent in cocoa regions compared to increase of 27 per cent in non-cocoa areas. Simple tests of difference of means show that these differences are statistically significant. Whereas the change in the proportion listening to radio might be ubiquitous, the differential change in listening to radio-only is most likely not.

It is straightforward to reconcile the statistics from community surveys and those from the DHS data. Whereas extension services and cooperatives that constitute the orthodox knowledge diffusion mechanisms grew slightly in cocoa areas but declined in non-cocoa areas, farmers in non-cocoa areas are differentially more engaged in social learning through the radio. Because extension services are closely related to fertilizer usage, a decrease in extension services is accompanied by a decrease in fertilizer usage in non-cocoa areas[10]. It is plausible to assume that knowledge shared on rural radio is not tied to fertilizer usage but perhaps more generally related to efficient cropping practices. However, the comparisons presented in Table 2 are subject to a caveat: we are only able to match changes in knowledge infrastructure to cocoa versus non-cocoa *regions* rather than cocoa versus non-cocoa crop *cultivation*. Farmers cultivating non-cocoa crops in the cocoa regions may participate in rural radio differentially than farmers cultivating cocoa, but this possibility is obscured by these statistics. Indeed, the growth of non-cocoa crop yield in cocoa areas by a wide margin over its growth in non-cocoa areas may reflect a more intensive participation among non-cocoa farmers in cocoa regions than in non-cocoa regions. Another possibility is that access to best practices through knowledge sharing is not matched by access to inputs to implement them; the results are obtainable if access to vital inputs such as fertilizer is constrained in the non-cocoa regions relative to the cocoa regions. Decrease in extension services and fertilizer usage in non-cocoa regions are consistent with this supply constraint.

5. Results

We present the results of estimating the cocoa yield function with additional controls separately for each survey data. In model I we include farm direct inputs, farmer's sale outlet (market traders or other buyers such as farm gate and institutional buyers) and community infrastructure dummies. We expand the regressors in Model II to include the orthodox knowledge infrastructure – extension service and cooperatives. We add newspaper readership and television viewership in Model III and add the radio-only listenership variable in Model IV. We included additional controls in Model V in order to isolate potential bias due to wealth and population density. In all the models, we include controls for ecological zone and rainfall deviations.

The results for cocoa cultivation are summarized in Table 3. The results from both surveys suggest that variation in expenditure on labor input does not explain cocoa yield. Expenditure on non-labor inputs has no effect on crop yield in 1991/1992 but yield increases with non-labor costs in the 2005/2006 survey. Crop yield turns out to be higher in communities where farmers use fertilizer in the 1991/1992 survey but the effect disappears in Model 3 when we include regional level media-related knowledge sources. This suggests that perhaps fertilizer use is part of the knowledge shared on media so that inclusion of media variables reduces the fertilizer coefficient. Crop yield was not different between communities where farmers use insecticides in the 1991/1992 survey, but farmers in those communities seem to obtain significantly lower yield in the 2005/2006 data. Rather than insecticide reducing crop yield, the plausible interpretation is that communities applying insecticides are those that have difficulties with pest control, and pests reduce crop yield. The results also show that crop yield was higher in communities where individuals are allowed to buy and sell land, but the effect only applied to cocoa farming in the 1991/1992 survey. This perhaps reflects the potential effect of private land rights on investments. Crop yields do not differ by crop sales outlets in the 1991/1992 survey but differ in the 2005/2006 survey. Communities where farmers sold their major crops to market traders—rather than other buyers such as institutional, contract and farm gate buyers—tend to be communities associated with low cocoa crop yields in the 2005/2006 survey. Indeed, it is plausible that institutional and contract buyers would source their supply from high-yield cocoa farming communities. Availability of agricultural extension service seemed to help raise cocoa yields in the 1991/1992 survey but the effect disappeared in the 2005/2006 survey. The other institution through which farmers learn from one another – farmers' cooperatives – does not have any effect on crop yields in both surveys. One potential explanation for this finding that we verified anecdotally in Ghana is that the cooperatives are more focused on issues of farm credit and political representation than the traditional purpose of knowledge dissemination.

The results in Models III and IV show positive correlation between crop yield and television intensity in both years but the positive coefficients of newspaper readership and radio listenership in 1991/1992 data disappeared in the 2005/2006 data. Moving from Model III to Model IV by including radio-only listenership intensity resulted in an increase in the coefficient of television intensity. We anticipate this change because the two variables are negatively correlated by construction. We include income and regional population density in Model V, but the coefficient of radio-only listenership did not change by much. Changes in the coefficient of determination, or alternatively, the goodness of fit of the model are also instructive as we look across the surveys. Inclusion of the media variables in the 1991/1992 data increased the coefficient of determination from 17 per cent in Model II to 29 per cent in Model IV but only from 10 per cent to 12 per cent in the 2005/2006 data. Overall, the lower coefficient of determination in the 2005/2006 data suggests that the models we estimate do poorly in explaining variations in cocoa yield relative to the 1991/1992 data.

