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IMPACT OF PERENNIAL CASH CROPPING ON FOOD CROP PRODUCTION AND PRODUCTIVITY[1]

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Abstract

The argument for promoting cash crops in developing countries has generally been based on their contribution to small farmer incomes and their impact on other household activities such as household crop production through interlinked markets. While these arguments are supported by some empirical results, there is little information on the impacts cash cropping can have on these household activities in the absence of interlinked markets. In addition, the impacts of cash cropping may depend on the types of cash crops studied, time and place. Perennial cash crops (PCC) can relax household liquidity constraints for purchasing productive inputs, maintain soil fertility and moisture and save inputs such as seeds and draft power, which can be used for food crop production even in the absence of arrangements for interlinked markets. In this study we build on previous studies by developing key hypotheses by which PCC (Chat, coffee and sugarcane) affect food crop production and the implication for household food security. In addition, we look at the link between perennial food crop, enset (Ensette venttricosum), and other annual food crops. We empirically measure these effects using survey data on 150 rural households collected in 1999 in Ethiopia. Our results indicate that-after controlling for conventional inputs, household wealth variables, education and other variables, higher chat (Catta edulis) production is associated with reduced value of food crop yields and total value of food crop production. On the other hand, higher sugarcane production is correlated with higher value of total food crop production and productivity. Moreover, more intensive coffee production is associated with more intensive enset production. However, production of coffee and enset do not have significant effects on food crop production and productivity. These results suggest that while farmers can gain from sugarcane production through cash income and its impact on food crops, coffee and enset can be produced to bring additional income to the household at no significant cost to food crops. The real impact of chat on the welfare of households should be viewed in terms of its opportunity costs and its contribution to household income.

Keywords: Ethiopia, Cash crops, Food crops, Productivity, Enset.
JEL Classification Numbers: D13, Q12, Q15, Q16, Q18.

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1. Introduction

The role of cash cropping in reducing rural poverty and improving food security is one of the most debated among development scholars with often different and opposing views. Generally, those who favour cash crops argue that cash crops can potentially contribute to alleviating poverty and food insecurity and to growth. On the other hand, others who deny these benefits and say that cash crops exacerbate food security problems oppose cash cropping.

The contribution of cash crops at the household level is one of the elements constituting the debate about cash cropping. These analyses at the household level used different definitions of the term "cash crops" and cut across arguments, crops, countries and time periods. The case for the contribution of cash crops to improve household food security at the household level is often based on the income cash crops bring to the households through specializing in producing cash crops as dictated by comparative advantage and through synergies that may exist between cash cropping and subsistence food cropping activities with arrangements for interlinked markets (e.g., Govereh and Jayne, 2003; Goetz, 1993). The concept of comparative advantage is based on the argument that households with resources to produce cash crops most efficiently can specialize in the production of cash crops and buy food crops, which raises their overall income. On the other hand, the concept of interlinked markets is based on the argument that cash crops can attract potential buyers who provide inputs to cash crop producers on credit basis to be used to increase production and productivities of both cash crops and food crops (e.g., Govereh and Jayne, 2003; Govereh, et al., 1999).

While the importance of comparative advantage is well understood in places where food markets work well, the problem of imperfect markets does not allow farmers in many developing countries to benefit from specializing in cash crop production. Moreover, arguments based on interlinked markets give little attention to the benefits that cash crops may deliver to households in the absence of market interlinkage. Research results that focus on interlinked markets neglect the areas, which have little or no arrangements for market interlinkage and cannot be generalized to these areas. For example, Govereh et al. (1999) and Maxwell and Fernando (1989) suggest that little chance may exist for synergies between food and cash crops in the absence of interlinked market arrangements.

However, evidences suggest that even in the absence of interlinked markets, households could benefit from producing both food crops and cash crops on the same farm. For example, a study by Goetz (1992) found that economies of scope exist on farms producing both cash and food crops. Similarly Coelli and Fleming (2004) show that there are gains in technical efficiency and diversification economies from producing both cash crops (coffee and food crops produced for sale) and subsistence crops. However, although there are indications that farmers could raise their incomes by producing both cash and food crops, empirical evidences on synergies or trade-offs between the two crops are scant to address the concerns that cash cropping can exacerbate food insecurity.

In addition, research results regarding the contribution of cash crops at the household level vary greatly with respect to the type of cash crops studied, agro-ecological and socio-economic conditions, time periods and other factors specific to a given country or region, making it difficult to generalize these findings to all countries and regions (e.g., Maxwell and Fernando (1989) This calls for country level studies on different types of cash crops.

This paper deals with the impact of cash cropping (defined as crops grown mainly for sale) on subsistence food cropping activities in southern Ethiopia characterized by an integrated set of cash cropping and subsistence food cropping activities. The study differs from previous studies in three main aspects. First, all cash crops studied are perennials. Second, it deals with synergies between cash cropping and subsistence food cropping in a region where there are no arrangement for interlinked markets and any program targeting the area. Third, the study area is one of the most densely populated in the world, as opposed to other studies conducted in land abundant tropical agriculture (e.g., Govereh, 1993).

As indicated by Maxwell and Fernando (1989), the impacts of cash cropping on household income and food security may differ from crop to crop. Perennial cash crops differ from annual cash crops in input requirement, impact on environment and in the extent of their ability to allow for intercropping with other crops. Given the scarcity of agricultural land owing to high population density, these perennial cash crops enable farmers to get higher returns from given resources both through their higher and relatively stable prices and through intercropping. The income from these cash crops can relax households' liquidity constraints to buy productive inputs in turn to increase production and productivity of food grains. On the other hand, cash crops and food crops may compete for some resources to some extent and there may also be negative technical relationships between intercrops. If these competitions and negative relationships outweigh the perceived synergies, cash cropping may reduce the outputs of subsistence food crops. If this happens to be the case, it should alert policy makers to take appropriate measures to ensure food security.

In addition to cash crops, the southern part of Ethiopia is characterized by production of a perennial food crop known as enset (ensette ventricosum), which is not common in other parts of the country. This crop is believed to be a response by farmers to the ever-shrinking agricultural land in this region because of its higher yield from a given area of land (e.g., Brandt, et al., 1997; Rahmato, 1996). Like PCC, enset saves input such as seeds and draft power, protects soil erosion, and conserves moisture thereby contributing positively to environmental sustainability. Enset can also be intercropped with other perennial crops (including PCC) and annual food crops thus increasing returns from resources. However, although it gives higher yield per unit of land, the food that is produced from enset is believed to have low protein content and additional type of food is often required to supplement the low protein content of enset food eaten by humans (e.g., Brandt et al., 1997). This raises the question about the carrying capacity of enset-based farming system since the concept of food security includes the nutritional adequacy of the available food. The important question that follows is whether the higher yield of enset can compensate for its low protein content if enset displaces annual food crops that have higher protein content The importance of this crop compared to other annual food crops in the area has its own implications regarding agricultural research, agricultural practices and technologies and extension services to be carried out in the area and the carrying capacity of the system in terms of both the amount and nutritional adequacy of food to ensure food security.

The objectives of this paper are two-fold. First, we study the impact of PCC and enset on annual food crop production and productivity. Second, we study the impacts of PCC and annual food crops on enset intensification. We use household level cross sectional data collected in 1998/1999. The study is intended to contribute to the cash crop-food crop dilemma, to assist in developing policy to help smallholder farmers achieve food security and better income in a region characterized by high population density, land degradation and market imperfections.

In section two, we present the conceptual framework of the study; section three presents data and description of the study area; in section four methods of data analysis are presented; results and discussions are provided in section five; and section six concludes the paper.

2. Conceptual framework

2.1 Synergies between cash crops, enset and food crops

Existing studies on synergies between cash crops and food crops are based on the concept of interlinked markets. Consequently, these studies are confined to areas where there are arrangements for interlinked markets. The perceptions of interlinked markets are that cash crops attract input supply agents, which provide agricultural inputs on credit basis to enhance the productivity of both food and cash crops in return for the purchase of the cash crops (e.g., Timmer, 1997).

The concept of interlinked market, while supported by empirical evidences (e.g., Govereh and Jayne, 2003), cannot be applied to areas where there are no interlinked markets. Although PCC compete with food crops for some resources, they make cash income available, which can be used to buy inputs to increase food crop productivity in situations where farmers are credit constrained (Strasberg, et al., 1999; Kelly et al., 1996). Unlike food crops, cash crops face a relatively higher price because some of them are exported and some are needed elsewhere domestically. In addition to their impact on cash income, cash crops may increase the credit worthiness of farmers from moneylenders through interlocked markets since lenders think default is less probable. Reducing soil erosion is another contribution of PCC. For example, Haileselassie et al. (2005) and Brandt (1997) show that in Ethiopia soil nutrient stocks did not decrease in areas under PCC. This can enhance sustainable productivity of crops intercropped with perennials. The ability to conserve soil moisture is another important contribution of PCC, especially in water stress areas of Ethiopia. There are also empirical findings relating cash cropping to income diversification strategy (e.g. Abdulahi and CroleRees, 2001)

Moreover, PCC save inputs such as draft power and seeds. These inputs can be used to intensify food crop production. They can also allow intercropping with other crops easing the problems of population pressure. Studies also indicate that households can reduce total costs by producing cash crops and food crops on the same farm. For example, Goetz (1992) found that producing both cash and food crops on the same farm results in 22.3% cost saving relative to producing the same quantities in two separate (specialized) farms.

Enset is one of the staple food crops in the southern parts of the country. Enset ensures food security in this part of the country (e.g., Brandt, et al., 1997). Like PCC, enset can save inputs, draft power and conserve soil and moisture thereby protecting the environment. Enset can also be intercropped with other crops, in which case younger enset plants are intercropped with annual food crops and older enset plants are intercropped with perennials such as coffee and citrus. Brandt et al (1997) note that although there are no research results on the impact of intercropping on the yield and growth of enset and other crops, farmers .know that it reduces the growth of enset. Therefore, to the extent that annual food crops could be intercropped with enset, these crops could benefit from the positive impacts enset has on the soil. On the other hand, if intercropping reduces growth of enset, the impact of intercropping depends on the gains from annual crops and the losses of enset yields from intercropping.

Brief descriptions of the three PCC and enset follow.

Coffee:
Coffee is one of the main PCC in Ethiopia and also in the study area. It is produced mainly for export although some of the production is consumed at home. It takes about three years for a coffee tree to bear its fruit. Coffee can be intercropped with other crops.

Chat:
Chat is a large perennial shrub, which can grow to tree size (e.g., Klingele, 1998). It is mainly grown in Ethiopia and Kenya and the main markets are in Ethiopia, Kenya, Somalia, Yemen, etc. Harvesting of chat takes place at least two years after planting. Chat is an important cash crop in the area. The leaves of chat are chewed for their stimulating effect and to dispel feelings of hunger and fatigue (e.g., Parker, 1995). This crop has been the most important cash crop in most parts of Ethiopia because of its high prices and the fact that it is harvested year-round. In addition to being a source of cash income, it is consumed by family members to abate hunger. Chat can be intercropped with coffee. However, farmers prefer to grow chat as a monocrop.

Sugarcane:
Sugarcane typically is a 12 to 18 month crop although it can be left in the ground for a further growing period if favourable conditions exist. In this case it becomes a ‘ratoon’ crop (when new shoots grow from the sugarcane root after cropping) (Mushtag and Dawson, 2002). Sugarcane has been an increasingly important cash crop in the area. Traders come from as far as the capital city to buy sugarcane. The cane from these smallholders is chewed for its juice, unlike cane from the big plantations, which is converted to white sugar. Sugarcane can be intercropped with food crops such as potato. Imam et al (1990) indicated that intercropping potato with sugarcane exploits the temporal complementarity between crops.

Enset:
Enset is related to and resembles the banana plant and is produced primarily for the large quantity of carbohydrate-rich food found in a false stem (pseudostem) and an underground bulb. It takes 6-7 years to be ready for harvesting although earlier harvesting may take place. More than 20 percent of Ethiopia’s population concentrated in the highlands of southern Ethiopia depend up on enset for food, fibre, animal forage, construction materials and medicine (Brandt et al, 1997). Enset resists

water stress, is less prone to other risks and yields more per unit area than other food crops in the area. Enset can also be intercropped with other food and cash crops.

2.2 Theoretical model

Farmers in developing countries operate under many forms of market failures, including markets for food crops, credit and land (Sadoulet and de Janvry, 1995; Singh et al, 1986; Heltberg, 1998; Taylor and Adelman, 2003; de Janvry et al, 1991). Market failures introduce binding constraints in production where households cannot make separate decisions on consumption and production, rendering the household model nonseparable. We start with a household model, which draws on the model developed in Singh et al (1986).

Assume a given household produces food crops (Q_o), enset (Q_e) and PCC (Q_c) using labor (L_o, L_e, L_c) and other inputs (Y_j, j=o, e, c) and consumes food crop commodity (x_o), enset (x_e) a purchased commodity (x_m), a PCC commodity (x_c) and leisure time (x_l); and let z^h represent a vector of household characteristics which parameterizes the utility function of the household. Then the problem of the household is to maximize the household's utility function

$$\text{Max}\, u\left(x_o, x_e, x_c, x_m, x_l, z^h\right) \qquad \textbf{(1)}$$
$$(x_0, x_e, x_c, x_m, x_l, L_0, L_e, L_c, y_j \ )$$

Subject to:

Budget constraint: $p_0 x_0 + p_e x_e + p_c x_c + p_l x_l + p_m x_m \leq p_0 Q_0 +$

$$p_c Q_c + E + p_l T - p_l L - \sum_{j=0}^{e} w\, Y_j - rB \qquad \textbf{(2)}$$

Where p_o, p_e, p_c, p_m and r are prices of produced food crops, enset, PCC and purchased commodities and interest rate on loan B, respectively; p_l is wage rate and w is a vector of prices of other variable inputs; L is total labor demand by the household, both family and hired; y is a vector of variable agricultural inputs other than labor; E is exogenous income We assume households can sell parts or all of food crop, PCC and enset

In addition, farmers face credit constraint to purchase agricultural inputs at the time of planting. There is no formal credit facility in the area except for fertilizer credit given in kind. Therefore, farmers have to cover the costs of other purchased inputs and fertilizer beyond those provided by the government agencies. Framers have to use their own savings, income from sale of cash crops and income from hired out labor. Farmers may also get informal credit from village money lenders based on their credit worthiness, which again depends on their stock of cash crops. This informal borrowing is given by $B(Q_c)$ $(\frac{\partial B}{\partial Q_c} > 0)$. The cash from the sale of PCC is predetermined (produced during the previous years) at the time of planting food crops.

Credit constraint: $\sum_{i=1}^{N} w_i y_i + p_l(L^{hi} - L^{ho}) \leq p_c Q_c + B(Q_c) + K + A + S$ **(3)**

Where L^{hi} and L^{ho} are labor days hired in and out, respectively; L^{hi} =L-F where F is family labor and L= $L_0 + L_c + L_e$; K is the amount of fertilizer credit. We assume that labor market exists at the same wage rate for hiring in and out[3].

Food crop production function constraint: $Q_o = f_o(A_o, L_o, Y_o, Z^q)$ **(4)**

Enset production constraint: $Q_e = f_e(A_e, L_e, Y_e, Z^q)$ **(5)**

Cash crop production constraint: $Q_c = f_c(A_c, L_c, Y_c, Z^q)$ **(6)**

where $A_c + A_o + A_e = \overline{A}$; $\overline{A}$ is total operated land holding; A_c, A_e and A_o are sizes (shares) of total operated holding planted to PCC, enset and food crops, respectively. z^q is a vector of farm characteristics; and $f(.)$ is a strictly concave production function. We assume that land is fixed due to imperfections in land rental markets.

Furthermore, the household utility function, u (equation (1)), is assumed to be strictly quasiconcave and twice continuously differentiable[4].

[3] This seems a realistic assumption for the study area since land holdings are generally small and some of the households have reported they have hired in or out labour.
[4] This assumption is made for convenience (for the second condition to be satisfied) and is consistent with the classical consumer theory that the marginal utility of a given commodity increases at decreasing rate.

