

Prospects and Challenges of Agricultural Technology-Market Linkage under Liberalisation in Ghana: Evidence from a Micro-data

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African Development and Poverty Reduction: The Macro-Micro Linkage

Forum Paper 2004

13 - 15 October 2004
Lord Charles Hotel, Somerset West, South Africa

 Development Policy Research Unit  Trade and Industrial Policy Strategies
 Cornell University

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Prospects and Challenges of Agricultural Technology-Market Linkage under Liberalization in Ghana: Evidence from a micro-data

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Abstract

There is a general consensus that bad economic policies, among other factors, are to blame for the poor performance of economies in sub Saharan African (SSA). However, there is no similar consensus on the effect of economic reforms on poverty alleviation, a primary goal of any economy in the region. This paper looked into the effect of macro-economic reforms, particularly the removal of subsidized agricultural credit for irrigator farmers in Ghana, a pioneering reform country in SSA. A theoretical model of this scenario is constructed in which it is shown that, under multiple market imperfection, farmers resort to alternative financial sources to finance irrigation. Particularly in the presence of off-farm alternative, farmers divide their labor resource between irrigation farming and off-farm employment. The long term implication of a predominant dependence on off-farm income for financing irrigation farming will be an induced increase in family size. This model is subsequently tested and validated with a household data collected from northern Ghana. Household labor endowment and off-farm participation have a positive and significant effect on household irrigation decisions. This implies that, irrigation and off-farm employment are complimentary activities, which indicates a possible induced family size increase.

I. Introduction

Poverty in sub Saharan Africa has rural, agro-ecological and social dimensions. In West Africa, in several countries with a savannah in the north and a forest in the south, rural poverty tends to be significantly higher in the north. In Ghana, which is the focus of this paper, poverty incidence is highest in rural savannah areas (IFAD 2001), this difference in poverty has its roots both in the difference in their socio-economic and bio-physical features. During the colonial period people in the north were major source of labor for the commercial plantations in the south and there was very little attention given to the provision of social services to the north (Konings 1986).

In addition to that, the agro-ecology in northern Ghana is semi arid which is characterized by erratic rainfall and poor soil quality. These bio-physical features coupled with poorly developed credit and insurance markets, made agriculture a risky venture. To offset this incidence, especially after the end of the colonial period, poverty alleviation focused on reducing the risk associated with rainfall variability and the uncontrolled influx of labor force from the north to the south. To this end provision of irrigation services which ensure water supply and help create local employment in place of migration was taken as a major strategy. The irrigation strategy was envisaged with the notion of transforming the 'conservative and backward' producers who were forced to sell their labor power both to the Southern and, increasingly, to the newly established Northern capitalist sector-into 'modern' producers of cash crops for Southern markets and agro-industries (Konings 1986). Tono and Vea were the two projects built in the Upper East Region (UER) with irrigation areas of 2490 & 850 hectares respectively (ICOUR 1995). Farmers were allocated plots of land in the irrigation schemes and were supplied with subsidized inputs and services from the state run irrigation company.

However, the introduction of the Structural Adjustment Program (SAP), which Ghana embarked on since the early 1980's changed the paradigm of irrigation farming in general and that of the poor in particular. There was a drastic drop in government support to inputs

and credit. In addition, the Irrigation Company of Upper Region (ICOUR) has been reorganized to make profit from the service it renders or at least cover its running costs. As a result the company has started charging irrigation levy per hectare bases, which is higher than what used to be, in addition to that it stopped providing inputs at a subsidized rate. The system can in short be described as a “cash and carry” system, where only those who can pay on the spot have access to the services.

To study the effect of the reforms on poverty alleviation, we addressed the following questions: Who are the irrigators under the new paradigm? Are the poor marginalized? What alternative financial sources are farmers relying on? What are the implications of the alternative financial sources, that is are the alternatives sustainable? The main objective of this paper will be to shade light on these questions. The other objective of this paper will be to construct a theoretical model that relates off-farm income and household fertility decisions under different market settings.

The remaining parts of this paper are arranged as follows: in part II we will give a short review of the macro-economic reforms in Ghana, off-farm income and their implications, in part III we will build a theoretical model which shows the relationship between on and off-farm labor allocation and its implication on family size; in part IV we will provide a description of the empirical model applied to test the hypothesis and part V will present the data and results of the analysis. The final part will present the conclusion of the paper.

II. Macro-economic Reforms, Credit, Off-farm Income & Fertility Decisions

Starting in the early 1980s countries all across the development spectrum had to adopt a series of policy measures aimed at coping with the severe international economic crisis. An increasing number of countries had to go through the adjustment process, either because absence of further capital inflows left no other option, or because this type of adjustment was made a precondition by the private banks and the multilateral agencies before new money would be released (Edwards and van Wijnbergen 1992). These programs have become known as structural adjustment programs. Structural adjustment is a process of market-oriented reform in policies and institutions, with the goals of restoring a sustainable balance of payments, reducing inflation, and creating the conditions for sustainable growth in per capita income (Corbo and Fischer 1995).