The results for non-cocoa crops presented in Table 4 differ in many respects from the pattern in Table 3. The negative coefficient of labor cost in 1991/1992 is surprising; otherwise, the labor cost coefficient is similar to those found in Table 3. Expenditure on non-labor input is positively correlated with crop yield in both surveys. Communities where farmers use fertilizer do not seem to achieve greater crop yield than non-user communities in both surveys. Similar to cocoa, use of insecticide is associated with lower non-cocoa crop yield and the negative effect holds in both datasets. Communities where individual property right exists in land were associated with higher crop yields in 1991/1992 but are associated with lower crop yield in the 2005/2006 survey. In contrast to the case of cocoa, communities where farmers sold their major crops to market traders rather than institutional buyers such as contract and farm gate buyers tend to be associated with higher crop yields both in 1991/1992 and 2005/2006 surveys. While existence of farmers' cooperatives did not exert any influence on crop yield in both surveys, communities where extension services are available in the 2005/2006 data are associated with lower crop yields. In Models IV and V, higher newspaper intensity is associated with reduced crop yield while increase in television viewership and radio listenership are both associated with higher crop yield in both surveys. Relative to 1991/1992 data, both coefficients increased in the 2005/2006 data but the increase in radio intensity coefficient is more dramatic (from 0.06 to 0.21) compared to television viewership coefficient (from 0.07 to 0.11). The differential increase in the coefficient of radio intensity over television may capture the possibility that farmers are able to share more information on radio than on television, implying that a 1% increase in radio intensity provides more productive knowledge than television.

The results thus far support the hypothesis of a positive conditional correlation between social learning through radio and growth of non-cocoa yield between 1991/1992 and 2005/2006, consistent with the statistics reported in the bottom panel of Table 1. The next challenge is to demonstrate the extent to which social learning contributes to non-cocoa yield growth differentially in cocoa areas compared to non-cocoa areas, because crop yield statistics show that the growth rates are different by area. To proceed, we pool data for non-cocoa crops from both 1991/1992 and 2005/2006 surveys and separate them into cocoa and non-cocoa regions. In addition to Model V of Table 4, a dummy for 2005/2006 survey and an interaction term of this dummy with radio intensity variable will capture the change in correlation between radio intensity and crop yield between 1991/1992 and 2005/2006 and enable us to examine how the change differs between cocoa and non-cocoa regions. We present the results in Table 5. In Model V, the coefficient of the interaction term *Radio-only intensity x Year 2006* in cocoa regions, 0.13, is more than double the coefficient in non-cocoa regions: 0.06, implying that similar increase in radio intensity is associated with increase in crop yield in cocoa areas that is twice the rate at which it occurs in non-cocoa areas. This difference is consistent with the bottom panel of Table 1 where non-cocoa crop yield grew by 130% in cocoa regions compared to 87% in non-cocoa regions.

Our finding that non-cocoa crops have done better in cocoa regions than in non-cocoa regions may have several potential explanations. First, differences in ecological conditions may induce cultivation of different types of non-cocoa crops in the cocoa and non-cocoa regions. If non-cocoa technologies in cocoa regions are more amenable to learning-by-doing than non-cocoa technologies in non-cocoa regions, then non-cocoa farmers in cocoa regions might be able to find the frontier faster and achieve higher yield than farmers in non-cocoa regions. A second possibility is that non-cocoa technologies may be regionally invariant but differences in access to other farm inputs such as rainfall and fertilizer between regions may generate differences in crop yield. Third, there may be knowledge spillovers from formal extension services that are more common in cocoa regions than in non-cocoa regions. Because research facilities exist more in cocoa regions, non-cocoa technologies may also be subject to scientific analysis to some extent in cocoa regions and non-cocoa farmers may benefit from this knowledge. In effect, while farmers in non-cocoa regions would only be applying tacit knowledge, farmers in cocoa areas would have access to both tacit and scientific knowledge. We presently do not have the data to discriminate between these competing hypotheses.

6. Conclusion

We analyze the trends in crop yield in Ghana over a period when farmers gained cheaper and easier access to frontier tacit farming knowledge. Our results establish positive correlation between the intensity of participating in rural radio networks and increase in non-cocoa crop yield, and we interpret this association as having emerged through socialization of farming knowledge through the radio.