The Lagrangian function for the above maximization problem can be written as

$$L = U\ (x_o, x_e, x_c, x_m, x_l, z^h) + \lambda(p_oQ_o + p_eQ_e + p_cQ_c + p_lT + E - \sum_{j=o}^{e} w\,Y_j - p_lL$$

$$-p_ox_o - p_ex_e - p_cx_c - p_mx_m - p_lx_l - rB(Q_c)) + \mu(p_cQ_c + B(Q_c) + A + K + S - \sum_{j=o}^{e} wY_j - p_l(L^{ho} - L^{hi}) \quad \textbf{(7)}$$

Denoting the consumer goods by c_i (i=o, e, c, l, m) the interior first order conditions of interest are[5]:

$$\frac{\partial L}{\partial c_i} = \frac{\partial U}{\partial c_i} - \lambda p_i = 0 \quad \textbf{(8)}$$

$$\frac{\partial L}{\partial L_0} = \lambda p_o \frac{\partial Q_o}{\partial L_o} - p_l\mu - \lambda p_l = 0 \quad \textbf{(9)}$$

$$\frac{\partial L}{\partial L_e} = \lambda p_c \frac{\partial Q_c}{\partial L_c} - p_l\mu - \lambda p_l = 0 \quad \textbf{(10)}$$

$$\frac{\partial L}{\partial L_c} = \lambda p_c \frac{\partial Q_c}{\partial L_c} + -\lambda r \frac{\partial B}{\partial L_c} + p_c\mu \frac{\partial Q_c}{\partial L_c} - p_l\mu + \mu \frac{\partial B}{\partial L_c}. - \lambda p_l = 0 \quad \textbf{(11)}$$

$$\frac{\partial L}{\partial Y_o} = \lambda p_o \frac{\partial Q_o}{\partial Y_o} - \lambda w - \mu w = 0 \quad \textbf{(12)}$$

$$\frac{\partial L}{\partial Y_e} = \lambda p_e \frac{\partial Q_e}{\partial Y_e} - \lambda w - \mu w = 0 \quad \textbf{(13)}$$

$$\frac{\partial L}{\partial Y_c} = \lambda p_c \frac{\partial Q_c}{\partial Y_c} - \lambda w - \mu w = 0 \quad \textbf{(14)}$$

Equations (9) and (12) indicate that $P_o \frac{\partial Q_o}{\partial L_o} = P_l(\frac{\mu}{\lambda} + 1)$ and $P_o \frac{\partial Q_o}{\partial Y_o} = w(\frac{\mu}{\lambda} + 1)$ suggesting that if the credit constraint is binding (i.e., μ >0), farmers cannot use the optimal level of inputs that they would use in the absence of credit constraint. Furthermore, the higher the value of μ, the smaller is the amount of labor and other

[5] For households, which do not grow, some or all of the cash crops or enset the formulation of Kuhn-Tucker conditions for optimisation are omitted to save space.

inputs used for food crop and enset production, leading to lower productivity and production. The size of μ is determined by the stock of PCC the household owns since PCC relax credit constraints which means that farmers with larger stock of PCC are more productive since they can use optimal or closer-to-optimal level of inputs.

Manipulating the first order conditions gives us the reduced form model for food crops and enset production, which are functions of PCC and other variables:

$$Q_{oi}^{*} = Q_{oi}^{*}\left(z^{q}, A_{oi}^{*}, A_{ei}, A_{ci}^{*}, L_{i}^{*}, y_{i}^{*}, z^{h}\right), \text{ and} \quad \textbf{(15)}$$

$$Q_{ei}^{*} = Q_{ei}^{*}(z^{q}, A_{oi}^{*}, A_{ei}^{*}, A_{ci}^{*}, y_{i}^{*}, z_{i}^{*}) \quad \textbf{(16)}$$

where Q_{oi}^{*} is total aggregate value of food crops or value of food crops per unit of land (productivity) for household i; Q_{ei}^{*} is production of enset; and L_{i}^{*} and y_{i}^{*} are optimal labor and other inputs, respectively; and A_{oi}^{*}, A_{ei}^{*} and A_{ci}^{*} are sizes (shares) of operated land holding planted to food, enset and cash crops, respectively. A similar procedure can be used to derive the theoretical model of cash crop production indices.

3. Data and the study area

The data used for this study was collected in the 1998/1999-production year from Wondo Genet area located in the Southern Nations and Nationalities Regional State, 270 KM south of the capital, Addis Ababa. It lies within the southern rift valley of Ethiopia. Awassa serves as the administrative capital of the region, with Shashemene town being the nearest local market.

Households were randomly selected from two peasant associations, Wesha and Chuko. The area is characterized by a mixed crop-livestock production system. It is well known for its cash crops such as coffee, sugarcane and chat (khat), making it appropriate for cash crop research. Other main crops are enset, maize, bean, kale, banana, avocado and papaya. Maize is the main staple food crop, while enset is a well-known perennial food crop in the area. Chat trading is common in Chuko, while sugarcane trade is common in Wesha. The area has been a centre of rural business because of its cash crops and proximity to Awassa and Shashemene markets (Adya, 2000). Farmers in the area produce sugarcane, coffee, and chat, mainly for markets.

Although there is no statistics on how much of the total of cash crops is sold, the number of farmers who sold the crops is presented in Table 1.

Although there are other crops grown by farmers in the area, they have little significance in terms of their area and contribution to household income. Production is mainly based on rainfall, which is bimodally distributed throughout the year. The area is among the highest annual rainfall areas in the country, making it suitable for coffee, sugarcane, and especially chat production, the yield of which is highly dependent on the amount of soil moisture throughout the year.

Interlinkages of input supply and output markets are not common in the area. Thus, most of the products are sold in the market and inputs are purchased both from the markets and from government agencies on credit basis. The inputs purchased from government agricultural development offices are mainly fertilizer and improved seeds. Farmers are expected by government offices to pay a certain portion of the input prices at the time of purchase with the remaining balance due at the end of the harvest period. Farmers cannot get these inputs on credit basis for the next season unless the previous year's credit is completely repaid. Seventy-five households were randomly selected from each of the two peasant associations. Households were interviewed about demographics, farm and non-farm activities, agricultural practices, asset holdings and attitudes and perceptions about different farm and non-farm activities. The data were collected using trained enumerators from the area with strict follow up by researchers for good quality data. Out of 150 households selected we use 127 households for econometric analysis because of incomplete information and outlier observations on some variables. However, data in Table 1 is for 147 households for which most of the data were recorded.

4. Methods of analysis and econometric procedures

In our conceptual framework, we hypothesized that cash cropping could influence food crop production and productivity in different ways. This section develops an empirical model, which enables us to measure the impact of the intensity of these crops on food crop production and productivity.

4.1 Impact of PCC and enset on food crop production and productivity

Since it is difficult to measure the production of PCC and enset (Q_c and Q_e) in one-year time, as they are perennials harvested over cropping cycle, we define a measure of the level of involvement (intensities) of households in the production of these crops. Based on the hypothesis that the intensity of PCC production can affect food crop production and productivity, we develop indices of intensity of PCC and enset cultivation. We define household i's PCC and enset cultivation indices as C_{ij} where j indexes the type of crop (j=coffee, chat, sugarcane, enset). For coffee this index (C_{icof}) is defined as the number of coffee trees divided by total operated land holding; for chat the index (C_{ichat}) is defined as the size of land planted to chat over total operated holding multiplied by 100. The sugarcane production index (C_{isugar}) is defined as the area planted to sugarcane divided by total operated holding and multiplied by 100; and the index for enset production (C_{ienset}) is defined as the number of enset trees divided by total operated holding. We use the number of trees for coffee and enset because they are intercropped with other crops more often than sugar and chat.

These indices simply measure the households' level of involvement in these crops' production relative to its available land for operation and do not show a production function relationship. The indices assume values of zero for some households. To study the impact of these indices on food crop production and productivity, we specify models for y_i, the aggregate gross value of food crops output for household i, and $\frac{y_i}{fland_i}$, the aggregate gross value of food crops output over the total land planted to food crops. Thus, the empirical specification of equation (15) can be written as:

$$y_i = f(C_{ij}, x_i, fland_i, z_i^h, z_i^q,) \quad \textbf{(17)}$$

$$\frac{y_i}{fland_i} = f(\ C_{ij}, z_i^h, z_i^q, fland_i, \frac{x_i}{fland_i}) \quad \textbf{(18)}$$

Where x_i is a vector of variable inputs; z_i^h and z_i^q are vectors of household characteristics and farm characteristics, respectively, which include non-conventional production variables that affect production and productivity). Equation (17) specifies the empirical model of the aggregate value of total food crop production (y_i) while equation (18) specifies the aggregate value of total food crop production divided by total land planted to food crop ($\frac{y_i}{fland_i}$). Descriptions and overview of variables used in the analysis are presented in Table 2.

We use Cobb-Douglas (C-D) type as the basic functional form of production functions given by (17) and (18) since this is a commonly used form of production in agricultural economics research (Hayami, 1970). The C-D form is also easy to interpret and holds the promise of more statistically significant parameter estimates (Liu and Zuang, 2000). Debertin (1986), Chambers (1988) and Brown (1970) present properties of the C-D production function

The aggregate value of food crops produced by a household, y_i; include maize, teff, wheat, barley, sweet potato, potato, yam, taro, soybean, horse bean, and chickpea. To get the total value of gross output, the outputs of individual crops are weighted by average market prices, which do not vary across households. The aggregate value is used because it solves the problem associated with mixed cropping (Rao and Chotigeat, 1981; Byiringiro and Reardon, 1996). There is no high-value crops in the aggregate value of food crops, and it is assumed that differences in aggregate productivity between small and large farms are attributed to size or returns to scale (Byiringiro and Reardon, 1996.

The dependent variables and all continuous explanatory variables, including the crop indices are transformed into logarithmic form. For censored right-hand side variables (with zero observations), we add one to all observations before transforming them into logarithmic form. Transforming the data into logarithmic form helps reduce heteroskedasticity in error variance (Maddala, 1998; Mukherjee et al, 1998). These transformations reduce problems associated with non-linearity and outliers, improving the robustness of the regression results (Mukherjee et al, 1998; Godfrey et al, 1988).

Consistent estimation of (17) and (18) depends on two conditions. First, y_i and $\frac{y_i}{land_i}$ are not all positive observations. A significant number of farmers reported zero values for these variables. Since there could be systematic differences between farmers with positive and zero values of these variables, taking only observations with positive values and estimating (17) and (18) can introduce selectivity bias (Heckman, 1979; Greene, 2000; Wooldridge, 2002). To correct for this selectivity bias, we use the Heckman's selection model ((Heckman, 1979) which involves running a separate probit model using all observations, generating the inverse Mill's ratio (IMR) and including this in the regressions for, y_i , $\frac{y_i}{fland_i}$ >0 observations.

However, since the standard errors of the second stage estimates become incorrect because the IMR is estimated, we have to bootstrap the standard errors from the second stage to get the correct standard errors (Deaton, 1997). Second, the PCC and enset production indices are basically the result of choices made by the households. If these indices are endogenous in equations (17) and (18), we get inconsistent parameter estimates (Shively, 1997). However, as we will show below, although they are endogenous to the household, they are predetermined variables and exogenous at the time of making food crop planting decisions as the latter are annual and the former (PCC and enset) having been planted before the annual food crops.

To make sure that they are predetermined only perennial crops older than one year are included in the indices, as they are not harvested before this age. As a precaution we use both the predicted and unpredicted values of the indices for comparison purposes and test the unpredicted indices for endogeneity. We use Tobit models to predict the indices, as many observations of the dependent variables assume zero values. We also use the log-log specification for these equations adding one before transforming the dependent variables and the right-hand side variables with zero observations. Thus, the impact of the PCC and enset production on food crop production and productivity are determined by the coefficients of the indices in (17) and (18).

In addition to PCC and enset indices and the conventional inputs, we include other explanatory variables including sex, education, and age of the household head, wealth variables such as total livestock unit, size of operated land holding, dependency ratio (consumer-worker ratio), size of male and female work forces, number of consumer units, the ratio of rented in land to total operated holding, the number of oxen owned by households, distance from markets and a dummy variable for location of the households (see Table 2). We use market distance and location of the households (dummy variable for the two peasant associations) as instruments in the first stage probit equation to identify equations (17) and (18).

While the conventional inputs are physical controls for production and productivity, inclusion of sex, education and age of household head assume that household head is the primary decision maker and thus provide additional controls for management input. Total land planted to food crops, on the other hand, measures the controversial relationship between the size of land and productivity on (18) and we expect positive and negative signs in (17) and (18), respectively. In areas where markets are imperfect, labour, wealth (livestock and operated land holding) and the number of oxen can put a given household at the advantage of early operation and credit worthiness and hence we expect positive signs both in (17) and (18). On the other hand, dependency ratio and the ratio of rented in land to total operated holding may reduce productivity and production.

4.2 Impact of cash and annual food crops on enset intensification

We use the indices defined in the previous section in a model for enset intensification with a slight modification as:

$$c_{aenset} = f(c_{iacof}, c_{ichat}, c_{isugar}, y_i, z_i^h, z_i^q, tophold) \tag{19}$$

where $c_{iaenset}$ now indexes total number of enset trees at all ages divided by total operated holding (tophold); c_{iacof} is the number of all-age coffee trees divided by total operated holding; c_{ichat} and c_{isugar} are the same as defined in the previous section since no chat and sugar cane of less than two years were recorded, unlike coffee and enset, which include trees of less than two years of age; y_i is aggregate value of food crop production; z_i^h, z_i^q are vectors of household and farm characteristics as defined previously; and tophold is total operated holding.

The dependent variable in (19) involves zero values for households who do not plant enset. However, the number of households with zero enset production is only 5% of the total households used for econometric analysis. Therefore, we use only observations with positive values of enset production. On the other hand, if all the three PCC and food crop production are endogenous in (19), the model will form a system of simultaneous equations system and the OLS estimates will be biased and inconsistent. Nevertheless, tests of simultaneity show that the PCC and food crops production are not endogenous in (19). We have also tested for heteroskedasticity and could not reject the null hypothesis of constant variance.

5. Results and discussion

5.1 Characteristics of cash cropping and enset farmers

Before we start discussing the results of the econometric analysis, we provide some descriptive insights on three categories of sample farmers based on their involvements in the production of cash crops and enset. Accordingly, we divide them into non-growers, average or below average growers and above average growers. We discuss only the main variables, which are used in (17), (18) and (19), the dependent variables and some important characteristics in relation to the categories (see Table 3). As the table shows, the average aggregate value of food crops is highest for non-chat producing farmers while it is lowest for farmers with more than average involvement in chat production. On the other hand, average total production is higher for farmers with more than average involvement in sugarcane production than it is for farmers with average and less than average involvement. Generally, aggregate value of food crop production per household is higher for non-producers of the PCC (except sugarcane) and enset suggesting that these crops tend to be produced at the expenses of food crops although the decrease may not be significant.

Total operated holding and livestock holdings are generally lower for non-cash and non-enset farmers. This is in line with the argument by Timmer (1997) that farmers with larger land holdings engage in cash crop production more than their counterparts as a means of diversification or to increase their income. Both total operated holding and food crop areas increase for above average enset producers indicating that larger farms have more advantage of both diversifying into enset and ensuring the family with food crops. This is in contrast with the belief that farmers with smaller holdings plant enset to intensify enset production, which is believed to give higher yields.

Growers of chat, sugarcane and enset also have higher number of male work force. However, the number decreases with the intensity of production. The value of fertilizer applied per unit of land of food crop is higher for non-producers of chat, sugarcane and enset but it increases with chat production intensity while it reduces with the intensities of sugarcane and enset production. On the other hand, it is higher for producers of coffee than non-producers but it decreases with the intensity of coffee production. Per unit of land uses of labour, oxen and seed are higher for sugarcane and coffee producers than non-producers while it is lower for chat producers. However, there is no indication that cash crops enable farmers to apply more fertilizer per unit of food cropland from these statistics. One reason for this might be that fertilizer is obtained on credit basis from government and non-cash crop (and poorer) farmers substitute fertilizer for other inputs, which require immediate cash outlays. Nevertheless, sugarcane and coffee producers produce more food crops per unit of land than non-producers of these crops in line with our hypothesis while chat producers are less productive.

These descriptive statistics may not provide clear insights into the impacts of cash crops and enset on household crop production and productivity since we cannot control for other variables at the same time. These will be addressed in the next sections.