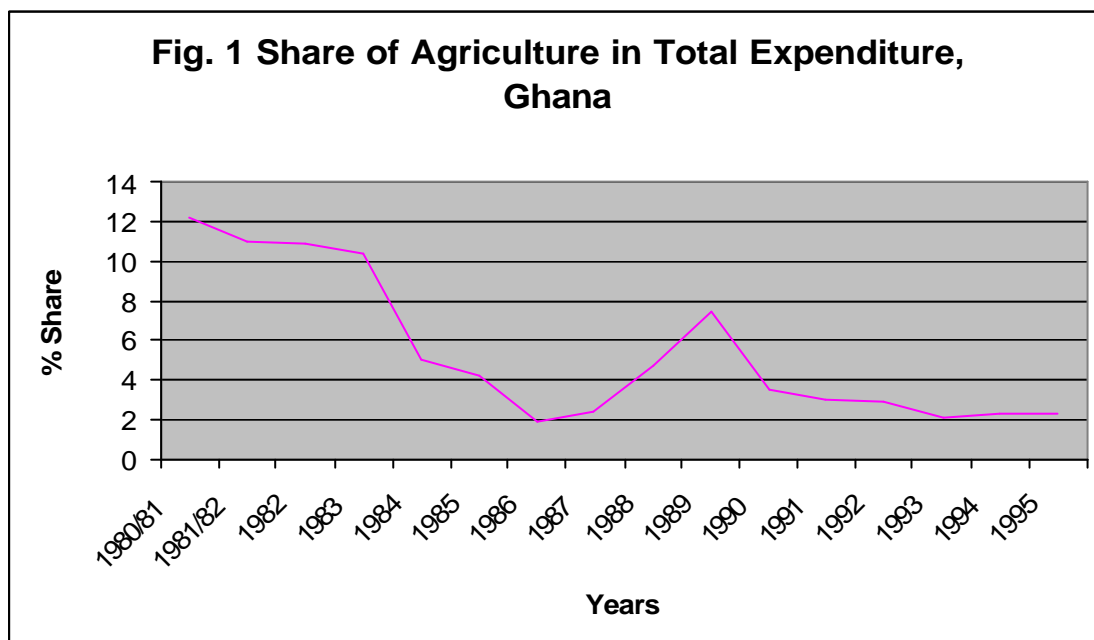
Ghana is one of the few African countries, who have embarked on the adjustment program in the early 1980s and it was counted as a success story in Africa, where economic adjustment and recovery of growth have been exceptionally difficult (World Bank 1993). When it began its Economic Recovery Program in April 1983, Ghana was submerged in a deep economic crisis. The poor economic performance during the 1970s and early 1980s was due to inadequate domestic policies and sever internal and external shocks (Dordunoo and Nyanteng 1997). The main initial measure of the reform included a large nominal devaluation of the cedi¹ and a fiscal contraction to achieve and sustain a real devaluation, which led to a reduction in the fiscal deficit from 5.6 percent of GDP in 1982 to 0.7 percent in 1989. Credit and monetary policies were also designed to reduce inflation and the current account deficit with the elimination of controls on deposits and lending interest rates in 1988 (Corbo and Fischer 1995).

The evidence on the impact of SAP on poverty is mixed and neither theory nor evidence is conclusive on the impact of adjustment on the poor (Lipton and Ravallion 1995). However, in economies where agriculture is the predominant sector and the main stay of

¹ Ghanaian National Currency

the poor, policies that affect the national economy will have substantial implications for the poor (Bardhan and Udry 1999). Though the effect of SAP is not uniform, there is one distinctive feature, however, when it comes to Africa and the agricultural sector. SAP has significantly reduced the agricultural sector's share of government spending in SSA (Fan and Rao 2003).

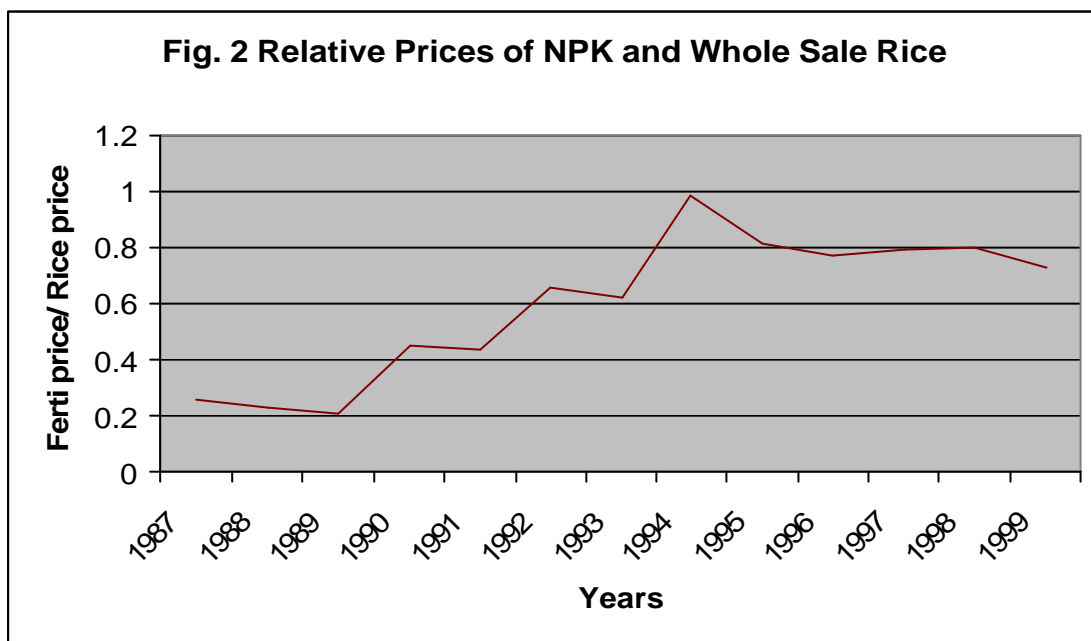
In Ghana (Figure 1) the budget share of agriculture has dropped from 12 % prior the reform to only 2 % in the 1990s. The drop in budget share resulted in a huge cuts in formal credit and input supply programs, and in subsidies for fertilizer, credit, and animal traction equipments (Reardon et al. 1994).