Our finding of conditional correlations between participation in rural radio and crop yield does little in establishing the channels through which information shared on radio programs influence farm technology. Further work in this area will involve developing testable frameworks to understand how farmers interact on radio programs, analyzing the content of agricultural programs on rural radio and developing a model of learning through radio networks.

The correlations that we found in this paper suggest existence of enormous potential for agricultural research to impact farm practices at a faster rate than orthodox extension services if research institutions take advantage of sprawling community radio programs. Utilizing this recommendation, agricultural research products would not simply sit on shelves or in conference papers, but would be communicated directly to the end-users, the farmers. Chapman et al (2003) demonstrates that this approach has been useful in enabling farmers to adopt soil water conservation practices in northern Ghana.

Notes:

1. Under orthodox agricultural extension, designated officers from agricultural research institutes or equivalent institutions visit farmers on their farms or in group meetings to educate them about new scientific knowledge.
2. Existing studies examining social learning from neighbors in other settings such as Foster and Rosenzweig (1995) and Munshi (2004) who analyze the Indian green revolution found similar results.
3. Rural radios have also become the medium through which neglected folks voice out their concerns over all issues affecting them. In particular, peasants have used the rural FM radios as platforms to reach their political leaders and to organize community development efforts.
4. The reach of radio programs have widened tremendously since 1996. A World Bank estimate shows the number of radios per capita to have increased from 231 per 1000 in 1995 to 710 per 1000 in 2001 (World Bank 2003). Rural FM stations would have a tremendous impact on this change.
5. Prior to 1996, the Ghanaian Broadcasting Service (GBS) maintained monopoly over radio transmission.
6. Nowhere is this shift more nationalized than in Uganda. After several decades of orthodox agricultural extension services that fail to stimulate productivity growth and expansion, the Ugandan Ministry of Agriculture in 2000 created a National Agriculture Advisory Services (NAADS) system where farmers themselves are the lead players in knowledge extension (Government of the Republic of Uganda 2000). Under this new approach, farmer groups instead of extension officers are responsible for planning, prioritization, resource allocation, monitoring and evaluation of extension services. Importantly, farmers are able to socialize their successful private farming practices through this process. An evaluation of the program in 2005 by Benin et al. (2007) shows that compared to areas that remain under orthodox extension services, NAADS has been successful in promoting adoption of improved crop varieties and adoption of yield-enhancing technologies and post-harvest systems. There is also evidence that the program helped farmers to avoid income declines that affected most farmers between 2000 and 2004.
7. The co-movement of extension services and fertilizer usage in community is naturally expected. Community leaders are asked whether extension agents visit the community and whether farmers in the community use fertilizer. A greater part of the advice given by extension agents might involve fertilizer usage and application.
8. Our focus in this paper is to isolate the effect of knowledge that is socialized among farmers through radio on crop yield. Inevitably, segments of television programs that are broadcast in rural areas would be dedicated to local development issues similar to the ones that are transmitted on local radio. There is therefore the potential that radio and television serve the same purpose at least by devoting some air time to similar issues. However,

opportunities for rural indigenes to share their knowledge and learn from others will be captured more intensively on radio than television. The on-air discussions that enable people in rural communities to share their knowledge and experience are unlikely to take place on television sets.

9. The idea of radio-only or more appropriately radio but not television is similar to the idea of differencing in set theory. Given two sets A and B, the difference “A less B” denoted as A\B is the set of elements that are present in A but not in B. It is plausible to consider the content of broadcast on radio and television as elements of two sets. The differencing isolates the content of segments broadcast on radio but not on television.

10. The decrease in fertilizer usage may be due to prices or issues related to availability. Indeed, while farmers in non-cocoa regions may be learning the best practices, inability to obtain the needed inputs, especially in the case of fertilizer, may constrain the effect of socialized learning.

References:

Bediako, J. A., Nkegbe, P. and Iddrisu, A. (2005) Establishing the future potential for the use of mud silos by smallholder farmers: an assessment of mud silos promotion in the Northern region of Ghana, University of Development Studies, Tamale, Northern Region , Ghana.

Boateng, W. (2006) Knowledge Management Working Tool for Agricultural Extension Practice: The Case of Ghana, *Knowledge Management for Development Journal,* 2(3), pp. 19-29.

Borts, G.H. and Stein, J. L. (1964) *Economic Growth in a Free Market* (New York: Columbia University Press).