5.2 Econometric results

5.2.1 Determinants of the probability of food crop production

First we look at factors influencing the probability of growing food crops. Results of probit models of determinants of the probability of growing food crops are presented in Table 4 (Model I). Column two of Table 4 provides the two-stage limited dependent variable (2SLDV) estimation results while column three (b) presents the probit estimation without predicting the four crop indices.

The results of the tests of the null hypothesis that the cash crops and enset indices are exogenous are reported at the lower part of Table 4. As we can see from the tests for the endogeneity of the crop indices, we cannot reject the hypothesis that the indices are exogenous in the model. As a result, model 1 (b) can consistently estimate the parameters of the probit model and our discussions are based on results reported in column three (b)

The results show that the intensity of coffee production is associated with lower probability that the household produces food crops. This could be because of the fact that coffee is intercropped with food crops and other crops less often, which means that once land is occupied with coffee, the probability of growing food crops is low. Other PCC and enset are not related with the probability of growing food crops significantly.

Both male and female workforces are positively correlated with the probability of growing food crops. This is an indication that food crops are demanding in terms of labour. The ratio of consumers to workers or dependency ratio (cwr) is also associated with the probability of growing food crops positively. On the other hand, total consumer unit (cu) is correlated with food crop planting probability negatively suggesting that households may use enset as a means of intensification given higher consumer unit. This result seems strange at first sight but given that enset productivity is higher, households may resort to producing enset instead of other food crops to meet their consumption needs.

5.2.2 Impacts of PCC and enset on annual food crop production

In the second stage, we estimate equations (17) and (18) including the IMR generated from the probit model in the first stage. Model 2 of Table 4 provides estimation results of the determinants of food crops production. The coefficient of IMR is not statistically significant (Column four, (c)), which also uses the predicted values of the four crop production indices, suggesting that there is no selectivity bias resulting from using the sub sample for which food crop production is greater than zero. Subsequently we estimated model (d) (column five) excluding IMR and using unpredicted crop indices. This enables us to test whether these indices are endogenous in the model. The test for endogeneity shows that we cannot reject the exogeneity of these variables with F= 1.96. The test for heteroskedasticity also shows that we cannot reject the homoskedasticity of the variance (column five, (d)). This means that we can use OLS estimates with ordinary standard errors to get the consistent parameter estimates of the household total food crop production determinants. These estimates are given in column (column six (e)). The estimates show that the intensity of chat production is associated with reduced total household annual food crop production. This may be because the results of competition for resources including land may outweigh the potential synergies between chat and food crops. In addition, the frequent harvest of chat may not be suitable for food crop production. Farmers may also neglect food crops altogether and commit resources to chat affecting food crops adversely. This is evident in some areas where farmers replace food crops and other perennial crops such as coffee with chat, which has raised concerns about its impact on food security.

On the other hand, sugarcane production is correlated with increased annual food crop production. Thus, an increase in the area of sugarcane by one percent is associated with 0.08 percent increase in value of total annual food crop production.[6] While sugarcane production apparently competes for land (although they can be intercropped) with food crops, the synergies between the two crops possibly resulting from reduced soil erosion, and moisture conservation and use of optimal inputs may outweigh the loss of production due to competition for land. Coffee and enset production do not have significant effect on food crops. This could be because of the counteracting effects of competition for resources and synergies between the perennials and food crop productivity and shows that these two crops can be grown at little expenses to food crops.

The availability of male workforce is positively and significantly associated with food crop production as expected. This is believed to be because of the fact that annual food crop production requires male labour for ploughing, threshing, and other

[6] This is a measure of elasticity because both variables are expressed in logarithm form.

activities. On the other hand, female workforce is negatively and significantly related with food crop production. Women in Ethiopia are not involved in some of field crop operations including ploughing and threshing. They are more involved in operations of PCC and enset, which are planted closer to the household. The educational level of household head is also positively and significantly associated with food crops after controlling for other variables. Household annual food crop production is positively and significantly associated with the size of land planted to food crops as expected. A one percent increase in land is associated with about 0.5 percent increase in the value of food crop production, other factors held constant. This result is similar with previous studies (e.g. Govereh and Jayne, 2003).

Households' annual food crop production is also positively and significantly associated with the amount of seed used probably suggesting farmers do not use optimal seed rate

5.2.3 Effects of PCC and enset on annual food crop productivity

Given that the IMR is not significantly different from zero (F statistic) and that we cannot reject the exogeneity of the cash crops and enset production indices in model (g) of Table 4, we use the OLS estimates of the food crop productivity model with robust standard errors since homoskedasticity is rejected (see (h), Table 4).

Similar to our estimation results for total food crop production (model (e)), there is negative and significant relationship between chat production and food crop productivity (yield). This could be associated with the decreased use of inputs such as labour and seed per hectare with the intensity of chat production (Table 3) and other effects not measured in our data. On the other hand, food crop productivity is positively and significantly associated with the intensity of sugarcane production. Possible explanations could include the fact that more intensive sugarcane production is associated with higher use of labour and seed per hectare of food crops in addition to other possible synergies in terms of preventing soil and moisture losses. However, the intensities of coffee and enset production do not have any significant effect on food crops productivity. While coffee production is associated with the increased use of labour, seed, and fertilizer inputs per unit of food crop area, the intensity of enset production is associated with decreased use of seed, labour and fertilizer for food crops indicating the shift of attention from other food crops to enset. Nevertheless, the decreases and increases may not be big enough to affect food crop productivity significantly.

Educational level of household head is associated with higher food crop productivity , suggesting that farmers with higher education are more productive than those with lower or no education farmers. Total area of food crop production has a negative and significant effect on food crop productivity, other factors held constant. Farmers with smaller area of food crops have higher yields. Results of model (h) suggest that a one percent increase in food crop area reduces yield by about 1.05 percent, which is an inverse relationship between farm size and productivity. This is in line with the results found by, among others, Assuçãno and Ghatak (2003) and Heltberg (1998).

Labour and seed inputs measured by man-days and Eth. Birr, respectively, and normalized by total area of food crops are positively related with food crop productivity, with labour input having the biggest elasticity of the conventional inputs. Total male labour force available to households has a positive effect on food crop productivity suggesting the importance of male labour in food crop production. Surprisingly, the ratio of rented in land to total operated holding has a positive and significant effect on food crop productivity. Since this is the total rented in land rather than the rented in land dedicated to food crops, it may suggest that farmers use more of this land for food crop production and thus use more inputs for food crops, which outweighs the negative impact of tenure insecurity. In addition, the type of land contract is mostly of fixed rent and this minimizes the presence of inefficiency resulting from share tenancy. Research results from Ethiopia and else show that informal land rental contracts do not affect input use adversely (e.g., Place and Hazel, 1993; Gavian and Ehui, 1999)

5.2.4 Effects of cash crops and other food crops on enset intensification

Results of the estimation of number of enset plants per total operated holding are presented in Table 5.Having rejected the hypothesis that the model is a system of simultaneous equations and heteroskedasticity, we estimated the model using OLS. These results are reported in the third column of Table 5 (Model 5). In addition, we estimated the equation using the two-stage limited dependent variable (2SLDV) procedure since the cash crop indices are estimated using Tobit models for comparison purpose. These results are presented in the second column of Table 5 (Model 4). The signs of the two model estimates are similar. However, the OLS estimates are more efficient owing to the fact that the 2SLDV procedure gives inefficient estimates in the absence of simultaneity (Gujarati, 1995). Therefore, the following discussions are based on results of Model 5.

We excluded female workforce (fwf) from Model 4 because it was found to be collinear with consumer unit and yet insignificant. Total livestock unit (tlu) was also omitted from both models due to its collinearity with oxen. Results of Model 5 show that, surprisingly, the distance of the household from markets is negatively and significantly correlated with enset intensification. This raises a question whether households can depend solely on enset for food consumption. If households need other stables other than enset for consumption, this result makes sense since households have to insure themselves for these staples. This line of argument with discussions by Brandt et al (1997) that the low content of protein in enset diet makes it necessary to mix enset with other crops in human diet. The intensity of coffee production is positively and significantly correlated with enset intensification. Possible explanations include the fact that coffee and enset are intercropped since enset may provide shade to coffee,, hence the complementarity between the two crops. The number of female labour unit is negatively correlated with the intensity of enset production. This is contrary to our expectation, as enset production is believed to be female labour intensive.

On the other hand, the larger the number of consumer unit, the higher is the intensity of enset production. This is in line with the fact that enset can insure food security from a relatively smaller landholding.

Although there are apparent competitions between enset, on the one hand and cash and annual food crops on the other hand for some resources, these competitions do not seem to reduce the intensity of enset production. Unlike among cash crops and other food crops, most of the synergies among cash crops and enset may be the result of intercropping possibilities and other positive interactions, which make it possible to get more benefits from engaging in the production of many crops rather than specializing in certain crops.

6. Summary and conclusion

This study addresses the impact of emerging PCC production activities on enset intensification and on annual staple food crop production and productivity and the potential for the cash crops and enset production. We hypothesized that in view of the decreasing landholding owing to population pressure, PCC can have negative and positive impacts on food crop production and productivity, respectively, through competition for resources (especially land) and enabling farmers to get more cash income for purchasing and using productive inputs and through their impact on maintaining soil fertility and moisture. We also hypothesized that the intensity of enset production can have negative impact on annual food crops since farmers may substitute this crop for food crops, as it is a food crop itself and is more productive. Moreover, food crop production can reduce enset intensification due to competition for resources. Results show that after controlling for other relevant variables, chat production reduces both total production and productivity of annual food crops supporting the claims that chat is replacing food crops while sugarcane production increases both production and productivity of annual food crops. On the other hand, coffee and enset do not have any significant impact on food crop production and productivity. However, intensity of coffee production is positively and significantly related to enset production.

This point to the fact that the impacts of cash cropping on annual food crops depend on the types of the cash crops in addition to other factors such as market interlinkage.. Whilst there are frequently heard assertions that cash crop production comes at the expenses of food crops, some authors found out that there are synergies between cash crops (cotton) commercialisation and food crop productivity through interlinked markets and regional spillovers (e.g., Dorward et al, 1998; Govereh and Jayne, 2003). However, our results show that there is no guarantee that cash crop production per se can improve the production and productivity of food crops in areas where there are no spillover effects and interlinked markets. Moreover, interlinked markets are not necessary for cash crops to have positive impact on food crops. Thus caution must be taken when advocating rural development policies based on the trade-offs or synergies between cash crops and food crops under all conditions with out careful studies of the types of cash crops and other local conditions.

While further empirical studies are needed to answer some questions, for example, why female labour force is negatively related to both enset and food crop production, there is evidence that at least some of the PCC can be grown without reducing production of staple food crops. Although there are tradeoffs between chat production and food crops, the impact of this cash crop on household welfare depends on the level of income from chat production and the foregone food crop production. The net impact depends on the relative prices of the two crops and the amount of output of food crops lost due to chat production and the yield of chat.

On the other hand, coffee and enset can be grown to bring additional income to the household without significant costs to food crop production, while sugarcane is beneficial both for additional cash income and its positive impact on food crop production and productivity. The results also suggest that complementarity exists between coffee and enset production.
Improving market infrastructure to reduce marketing costs and provision of credit to bridge the income gap between planting and harvesting of perennial crops can improve household welfare by encouraging farmers to produce PCC, enset and other

food crops, which can alleviate problems arising from population pressure because PCC and enset productions are ways of farm intensification in the area ensuring food security. On the other hand improving improved market infrastructure to reduce marketing costs can allow farmers to grow cash crops that give higher returns to resources but which reduce production of food crops.

References

Abdulahi, A. and CroleRees, A. 2001. Determinants of income diversification amongst rural households in Southern Mali. Food Policy 26, 437-452.

Adya, S. 2000. Determinants and measurement of crop Diversification: A study in Wondo Genet, Southern Ethiopia. MSc. Thesis (unpublished), department of Economics and Social Sciences, Agricultural University of Norway, Aas.

Assução, J. j. and Ghatak, M. 2003. Can unobserved heterogeneity in farmer ability explain the inverse relationship between farm size and productivity. *Economic letters* 80, 189-194.

Brandt, S. A., Sunita, S., Clifton, H., McCabe, J. T., Tabogie, E., Diro, M., Woldemichael, G., Ytingo, G., Shigeta, M., and Tesfaye, S. 1997. *The tree against hunger: enset-based agriculture systems in Ethiopia*. American Association for the Advancement of Science, Washington, DC, Awassa Agricultural Research Center, Kyoto University Center for African Area Studies and University of Florida. (WWW.aaas.org/international/africa/enset/)

Brown B. W. 1970. Tests for Cobb-Douglass and CES production functions. *International Economic Review* 11(1), 77-83.

Byiringiro, F. and Reardon, T. 1996. Farm productivity in Rwanda: effects of farm size, erosion, and soil conservation investments. Agricultural Economics 15, 127-136.

Chambers, R. G. 1988. *Applied production Analysis: A dual approach*. Cambridge University Press, Cambridge

Coelli, T. and Fleming, E. 2004. Diversification economies and specialization efficiencies in a mixed food and coffee smallholder farming system in Papua New Guinea. Agricultural Economics 31, 229-239.

de Janvry, A., Fafchamps, M. And Sadoulet, E. 1991. Peasant household behaviour with missing markets: Some paradoxes explained. *The Economic Journal,* 101, 1400-1417

Deaton, A. 1997. The analysis of household surveys: A microeconomic approach to development policy. The World Bank, Washington, D.C.

Debertin, D. L. 1986. *Agricultural production Economics*. Macmillan Publishing Company, New York.

Dorward, A., Kydd, J. and Poulton, C. eds. 1998. *Smallholder cash crop production under market liberalization*. CAB International, New York.

Gavian, S., Ehui, S. 1999. Measuring the production efficiency of alternative land tenure contracts in a mixed crop-livestock system in Ethiopia, *Agricultural Economics*, Vol. 20, 37-49.

Godfrey, L. G., McAleer, M. and McKenzie, C. R. 1988. *Variable addition and Lagrange Multiplier test for linear and logarithmic regression models*. The Review of Economics and Statistics 70(3), 492-503.

Goetz, S. J. 1993. Interlinked markets and the cash crop debate in land-abundant Tropical agriculture. Economic Development and Cultural Change 41, 343-361.

______. 1992. Economies of scope and the cash crop-food crop debate in Senegal. World Development 20(5), 727-734.

Govereh, J. and Jayne, T.S. 2003. Cash cropping and food crop productivity: synergies or trade-offs? *Agricultural Economics* 28, 39-50.

Govereh, J., Jayne, T. S. and Nyoroo, J. 1999. Smallholder commercialisation, interlinked markets and food crop productivity: Cross-country evidence in eastern and southern Africa. Michigan State University.

Gujarati, N. D. 1995. *Basic Econometrics*. McGRAW-Hill International Editions.

Haileslassie, A., Pries, J., Veldkamp, E., Teketay, D., and Lesschen, J. P. 2005. Assessment of soil nutrient depletion and its spatial variability on smallholders' mixed farming systems in Ethiopia using partial versus full nutrient balance. Agriculture, Ecosystems and Environment 108:1-16.

Hayami, Y. 1970. On the use of the Cobb-Douglass production function on the cross-country analysis of agricultural production. *American Journal of Agricultural Economics* 52, 327-329.

Heckman, J. 1979. *Sample bias as a specification error*. Econometrica 47(1), 153-161.

Heltberg, R. 1998. Rural market imperfections and the farm size-productivity relationships: Evidence from Pakistan. World Development 26 (10), 1807-1826.

Imam, S. A., Hossain, A. H. M. D., Sikka, L. C., and Midmore, D. J. 1990. *Agronomic management of potato/sugarcane intercropping and its economic implications*. Field crops Research 25, 111-122.

Kelingele, R. 1998. Hararghe farmers on the crossroads between subsistence and cash economy. University of Pennsylvania-African Study Center. (www.africa.upenn.edu/Hornet/hararghe998.html#heading5) (Accessed April 2007)

Kelly, V., Diagana, B., Reardon, T., Gaye, M. and Eric, C. 1996. *Cash crop and food grain productivity in Senegal: Historical view, new survey evidence and policy implications*. Policy Synthesis No. 7. USAID, Africa Bureau.