Source: (Nyanteng and Dapaah 1997)

Though, the reforms were meant to create incentives to agricultural producers, to the majority of small holder farmers the negative impact from the removal of input subsidies over weighed the benefits from the market reforms. Before the reforms fertilizer subsidies have been in the range of 40 to 80 percent. However, after the reform on the average the prices of most agricultural chemicals used in cereal production increased in excess of 40 % per annum between 1986 and 1992 and the price of fertilizer in particular doubled between 1990 and 1992 (Seini 2002). The effect of the rise in input prices is

aggravated by seasonal output price collapses and the inability of the price of major crops to rise with equal pace as the input prices. The effect of the increase in input price as compared to whole sale output price can be observed from the increasing input output price (I/O) ratios (Figure 2). The I/O relationship shows that in the late 1980s a farmer required only 0.2 kg of rice to purchase a kg of fertilizer but in the 1990s that ratio has risen to about 0.8 kg. The situation at the farm gate can be even worse, if one takes in to account the fact that farm gate prices do not follow the same pace of development as that of services in Ghana (Gerken et al. 2001).



Source: (Gerken et al. 2001)

The reforms have not only changed the input price regimes but also the credit environment. That is, credit for the purchase of farm inputs for small holder farmers has been drastically affected by the reforms. By 1988, a period after the reform, the average size of a loan to farmers was cedi 20,000 and this was in real terms more than 500 percent smaller than the average size of agricultural loans before the reforms, in 1977 (Aryeetey et. al., 1990 as quoted by (Seini 2002)). According to a World Bank estimate in 1995 the effective demand for agricultural credit in Ghana was 196.7 billion Cedis (in

1988 prices) while the total loans to agriculture, forestry and fisheries was only 42.12 billion Cedis (Seini 2002).

Before the reform, the Agricultural Development Bank (ADB) used to provide credit to the agricultural sector with preferential conditions. In addition to the ADB, commercial banks were also obliged to lend not less than 25 percent of their loan able funds to the agriculture sector at a reduced interest rates (Nyanteng and Dapaah 1997). These policies were gradually abolished in 1990; subsequently the interest rates charged for agricultural credit have been raised to levels comparable to rates of non-agriculture. Loans to small-scale farmers have virtually evaporated after the liberalization of interest rates. On the other hand there is no evidence to show that declining institutional credit to agriculture is being replaced by informal credit (Seini 2002). Compared to the rural semi-arid Asia, the West African semi-arid tropics generally faces less developed rural capital and insurance markets, an extreme climatic variation and severe environmental degradation (Reardon and Taylor 1996).

In the absence of financial markets, such as insurance, saving and credit, to smooth inter temporal consumption risk-averse households will have incentives to devote resources in an effort to secure a more stable income stream. One of the ex ante strategies in agricultural communities is diversifying their activities through migration or local non-agricultural employment (Bardhan and Udry 1999). In the study area, emigration, both seasonal and permanent is prominent. Among residents of both the Frafra and Kasen, the two major ethnic groups in the UER, about 75 percent of farmers reported to have previously engaged in wage labor for varying periods of time, mostly in Southern Ghana (Konings 1986). One of the peculiar features of inland migration in Ghana is the little attachment migrants have with their destination communities and their have high affinity to their origins. This strong attachment is reflected through remittances and frequent visits (Daniel 2004).

This is in conformity with the observations that unlike other places the urban-rural remittances are very large in Africa, ranging from 10 to 13 percent of urban incomes (Rempel and Lobdell (1974) quoted in (Williamson 1995). Particularly, in cases of credit

constraint and risky environment, off-farm income is used to increase households' farm productivity by mitigating risk and promoting farm investment (Abdoulaye and Sanders 2003; Evans and Ngau 1991; Reardon et al. 1994; Schrieder and Knerr 2000). Even in cases where some credit markets exist off-farm income serves as a collateral, for example Benin (Hoffman and Heidhues 1993). In Senegal farm households finance irrigation facilities through remittances from family members who are specially sent out for this purpose (Dia 1992) as quoted by (Konseiga 2004). The level of fertilizer demand is positively related to the depth of the village labor market, whether measured using the unemployment rate or the share of non-agricultural employment in semi-Arid Tropics of India (Lamb 2001).

This shows that, in an African setting there is complementarity between on and off-farm employments. The complementarity becomes more important in cases where a household depends on income generated from off-farm employment to finance agricultural activities, which also take place during the same season. When both on and off farm employments are undertaken during the same season, there will be a demand for a bigger pool of household labor that can satisfy both the on and off-farm demands. In the long term it will have significant implication on household fertility decision (Williamson 1995). In the above works and in most cases the remittance is taken as a positive alternative to the absent financial markets. However, this same blessing can be a curse if the sole dependence on remittances induces increase in family size.

The bulk of the cross-country variation in the total fertility rates is explicable by differences in desired fertility-access to contraceptives matter little Pritchett (1994) as quoted by (Lipton and Ravallion 1995). That means high fertility occurs not because poor families are ignorant but the cost of rearing a child is less than the benefit from child rearing. Children provide investment returns since they can work on the family farm or in the family businesses and may eventually contribute to the support of parents (Birdsall 1995; Dasgupta 1993).

In Western Europe and the US, child default, that is the probability that adult children will emigrate from rural areas and will not remit, and lack of financial markets have led to the decline in fertility (Williamson 1985) as cited by (Birdsall 1995); (Carter et al. 2003). However, the effect of the combination of an increasingly integrated labor market and a poor capital market has not been explored in developing country settings (Birdsall 1995). One objective of this paper will be to construct a theoretical model that relates off-farm income and household fertility decisions under different market settings.