Chapman, R., Blench, R., Kranjac-Berisavljevic’, G. and Zakariah, A.B.T. (2003) Rural Radio in Agricultural Extension: The Example of Vernacular Radio Programmes on Soil and Water Conservation in N. Ghana. Overseas Development Institute AgREN Network Paper No. 127

Conley, T. G. and Udry, C.R. (2010) Learning About a New Technology: Pineapple in Ghana. *American Economic Review* 100 (1), pp. 35-69

Eicher, C. K. and Rukuni, M. (2003) The CGIAR at 31: An Independent Meta-Evaluation of the Consultative Group on International Agricultural Research. Thematic Working paper, The World Bank, Washington DC.

Foster, A., and Rosenzweig, M. (1995) Learning by Doing and Learning from Others: Human Capital and Technical Change in Agriculture. *Journal of Political Economy* 103 (6), pp. 1176-1209.

Girard, B. (2001) The challenges of ICTs and rural radio. Paper presented at the First International Workshop on Farm Radio Broadcasting, 19–22 February 2001, FAO, Rome.

Benin, S., Nkonya, E., Okecho, G., Pender, J., Nahdy, S., Mugarura, S., Kato, E. and Kayobyo, G. (2007) Assessing the Impact of the National Agricultural Advisory Services (NAADS) in the Uganda Rural Livelihoods. International Food Policy Research Institute Discussion Paper No. 00724.

Government of the Republic of Uganda (2000) Plan for Modernization of Agriculture: Eradicating Poverty in Uganda. Ministry of Agriculture, Animal Industry and Fisheries http://api.ning.com/files/ffRLhO7x-pp8FfrnIEFfaTgGP5wzeKG2UAhWQzkkYkM_/PMAMaindocument.pdf

McKay, B. (2003) Fishers and radios: a case study of Radio Ada in Ghana. *www.kit.nl/-/INS/15587/Royal-Tropical.../KIT.../ILS-Dossiers.pdf*

Mugera, A. and Ojede, A. (2011) Agricultural productivity Growth in Africa: Is Efficiency catching-Up or Lagging Behind? Paper presented at the 55th Annual National Conference of the Australia Agricultural and Resources Economics Society, Melbourne, Victoria, February 8-11, 2011

Munshi K. (2004) Social learning in a heterogeneous population: technology diffusion in the Indian Green Revolution. *Journal of Development Economics* 73 (1), pp. 185-215

Quarmyne, W. (2001) Participatory Research for Community Radio Program Series for Social Change. Ghana Community Radio Network and Radio Ada http://asiapacific.amarc.org/files/OURMedia6_Sydney/NM6_Community%20Radio%20in%20Ghana_2007.04.pdf

Ray, H. E. (1978) The basic village education project: Guatemala (Washington: Academy for Educational Development).

Roling, N. (1992) The emergence of knowledge systems thinking: A changing perception of relationships among innovation, knowledge process and configuration. *The International Journal of Knowledge Transfer and Utilization* 5(1), pp. 42-64

Sangare, O. (2000) Impact of Radio Broadcasts in the Mali-South Region: Follow-Up and Evaluation. An evaluation of the GCP/MLI/020/NET Project of the Food and Agriculture Organization (FAO), http://www.fao.org/docrep/003/x6721e/x6721e14.pdf

Whaites, N. (2005) Tuning In: An Inventory of Rural FM Radio in Ghana. Unpublished Thesis, Faculty of Graduate Studies, University of Guelph.

World Bank (2007) *World Development Report 2008 - Agriculture for Development*, The International Bank for Reconstruction and Development/The World Bank, Washington DC; Available at http://siteresources.worldbank.org/INTWDR2008/Resources/WDR_00_book.pdf

Appendix

Variable	**Definition**	**Source**
Crop Yield	Output per acre cultivated	GLSS
ln_croplab	Log of labor input for all crops	GLSS
ln_cropnlab	Log of non-labor input for all crops	GLSS
agric fertilizer use	Whether farmers use fertilizer in the community	GLSS
agric insecticide use	Whether farmers use insecticides in the community	GLSS
agric land sale	Whether individuals can buy or sell land in the community	GLSS
crops sold to market traders	Whether crop output is sold in regular markers	GLSS
agric extension worker	Whether an extension worker is located in the community	GLSS
agric cooperative	Whether farmers' cooperative exists in the community	GLSS
newspapers intensity	Region-level rate of newspaper readership	DHS
television intensity	Region-level rate of television viewership	DHS
Radio-only intensity	Region-level rate of radio-only listenership	DHS
Population density	Population per cluster in a given region	GLSS
Log Income	Log of total household income	GLSS