Liu, Z. and Zhuang, J. 2000. Determinants of technical efficiency in post collective Chinese agriculture: Evidence from farm level data. *Journal of Comparative Economics* 28, 545-564.

Maddala, G. S. 1998. *Introduction to Econometrics*. MacMillan Publishing Company, New York.

Maxwell, Simon and Fernando, A. 1989. Cash cropping in developing countries: The issues, the facts, the policies. World Development, Vol. 17 (11), 1677-1708.

Mukherjee, C., White, H. and Muyts, M. 1998. *Econometrics and data analysis for developing countries*. Routledge, London.

Mushtaq, K. and Dawson, P. J. 2002. Acreage response in Pakistan: a cointegration approach. *Agricultural Economics* 27, 111-121.

Parker, B. 1995. *Everything about Khat*. University of Pennsylvania-African Study Center. (www.Africa.upen.edu/Hornet/qat.html.) (Accessed April 2007)

Place, F., and Hazel, P. 1993. Productivity effects of indigenous land tenure systems in Sub-Saharan Africa. *American Journal of Agricultural Economics*, 75: 10-19

Rahmato, D. 1996. *Resilence and vulnerability: Enset-based agriculture in southern Ethiopia*. In: Abate, T., Hiebsch, C., Brandt, S., and Gebremariam, S. (eds.). Enset-based sustainable agriculture in Ethiopia. Addis Ababa. Institute of Agricultural Research.

Rao, v. and Chotigeat, T. 1981. The inverse relationship between size of landholdings and agricultural productivity. *American Journal of Agricultural Economics*, 63: 571-74.

Sadoulet, E. and de Janvry, A. 1995. *Quantitative development policy analysis*. The Johns Hopkins University Press, Baltimore and London.

Shively, G. E. 1997. Consumption risk, farm characteristics and soil conservation adoption among low-income farmers in the Philippines. *Agricultural Economics* 17, 165-177.

Singh, I., Squire, L., and Strauss, J. 1986. *Agricultural household models: extensions, applications and policy.* Johns Hopkins University Press, Baltimore, M. D.

Smith, N. J. H, Alvim, Paulo de T., Serrão, E. A. S. and Falesi, I. C., 1995. *Amazonia.* In: Kaperson, J. X., Kaperson, R. E., and Turner II, B. L. (eds.). *Regions at risk: Comparisons of threatened environments.* United Nations University Press, Tokyo, N.Y., Paris.

Strasberg, P. J., Jayne, T. S., and Yamano, T. 1999. *Effects of agricultural commercialisation on food crop input use and productivity in Kenya.* Policy Synthesis No. 41, USAID, Africa Bureau.

Taylor, J. E., and Adelman, I. 2003. *Agricultural household models: Genesis, evolution, and extension*. Review of Economics of the Household, 1, 33-58.

Timmer, C. P. 1997. Farmers and markets: the political economy of new paradigms. *American Journal of Agricultural Economics*, 79, 621-627.

Wooldridge, J. M. 2002. *Econometric analysis of cross section and panel data*. Massachusetts Institute of Technology, London.

Table 1: Overview of main crops, production intensity and market orientation

Crops	Percent of sample households producing	Percent of growers who sold crops
Enset	77	9.7
Wheat	0.68	0
Coffee	71	17.1
Barley	1.4	0
Maize	69	8.8
Sugarcane	54	84.4
Chat	29	46.5
Soya bean	15	4.5
Sweet potato	8	75
Teff	6	11

Table 2: Overview and description of variables

Variable	Description	Expected sign: Probit for food crop production	Food crop production	Food crop productivity	Mean	Std. error
A. endogenous variables						
Fcropvalue (y_i)	Aggregate Value of food crop production				480.82	1789.48
Fcropdum	Dummy variable: 1=if fcropvalue>0, 0=other wise				0.74	0.44
Fcroppdvty ($\frac{y_i}{fland_i}$)	Aggregate value of food crop output (Fcropvalue) divided by total food crop area (fland)				1068.84	2222.06
Chathold (C_{ichat})	Land planted to chat divided by total operated holding (tophold) times 100	-	-	+	0.059	0.16
Cofhold (C_{icof})	Number of coffee trees over total operated holding (tophold)	-	-	+	17.49	27.88
Sughold (C_{isugar})	Area of sugarcane over tophold times 100	-	-	+	0.276	0.33
Ensethold(C_{ienset})	Number of enset trees over tophold	-	-	-	171.69	328.30
B. Exogenous variables						
Age	Age of household head in years	?	?	?	44.22	14.27
Sex	Household head sex dummy: 1=male, 0=female	?	?	?	0.9	0.30
Mwf	Size of male workforce in standardized unit	+	+	+	2.22	1.44
Fwf	Size of female workforce in standardized unit	+	+	+	1.52	0.99
Cwr	Ratio of consumer unit to worker unit	+	-	-	1.72	0.34
Edu	Educational level of household head in years	?	?	+	2.19	2.90

Variable	Description	Expected sign			Mean	Std. error
Rrl	Ratio of rented in land to tophold	+	+	-	0.09	0.25
Tlu	Size of livestock holding in tropical livestock unit	?	+	+	1.68	1.67
Cu	number of consumers in standardized unit	+	+	-	6.14	2.80
Oxen	Number of oxen owned by household	+	+	+	0.25	0.64
Tophold	Total operated holding (in timad)	+			1.64	1.03
Fland	Size of land planted to food crops (in timad)*		+	?	0.58	1.01
Fertland	Cost of fertilizer used in food crop production in Birr over fland		+	+	37.63	153.50
Labland	Amount of labour in man days used in food crop production over fland		+	+	36.44	51.52
Oxland	Number of oxen days used in food crop production over fland		+	+	2.44	9.83
Seedland	Value in Birr of seed used in food crop production over fland		?	?	101.82	241.93
Mktdist	Average distance of households from markets in hours	+	+	-	1.99	3.48
Padum	Dummy variable for location of household: 1=Wesha, 0=Chuko	?	?	?	0.7	0.46
Lnvarname	Logarithmic transformed variable where varname is the name of one of the above variables					

*Timad is a local measure of land, equivalent to what an adult male can plough in a day using a pair of oxen: on average it is approximately equal to 0.25 hectare of land.

Table 3: Characteristics of households based on their cash crop and enset production indices in Southern Ethiopia, 1998/99[7]

Characteristics	Cash crops and enset production Indices					
	Chathold			Sughold		
	Nongrowers	≤average	>average	Nongrowers	≤average	>average
Sample size	111	15	12	62	49	27
Dummy variable: 1=produces food crops, 0=no food crops	0.721	0.866	0.75	0.79	0.714	0.666
Total value of food crops (Et Birr)	564.63	139.83	131.88	572.89	221.23	740.51
Age of household head in years	44.25	43.14	45.25	46.33	43.5	40.7
Sex of household head: 1=male, 0=female	0.88	0.93	1	0.9	0.89	0.88
Male work force (mwf)	2.13	2.15	3.1	2.16	2.18	2.38
Female work force (fwf)	1.49	1.75	1.46	1.45	1.58	1.56
Consumer-worker ratio (cwr)	1.71	1.84	1.65	1.69	1.73	1.75
Education of household head	2.36	1.17	1.75	2.16	1.85	2.92
Ratio of rented in land to operated holding (rrl)	0.10	0.04	0.1	0.1	0.1	0.16
Livestock holding in tropical livestock unit	1.66	1.43	2.13	1.54	1.88	1.61
Total value of food crops over total food crop area (fcropdvty)	1262.1	334.13	433.84	947.53	1021.6	1484.3
number of consumers in standardized unit (cu)	5.9	7.08	7.2	5.86	6.22	6.64
Number of oxen owned by household (oxen)	0.27	0.133	0.166	0.27	0.27	0.15
size of total operated holding in timad (tophold)	1.58	1.99	1.78	1.45	1.84	1.69
Land allocated to food crops in timad (fland)	0.59	0.65	0.46	0.65	0.47	0.64
Value of fertilizer in Birr over fland (fertland)	47.28	1.23	5.56	53.15	27.73	15.49
Labour in days applied per timad of fland (labland)	40.18	21.6	25.1	25.52	46.89	45.24
Number of oxen days per fland (oxland)	2.98	0.77	0.00	0.77	2.29	7.16
Value of seed per fland (seedland)	118.84	35.8	47.76	58.21	135.47	152.68
Distance of household from market in hours (mktdist)	1.92	2.31	2.24	1.85	2.28	1.81

[7] The figures in the cells show average values of the variables based on the criteria

Table 3. (continued)

Characteristics	Cash crops and enset production Indices						Total
	Cofhold*			Ensethold*			
	Nongrowers	≤average	>average	Nongrowers	≤average	>average	
Sample size	45	66	27	42	65	31	138
Dummy variable: 1=produces food crops, 0=no food crops	0.8	0.742	0.629	0.666	0.707	0.903	0.739
Total value of food crops (Et Birr)	828.33	368.28	176.75	531.94	305.1	202.86	352.51
Age of household head in years	42.1	44.5	46.96	44.87	42.84	45.32	44.22
Sex of household head: 1=male, 0=female	0.88	0.92	0.85	0.83	0.89	1	0.89
Male work force (mwf)	1.98	2.49	1.92	1.81	2.39	2.41	2.22
Female work force (fwf)	1.48	1.55	1.52	1.3	1.761	1.33	1.52
Consumer-worker ratio (cwr)	1.74	1.71	1.7	1.68	1.73	1.76	1.72
Education of household head	2.18	1.95	2.81	2.32	2.49	2.48	2.19
Ratio of rented in land to operated holding (rrl)	0.13	0.1	0.1	0.18	0.1	0.03	0.1
Livestock holding in tropical livestock unit	1.45	1.86	1.62	1.58	1.6	2.02	1.68
Total value of food crops over total food crop area (fcropdvty)	1001.8	1231.2	722.53	1561.0	1092.43	342.77	1068.8
number of consumers in standardized unit (cu)	5.83	6.56	5.63	5.1	6.78	6.37	6.14
Number of oxen owned by household (oxen)	0.27	0.29	0.11	0.26	0.25	0.23	0.246
size of total operated holding in timad (tophold)	1.56	1.9	1.13	1.46	1.72	1.74	1.64
Land allocated to food crops in timad (fland)	0.7	0.6	0.33	0.64	0.49	0.7	0.58
Value of fertilizer in Birr over fland (fertland)	18.1	60.88	10.45	71.97	27.52	20.27	37.63
Labour in days applied per timad of fland (labland)	29.94	40.96	37.22	46.1	39.7	21.77	36.44
Number of oxen days per fland (oxland)	0.42	4.68	0.1	0.5	5.0	0.23	2.44
Value of seed per fland (seedland)	70.88	108.74	150.24	122.28	125.77	44.19	101.82
Distance of household from market in hours (mktdist)	1.93	2.19	1.62	1.52	2.34	1.93	1.99

* coffee and enset do not include trees less than two years old

Table 4: Results of econometric estimation of impacts of cash crops and enset on food crop production and productivity

Variables	Model 1: Probit model for probability of food crop production		Model 2: Value of food crop production per household in Eth Birr		
	(a) 2SLDV (predicted indices)[a,+]	**(b) one-stage Probit**[p]	**(c) Heckman 2SLDV**	**(d) OLS**	**(e)OLS**[p]
	coefficient (std. errors)	coefficient (std. errors)	Coefficient (Std. errors)[a]	Coefficient (Std. errors)[b]	Coefficient (Std. errors)[c]
Imr	-	-	-.2238(.5224)	-	-
Lnchathold	-.1344(.2894)	.0639(.1238)	-.0318(.1488)	-.1217**(.0564)	-.1217* (.0646)
Lncofhold	.0270(.0427)	-.1939*(.1043)	-.0135(.0147)	-.0137(.0505)	-.0137(.0553)
Lnensethold	.0658(.5518)	.0563(.0655)	-.2950**(.1459)	.0023(.0356)	.0023(.0356)
Lnsughold	-.1174(.3177)	-.0762(.0817)	-.0285(.0749)	.0801*(.0417)	.0801*(.0439)
Lnage	-1.3735(1.3967)	-.4095(.5862)	.4316(.4705)	.2497(.3275)	.2497(.2966)
Sex	.7011(.5334)	.5517(.4925)	-.0607(.4329)	-.0775(.3692)	-.0775(.3683)
Lnmwf	3.3722*(1.7664)	3.6351**(1.7416)	.9258***(.3270)	.8065**(.2685)	.8065***(0.304)
Lnfwf	2.1364(1.3312)	2.2476*(1.3437)	-.2177(.3099)	-.5791*(.3138)	-.5791**(.2769)
Cwr	2.6709* (1.4813)	2.9167**(1.2178)	.2727(.3985)	-.2102(.3447)	-.2102(.3181)
Edu	-.1281(.0900)	-.0698(.0554)	.1045**(.0438)	.0843***(.0292)	.0843**(.0334)
Rrl	-.3158(1.5889)	-.8572(.5943)			
Lntlu	.3781(.6282)	.4834(.3519)	.2965(.2827)	.1340(.2004)	.1340(.1954)
Lncu	-3.4269*(1.9263)	-3.4913*(1.8539)			
Oxen	.1958(.5380)	.3069(.3383)	-.1881(.2046)	.0234(.1673)	.0234(.1679)
Lntophold	.2836(.7084)	-.3435(.2818)			
Lnfland			.3837(.3264)	.5053(.3647)	.5053*(.2751)
Infert±			.0597(.0620)	.0687(.0618)	.0687(.0589)
Inflab±			.3105**(.1436)	.2674**(.1345)	.2674**(.1309)
Infoxen±			.0693(.1466)	.0590(.1291)	.0590(.1192)
Infseed±			.1517*(.0794)	.1525**(.0599)	.1525**(.0702)
Constant	.5387(5.3606)	-2.8132(3.3137)	1.9731(1.4707)	2.6758**(1.187)	2.6758**(1.283)
No.of observations	124	124	94	94	94
No.of replications			100	100	100
Log likelihood	-58.5683	-56.4719			
Pseudo R2 (R-squared)	0.1463	0.1769		(0.6663)	(0.6663)
LR chi2(15)	20.08	24.27			
Breusch-Pagan/Cook-Weisberg test for heteroskedasticity				Chi2(1)=0.8 Prob>chi2=0.774	
Endogeneity test for crop indices		chi2(4) = 6.66 Prob >chi2=0.1551		F(4,73) = 1.96 Prob >F=0.1098	F(4,73)=1.61 Prob.>F=0.1797
F				F(17,76)= 12.05	F(17,76)= 8.93

[a] numbers in parentheses are bootstrap standard errors; [b] numbers in parentheses are robust standard errors; [c] numbers in parentheses are ordinary standard errors; [p] preferred model; *, ** and *** denote significance at or below 10%, 5% and 1% levels.[+] indices predicted based on separate regressions. ± these inputs are normalized by the size of land planted with food crops in Model 3.