Theoretical Model

To capture the relationship between on and off-farm labor demand and credit on household welfare and the natural resource based in northern Ghana. We based our theoretical model on household fertility decision by (Basu and Van 1998). Their major assumptions, with a modification to meet our purposes are: preferences are such that a family with small size will prefer to remain small and work off-farm during the dry season and supplement its consumption through buying. It will opt for larger family, only if the income from adult off-farm can not meet minimum consumption requirement S ; second technology is such that adult and child labor are substitutes; finally children are capable of providing net economic benefits to the family. That is, children can make a positive net contribution to the family. This final assumption is more valid in developing countries where agricultural productivity is less tied with human capital than is the case in rich countries (Dasgupta 1993). In addition to these, we made the following assumptions:

- There is no credit market or it is very thin,
- Farmers have the possibility of both hiring in and selling out their labor that is there is perfect labor market. There is off farm employment possibility either in other farmers' irrigation farms or through seasonal migration to the southern Ghana,
- For part of their consumption households depend on the market,

Let income from off-farm employment equals wL_0 , where w is wage rate and L_0 is amount of labor supplied to off-farm, and let X_m be the amount of market goods purchased at a price of P_m . Let us consider a household which is very small to finance and operate its own irrigation plot and its marginal benefit from irrigation is negative. Thus, the optimal decision for it will be to engage all its labor to off-farm activities during the dry season and use the income generated from the off-farm market for smoothing consumption during the dry season.

Let a household's irrigation decision be represented by $I \in \{0,1\}$, 1 if the household irrigates and 0 otherwise. Let us also assume that there is a household preference ordering over pairs of consumption X_m and irrigation participation I . Under this preference ordering the household decides to irrigate only if consumption would fall below some exogenously determined consumption level, which is equal to S , in the absence of irrigation participation. Following the argument in (Bardhan and Udry 1999) for fertility decision, the household preferences are defined over pairs (X_m, I) for $X_m \geq 0$ and $I \in \{0,1\}$. Thus the orders are:

$$\begin{aligned}
 &(X_m + \Phi, I) \succ (X_m, I) \\
 &(X_m + \Phi, 1) \succ (X_m, 0) \text{..if ..} X_m < S, \text{----- (Eqn1)} \\
 &(X_m + \Phi, 1) \prec (X_m, 0) \text{..if ..} X_m \geq S.
 \end{aligned}$$

For $F=0$, $S=0$, Preferences are such that higher (average) consumption is preferred to lower consumption.

Given the underlying assumptions and the smallness of our household a decision to irrigate implies decision to increase family size. Increasing family size or a fertility decision can be taken as an investment decision (Birdsall 1995) that should be evaluated in a dynamic setting. For our case we assumed a two period decision. Consumption and labor participation decisions are made in both periods 1 and 2, while fertility decision is made in period 1. When a household decides to increase its size in period 1, it will incur costs and will get return on its investment in period 2. The required cost in period 1 is assumed to equal to C , which is the consumption requirement of the additional member. Capitalizing on the productivity of children at early age in developing countries (Dasgupta 1993) we assume that in period 2 the additional child labor force will be able to produce sufficient output from irrigation that can satisfy the household consumption.

In summary:

Period 1:

- Income from off-farm: wL_o ----- (Eqn2)

- Consumption Expenditure = $\begin{cases} X_m (P_m + e) & \text{---if } I = 0 \\ (X_m + C)(P_m + e) & \text{---if } I = 1 \end{cases}$ --- (Eqn3)

Where e is transaction cost in output market.

Period 2:

- Discounted off-farm income: $=dwL_o$ for both $I=0$ and $I=1$, ----- (Eqn4)

- Discounted Consumption Expenditure = $\begin{cases} d(P_m + a)X_m & \text{---if } I = 0, \\ 0 & \text{---if } I = 1. \end{cases}$ --(Eqn5)

Budget constraint: $\begin{cases} wL_o + dwL_o = (P_m + e)X_m + d(P_m + a)X_m & \text{---if } I = 0 \\ wL_o + dwL_o = (P_m + e)(X_m + C) & \text{---if } I = 1 \end{cases}$ --(Eqn6)

Where d is discount rate.

The levels of X_m conditional on the state of irrigation decision will be:

$$X_m = \begin{cases} \frac{wL_o (1 + d)}{(p_m + e) + d(P_m + a)} & \text{---if } I = 0, \\ \frac{wL_o (1 + d) - (P_m + e)C}{(p_m + e)} & \text{---if } I = 1 \end{cases} \text{----- (Eqn7)}$$

In this case, the superiority of one state from the other depends on the assumption we make about the imperfection in the output market. For our case household, which is small and in an ideal case will be better off only if it engages in off-farm, the decision on whether to participate in irrigation or not depends on the transaction cost it faces in the

output market. To proof this let us look at the two extreme scenarios of the output market, the case of very high transaction cost and zero transaction cost.

Let us assume that in the first case the household anticipates a complete imperfection in the output market in period 2 that is $a \geq 8$. Evaluating X_m at extreme a levels, U_1 , which is preference with irrigation, will be greater than U_0 , preference without irrigation. This implies that the household will decide to irrigate in period 2 and increase its family size in period 1.

On the other extreme let the household anticipates no transaction costs in the output market in both periods. Thus, the corresponding levels of X_m will be:

$$X_m = \begin{cases} \frac{wL_o}{P_m} & \text{if } \dots I = 0, \\ \frac{wL_o + (dwL_o - P_m C)}{P_m} & \text{if } \dots I = 1. \end{cases} \quad \text{----- (Eqn8)}$$

In this case the superiority of one state from the other depends on the value of the term in parenthesis, which is the difference between the discounted future income and the present cost of child consumption. Therefore:

$$\text{If } \begin{cases} dwL_o = P_m C & \text{then } \dots U_1 = U_o \\ dwL_o > P_m C & \text{then } \dots U_1 > U_o \\ dwL_o < P_m C & \text{then } \dots U_1 < U_o \end{cases} \quad \text{----- (Eqn9)}$$

U_1 and U_0 are preferences under irrigation and without irrigation respectively. When the discounted future income is exactly equal to the additional cost in period 1, the household will be indifferent between irrigating and not irrigating. However, if the discounted future income is greater than the period 1 cost, the household will be better off if it irrigates and the vice versa. Comparing the result of the case where $a \geq 8$ and Eqn9, one can see that the decision to irrigate, which is the only feasible decision under extreme output market imperfection is identical to the case where the discounted future income is greater than present consumption cost on additional children, under a perfect output market. This implies that an imperfection in the output market can give the same incentive as a

condition where the marginal benefit from irrigation is positive and will lead to a socially inferior level of decision. The policy implication is that in the absence of credit market and a perfect labor market, correcting the imperfection in the output market will give a household with smaller size an incentive to remain so and engage only in off farm employment.