TABLE 1

SUMMARY STATISTICS

	1991/92	Number of Households	2005/06	Number of Households	Change
CROP INPUT AND OUTPUT					
Cocoa Output (Kg)	723.00	244	1,606.83	607	122%
	(1,021.50)		(7,982.91)		
Cocoa acres	344.58	244	335.46	607	-3%
	(807.92)		(817.09)		
Non-cocoa Output (kg)	837.33	1,225	1,439.20	1,779	72%
	(1,006.69)		(5,453.70)		
Cocoa Regions	618.98	754	1,028.16	883	66%
	(913.33)		(7,105.87)		
Non-cocoa Regions	1,186.88	471	1,844.28	896	55%
	(1,050.64)		(2,999.33)		
Non-cocoa acres	107.77	1,225	62.32	1,779	-42%
	(383.42)		(305.27)		
Cocoa Regions	158.60	754	103.22	883	-35%
	(470.01)		(404.92)		
Non-cocoa Regions	26.40	471	22.02	896	-17%
	(134.00)		(142.39)		
Total Crop Output (kg)	886.15	1,469	1,568.63	2,386	77%
	(1,066.83)		(6,298.87)		
Total Crop acres	148.12	1,469	134.47	2,386	-9%
	(490.36)		(507.03)		
Crop labor input (GHC)	9,899.98	1,469	529,506.70	2,386	
	(23,756.75)		(5,022,236.00)		
Crop non-labor input (GHC)	4,772.59	1,469	531,818.30	2,386	
	(9,998.37)		(4,011,944.00)		
Non-labor Costs/Variable Costs	0.43	1,196	0.56	1,881	31%
	(0.42)		(0.40)		
CROP YIELD					
Total Crop Yield(kg/Ha)	131.22	1,469	244.73	2,386	87%
	(195.54)		(1,605.86)		
Cocoa Yield (Kg/Ha)	88.29	244	105.78	607	20%
	(197.52)		(215.57)		
Non-cocoa Yield (Kg/Ha)	129.59	1,225	273.67	1,779	111%
	(183.56)		(1,824.10)		
Cocoa Regions	119.61	754	275.67	883	130%
	(215.96)		(2,527.16)		
Non-cocoa Regions	145.58	471	271.70	896	87%
	(112.30)		(562.38)		

NOTE: Non-cocoa crops included are beans/pea, groundnut, guinea corn, maize and rice

TABLE 2

MEAN CHARACTERISTICS OF SURVEYED AREAS

GLSS Sources	Cocoa Regions				Non Cocoa Regions				Difference	
Community Dummies	1991/92	2005/06	Diff	sig	1991/92	2005/06	Diff	sig	Diff-in-Diff	sig
motorable road	0.83	0.91	0.08	**	0.72	0.69	-0.03		0.11	
land market	0.12	0.15	0.03		0.04	0.05	0.01		0.02	
local market	0.38	0.30	-0.08	*	0.45	0.26	-0.19	**	0.11	
agric cooperative	0.30	0.35	0.05		0.26	0.22	-0.04		0.09	
farmers use insecticide	0.64	0.81	0.17	***	0.32	0.44	0.12		0.05	
extension services	0.23	0.26	0.03		0.34	0.18	-0.16	**	0.19	**
farmers use fertilizer	0.49	0.72	0.23	***	0.81	0.60	-0.21	**	0.44	***
Number	195	226			47	102				
DHS Sources	Cocoa Regions				Non Cocoa Regions				Difference	
Percent of Households:	1993	2003	Diff	sig	1993	2003	Diff	sig	Diff-in-Diff	sig
Read Newspapers Weekly	0.17	0.20	0.03	*	0.08	0.09	0.01		0.02	
Watch Television Weekly	0.32	0.45	0.13	***	0.19	0.21	0.02		0.11	**
Listen to Radio Weekly	0.59	0.93	0.34	***	0.48	0.80	0.32	***	0.02	
Listen to Radio Only Weekly	*0.34*	*0.50*	***0.16***	***	*0.33*	*0.60*	***0.27***	***	*-0.11*	**
Number of Clusters	204	164			46	74				

NOTE: * difference is significant at 10%; ** difference is significant at 5%; *** difference is significant at 1%

TABLE 3

DETERMINANTS OF COCOA YIELD (OUTPUT PER ACRE)