Table 4. continued

Variables	Model 3: Value of food crop production per timad of land (Eth Birr/timad)		
	(f) Heckman /2SLDV	(g)CLAD (without prediction)	(h) OLS [P]
	Coefficient (Std. errors)[a]	Coefficient (Std. errors)[a]	Coefficient (Std. errors)[b]
Imr	-.2577(.5612)	-	-
Lnchathold	-.1783(.1565)	-.2002***(.076)	-.1682***(.063)
Lncofhold	-.0184(.0177)	-.0359(.0730)	-.0031(.0570)
Lnensethold	-.2709(.3477)	.0225(.0465)	.0199(.0413)
Lnsughold	-.0259(.1646)	.1360**(.0676)	.0995** (.0445)
Lnage	.7233(.5552)	.6519(.5269)	.5788(.3706)
Sex	-.2351(.4331)	-.4654(.6255)	-.2648(.4663)
Lnmwf	.8288(.5908)	.8806**(.4191)	.7524**(.3166)
Lnfwf	-.0587(.3999)	-.1363(.5357)	-.4968(.3237)
Cwr	.4200(.9540)	-.1218(.4476)	-.2008(.4134)
Edu	.1113**(.0435)	.0885*(.0497)	.0907***(.0322)
Rrl	.2830(1.1507)	1.2719*(.7215)	.9466*(.5050)
Lntlu	.3809(.4005)	.1213(.2412)	.1667(.2247)
Lncu			
Oxen	-.2844(.3101)	-.0861(.3550)	-.0173(.1994)
Lntophold			
Lnfland	-.9534***(.335)	-1.053***(.390)	-1.052***(.307)
Infert[±]	.0435(.0634)	-.0012(.0716)	.0567(.0553)
Inflab[±]	.3237** (.1455)	.3501*(.2008)	.2671*(.1384)
Infoxen[±]	.1033(.1565)	.1829(.1651)	.0760(.1065)
Infseed[±]	.1583**(.0787)	.1958*(.1078)	.1671***(.0611)
Constant	1.8728(1.6004)	1.7624(2.0875)	2.6369*(1.3391)
No.of observations	94	136	94
No.of replications	100	100	-
Log likelihood			
Pseudo R2 (R-squared)			0.5315
LR chi2(15)			
Breusch-Pagan/ Cook-Weisberg test for heteroskedasticity			chi2(1) = 4.31 Prob>chi2=0.038
Endogeneity test for crop indices			F(4,71) =1.74 Prob >F=0.1514
F			F(18,75)=4.18

Table 5: Results of econometric estimation of impacts of cash and food crop production on enset intensification: Dependent variable: laensethold

Explanatory Variable	Model 4. 2SLDV estimates of number of enset plants per operated holding	Model 5. OLS estimates of number of enset plants per operated holding
	Coefficient (Standard error) [a]	**Coefficient (standard error)**
mktdist	-.0353(.0987)	-.0538(.0294)*
lfcropvalue	-.00004(.0002)	-.1412(.1455)
lacofhold	-.0068(.0292)	.2237(.09383)**
lchathold	.0139(.0075)*	.0619(.0967)
lsughold	.0032(.0064)	-.0616(.0670)
lage	.8806(.8407)	.1281(.4773)
sex	.9082(.5996)	.8945(.5376)
fwf		-.5745(.2726)**
mwf	-.1473(.1812)	-.2179(.1920)
Edu	-.0150(.0819)	-.0758(.0539)
Cu	.0301(.0984)	.2530(.1395)*
rrl	.3876(2.7426)	.8783(.6571)
oxen	.4370(.5272)	.2123(.2103)
ltophold	-.6340(.4016)	-.2741(.2585)
_cons	2.5334(2.8977)	4.4211(1.9348)**
Breusch-Pagan/Cook-Weisberg test for heteroskedasticity.H0: constant variance		$chi^2(1)$ =2.13 prob> $chi^2(1)$ =0.0.1442
Simultaneity test for cash and food crops. H0: No simultaneity	F(4,74)=1.15 Prob>F=0.3385	
Adjusted R^2		0.1382
Number of observations	93	93
F		F(15,78)=2.05 Prob>F=0.0238
Number of replications	100	

[a]standard errors are bootstrapped

DETERMINANTS OF INCOME DIVERSIFICATION IN RURAL ETHIOPIA: EVIDENCE FROM PANEL DATA[1]

Adugna Lemi[2]

Abstract

The aim of this study is to examine the determinants of income diversification in rural Ethiopia.

Rural households allocate their work time between farm and of-farm activities to have secure income (consumption) for their family members. However, it is not clear why some households participate only in farm activities while others engage in both. Using survey data collected from 1500 rural households in 1994 and 1997, this study investigates the impacts of demographic, economic, and risk factors on participation and intensity of off-farm activities. The results of the study show that families with high dependency ratio, female household heads, high livestock value, and poor quality of land participated less in off-farm activities. Competition between off-farm and farm activities and effects of seasonality were more apparent from the intensity results than from participation. Increased crop production and sale of part of production during the main harvest season led households to engage less in off-farm activities. The results also confirm that off-farm activities were practiced as a means of subsistence when crop production fails; otherwise farmers abandon off-farm activities.

JEL Classification: D1, J2
Key Words: Dynamic Livelihood, Off-farm Income, Diversification, Ethiopia

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1. Introduction

Diversification of income sources, assets, and occupations is often common practice for individuals or households in different parts of the world, but for different reasons. Households in sub-Saharan Africa, whose livelihood heavily depends on agriculture and related activities, often diversify by engaging in farm and off-farm activities. The significance of the sub-sector is widely recognized in scholarly works even more so than in the policy making arena. In 2000s, three journals (*World Development,* 2001 on Latin America; *Food Policy*, 2001 on Africa, and *Agricultural Economics*, 2006 on Asia and Africa) devoted special issues to focus on the significance and determinants of off-farm activities in different parts of the world. Although less productive compared to modern sectors, the contributions of rural off-farm activities to economic growth, rural employment, and poverty reduction (Lanjouw and Lanjouw 2001), as well as to growth and welfare by slowing rural-urban migration (Lanjouw and Lanjouw 1999), are well documented. In Africa, studies indicate the role that off-farm activities play to help countries get out of poverty (Lanjouw, et. al. 2001) and to increase food consumption, as well as access more stable income and consumption over years (Reardon, et. al. 1992).

Although scholars seem to agree on the significance and importance of off-farm activities rural Africa, there seems to be no consensus regarding the most important factors that drive participation and intensity of off-farm activities (Ellis, 2000) and its definition (Barret, et. al. 2001a). There is no agreement on the terminologies used to refer to such activities. The same activities are referred to as off-farm or non-farm. Ellis (2000) defines the former as 'wage or exchange labor on others' farms, including payments in kind and cash' and the latter as 'non-agricultural income sources that includes non-farm rural wage or salary employment, non-farm self-employment income and remittances. In this paper, no distinction is made between non-farm and off-farm income, and the term off-farm is used to refer income sources included in both off-farm and non-farm[3]. In terms of factors driving off-farm activities, one of the hypotheses is that households engage in off-farm activities out of necessity; the other is that participation in off-farm activities is a choice to maximize profit. Still others argue that farmers engage in off-farm activities in response to policy shocks (Barrett, et. al. 2001). For instance, it has been indicated that the implementation of Structural Adjustment Program (SAP) and economic liberalization throughout sub-Saharan

[3]The exception is that remittances are not included since it is not an income from supply of household resources. The activities may be agricultural or otherwise. In African economies, most off-farm activities are related to agricultural activities, since in rural part of most of these countries the main income source is agricultural activities. Other activities, like handicraft works and petty trading, are also heavily dependent on agricultural sector.

Africa during the last fifteen years has coincided with rapid expansion of rural income diversification (Bryceson 1999). During these reform periods, synergy between farm and non-farm activities in Africa have been documented in de Janvry (1994), Delgado and Siamwalla (1999), and Reardon et. al. (1994).

In the context of rural Ethiopia where subsistence farming is common, off-farm activities serve as an alternative outlet to cope with unexpected income shortfalls. Given limited arable land, and low agricultural productivity to accommodate the high population growth, the significance of off-farm activities cannot be overstated. In rural Ethiopia, crop income accounts for the largest share of total income, 71%, followed by share of off-farm income, 17%, in 1994. In 1997 the share of crop income increased to 83% while that of off-farm income decreased to 7%. Although the off-farm income share is low compared to other African countries, 7-17% is not a negligible percentage. On top of that, off-farm activities are opportunities that rural farmers fall on during times of crisis or production shortfalls. In recent years one can easily witness some responses to changes in policy that promote the role of the market, even in the rural setting where increased market participation has just begun to have an impact. Ethiopia undertook significant policy reforms starting in 1992 especially on policies related to the agricultural sector. The period since 1992 can be described as the period when the country opened up the market both domestically and globally, removed some trade barriers, lifted quantitative restrictions on trade and established institutions to support the export sector. With the launching of reform measures one can reasonably expect responses in income diversification including off-farm. These changes are expected to have an effect on farmers' labor allocation and diversification decisions as well. The significance of this study should be looked at with these backdrops.

The purpose of this study is, therefore, to examine the determinants of income diversification. I specifically looked into determinants of participation in and intensity of off-farm activities between 1994 and 1997 harvest years in Ethiopia. The two harvest years have been selected to coincide with the economic policy reform periods. The two years have also differences when it comes to agricultural production. Ethiopia had experienced bad weather condition in 1994 compared to 1997. As a result there was low production in 1994. These differences in weather condition may have implication for the degree and timing of off-farm activities in rural Ethiopia. This study attempts to provide an insight into how households responded to changes in policy reform and weather conditions. The results of this study attempt to answer the following questions: What were the key determinants of participation in and intensity of off-farm activities? Do households tend to engage more in the off-farm activities as a result of policy reforms or just a response to seasonal weather conditions? The remaining sections of the paper are organized as follows. Section II presents a brief review of literature and previous studies on Ethiopia. Section III provides a brief description of the model and model variables. Section IV discusses the data and estimation issues. Results of the estimation are presented in section V. The last section provides concluding remarks and policy implications.

2. Literature review

Despite the view that rightly associate rural off-farm sector as a low-productivity sector, recent years have witnessed a move towards recognition of its various roles (i.e. economic growth, rural employment, poverty reduction, and slowing rural-urban migration) (Lanjouw and Lanjouw, 2001; Lanjouw and Lanjouw, 1999). The significance of this sub-sector has also been manifested through the importance of non-farm wage labor (compared to self-employment), and local non-farm earnings (compared to earning by migrants) (Reardon 1997). Studies in Latin America also confirm the significance of the sub-sector. For instance, as indicated by Deininger and Olinto (2001), in Colombia, off-farm employment contributes a significant share (45%) to household income, although the importance of off-farm income and returns to household labor vary over the range of income distribution. In Peruvian rural areas, 51% of the net income of rural households comes from these off-farm activities (Escobal 2001). In Honduras, income from non-farm wage and self-employment represents 16-25% of farm household income, and is especially important for middle and higher income strata (Ruben and van den Berg 2001). Related studies in other parts of Latin America also demonstrate similar results (Lanjouw 2000; Reardon, et. al. 2001, Yunez-Naude and Taylor 2001)[4]. Similar studies on African economies (more on this later) are scanty by growing as the importance of off-farm activities is appreciated at the level of policy makers.

Unlike agreement on the significance and importance of off-farm activities, there is no consensus on the most important factors that drive participation and intensity of off-farm activities (Ellis, 2000). Necessity and profit maximization are the two competing arguments as stated above. The view of the necessity hypothesis is that households engage in off-farm activities for survival, to secure basic needs during times of distress. Whereas, the choice hypothesis argue that the decision to engage in off-farm activities is determined by the return to labor in the labor market, as most household models predict. However, Ellis (2000) argues that, although the division of the determinants seems attractive, it is misleading since it attempts to assign the range of experiences to one process or another. For instance, given the rural

[4]Also see studies by Ellis (1998, 2000) that relate the issue of income diversification and off-farm activities to poverty, employment, and income distribution.

settings in Africa, where there are constant fluctuations in weather conditions and farming determinants, farmers may engage in off-farm activities out of necessity when they are in distress; on the other hand, farmers may engage in off-farm activities by choice when there are favorable environment and if they have the necessary resources. Hence, it is difficult to have a clear-cut necessity-choice dichotomy as an argument. Others argue that farmers simply respond to underlying trends and processes when they make decisions to engage in off-farm activities, as opposed to decision process that looks into short-term objectives. These arguments make it difficult to come up with a list of major determinants that influence the decision process.

Barrett et. al. (2001a), without divulging into the dichotomy, argue that diversification into nonfarm activities emerges naturally from diminishing or time-varying returns to labor or land, from market failures or incomplete markets, from entry barriers to enter into high-return niches, from ex ante risk management, and from ex post coping with adverse shocks. They also indicate that diversification is understood as a form of self-insurance in which people exchange some foregone expected earnings for reduced income variability. The latter could be achieved by selecting a portfolio of assets and activities that have low or negative correlation of incomes. However, it is difficult to strongly follow the argument of negative correlation of incomes for cases like rural Ethiopia where most of the off-farm activities highly correlate with agricultural activities. I expect to see that what is seen for the case of Ethiopia and other similar rural small farm setting is a combination of an ex post coping with adverse shocks and ex ante risk management.

Ellis (2000) also argues that classical household models do not capture inter-temporal dimensions of livelihood strategies, and do not describe circumstances of survival under stress. According to Ellis, the following key factors should be taken into account as causes for diversification: seasonality, risk strategies, coping strategies, as well as labor and credit market conditions. Seasonality refers to the heavy reliance of farming on weather conditions and/or fluctuations in prices as a response to changes in demand and supply conditions. Seasonality in crop production and income results in some slack seasons during which farmers may have time to engage in off-farm activities. It is also possible that households diversify activities to ameliorate the threat to its overall welfare from risky concentration in a single (i.e. farm) activity. This coping strategy argument resembles that of the necessity reasoning, which states that household's diversification is a survival response to crisis or disaster. Market failures, which in the case of rural Africa are often the case for credit, labor and land markets, leave households with limited option to engage in off-farm activities to compensate for the market failures[5]. The absence of such markets requires households to take advantage of their demographic composition to use its resources effectively and to respond to market failures. Lack of functioning markets coupled with inter-temporal decision-making, and decisions under stress call for the aforementioned factors, which often are not included in the standard household models. In addition to these key factors, other factors outside the control of households, including regional and local features, environmental factors, social and governmental factors, should also be considered in addressing the question of rural households' decision process.

Studies in Africa and other developing economies provide support for the significance of the above factors. For instance, access to public assets such as roads, and private assets such as education and credit, are pointed out as factors that encourage more participation and intensity (Escobal 2001; Lanjouw, et. al, 2001). These studies conclude that under the precarious conditions that characterize rural survival in many low-income countries, diversification has positive attributes for livelihood security that outweigh any implied cost associated with it. A study in Burkina Faso and Guinea shows that harvest shortfalls and terms of trade are found to drive diversification towards off-farm activities (Reardon, et. al 1992). Other studies indicate that a relative lack of capital (Abdulai and CroleRees 2001), entry barriers, lack of liquidity, market access, and skill constraints (Barrett, Reardon, and Webb. 2001) are some of the impediments to diversification, and to breaking the poverty trap in rural Africa. Barrett, et. al. (2001a) summarized various studies on Africa and concluded that there is a positive relationship between non-farm income share and total household income and land holdings. They contend that, in Africa, investment or asset (such as education, credit) requirement is a barrier to entry. Several studies echo similar sentiment about the impact of access to both public and private assets (Woldehanna and Oskam, 2001; Smith et al., 2001; Lanjouw, 2001; Matsumoto et. al, 2006; Kijima et. al, 2006; Abdulahi and CroleRees, 2001; Barrett, Bezuneh and Adbulahi, 2001). However, a recent study in Ethiopia claims that the entry barrier to non-farm activities is low and the general growth of non-farm subsector benefits the poor (Berg and Kumbi, 2006).

Only few studies specifically address the significance of off-farm activities in Ethiopia. The studies are either regional (Woldenhanna and Oskam 2001; Carswell 2002; Holden, Shiferaw and Pender 2004; Berg and Kumbi, 2006) or focus only on drought-prone villages (Dercon and Krishnan 1996, Block and Webb 2001). The latter two

[5] In the case of Ethiopia, there is also complete absence of land market due to government ownership of land. This also requires households to find means to allocate other resources, mainly labor, to compensate for the absence of such markets.

studies used similar nation-wide household survey data as the one employed in this study, but limited their analysis to very few sample households from drought-prone parts of the country. Using data from the southern part of Ethiopia, Carswell (2002) reported that women play a positive role in income diversification; in particular they contribute to diversify activities to cash incomes for poorer households. Dercon and Krishnan (1996) analyzed the different income portfolios of households using survey data from Ethiopia and Tanzania. The results of their study indicate that the different portfolios held by households cannot be explained by their behavior towards risk; it is better explained by differences in ability, location, and access to credit (Dercon and Krishnan, 1996). Their result, with respect to risk, is contrary to theoretical explanations (Ellis, 2000) and empirical findings (Block and Webb, 2001).