Empirical Specification of the Model

Irrigation decision during a given dry season is a discrete decision, which is made based on farmer's calculation of the difference between the benefits accrued to irrigation during that season and the associated costs. If we represent this difference between the benefits and costs from irrigating by an unobserved index Y_i^* , the analysis will render itself to be handled by the index function models (Greene 2003).

Let the data generating process be represented by:

$$Y_i^* = X_i \mathbf{b} + U_i \quad \text{----- (Eqn10)}$$

The latent variable, Y_i^* , is unobservable for us, what we can observe is only its effect, which is revealed in the decision maker's irrigation decision. The relationship between the latent variable and the observation can be mathematically represented as:

$$\begin{aligned} Y_i &= 1 \dots \text{if } Y_i^* > 0, \\ Y_i &= 0 \dots \text{if } Y_i^* \leq 0 \end{aligned} \quad \text{----- (Eqn11)}$$

The probabilistic equivalent of Eqn. 11 is:

$$\begin{aligned} \Pr(Y_i = 1) &= \Pr(Y_i^* > 0) \\ \dots &= \Pr(X_i \mathbf{b} + U_i > 0) \\ \dots &= \Pr(U_i > -X_i \mathbf{b}) \\ \dots &= \Pr(U_i \leq X_i \mathbf{b}) \end{aligned} \quad \text{----- (Eqn12)}$$

Estimating the parameters requires assumption on the distribution of the disturbance term, U_i . Once the distribution function is known, its integration will give us idea about the probability that U_i fell above some point. The most commonly assumed distributions are the logistic distribution and the normal distribution, which will generate the logit and probit models respectively. There is no difference between the two methods; one is as good as the other. However, because the standard logistic distribution has a larger variance, $\pi^2/3$ as compared to 1 for a normal distribution, it will also yield larger

estimated $\hat{\mathbf{b}}$ s and correspondingly larger standard error estimates (Greene 2003). Logit estimates are roughly 1.7 times probit ones (Amemiya 1981).

For our case if we assume U_i s to be logistically distributed, then the probability that a farm household will irrigate, that is $\Pr(Y_i=1)$ will be:

$$\Pr(Y = 1) \equiv \Lambda(X_i \mathbf{b}) = \frac{\exp(X_i \mathbf{b})}{1 + \exp(X_i \mathbf{b})} \text{----- (Eqn13)}$$

To calculate a probability statement for every observation i in our data, that is the probability of getting a zero (one) given the values of the covariates and the parameters, requires analyzing its likelihood, which is represented by (Eqn. 14) below:

$$L_i = \left(\frac{\exp(X_i \mathbf{b})}{1 + \exp(X_i \mathbf{b})} \right)^{Y_i} \left(1 - \frac{\exp(X_i \mathbf{b})}{1 + \exp(X_i \mathbf{b})} \right)^{1-Y_i} \text{----- (Eqn14)}$$

That is, irrigating observations will contribute $\Pr(Y_i=1/X_i)$ to the likelihood, while the non-irrigators contribute $\Pr(Y_i=0/X_i)$. Assuming independent observations, we can take the product over the N observations in our data to get the overall likelihood:

$$L = \prod_{i=1}^n \left(\frac{\exp(X_i \mathbf{b})}{1 + \exp(X_i \mathbf{b})} \right)^{Y_i} \left(1 - \frac{\exp(X_i \mathbf{b})}{1 + \exp(X_i \mathbf{b})} \right)^{1-Y_i} \text{----- (Eqn15)}$$

The natural log of the likelihood function, Eqn 15, will give us the log-likelihood function of the form:

$$\ln L = \sum_{i=1}^n Y_i \ln \left(\frac{\exp(X_i \mathbf{b})}{1 + \exp(X_i \mathbf{b})} \right) + (1 - Y_i) \ln \left(1 - \frac{\exp(X_i \mathbf{b})}{1 + \exp(X_i \mathbf{b})} \right) \text{----- (Eqn16)}$$

Maximizing the log-likelihood function with respect to the $\hat{\mathbf{b}}$ s will give us the MLEs. The so far procedure of the logit model is valid if observations are randomly. However, if any non-random sampling is pursued the estimates will be biased. In our case, the number of $Y=1$, irrigators has been deliberately increased as compared to the true proportion of

irrigators in the population. Since irrigators are relatively few, random sampling would have picked very few of them and that would limit our analysis on the irrigators. Our sampling procedure is referred to as choice based sampling, a procedure particularly important in case of rare events.

With the ML logit estimator, the bias resulting from choice based sampling is restricted to the constant and the coefficient of any variable which is also involved in the sampling (Dietrich 2001). For example in credit default study, if race is used as one variable to group the samples and also used to measure the probability that a subject has defaulted or not, then there will be bias in the estimate of the coefficient for race. The marginal benefit of correcting the bias depends on the objective of model estimation. If the objective is estimating the contribution of individual estimates, then the uncorrected model can still be of use, because the bias is mainly on the constant. However, if the objective of the model is to estimate the probability that an event occurs, in our case probability of irrigation, thus all parameters play role, the correction of the biases is important.