Dependent variable = Log yield	1991/92 Survey					2005/06 Survey				
	I	II	III	IV	V	I	II	III	IV	V
Log value of labor Input	0.0208	0.0052	0.0055	0.0169	0.0065	0.027	0.0246	0.0246	0.0237	0.016
	[0.0389]	[0.0389]	[0.0367]	[0.0364]	[0.0368]	[0.0175]	[0.0175]	[0.0173]	[0.0174]	[0.0176]
Log value of non-labor Input	-0.053	-0.0495	-0.0093	-0.006	-0.0091	0.0357**	0.0356**	0.0290*	0.0299*	0.0272
	[0.0356]	[0.0352]	[0.0349]	[0.0344]	[0.0353]	[0.0166]	[0.0166]	[0.0169]	[0.0169]	[0.0171]
Fertlizer use	1.2488***	1.0973***	0.4596	0.5689	0.6427*	0.1824	0.1266	0.123	0.1565	0.2397
	[0.3587]	[0.3610]	[0.3595]	[0.3560]	[0.3584]	[0.3042]	[0.3061]	[0.3127]	[0.3141]	[0.3134]
Insecticide use	-0.5472	-0.3102	-0.0282	-0.1429	-0.1899	-1.0095**	-1.0764**	-0.9804**	-0.9530**	-0.9643**
	[0.3908]	[0.3962]	[0.3777]	[0.3740]	[0.3754]	[0.4407]	[0.4428]	[0.4408]	[0.4413]	[0.4435]
Land market	1.5431***	1.7007***	1.4844***	1.1568***	1.0133**	0.4808	0.4377	0.3092	0.3328	0.1883
	[0.4211]	[0.4199]	[0.3999]	[0.4100]	[0.4248]	[0.3432]	[0.3465]	[0.3473]	[0.3478]	[0.3494]
Crops sold to market traders	0.3005	0.2232	0.0758	0.1458	0.114	-1.5334*	-1.5237*	-1.4337*	-1.4457*	-1.4894*
	[0.7859]	[0.7775]	[0.7338]	[0.7229]	[0.7229]	[0.8451]	[0.8444]	[0.8380]	[0.8379]	[0.8299]
Agric extension service		0.8866**	0.9775***	0.8211**	0.8397**		0.3360	0.261	0.2457	0.2156
		[0.3645]	[0.3450]	[0.3441]	[0.3454]		[0.2372]	[0.2373]	[0.2377]	[0.2435]
Agric cooperative		-0.4594	-0.1556	-0.067	-0.0594		0.1734	0.2261	0.2001	0.3007
		[0.3263]	[0.3230]	[0.3195]	[0.3209]		[0.2304]	[0.2338]	[0.2349]	[0.2375]
Newspapers intensity			0.1067***	0.0707**	0.0782**			0.0079	0.0355	0.035
			[0.0252]	[0.0278]	[0.0312]			[0.0358]	[0.0433]	[0.0434]
Television intensity			0.1009***	0.1432***	0.1327***			0.0585***	0.0878**	0.0713
			[0.0231]	[0.0271]	[0.0277]			[0.0226]	[0.0344]	[0.0449]
Radio-only intensity				0.0885***	0.0783**				0.0583	0.0465
				[0.0308]	[0.0311]				[0.0516]	[0.0640]
Population Density					0.0220					0.0249
					[0.0418]					[0.0419]
Log Income					0.3134*					0.4605***
					[0.1679]					[0.1068]
Constant	0.3484	0.1163	-3.6619***	-6.4897***	-11.0796***	0.0426	0.0677	-2.3040**	-6.9735*	-14.4302***
	[0.6789]	[0.6956]	[0.9466]	[1.3559]	[2.9509]	[0.5632]	[0.5630]	[0.8924]	[4.2275]	[4.6591]
Observations	244	244	244	244	243	607	607	607	607	590
R-squared	0.14	0.17	0.27	0.29	0.31	0.10	0.10	0.12	0.12	0.15

Standard errors in brackets; Regresion models include ecological zones and rainfall deviation

* significant at 10%; ** significant at 5%; *** significant at 1%

The basic model we estimate is given by: $\ln Y = \alpha_0 + \alpha_L \ln L + \alpha_K \ln K + \sum_{i=1}^{n} \delta_i N_i$ where N_i is a source of knowledge. We include interaction terms in the model in subsequent tables.