Block and Webb (2001), using 300 households from drought-prone parts of the country collected in 1989 and 1994, attempt to find which households increased their share of income from non-cropping activities the most during the inter-survey years. They find that wealthier households tend to have more diversified income streams; households with greater concentration of assets were more likely to fall in their relative income ranking (as were female-headed households). They also found that initially less diversified households subsequently realized greater gains in income diversification. Contrary to Dercon and Krishinan (1996)'s work, they find evidence that personal perceptions of risk factors guided subsequent diversification decisions. Using survey data from the northern part of the country, Woldenhanna and Oskam (2001) argue that farm incomes and off-farm incomes are substitutes. They divided the off-farm employment into off-farm wage employment and off-farm self employment and arrive at the finding that farm households diversify their income sources into off-farm wage employment as a result of low farm income and the availability of surplus family labor, whereas they enter into off-farm self employment to earn an attractive return (Woldenhanna and Oskam 2001). The present study did not distinguish wage off-farm activities from self-employment off-farm activities since the data does not allow for such grouping of off-farm activities reported in the survey.

Despite the increasing significance of off-farm activities and their increased importance as alternative income source, most previous studies address the problem and significance only from a static point of view. The dynamics in intensity and participation in off-farm activities in Africa have not been given due attention, especially when the underlying determinants change from time to time. These changes may be due to economic growth and economic policy reform (specifically, changes in farm input and output market situations).

The present study is different from previous studies in three aspects. First, the survey sites covered are representative of the main agricultural regions and the different cropping systems of the country (except pastoralist areas). Second, the survey years used in this study (1994 and 1997) were the periods in which the government undertook significant economic policy reforms, to which significant response is expected from farm households. Reform programs were launched in 1992 including liberalization of agricultural input and output markets (Lemi, 2009). Third, this study addresses not only determinants of intensity but also determinants of participation in off-farm activities during the two survey years. Unlike previous studies, this study also incorporates key factors implied by the literature including seasonality, risk strategy, farm activities (income), asset ownership, and demographics in the off-farm income estimation models.

3. Model and model variables

3.1 Model

Consider a standard utility maximization problem, where household members jointly choose their consumption (C^i), where i = 1, 2,….., 5 for each household member (the average family size of each household is considered to be 5). Household members also decide on the allocation of their total time endowment, (T^i) as in Sicular (1986)'s team labor allocation. Each member's time endowment is divided in to three activities: Leisure (L^i), off-farm work (O^i), and on-farm work (F^i). Given income from farm work (w^i), income from off-farm work (y^i), and fixed capital stock of the household (K_o), each household maximizes a utility function. Consider that the utility function is assumed to be additively separable, continuously differentiable, increasing, and concave in all of its arguments:

$$\underset{C^i, L^i, O^i, F^i}{Max}\, \mathrm{U}^1(C_1, L_1; Z) + \mathrm{U}^2(C_2, L_2; Z) + \mathrm{U}^3(C_3, L_3; Z) + \mathrm{U}^4(C_4, L_4; Z) + \mathrm{U}^5(C_5, L_5; Z) \qquad \textbf{(1)}$$

Z^i is a vector of a household member's characteristics (like Gender, age, education, etc) that affects household preferences with respect to consumption, and leisure. As in Strauss (1986), equation (1) is maximized subject to budget constraint, and time constraint. Given these constraints, maximization results in the Marshallian household labor supply for farm and off-farm works as[6]:

[6]Since consumption and leisure time determinants are not the interest of the present study, their equation is not reported here.

$$F^i = F(w^i, y^i, k_o) \qquad (2)$$
$$O^i = O(w^i, y^i, k_o)$$

This model is too simplistic since it assumes perfect information in all markets (i.e. output, labor, capital (credit), and land). Note also that it is assumed that income from farm and off-farm work will be spent partly on consumption and partly on accumulation of fixed capital. However, the time spent on farm work is affected by income from off-farm work and vise versa. One can consider a more sophisticated model by brining in time horizon, savings, borrowings, and labor hired on farm, among other things. But for this study, the purpose of this model is only to fix ideas and to give structure to the issue at hand. For estimation purposes, reduced form of (2) will be used. Since households is the unit of analysis in this study, the above equations will be aggregated over the superscript *i* to get the value of each variable at household level. To get aggregate values for household characteristics, either average is taken, or head of the household characteristics is used as the case may be to get a figure that represent all household members.

In the absence of actual time allocation data, income received from farm and off-farm activities can be used as a proxy. The equation could be rearranged to define off-farm income as a function of other variables including variable *Z* as key determinants of time spent (or income earned) from off-farm activities, given the income from farm work. The question is, therefore, what makes farm households to switch between farm and off-farm works or what makes them to engage in both types of works at the same time?

3.2 Model variables

As implied above, the key determinants that are believed to drive diversification to off-farm income sources in rural settings can be grouped into five: demographics, asset ownership, risk strategies, seasonality, and income from other sources (see Ellis, 1998, 2000). Specifically, one should take into account demographic composition of households in terms of age, gender and education level of household members. For asset ownership, livestock and land are the two major assets for farm households in rural Ethiopia[7]. Value of livestock that each household owns is used not only as a farm input but also as a saving. In the context of free market system, one would expect that access to assets promotes households to engage in off-farm activities

[7] Farm tools and rented in land are not included in asset ownership since very few households report these two assets and for those who report the values are too small to make significant difference in estimation.

more. However, in a situation where market is very thin or non-existence for some of these assets (like land, and labor), it is difficult to expect similar relationships. Moreover some of these may be suitable to agricultural sector than to off-farm activities. In the context of Ethiopia, since these assets are more suited for agricultural activities, we expect a negative relationship between these asset ownership and participation in and intensity of off-farm activities. Land holding is also one of the major farm inputs and is expected to play a significant role. In the context of Ethiopia, where farm households do not have ownership rights but only use rights, in some regions right to rent, farmers cultivate their own allocated land and/or rental land from other farm households. To this effect, status of ownership – 'owned' or rented- may not matter in decision-making but rather what matters the most is quality of land and its impact on productivity.

For risk or risk aversion indicators it is difficult to think of a single variable to capture the degree of risk perception of all households in all survey sites. Farm households have different degrees of risk perception depending on their asset ownership and the degree of their vulnerability to weather conditions. Farmers may respond to risk by diversifying farming activities through planting different types of crops and/or by spending more time on farm to guarantee adequate food for the family. In this study, the degree of exposure to risk by households is captured using two variables. One of the signals for farmers to perceive risk is the quality of their land. This is captured by the weighted average of the quality of land indicator[8] as reported by households. Some areas or plots are considered low quality for any crop, even after applying natural or man-made fertilizer, and that is how farmers categorized the plots into high, medium and low quality. It is expected that the lower the quality of land, the higher the possibility that farmers may experience crop failures. Farmers who own poor quality land are expected to engage in off-farm activities to guarantee food for their families from other sources in case of crop failure.

The other risk indicator used is the number of crops that farmers plant each year[9]. Farmers often diversify their crop production by planting different crops during a crop season as a mechanism to avoid crop failure risk in one or two crops. Even though some sites or villages are suitable for one of two crops for farmers to specialize in,

[8] Quality of land variable indicates degree of fertility of the land. Farmers were asked about the quality of each plot of land that they cultivate. Farmers respond one of the three answers for each plot: best quality (3), medium quality (2) and poor quality (1). Then I assigned the values in brackets for each level of quality. Finally, we calculate weighted average (the weight is size of each plot) of the quality of land for each household.

[9] The number of crops may be correlated with the number of plots that a farmer owns. However, in the dataset I have employed, I have only the total land size owned not the number of plots at the household level, and hence I can not determine if this is the case.

there may be some unobservable and uncontrollable factors that diminish the chance of high yield even for those suitable crops. Farmers diversify even among those suitable crops. If there is only one or two crops to which farmers can diversify, they are likely subject to high risk. Hence, the total number of crops cultivated is used as another risk indicator. It may be that households may plant different crops to diversify to cash and staple crops, which again confirms that the reason for planting different crops is to secure enough food and cash income.

Seasonality is another factor that affects off-farm activities. Issues of seasonality could be within a given year or across years. Given the two major crop seasons (*meher* and *belg)*, farmers may be idle during times other than the crop seasons. It is also important to note that due to different weather conditions year after year, we expect to see variations across years. As can be seen in Table A.4 in the appendix, different time periods had been used for each district to collect the data and hence the recall periods were different for each district. To account for this, dummy variables are created for survey periods and recall months. The season dummy variable takes value of 1 for a district if the survey was conducted in that district during the slack months of the year and takes 0 otherwise. The year dummy variable takes 1 for 1997 and 0 for 1994. As indicated in the descriptive statistics, farmers engage more in off-farm activities in 1994 compared to 1997. The key difference between these two years, when it comes to agriculture, is that year 1994 is considered as the year with sever weather conditions that was not favorable for agricultural production; the other difference was that year 1997 is considered as the year where farmers have been fully exposed to the policy reforms undertaken by the government. The year dummy is expected to pick these effects. Although it seems difficult to distinguish between the effects of the weather condition and the effect of policy change from the year dummy coefficient, I have also controlled for crop income to examine whether households are substituting farm and off-farm activities during the harvest years.

It is clear that one need to account for crop income received from farm activities per se in off-farm estimations. To account for income from the two crop seasons, values of crops produced during *meher* (main harvest season) and *belg* (slack season) are incorporated in estimation models*.* Having crop production alone may not be enough for cash-poor farmers; the amount of cash income from production also matters. It is important to somehow account for the actual cash income obtained from the sale of crop in each season, in addition to just controlling for total production. The amount of sale by each household may help explain not only the degree of market access but also their access to cash. However, variable that accounts for the actual income received from the sale is not available. Short of that, households were asked if they had sold any part of the harvested crops during each crop season. Using this information, one can create a dummy variable to indicate sale of part of the harvested crops during each season. Two dummy variables were created, one for those households who sold part of their crop during *meher* and the other for those who sold part of their crop during *belg*. There may be issue of endogeniety of crop income and off-farm income. It is not clear whether crop income determines off-farm income or the other way around. I have adopted appropriate estimation technique to respond to this concern.

In addition to these key indicators, to capture regional and local effects that might affect decision-making, village dummies[10] are added to each model either automatically through panel estimation model or manually by creating the dummy variables where appropriate. Village dummies help to capture difference in physical infrastructure, and access to markets, as well as differences in climate variation (i.e. drought-prone vs. surplus villages). The demographic variables include age of household head, age squared to capture experience and old age, dummy for female-headed households, dependency ratio[11], family size in adult equivalents, the number of students in each household.

From the classical household models it is not clear which of these variables affect participation and which of them affect intensity of off-farm activities. The eclectic approach (Ellis, 1998 and 2000) also does not distinguish between determinants of participation and intensity for off-farm activities. This study will use Heckman two-stage estimation technique to identify if there is any difference in factors that affect participation and intensity (more about the estimation approaches in the next section). Given the condition in Ethiopia, I expect to see negative effects from crop incomes due to competition between farm and off-farm activities over labor. For asset **ownership,** specifically agriculture related resources, I also expect to see negative effect as these resources (livestock and land) are more suitable for farm activities than off-farm. For risk indicators, it is expected that those households who face high risk situation ex ante (for instance, poor quality of land) may engage more in off-farm activities to ameliorate the impact of the risk.

[10] There are a total of 19 villages and hence 18 dummies. The coefficients for the dummies are not reported here to save space.
[11] Dependency ratio is defined as ratio of family members below age 15 and above age 60 to total family size.

4. Data and estimation

4.1 Data and descriptive statistics

Household survey data from rural Ethiopia during 1994 and 1997 harvest years are used in this study[12]. The Department of Economics at Addis Ababa University, in collaboration with various institutions (University of Oxford, UK and International Food Policy Institute (IFPRI), USA), has collected socio-economic data from 1500 representative farm households in Ethiopia since 1989[13]. With only few attrition, about 1450 households are used for each the two survey years in this study. The survey, which gathers information from the same households, is in its sixth round (although not on a regular interval). The core modules that appear on the questionnaires are information on demographics, assets, farm inputs, farm outputs, livestock, and health indicators. The survey covers six regions (formerly regions 1, 3, 4, 7, 8, and 9)[14] and fifteen sites representing the different ecology of the highland farming systems in the country with the exception of pastoral systems. Table A.4 in the appendix displays the survey sites, the main harvest months and the time of interview for the first four rounds. Given the different times of survey for each district in each region, response of farmers on recall questions may be different since recalls of up to four months were asked. Most surveyed areas have two crop seasons: the main season (*meher)* and the slack season (*belg*). The different survey times for each district may raise issue of seasonality; hence it needs to be accounted for in estimation.

During both survey years, households were asked questions specific to their participation in off-farm activities ranging from the location of the activities to the reasons why other family members were not seeking off-farm employment. Information on the income earned from these activities, both in cash and in kind, was

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[12] These two years were selected for two reasons. First, 1994 and 1997 give us a natural experiment where one can see the effect of both policy and weather shocks. It helps to see how farmers respond when they face these shocks at the same time. Second, the other two survey years in between (1995 and 1996) are too close to the base year to see any significant response from the farmers. The later years (especially 1999 and 2000) may be ideal to conduct longer panel analysis and they may also introduce other shocks. However, for these years some of the variables that refer to demographics and household composition and related covariates are not consistent with previous year variables and it creates difficulty to pool the data together from these years. In addition, given the length of time between 1994 and 2000 (and later years for that matter) other significant changes, other than policy reform and weather condition, might have occurred to influence famers to respond and hence it creates difficulty to distinguish responses to policy and other factors that sets during these periods.

[13] The 1989 survey covered only six (drought-prone sites) of the fifteen sites covered during the other survey years. The next four surveys were conducted in 1994, 1995, 1996 and 1997.

[14] These regions were later named as Tigray (for region1), Amhara (for region 3), Oromia (for region 4) and Southern Nation and Nationalities People (SNNP) (for regions 7, 8 and 9).

gathered from each household. Tables A.1 and A.2 in the appendix provide participation rates and reasons for not participating in off-farm activities, respectively, both by region and year. Off-farm activities participation rate declined from its 35% in 1994 to 23.6% in 1997, with significant variation across regions. For instance, in Tigray region participation rate dropped from almost 71% to 19%, in Oromia region participation dropped from 45% to 23% whereas in Amhara and SNNP, participation rate remained almost constant over the two years period (see Table A.1). The difficulty of access to off-farm activities outside of farmers' residential locality were manifested by the fact that, during both survey years, over 74% of households reported that they participated in off-farm activities only in their villages.

Pervious study done in the southern part of the country shows that the single most important non-farm activity was trading and laboring for others (Carswell, 2002); this was also found to be significant in these surveys. The major activities in which farm households engaged in during the 1994 and 1997 harvest years were farm work (i.e. on others' farm), labor sharing activities[15], laboring (skilled builder, thatcher) and other unskilled activities. In 1997 there was an increase in participation in skilled labor and unskilled labor activities; and there was a decrease in participation in food-for-work and labor sharing activities. This trend is expected, because as the size of per capita land holding gets smaller, family members needed to engage in those off-farm activities with limited entry barriers, especially for resource-poor households. This confirms what is indicated in the literature, especially for households in rural Africa. The decline in food-for-work may be due to good crop harvest in 1997 compared to 1994.

Farm households were also asked why they participated in off-farm activities during the 1997 harvest year. One of the main reasons for participating in off-farm activities was limited agricultural income (over 68% of the responses). This supports the view that farm and off-farm incomes are complements for households with limited access to other resources like asset and credit. In response to the question as to why some members of the household were not seeking off-farm jobs in 1994 and 1997 harvest years, farmers point out two reasons as major impediments: lack of employment opportunities, and competition for labor by farm and off-farm activities. The number of households who reported lack of employment opportunities decreased in 1997 for all regions, whereas those who reported competition between farm and off-farm activities increased in 1997 (see Table A.2 in the appendix). This is consistent with the substitution hypothesis, which argues that when there is favorable weather, off-

[15] Traditionally, labor sharing activities do not involve payments in cash or kind. Families exchange labor on each others farm for different activities. Off-farm income does not capture this labor allocation unless households receive some kind of payments in in cash or in kind.

farm employment opportunities increase and at the same time demand for on farm labor increases. There are some regional variations in terms of the reasons for participating and not participating in off-farm activities. For instance, with some variations, some regions report taboo as one of the reasons for not participating in such activities in 1994 but not in 1997 (see Table A.2).