Designs that select on Y can be consistent and efficient with appropriate statistical corrections, such as priori correction and weighting. In the weighting method, the procedure is to weight the data to compensate for differences in the proportion of ones in the sample, \bar{y} and the proportion of ones in the population t. The estimation procedure is referred to as *weighted exogenous sampling maximum-likelihood estimator* (WESMLE) (Greene 2003). In WESMLE, the log-likelihood function to be maximized will be the weighted log-likelihood as is represented in Eqn. 17 below (King and Zeng 2001). And it is:

$$\ln L_w = w_1 \sum_{i=1}^n Y_i \ln \left(\frac{\exp(X_i \mathbf{b})}{1 + \exp(X_i \mathbf{b})} \right) + w_0 (1 - Y_i) \ln \left(1 - \frac{\exp(X_i \mathbf{b})}{1 + \exp(X_i \mathbf{b})} \right) \dots \text{(Eqn17)}$$

Where the weights are $w_1 = t / \bar{y}$ and $w_0 = (1 - t) / (1 - \bar{y})$. Then maximization of the log-likelihood function with respect to β 's will give us the maximum likelihood estimates of the parameters.

After settling the issue of estimation, the next important question is that of interpreting the estimates. The logit model is a non-linear model; as a result, the estimated coefficients do not directly measure the marginal effect of individual covariates. The effect of a change in a particular X_k on the probability of irrigation, that is $Y=1$ depends not only on X_k , but also on the values of the other X 's, parameter estimates, and on the constant.

Odds ratio is an easy way of substantively interpreting a logit model. If η is the odds, then $\ln \eta$ is the "log-odds", also known as the logit a value which ranges from zero to infinity.

$$\ln \eta(X) = \ln \left(\frac{\frac{\exp(X\mathbf{b})}{1 + \exp(X\mathbf{b})}}{1 - \frac{\exp(X\mathbf{b})}{1 + \exp(X\mathbf{b})}} \right) = X\mathbf{b} \text{ ----- (Eqn18)}$$

That is, in a logit model, the log-odds are linear in X . Therefore, the estimated $\hat{\mathbf{b}}_k$ from the estimated logit equation tell us the change in the log-odds which accompanies a one-unit change in X_k .

Data and Variable Description

The empirical testing of this study is based on a sample of 196 households in the Upper East Region of Ghana. The households were sampled from 10 communities located in the White Volta basin, a sub-basin of the Volta basin. 20 households from each community were selected and four households were dropped because of missing data. The data collection was done between November, 2003 and January, 2004 using a structured questionnaire. Our survey was a follow up of a larger survey in 2001 by the GLOWA-Volta project of the Center for Development Research of the University of Bonn, Germany. From that survey in the whole Volta Basin we found that only 13 percent of households did irrigation farming. Since the main interest of this work is the irrigating households, in our survey we deliberately increased the number of households who have irrigation activities. As a result out of the 10 communities surveyed three are located in or in the vicinity of Tono and Veia irrigation projects. That means 30 % of the samples are located near these irrigation facilities. As a result 33.5 % of sample households have irrigated during the surveyed cropping season. In the empirical analysis we took care of the bias introduced during sampling by estimating our probability model with *weighted exogenous sampling maximum-likelihood estimator*.

According to information pamphlet prepared by ICOUR (ICOUR 1995) there are approximately 6000 small-scale farmers eligible to farm in the projects and they come from the village communities around the project (Tono 8 and Veia 8 villages). Each farmer is allocated a plot of land between 0.2-0.6 hectares through village irrigation committees, which liaison between ICOUR and the farmers. Areas of land not yet needed by small-scale farmers are made available temporarily to other users, such as government organizations and private contractors. ICOUR charges a project levy during the rainy seasons, on those farmers who want to do supplementary irrigation and an irrigation levy during the dry season. The charges for the different services provided by ICOUR are announced usually at the beginning of each season, see (Annex 2) for the 2004 announcement.

According to a personal communication with the project management, the irrigation facilities are not fully utilized mainly because of the lack of credit for farmers to engage in irrigation. The following table gives descriptive statistics of the variables selected for the analysis.

Descriptive Statistics

Variable	Mean	Std.Dev.	Minimum	Maximum	Cases
SEXHEAD	.85	.36	.0	1.0	196
AGEHEAD	44.87	13.97	15.0	82.0	196
EDUDUMY	.22	.41	.0	1.0	196
PROPOFF	.19	.19	.0	1.0	196
FAMLAB	5.42	3.08	1.0	20.95	196
IRRIVILA	.29	.46	.0	1.0	196
DISTMKT	4.40	4.25	.20	40.0	196
DISTROAD	1.7	2.08	.0	15.0	196
LNLANDOP	.80	.72	-1.61	2.81	196
CREDICED	112071	483096	.00	5800000.	196

Source: 2003/2004 UER Own Survey

Results and Discussion

For the research question considered, three forms of logit model have been specified (Annex 1) namely: a standard logit model (Model 1), a choice-based logit model, a model which accounts for the bias introduced during sampling (Model 2) and a robust version of Model 2 (Model 3). The signs as well as level of significances of most of the variables across the three models are the same; which indicates that the fit of the model is very stable. However, as is expected accounting for the sampling bias led to a change in the magnitude of the coefficients particularly that of the constant. Since Model 3 corrects for the major estimation biases it will be the base for the discussion here after. One important point to note before going into the discussion is the relationship between the estimated empirical models and the theoretical model. Though the theoretical model is a dynamic model and the major implication, the fertility decision is a time bound decision, our empirical model is based on a cross sectional data. Thus, the empirical model will give information on determinants of irrigation decision at a point in time and sheds light on the long run implications of the results.