TABLE 4

DETERMINANTS OF NON-COCOA CROP YIELD (OUTPUT PER ACRE)

Dependent variable = Log yield	1991/92 Survey					2005/06 Survey				
	I	II	III	IV	V	I	II	III	IV	V
Log value of labor Input	-0.0182	-0.0188	-0.0369***	-0.0393***	-0.0240**	-0.0047	-0.0042	0.0071	0.009	0.0028
	[0.0118]	[0.0118]	[0.0119]	[0.0120]	[0.0119]	[0.0067]	[0.0067]	[0.0067]	[0.0064]	[0.0067]
Log value of non-labor Input	0.0314**	0.0307**	0.0365***	0.0389***	0.0332***	0.0407***	0.0404***	0.0396***	0.0399***	0.0368***
	[0.0125]	[0.0126]	[0.0126]	[0.0126]	[0.0124]	[0.0073]	[0.0073]	[0.0071]	[0.0068]	[0.0069]
Fertlizer use	0.1173	0.092	0.1408	0.1515	0.1609	-0.098	-0.0927	-0.1860**	0.0204	-0.011
	[0.1158]	[0.1187]	[0.1168]	[0.1168]	[0.1158]	[0.0931]	[0.0937]	[0.0928]	[0.0894]	[0.0903]
Insecticide use	-0.1901*	-0.2327**	-0.2949**	-0.3111***	-0.1691	-0.6172***	-0.5885***	-0.3191***	-0.3481***	-0.3130***
	[0.1123]	[0.1181]	[0.1171]	[0.1174]	[0.1164]	[0.0980]	[0.1009]	[0.1020]	[0.0969]	[0.0985]
Land market	0.5008**	0.4855**	0.325	0.2953	0.5082**	-1.3180***	-1.2883***	-1.1294***	-0.9572***	-0.8940***
	[0.2042]	[0.2046]	[0.2013]	[0.2018]	[0.1992]	[0.1556]	[0.1573]	[0.1542]	[0.1469]	[0.1497]
Crops sold to market traders	0.3119***	0.3200***	0.2839***	0.2851***	0.2859***	0.5137***	0.5062***	0.5086***	0.5100***	0.4852***
	[0.1001]	[0.1003]	[0.0982]	[0.0981]	[0.0963]	[0.0844]	[0.0846]	[0.0829]	[0.0787]	[0.0805]
Agric extension service		0.1202	0.1817	0.1792	0.1054		-0.1623	-0.0921	-0.2231**	-0.2381**
		[0.1282]	[0.1254]	[0.1253]	[0.1236]		[0.1156]	[0.1126]	[0.1073]	[0.1092]
Agric cooperative		0.0732	0.0129	0.0049	-0.0718		0.0307	0.1237	0.1491	0.1566
		[0.1193]	[0.1177]	[0.1177]	[0.1150]		[0.1029]	[0.1006]	[0.0955]	[0.0974]
Newspapers intensity			-0.0453***	-0.0511***	-0.0392***			-0.0388***	-0.1829***	-0.1611***
			[0.0095]	[0.0101]	[0.0100]			[0.0125]	[0.0158]	[0.0222]
Television intensity			0.0530***	0.0574***	0.0720***			-0.0227***	0.1178***	0.1109***
			[0.0068]	[0.0073]	[0.0073]			[0.0052]	[0.0112]	[0.0125]
Radio-only intensity				0.0153*	0.0624***				0.2149***	0.2104***
				[0.0088]	[0.0102]				[0.0154]	[0.0170]
Population Density					0.0752***					0.0094
					[0.0092]					[0.0072]
Log Income					0.1667***					0.0951***
					[0.0461]					[0.0328]
Constant	0.8688***	0.8771***	0.2713	-0.2651	-8.1526***	2.1743***	2.1579***	3.6739***	-10.7241***	-12.6487***
	[0.1885]	[0.1890]	[0.2463]	[0.3946]	[0.9872]	[0.1375]	[0.1387]	[0.2116]	[1.0524]	[1.2045]
Observations	1225	1225	1225	1225	1203	1779	1779	1779	1779	1739
R-squared	0.38	0.38	0.41	0.41	0.45	0.28	0.28	0.32	0.39	0.39

Standard errors in brackets; Regresion models include ecological zones and rainfall deviation