The key variables for this study are share of income from different sources. In a rural setting, income sources can be broadly divided into three: crop income, off-farm income, and livestock income. Livestock income refers to income from byproducts of live animals including milk, butter, eggs as well as hides and skins. Some households received income for off-farm activities in kind. We have converted all payments received in kind into cash using price and unit conversion factors collected at nearby markets for each district. Table 1 presents descriptive statistics for the different sources of income during 1994 and 1997 harvest years in Ethiopia. For the three sources of income, mean, median, and inter-quartile ranges are reported for total, per capita and share of each income source. During the 1997 harvest year, when weather condition was suitable for farming, the share of off-farm activities significantly dropped from over 18% in 1994 to only 7% in 1997. In absolute terms, the average income received from off-farm activities was also lower in 1997 (birr[16] 97) compared to year 1994 (birr 107) (see Table 1). There were regional variations in terms of average off-farm income during the two harvest years; in 1994, part of southern region (region 7) had the highest average off-farm income (birr 168) followed by Oromia (birr 128). However, during the same year the share of off-farm income in total income was highest for Tigray (0.62) followed by part of Southern region (region 7) (0.26). In 1997, for all regions the share of off-farm income declined from its 1994 levels. Total crop income more than doubled in 1997 compared to its value in 1994. The opposite was true for the share of off-farm income. The median values of total off-farm and per capita off-farm incomes were zero in 1997, which is expected since farmers switched to farm income during this year. The fact that the survey sites had zero median values and positive skewness suggests that income values have relatively few high values but with long tails to the right. In 1997 skewness increased for two of the three income sources. However, unlike in 1997, in 1994 when the necessity argument seems to dominant, poor households engaged more in off-farm activities.

[16] Birr is the Ethiopian currency. The exchange rate as of October 2007 was $1= 9.0 birr.

Table 1. Mean, Median, and Inter-Quartile Range (IQR) of total and per capita incomes from different source in rural Ethiopia during 1994 and 1997 survey years.

Income Source	1994			1997		
	Mean	Median	Skewness	Mean	Median	Skewness
Off-Farm, Total	107.19	25.00	7.3	96.61	0.00	7.3
Crop, Total	1394.7	573.4	15.3	3383.3	1203.6	29.7
Livestock, Total	52.47	0.00	6.0	65.81	0.00	6.9
Per Capita Off-Farm	20.44	4.32	10.4	15.78	0.00	6.9
Per Capita Crop	233.92	106.54	5.9	443.79	180.9	27.4
Per Capita Livestock	9.74	0.00	6.3	10.41	0.00	7.9
Share Of Off-Farm	0.18	0.03	1.8	0.07	0.00	3.6
Share Of Crop	0.71	0.87	-1.1	0.83	0.96	-2.0
Share Of Livestock	0.06	0.00	4.2	0.05	0.00	4.4

Off-farm, total= total off-farm income (both in cash and in kind earnings); crop, total = total value of crops harvested; livestock, total = total income received from sale of livestock products (like milk and hides and skin). Values are in Ethiopian currency (birr). The exchange rate was about $1=5.42 birr in 1994 and $1= 6.1 birr in 1997.

One has to also note that both off-farm and crop income sources are mostly dependent on weather conditions (mainly reliable rainfall) since rural off-farm activities are highly linked to agricultural activities. Hence, it is not appropriate to attribute all the variability and dynamics of income sources over time only to the rational or irrational behavior of farmers. For example, the 1994 harvest year was considered as a relatively low production year due to relatively bad weather condition. During a good weather year, resource-poor farmers are expected to spend more time on crop production on their farm to have enough food production for the season not only for consumption but also as a source of cash income. For such resource-poor farmers, more labor time and resource spent on own farms lower their participation in off-farm activities. This descriptive statistics seem to support the idea that, in countries like Ethiopia, participation in off-farm activities is mostly as survival mechanisms rather than a choice[17]. The next section will present the methodology and estimation approaches employed in obtaining participation and intensity coefficients.

[17] There may be resource-rich farmers, in labor, land, and livestock, who engage in off-farm activities as a choice, since they can engage in both activities simultaneously. Nonetheless, the types of activities that these farm households – resource-poor and resource-rich – engage in may be different. Resource-rich farmers may engage in lucrative activities since they participate in these activities by choice not for survival. It is beyond the scope of this study to distinguish the activities by the type of farm households in each site.

4.2 Estimation

Equations estimated in this study have the following forms:

$$\begin{aligned} y_{it} &= \alpha X_{it} + \beta Z_{it} + \varepsilon_{it} \text{ (participation equation)} \\ y^{o}_{it} &= \phi X_{it} + \varphi W_{it} + \eta_{it} \text{ (Intensity Equaion)} \end{aligned} \quad \textbf{(3)}$$

For estimation of participation equation, y_{it} is dummy variable, which takes 1 for participating households and 0 otherwise. For estimation of intensity equation, y^{o}_{it} is the share of off-farm income to total income, and it is observed only when y_{it}=1. X_{it} is a vector of explanatory variables common for both equations. Z_{it} is a vector of explanatory variables that affect only participation but not intensity, where as W_{it} is a vector of explanatory variables that affect only intensity. For joint estimation of both equations, there should be at least one variable that is not common for both equations. We have identified one variable, dependency ratio, which affects only participation. The logic behind this is that households know ahead of time if their family labor composition allows them to participate in off-farm activities or not. Although households with large dependent ratio want to participate more in off-farm activities to secure enough food for the family, the available resource (i.e. human capital) doesn't allow them to do so. Large dependency ratio is a barrier to participation since dependent family members are not participating in any of the activities and the other members of the household have to make sure there is enough food production for the family members by spending more time on farm, not on off-farm. It may also be the case that household members spend time looking after the dependents and hence have less time to spend on off-farm activities.

There are two econometric issues that need to be addressed in estimating the above equations: endogeniety, and selection bias[18]. The endogeniety issue arises from the suspicion of dependence between off-farm and farm activities. Especially for resource-poor farmers who cannot perform both activities at the same time, it is reasonable to expect that engaging in one activity preclude farmers from other activities. It is necessary to test for exogenity of the suspected variables. The issue of self-selection bias may be due to those households who did not report participation in off-farm activities and who may be considered as if they didn't want to participate in off-farm activities at all. However, it may be the case that they may want to participate if some conditions were fulfilled. Hence, it would be an unfair assessment to consider

[18] Given the nature of the data, one may suspect issues related to outliers. Quantile estimation technique would be the appropriate estimation technique for outliners. However, Hausman's specification test indicates that quantile regression is not the best fit to explain the data.

those with zero off-farm income as if they didn't want to participate under any circumstance. They might have some reservation income from the off-farm activities, and if the market income from off-farm is below that income, they may not participate in off-farm activity. In this study, we first examine the severity of the issues (selection bias and endogenity), and where appropriate, we attempt to account for the issues using appropriate technique. For the issue of self-selection bias, initially I employed Heckman's two stage estimation technique to estimate both the selection and intensity equations. From the Heckman two-stage estimation, significant of the selectivity variable (mills lambda) confirms the existence of selectivity bias. The Heckman selection model is a two-equation model as in the following equations,

$$y = \beta X + \varepsilon_1 \qquad \textbf{(4)}$$

$$Z^* = \alpha W + \varepsilon_2 \qquad \textbf{(5)}$$

$$where \ \varepsilon_1 \sim N(0,\sigma), \varepsilon_2 \sim N(0,1), \text{and } \operatorname{corr}(\varepsilon_1, \varepsilon_2) = \rho$$

Where y is observed if and only if a second unobserved latent variable, Z*, exceeds some threshold level. The first equation is participation equation, where *y* takes 1 if a household participates in off-farm activities and 0 otherwise. The second is the selection equation. When ρ = 0, OLS regression provides unbiased estimates, when ρ ~= 0 the OLS estimates are biased. The Heckman selection model allows us to use information from non-participating households to improve the estimates of the parameters in the intensity regression model. The Heckman selection model provides consistent, asymptotically efficient estimates for all parameters in the model.

However, the Heckman two-stage estimators sometimes perform poorly (Nawata and Nagase, 1996). Alternative estimation technique should be used to see robustness of the results. Heckman's second stage estimation does not account for the panel nature of our data; it only estimates the selection equation with additional information variable from the participation equation using OLS. Another way to take advantage of the information hidden in the data for the non-participants and also to use the panel nature of the data is to employ panel-Tobit estimation technique.

Panel-Tobit estimation technique is as follows.

$$y_{it} = x_{it}\beta + v_i + \varepsilon_{it}, \text{for } i = 1,....,n_i. \ v_i \text{ are iid N}(0,\sigma_v^{\ 2}), \text{and } \varepsilon_{\text{it}} \text{ are iid N}(0,\sigma_\varepsilon^{\ 2}) \qquad \textbf{(6)}$$

The observed variable $y_{it}^o = \begin{cases} y_{it} & \text{if } y_{it} > 0 \\ 0 & \text{otherwise} \end{cases}$ represents censored version of y_{it}. v_i represents time-invariant (observed or unobserved) factors and ε_{it} represents the overall error term. It is assumed that $E(v_i\ v_j) = 0$, $E(v_i\ \varepsilon_{it}) = 0$, and that $E(\varepsilon_{it}\ \varepsilon_{jt}) = 0$ for all *i* and *j;* that means there is no correlation between error terms and there is no autocorrelation. For this study the data is left censored for those households who did not report any income from off-farm activities.

I have approached the issue of endogenity in two ways. First, I attempted to run regressions with and with out those variables suspected of being endogenous in each specification (i.e. crop incomes). If comparing the two results generates no significant differences in the magnitude and signs of the coefficients, one may assume that the issue of endogenity is not severe. I have also estimated the equations using Tobit Instrumental Variable (IV) technique that accounts for the censored values of the data as well as endogenity. To compare consistency and efficiency of the estimation techniques adopted in this study, Hausman's specification test is employed. Heckman's two-stage and panel-Tobit estimation techniques are compared to alternative standard random effects model, quintile models, and Tobit instrumental estimation techniques. In all cases, Heckman's two-stage and panel-Tobit become the best specifications to explain the data[19].

Hence, I have reported estimation results from different specification with and with out crop income to show robustness of the results. For Heckman two-stage estimation, village dummies are created and incorporated in each specification to account for village specific effects. Coefficients from the village dummies are not reported to save space. Results are reported in Tables 2-4. Table 2 presents Heckman's 1st stage estimation, which uses probit model. Table 3 presents the second stage of Heckman's estimation model, which incorporates mills lambda. In Table 4, in addition to panel-Tobit estimation results, standard random effects estimation results, which don't account for censored values, are also reported for purpose of comparison. For both the probit and panel-Tobit estimation models, marginal effects are reported, instead of the raw coefficient, to make interpretation of the coefficients easier.

5. Results

One result that stands out consistently in all specification is the effect of the dummy variable for year 1997. From the panel-Tobit result, during 1997 harvest year, compared to 1994, share of off-farm decreased by over 0.25 points (Table 4). The negative and significant coefficient of the year dummy in both participation and intensity equations confirm that households engage in off-farm activities as a substitute for farm activities. They tend to engage less in off-farm activities during a

[19] Regression results from quintile and Tobit IV models are not reported to save space. The results are available up on request.

year with relatively favorable weather condition. During 1994 harvest year, with relatively bad weather conditions, farmers had to practice off-farm activities to fill the income gap created by crop failures. Hence, off-farm activities were practiced for subsistence as a substitute for farm activities, whereas in 1997, with relatively better weather conditions (at least compared to 1994), farmers engaged less in off-farm activities. Could this be due to response to the favorable policy change in 1997? Due to the heavy dependence of the agricultural sector on weather conditions, it is difficult to say if there is systematic dynamism in off-farm activities in rural Ethiopia as a response to policy reforms. It seems rather a response to changes in the underlying weather conditions and farm activities. Even if we assume some positive response to the change in policy in 1997, the reform had the impact of encouraging farm activities than off-farm activities.

These results are in line with Matsumoto, et. al. (2006)'s conclusions in that only low-potential agricultural areas are more likely to participate in local nonfarm activities. In our case the year 1994 naturally became low-potential due to rain failure in most part of the country. Evidence from Uganda also alluded to this fact, where only low skilled workers tend to use off-farm activities to mitigate negative shocks in the traditional production (Kijima et. al., 2006).

Results for off-farm participation (Table 2) reveal that demographics, seasonality, asset ownership, and risk are the major determinants of participation in off-farm activities. Note that the impact from crop income is statistically zero. If any thing, it is the sale of crop during the *meher* season that led farmers to participate less in off-farm activities. Of the demographic factors, households with more dependents, and who are female-headed, tend to participate less in off-farm activities. A one point increase in dependency ratio decreases the probability of participation by about 0.33 points. One can safely say that these variables, large dependents and female headed, characterize poor farm households in rural Ethiopia (see for instance, Lemi, 2009). Although Carswell (2002) reported positive role that women play in diversification, the result I presented about female headed families may not be contradicting Carswell's finding. There are two reasons: first, Carswell (2002) considers the role of women within a household who could well be male headed households. Second, Carswell's study draws its data only from the southern part of the country, where enset farming system dominates and where most of the activities are undertaken by women. Age has a positive but insignificant effect; the negative and significant coefficient of the square term implies declining effect of age on participation. As head of the family gets older families participate in off-farm activities at a decreasing rate.

Table 2. Determinants of participation in off-farm activities in Ethiopia: Marginal effect of Heckman's 1st stage estimation (dependent variable is dummy for off-farm employment)

	Without crop income	Without crop sale dummy	With crop income and crop sale dummy
Demographics			
Age of head	0.02	0.01	0.01
	(1.62)	(1.61)	(1.51)
Age of head squared	-0.001***	-0.001***	-0.001***
	(-2.67)	(-2.67)	(-2.59)
Female headed	-0.35***	-0.35***	-0.36***
	(-5.27)	(-5.29)	(-5.39)
Number of students	0.0001	0.0001	0.0001
	(0.15)	(0.10)	(0.06)
Family size (in Adult equivalents)	0.02	0.02	0.02
	(1.41)	(1.42)	(1.41)
Dependency ratio	-0.33**	-0.33**	-0.33**
	(-2.56)	(-2.54)	(-2.54)
Seasonality			
Season	0.07	0.06	0.06
	(0.84)	(0.73)	(0.74)
Year 1997 dummy	-0.69***	-0.69***	-0.66***
	(-12.28)	(-12.18)	(-11.57)
Asset ownership			
Value of livestock	-0.001**	-0.001**	-0.001**
	(-2.53)	(-2.45)	(-2.25)
Total land owned	0.01*	0.01*	0.01*
	(1.72)	(1.71)	(1.65)
Risk indicators			
Number of crops	-0.01	-0.01	-0.001
	(-0.67)	(-0.58)	(-0.10)
Quality of land	0.08**	0.08**	0.07**
	(2.24)	(2.25)	(2.10)
Crop Income			
Value of *meher* crops		-0.001	-0.001
		(-0.93)	(-0.84)
Value of *belg* crops		0.0001	0.0001
		(1.33)	(1.44)
Meher sale dummy			-0.16**
			(-2.39)
Belg sale dummy			-0.04
			(-0.50)
Constant	0.54*	0.56*	0.58*
	(1.69)	(1.74)	(1.80)
N	2901.00	2901.00	2901.00
N-censured	1643.00	1643.00	1643.00
Chi2	890.48	944.81	1071.66
Rho+	0.78	0.76	0.64

+Heckman's rho, the inverse hyperbolic tangent of rho, is the correlation of the residuals in the two equations and sigma, which is the standard error of the residuals of the second stage equation. Values in brackets are z-values. *p ≤ 0.10, **p ≤ 0.05, ***p ≤ 0.01

Given the impacts of demographic factors, households who own more livestock tend to participate less in off-farm activities although the marginal effect on probability is very small (0.01 point). The other asset variable, land size, is positive and significant, but significant only at

10% level. Land is not as much an issue since it is not really owned by farm households. These results, also confirmed in intensity estimation equations, imply that land ownership has only little influence on households' off-farm activities. Block and Webb (2001) considered smaller land holding as one risk indicator. They argue that farmers with smaller farm size, which indicates risk, tend to engage more in off-farm activities. This argument is not supported in this study. But what is relevant here is the quality of land, which proxies land productivity. If land quality increases by one unit, the probability of households' participate in off-farm activities increase by over 0.07 points. This result is unexpected. One expects to see that the better the quality of land, the more farmers stay on farm and participate less in off-farm activities. But the results reveal otherwise. One possible explanation for this is that if the quality of land is good, farmers may not have to spend that much time and resource to secure enough food for the family. That gives farmers some extra time to spend on off-farm activities. Similar results are also obtained in the intensity estimation equations. This result is consistent with the risk aversion argument, where farmers with poor quality of land need to spend more time on farm to guarantee enough food for family members. The other risk aversion indicator is number of crops that farmers plant during a given year. The coefficient of the number of crops is insignificant, although negative, in participation equation. The negative sign is consistent with the risk aversion hypothesis. The link between risk aversion behavior and the number of crops planted is more apparent in the intensity estimation results.