The three measures of overall fit of a model, the χ^2 , McFadden R^2 and the proportion of observations correctly predicted, show that the model fits the data very well. The McFadden R^2 , of 40 percent indicates that the variables considered in the model represent 40 percent of the total variation in the dependent variable. In addition to that about 90 percent of the observations were correctly predicted by the model. We will follow the interpretation and discussion of our model by grouping the explanatory variables into three groups: namely *household head characteristics*, *household resource endowment* and *market and infrastructural features*.

The Role of Household Head Characteristics in Irrigation Decision

All the household head characterizing variables but sex of head showed the expected sign. The sex of the head was expected to have a positive sign, indicating that the probability that male headed households irrigate is greater than that of female headed households. However, the result shows that the probability of irrigating is greater for female headed households than male headed households. The unexpected sign could be

explained in light of the fact that most of the activities in irrigation farming except land preparation are mainly performed by women. Especially, in rice production, women are the major labor sources for transplanting, harvesting and winnowing activities. This implies that women-headed households have relative advantage in supplying the required women labor for irrigation activities. Another important factor could be in the studied irrigation projects, where farmers form groups and get land from the projects, farm groups are required to include women in their groups.

Age of the head showed the expected sign both in its value and its square term. The result implies that as the age of the head increases the probability of irrigating increases but at a decreasing rate. This is mainly because as the age increases the social capital of the head increases and will be able to get access to finances and also irrigable land. However, since irrigation is a labor intensive technology at older age the head will not be able to supply the required labor and this will lead to a decline in the probability of irrigation.

In our expectation the sign of education level was indeterminate. Education is one attribute, which facilitates individual's exit from agriculture and also is an attribute, which facilitates individuals' adoption of improved technologies like irrigation and increases the propensity to take risk. Therefore, a sign attributed to education will reveal which role education is playing in the socio-economic setting we are studying. In our case the sign is negative indicating the magnitude of the role of education as an exit facilitator from agriculture than its role as facilitator of risk taking in technology adoption. One potential explanation to the observed relationship is the phenomena of off-farm labor and migration to the southern part of Ghana, which is a prominent feature in the study area. As migration requires gathering information and acting upon the available information, educated heads are more equipped in this regard than their non-educated counterparts. As a result during the dry season the more educated farmers decide to migrate or engage in other off-farm activities than irrigation.

The Role of Household Resource Endowments in Irrigation Decision

As stated in the theoretical model irrigation activity is a labor and liquidity intensive, that is it saves land and capitalizes on other factors of production mainly, cash and labor.

Three variables describing household resource endowment were considered, namely, household labor endowment, FAMLAB, household land endowment, LNLANDOP, and off-farm participation, PROPOFF. Both the FAMLAB and LNLANDOP variables confirm to the expected sign while FAMLAB is significant at 1 % level. In addition to indicating the role of land endowment on irrigation decision the LNLANDOP variable also serves here as a proxy for land preparation capacity of the household as it is the logarithm of the size of land operated both during the rainy and dry season farming in the 2002/2003 cropping seasons. Since irrigation is land saving and labor intensive technology, the variable which measures household labor endowment showed the expected sign. This implies that as household labor endowment increases the probability that a household irrigates will also increase.

The variable indicating household off-farm participation, PROPOFF, confirms to the theoretically expected sign, which is positive. A negative sign for PROPOFF would have meant a substitutive relationship between irrigation farming and off-farm activities, both of which heavily depend on household labor endowments. However, the positive sign plus the statistical significance of this variable imply that irrigation farming and off-farm participation are complimentary activities. This confirms well with our theoretical model.

Other works like (Evans and Ngau 1991; Reardon et al. 1994) also found a complimentary relationship between off-farm income generation and agricultural productivity, but for most of the empirical works the two activities, agriculture and off-farm are undertaken in two different seasons. Usually agriculture takes place during the rainy season and off-farm activities come during the lean season as a diversification strategy. In that case the demand from the two activities on household labor is not that of competition. However, in our case where the two are complimentary during the same season, the implication has bearing on the household fertility decision.

Particularly, the joint implication of the variables FAMLAB and PROPOFF has important implications. The positive relationship between the two and the probability of irrigation indicates that there is a huge dependence on these two factors as a labor and liquidity, which are the two limiting factors in irrigation farming. As is argued in the

theoretical model, the absence of a credit market pushes the burden of financing the irrigation farming on households' capacity to generate income from off-farm sources. In turn, this capacity, among other things depends on the households' family size, which should be big enough to carry both the labor and liquidity demands. The overall implication is, in conformity with the theoretical model, there will be technology and market induced population pressure in the area. This is because the fact that irrigation agriculture has proved itself as one alternative for consumption smoother during the dry season, there will be a keen interest to make use of it by farm households.

The Role of Infrastructural Access on Irrigation Decision

The third group contains variables which indicate households' access to irrigation, IRRIVILA, access to markets, DISTMKT, access to road, DISTROAD and finally access to credit, CREDICED. In terms of sign all the arguments under this category showed the expected signs in addition IRRIVILA and DISTMKT variables are statistically significant at 1 % level. The access variables are good measures of the role of cost of irrigation on irrigation decision. For example, if a household does not belong to the communities, where the irrigation facilities are located there will be high transaction cost on top of the direct costs of irrigation, which will decrease its probability of irrigation. During informal discussions with people living in very far away localities from the irrigation sites, we observed that the major factor limiting their access to the irrigation sites is the associated cost. The IRRIVILA has the largest coefficient of all the variables; therefore the most important factor to irrigate is the physical access to the facilities.

Most irrigation activities are market oriented as a result access to the market, DISTMKT, is an important and significant variable in determining household irrigation decision. The distance to the market determines the direct and transaction costs associated to inputs and outputs. The positive relationship between irrigation and market access variables shows the complementarity relationship between different infrastructural developments.