* significant at 10%; ** significant at 5%; *** significant at 1%

TABLE 5

DETERMINANTS OF NON-COCOA CROP YIELD (OUTPUT PER ACRE) - POOLED SAMPLE

Dependent variable = Log yield	COCOA REGIONS					NON-COCOA REGIONS				
	I	II	III	IV	V	I	II	III	IV	V
ln_croplab	0.0237*	0.0282**	0.0153	0.0154	0.0195	-0.0161**	-0.0161**	-0.0168**	-0.0177**	-0.0229***
	[0.0131]	[0.0130]	[0.0131]	[0.0130]	[0.0133]	[0.0074]	[0.0074]	[0.0078]	[0.0078]	[0.0079]
ln_cropnlab	0.0226*	0.018	0.0049	-0.0024	-0.0053	0.0150**	0.0150**	0.0146*	0.0134	0.0115
	[0.0134]	[0.0132]	[0.0135]	[0.0136]	[0.0139]	[0.0074]	[0.0074]	[0.0084]	[0.0085]	[0.0084]
agric fertilizer use	0.1498	0.18	0.1871	0.2321**	0.2126*	-0.4686***	-0.4637***	-0.4914***	-0.5080***	-0.5560***
	[0.1198]	[0.1190]	[0.1172]	[0.1173]	[0.1190]	[0.0741]	[0.0742]	[0.0742]	[0.0745]	[0.0738]
agric insecticide use	-0.6856***	-0.6751***	-0.5576***	-0.5173***	-0.4982***	0.3383***	0.3349***	0.3096***	0.3100***	0.3412***
	[0.1280]	[0.1271]	[0.1257]	[0.1256]	[0.1278]	[0.0781]	[0.0783]	[0.0782]	[0.0781]	[0.0779]
agric land sale	-0.5347***	-0.5299***	-0.5156***	-0.4760***	-0.4633***	0.4391	0.4383	0.3706	0.3386	0.3815
	[0.1571]	[0.1559]	[0.1531]	[0.1528]	[0.1553]	[0.3820]	[0.3818]	[0.3805]	[0.3802]	[0.3804]
crops sold to market traders	0.4135***	0.4549***	0.4336***	0.3723***	0.3759***	0.4122***	0.4122***	0.4125***	0.4158***	0.4123***
	[0.1071]	[0.1064]	[0.1044]	[0.1052]	[0.1071]	[0.0612]	[0.0612]	[0.0610]	[0.0609]	[0.0612]
agric extension worker	-0.1358	-0.1467	-0.1843	-0.1747	-0.2109	-0.0358	-0.036	-0.0199	-0.027	-0.0444
	[0.1415]	[0.1404]	[0.1378]	[0.1372]	[0.1400]	[0.0811]	[0.0811]	[0.0812]	[0.0811]	[0.0811]
agric cooperative	0.0845	0.0739	0.0115	-0.0043	-0.0161	-0.1207	-0.1186	-0.1188	-0.1071	-0.1032
	[0.1210]	[0.1201]	[0.1180]	[0.1175]	[0.1195]	[0.0775]	[0.0775]	[0.0786]	[0.0786]	[0.0782]
newspapers intensity	0.0053	-0.0065	-0.0043	0.0217	0.0208	-0.0372***	-0.0366***	-0.0523***	-0.0724***	-0.0707***
	[0.0153]	[0.0148]	[0.0147]	[0.0162]	[0.0165]	[0.0104]	[0.0104]	[0.0111]	[0.0143]	[0.0142]
television intensity	-0.0019	0.0195***	0.0439***	0.0238***	0.0227**	0.0170***	0.0194***	0.0375***	-0.0163	-0.0048
	[0.0079]	[0.0064]	[0.0070]	[0.0087]	[0.0093]	[0.0058]	[0.0064]	[0.0079]	[0.0253]	[0.0257]
Radio-only intensity		0.0377***	0.0287***	0.0105	0.0092		0.0026	0.0015	-0.0261**	-0.0274**
		[0.0057]	[0.0064]	[0.0080]	[0.0088]		[0.0029]	[0.0032]	[0.0127]	[0.0127]
Year 2006			-7.4807***	-7.4205***	-7.6141***			-3.2115***	-3.2948***	-4.0296***
			[0.9284]	[0.9248]	[0.9455]			[0.8455]	[0.8451]	[0.8746]
Radio-only intensity x Year 2006			0.1244***	0.1220***	0.1257***			0.0510***	0.0521***	0.0645***
			[0.0168]	[0.0168]	[0.0171]			[0.0131]	[0.0131]	[0.0136]
Population density				0.0492***	0.0472***				0.0445**	0.0330
				[0.0130]	[0.0134]				[0.0199]	[0.0203]
Log Income					0.0218					0.0774***
					[0.0450]					[0.0236]
Constant	-0.3097	-0.8781**	-1.1523***	-2.8101***	-2.9067***	1.7661***	1.6848***	1.4503***	3.5994***	2.6599**
	[0.3286]	[0.3458]	[0.3432]	[0.5562]	[0.6351]	[0.4734]	[0.4979]	[0.4995]	[1.0823]	[1.1376]
Observations	1637	1637	1637	1637	1599	1367	1367	1367	1367	1343
R-squared	0.25	0.26	0.29	0.30	0.30	0.18	0.18	0.19	0.20	0.21

Standard errors in brackets; Regresion models include ecological zones and rainfall deviation

We include interaction of labor and non-labor costs with year dummy to isolate general increase in prices between the surveys.

* significant at 10%; ** significant at 5%; *** significant at 1%