Summary & Conclusions

In this paper we tried to look at the effect of change in macro-economic policy, particularly that of agricultural credit policy, on micro-level agricultural decision and its implications. In Ghana, where macro-economic adjustment program has been widely implemented the agricultural sector faced a decline in budget allocation, removal of subsidies on major inputs and a resulting increase in the price of imported inputs, such as fertilizer.

A two period theoretical model is constructed. In this model we showed that in the presence of a perfect labor market lack of agricultural credit results dependence on off-farm income for financing irrigation. We further showed that imperfection in the output market can give the wrong signal to households of small size to irrigate which otherwise do not have economic incentives to do so. Though our theoretical model is a dynamic one with clear implication on family size and sustainability, lack of a panel or time series data has limited a full testing. As a result the empirical model, which is based on a cross sectional data, can only tell part of the story addressed in the theoretical model. Though this is a limitation on the side of the empirical model, we still believe that the empirical model can serve the purpose of shading light on the long term implication of what is actual going on in the ground.

Farm households' resource endowment positively and significantly determines irrigation adoption. This implies that in the absence of credit the poor can be marginalized in the use of public infrastructures, like irrigation schemes still run by the state. If there are no policies to counter the marginalization of the poor, this can defeat the very sense of reducing poverty and can introduce inequality.

The other finding of this research, that both the absolute family size and off-farm participation have positive effect on irrigation decision, has a long term implication, which is addressed in our theoretical model. That is the positive relationship between irrigation and off-farm participation, in spite of the fact that both are undertaken during the same season, the dry season, implies that they are complimentary activities. Had this complimentarity been between two activities which are undertaken in two separate

seasons, the pressure on family size would not be huge. However, since they are undertaken during the same season they depend on the same family labor pool, which can induce pressure on the pool and lead to increase in family size to meet both demands.

The physical access to irrigation and market has positive impact on irrigation decision. This is because irrigation is mainly used for the production of cash crops. This implies that the damage done by macro-economic reforms through the reduction of direct agricultural supports, in terms of subsidized inputs, can be undone by investments in other infrastructures that decrease transaction costs. Therefore, provision of complimentary infrastructural services, like roads, need to be give due attention during the designing of irrigation projects in rural areas.

Annex 1: Irrigation Decision Models

Variables	Standard Logit		Choice-Based Logit		Robust & Choice-Based Logit	
	Coefficients	Marginal Effects	Coefficients	Marginal Effects	Coefficients	Marginal Effects
CONSTANT	-3.67*	-0.71*	-4.45	-0.19	-4.45**	-0.19*
SEXHEAD	-1.13*	-0.25*	-1.23	-0.08	-1.23	-0.08
AGEHEAD	0.08	0.02	0.06	0.002	0.06	0.002
AGESQU	-0.001	-0.0002	-0.001	-0.48E-04	-0.001	-0.48E-04
EDUDUMY	-0.41	-0.07	-0.15	-0.006	-0.15	-0.006
PROPOFF	2.80***	0.54***	2.81*	0.12*	2.81*	0.12*
FAMLAB	0.21***	0.041***	0.22**	0.009**	0.22***	0.009**
IRRIVILA	4.56***	0.81***	4.87***	0.71***	4.87***	0.71***
DISTMKT	-0.16***	-0.03***	-0.17**	-0.007**	-0.17***	-0.007**
DISTROAD	-0.15	-0.03	-0.14	-0.006	-0.14	-0.006
LNLANDOP	0.74*	0.14*	0.90*	0.04	0.90	0.04*
CREDICED	0.16E-05	0.31E-06	0.21E-05	0.88E-07	0.21E-05	0.88E-07
Log Likelihood	-64.68		-40.38		-40.39	
Correctly predicted Obser.	87 %		88 %		88 %	
McFadden R ²	0.48		0.39		0.39	
?2	121***		76.6***		76.6***	

*** 1 %, ** 5 % and * 10 % levels of significance

Annex 2: 2004 Dry Season ICOUR Service Charges

1. Irrigation Levy	Cedis per Unit
Rice	312,500 / ha
Tomato	422,500 / ha
Other Crops	211,250 / ha
2. Mechanical Levy	
Plough	350,000 / ha
Harrow	175,000 / ha
Ridge	236,500 / ha
Rotovation	550,000 / ha
Wet Level	375,000 / ha
Slashing	225,000 / ha
Dry Level	165,000 / ha
Crawler Combine	700,000 / ha
2-Wheel Combine	560,000 / ha
Tractor & Equipment hire	862,000 / day

Source: ICOUR Notice Board, Navrongo, December 22, 2003.

Annex 3: Description of Variables and expected signs of Coefficients

Variable Name	Variable Description	Expected Sign
IRRI	Dependent variable (1, if household has irrigated and 0 otherwise)	
SEXHEAD	Sex of the head of household: (1, Male, 0, female)	+
AGEHEAD	Age of the head of household (in years)	+/-
AGESQU	The square of the age of household head	-
EDUDUMY	Education dummy (1, read and write, 0 otherwise)	+/-
PROPOFF	Proportion of household members participating in off-farm work (both the off farm labor and total household labor are converted into Man Equivalent (ME) before analysis)	+
FAMLAB	Size of family members in ME	+
IRRIVILA	Whether the household lives in the irrigation project village or not (1, if in irrigation village, 0 otherwise)	+
DISTMKT	Distance of the household from the nearest big market (in Km.)	-
DISTROAD	Distance of the household from the nearest all-weather road (in Km.)	-
LNLANDOP	The logarithm of total land operated in the 2002/2003 cropping season)	+
CREDICED	Amount of total credit available for the household during the cropping season (in Cedis)	+

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