The only significant crop income variable in the participation equation is dummy variable for *meher* sale in the last specification. Value of crop income from both *meher* and *belg* harvest seasons do not affect participation decision. But sale of crop from *meher* season makes households to participate less in off-farm activities. Value of crop production is not enough to persuade farm households to stay on farm (to participate less in off-farm activities), but it is the sale of part of their crop production. In which case, off-farm and farm activities become substitutes, not complements. Similar, and even stronger, result confirms this argument in the intensity estimation results. This result is in line with the idea that mainly cash-poor farmers tend to engage more in off-farm activities, *ceteris paribus*.

Table 3. Determinants of share of off-farm income (intensity of off-farm activities) in Ethiopia: Heckman 2nd stage OLS estimation results (dependent variable is share of off-farm income)

Off-farm Share	Without crop income	Without crop sale dummy	With crop income and crop sale dummy
Demographics			
Age of head	0.0001	0.0001	0.0001
	(0.93)	(0.77)	(0.14)
Age of head squared	-0.001	-0.001	-0.001
	(-1.01)	(-0.88)	(-0.35)
Female headed	-0.02	-0.01	-0.01
	(-0.41)	(-0.40)	(-0.24)
Number of students	0.02**	0.02**	0.02**
	(2.20)	(2.47)	(2.54)
Adult equivalent	0.001	0.001	0.001
	(0.27)	(0.73)	(0.79)
Seasonality			
Season	0.11***	0.09***	0.08***
	(4.28)	(3.65)	(3.56)
Year 1997 dummy	-0.14**	-0.13**	-0.09
	(-2.15)	(-2.03)	(-1.57)
Asset Ownership			
Total land owned	0.0001	0.0001	0.0001
	(0.91)	(0.88)	(0.43)
Value of livestock	-0.001***	-0.001***	-0.001***
	(-4.52)	(-3.95)	(-3.72)
Risk Indicator			
Number of crops	-0.02***	-0.02***	-0.01***
	(-8.50)	(-6.78)	(-5.63)
Quality of land	0.07***	0.07***	0.06***
	(5.34)	(5.48)	(5.22)
Crop Income			
Value of *meher* crops		-0.001***	-0.001***
		(-6.00)	(-5.16)
Value of *belg* crops		0.001**	0.001**
		(2.43)	(2.37)
Meher sale dummy			-0.15***
			(-6.73)
Belg sale dummy			-0.03
			(-1.50)
Constant	0.0001	0.04	0.11
	(0.03)	(0.31)	(0.94)
Mills lambda	0.23*	0.22	0.17
	(1.65)	(1.59)	(1.29)
N	2901.00	2901.00	2901.00
N-censured	1643.00	1643.00	1643.00
Chi2	890.48	944.81	1071.66
Rho+	0.78	0.76	0.64

+Heckman's rho, the inverse hyperbolic tangent of rho, is the correlation of the residuals in the two equations. Sigma is the standard error of the residuals of the second stage equation. Mills Lambda is rho*sigma. Values in brackets are z-values. *p ≤ 0.10, **p ≤ 0.05, ***p ≤ 0.01

For the demographic factors, unlike the results from the second stage Heckman model (Table 3), the panel-Tobit and random effects (Table 4) most coefficients are statistically significant although the signs of the coefficients are the same. This is expected since the second stage Heckman estimation uses OLS model but accounts for the selection bias with mills lambda. Furthermore, in the second stage Heckman model mills lambda is significant only in the first specification. Once we incorporate crop income and sale of crops from both seasons, mills lambda became insignificant and hence there is no selection bias concern[20]. For the off-farm intensity results, as expected, there are some differences between the results reported from panel-Tobit and those from random effects models (Tables 4). As indicated above, Hausman's specification test confirms that panel-Tobit is the best specification for the data. Both specifications have the same signs for the coefficients but the results in the random effects model are weaker. Since results from the second stage of Heckman model are more or less similar (at lease in terms of the signs of the coefficients) to that of the panel-Tobit and to the random effects model, I only discuss results from panel-Tobit model below to save space.

One of the variables, that had no effect on participation but affect intensity of off-farm activities significantly, is the number of students in a household. An increase in the number of students in a household by one unit increases the share of off-farm income by over 0.01 points. Could it be because some of these off-farm activities require some education? There are some activities, like trading and professional works, that require some kind of skill, which attracts those households with kids in school to help them out with some of the skill requirements. The positive impact of education is consistent with result from previous studies (Escobal, 2001 and Lanjouw et. al. 2001). Age of household head coefficient also becomes stronger compared to results in participation estimation; age affects intensity of off-farm activities positively but at a decreasing rate as head of the household becomes older. Unlike the results in participation equation, seasonality also plays a significant role in the intensity equations. Off-peak months are the best time to engage in off-farm activities for households who already decided to participate in off-farm activities. The year 1997 is also a year when households engaged less in off-farm activities in line with the result in the participation equation. Previous studies also argue that harvest shortfall (as in 1994) drive farmers to diversify more (Reardon, et. al. 1992), and when there is suitable farming condition, farm activities competes with off-farm activities (Woldehanna and Oskam, 2001). As in the participation results, an increase in the value of livestock also lowers off-farm intensity.

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[20] Mills lambda is the product of rho and sigma. Its insignificance in the last two estimation equations indicates that there is no selection bias. However, the value of rho (the correlation between the error terms of the two equations) is not close to zero, which indicates that there is correlation between the two errors. Since I have used two-step estimation for the Heckman model, likelihood test for the value of rho is not generated.

Table 4. Determinants of intensity of off-farm activities in Ethiopia: Results from panel-Tobit and random effects estimation models (dependent variable: share of off-farm income)

	Panel-Tobit Estimations			Random Effects Estimations		
	Without crop income	Without crop sale dummy	With crop income and crop sale dummy	Without crop income	Without crop sale dummy	With crop income and crop sale dummy
Demographics						
Age of head	0.01***	0.01**	0.01**	0.001**	0.001**	0.001*
	(2.62)	(2.36)	(2.38)	(2.20)	(2.23)	(1.86)
Age of head squared	-0.001***	-0.001***	-0.001***	-0.001**	-0.001**	-0.001**
	(-3.08)	(-2.86)	(-2.93)	(-2.40)	(-2.39)	(-2.17)
Female headed	-0.09***	-0.09***	-0.09***	-0.03**	-0.02**	-0.03***
	(-3.88)	(-3.81)	(-4.17)	(-2.27)	(-2.08)	(-2.74)
Number of student	0.02**	0.02**	0.02**	0.01**	0.01**	0.01**
	(2.57)	(2.19)	(2.18)	(1.97)	(2.05)	(2.00)
Adult equivalent	0.01	0.01**	0.01**	0.001	0.001	0.001
	(1.61)	(2.31)	(2.22)	(1.13)	(1.07)	(1.46)
Seasonality						
Season	0.06***	0.05**	0.04*	0.04***	0.03***	0.04***
	(2.68)	(2.36)	(1.89)	(3.15)	(2.80)	(3.18)
Year 1997 dummy	-0.28***	-0.28***	-0.25***	-0.11***	-0.11***	-0.10***
	(-14.45)	(-14.25)	(-12.74)	(-11.91)	(-11.74)	(-10.23)
Asset Ownership						
Value of livestock	-0.001***	-0.001***	-0.001***	-0.001***	-0.001***	-0.001***
	(-8.89)	(-8.08)	(-7.89)	(-8.18)	(-7.99)	(-7.88)
Total land owned	0.00	0.00	0.00	0.00	0.00	-0.00
	(1.28)	(1.15)	(0.97)	(0.39)	(0.38)	(-0.10)
Risk Indicator						
Number of crops	-0.02***	-0.01***	-0.01***	-0.01***	-0.01***	-0.01***
	(-6.32)	(-4.63)	(-3.80)	(-8.27)	(-8.37)	(-6.13)
Quality of land	0.05***	0.05***	0.04***	0.02***	0.02***	0.02***
	(4.88)	(4.71)	(3.92)	(4.27)	(3.95)	(4.20)
Crop Income						
Value of *meher* crops		-0.001***	-0.001***		-0.001	-0.001
		(-2.92)	(-2.60)		(-0.55)	(-0.83)
Value of *belg* crops		0.001	0.001		-0.001	-0.001
		(0.84)	(1.07)		(-1.09)	(-0.46)
Meher sale dummy			-0.17***			-0.11***
			(-7.83)			(-9.46)
Belg sale dummy			-0.06**			-0.02
			(-2.08)			(-1.53)
Constant	0.01	0.02	0.06	0.16***	0.17***	0.20***
	(0.11)	(0.27)	(0.80)	(4.53)	(4.95)	(5.83)
N	2841.00	2841.00	2841.00	2841.00	2841.00	2841.00
Log-likelihood	-1499.69	-1495.17	-1459.60			
Chi2	466.75	472.43	509.09	445.63	443.84	562.98
R2_o				0.12	0.12	0.16
R2_b				0.09	0.12	0.21
Rho+	0.14	0.12	0.08	0.08	0.04	0.07

+The percent contribution of the total variance of the panel-level variance component for panel-Tobit and panel regression. For panel-Tobit estimation marginal effects are reported. Values in brackets are z-values. *p ≤ 0.10, **p ≤ 0.05, ***p ≤ 0.01

In all intensity specifications, risk indicators reveal that if households diversify risk by planting several crops, they engage less in off-farm activities. The other risk indicator is land quality. The result shows that as the quality of land increases, households engage more on off-farm activities. These results are consistent with the effects of risk on the probability of participation in Table 2.

This result is in line with the argument that high quality land demand less labor time and frees up some spare time for farm households to engage in off-farm activities. On the other hand, households who own poor quality land spend more time on own farm than on off-farm activities to guarantee enough food for the family. This is confirmed in both the second stage Heckman estimation and the panel-Tobit estimation. The number of crops planted, which is a proxy for risk diversification mechanism, affect off-farm activities negatively and significantly in all intensity specifications. This is in line with the argument that if households already diversify risk by planting a number of crops, they tend to engage less in off-farm activities compared to those households who planted less number of crops. These results agree with theoretical expectations and previous work on Ethiopia. For instance, Block and Webb (2001) arrived at the same result although they have used different risk indicators. However, Dercon and Krishnan (1996) reported that diversification could not be explained by a household behavior towards risk, contrary to theoretical expectation.

Almost all crop income variables (except the value of *belg* crops) affect off-farm intensity negatively and significantly. The key result from crop income (both in value and actual sale) is that farmers with more income from crop activities (especially during the main harvest season) engage less in off-farm activities. An increase in the value of *meher* crop by one unit decreases off-farm income share by 0.001 units. This, again, confirms that farm and off-farm activities are substitutes, not complements. The same result was alluded to from the negative coefficient of dummy variable for year 1997. Off-farm activities are not a choice for farmers in Ethiopia during the study years. The first priority for farmers is to guarantee enough food production and some cash from the sale of crop production. It is only when there is poor crop harvest that farmers engage in off-farm activities. I argue that the positive coefficient on the *belg* crops does not contradict these results.

Belg season is the period where only few areas harvest and those who harvest get only small fraction of what they get during *meher* season. Sites with belg crop income, compared to sites without belg crop income, create off-farm employment opportunities for the idle labor during this slack season of the year. Therefore, the income from *belg* season production is not enough to cover family needs and on top of that there may be some resources not deployed during this slack season since the farm activities are at low scale. In this situation, we expect to see increased off-farm intensity. In cases when *belg* crop sale dummy is significant, that is when farmers get more cash income, the positive effect of *belg* crop disappears (see Table 4), which again confirms that more cash income from crop production leads farmers to stick to farming.

The results support the view that off-farm and on-farm activities compete over limited household resources. It also implies that those households who expect secured agricultural income stay on farm and lower off-farm intensity. Moreover, if farmers sale part of their crops from the *belg* production, they tend to engage less in off-farm activities. This confirms the widely held view of labor shortage in rural Ethiopia, at least during the main harvest season of a year. The competition of farm and off-farm activities over limited household resources during the main harvest season leads farmers to focus less on off-farm activities during harvest years with favorable weather conditions. This is because staying on farm guarantees food security from own farm production and minimizes the risk of buying food from market when there is possibility of a food price hike.

6. Conclusions and implications

The purpose of this study was to examine the determinants of participation in and intensity of off-farm activities in rural Ethiopia during 1994 and 1997 harvest years. The study looked into five key determinants - demographics, seasonality, asset ownership, risk factors, and crop income – as suggested in the literature. The results of the study reveal that in addition to demographic factors, off-farm participation is influenced by asset ownership, seasonal factors, and risk considerations. Although competition from farm activities is not apparent from participation estimation, stronger competition effects emerge from intensity equations. From the demographic factors, one variable that affects intensity is the number of students in a household, which indicates that households with more kids in school tend to engage more in off-farm activities. All other demographic variables have the same effect on intensity and on participation. The year 1997 is the year when farmers engage less in off-farm activities. The expected response to policy reform in 1997 to engage more in off-farm activities was not materialized. It seems rather that farmers' response was to the changes in the underlying weather conditions and farm activities. Even if we assume some positive response to the change in policy in 1997, the reform had the impact of encouraging farm activities more than off-farm activities. Similar result is obtained in the intensity equation.

What is new for the intensity equation is that, as expected, farmers engage more in off-farm activities during the slack months of the survey years. Size of land owned appears to have no effect on intensity as an asset indicator. However, livestock ownership has positive and significant effects on off-farm intensity, similar to the results in participation. Risk indicators also become stronger in the intensity equation. Households who diversify by planting more crops engage less in off-farm activities and households with good quality land spend more time on off-farm activities than those households with poor land quality. One other result that distinguishes participation and intensity equation is the impact of crop income. Incomes from crop production during both seasons seem to have very little effects on the rate of off-farm participation but have strong significant effect on intensity. Stronger result is observed if households sale part of their crops during both seasons. Selling part of crop production provides farmers with the cash that they need to buy tradable goods that they could not produce on their farm. If households secure food from crop production and cash from sale of part of their production, they tend to engage less in off-farm activities.

The implications of the results are clear. Policy makers need to understand the priorities of farm households. Guaranteed food for the family members is the top priority. Farmers also fear price hikes to rely only on income from off-farm to purchase enough food from the market. Their risk perception adds fuel to this fear. One way to convince farmers is to stabilize food market and guarantee access to affordable food supply so that farmers can engage in off-farm activities with predictable cost to secure their family’s food requirements. Although it costs the government in the short run, the long run potential benefits outweigh the costs by making the structural transformation process a smooth transition. The type of off-farm activities in which farmers engage in should be understood well before designing any policy. From this study, it seems that the types of activities undertaken in the survey sites are low-productive, low-skill types mostly undertaken by resource-poor households. Before encouraging farm households to engage more in off-farm activities, the government must make sure to expand off-farm opportunities with potential for growth. It is also apparent from the results that off-farm activities are seasonal, which peaks not only in slack months but also during bad harvest years (during harvest shortfalls). The government should also expand job opportunities during this months, or years to expand off-farm activities that attract farm households by expanding the provision of the necessary inputs like credit, training and essential tools. It is also important to appreciate the degree of competition between off-farm and farm activities at least during the peak harvest seasons. Government could also tap into the seasonal idle labor during the slack months when farmers tend to engage more in off-farm activities. Government should also invest in infrastructure to create off-farm opportunities in remote parts of the country where most resource poor farmers reside and where market integration is very weak as the village effects show. Given the competition between farm and off-farm activities, the presumption of excess labor in rural sector should be reconsidered in formulating policies.

Finally, it is important to point out some of the caveats of this study as a guide for future research works. First, pastoral parts of the country are not represented in this study. Second, specific labor time allocation of households was not used due to data limitations. Other than village dummies, specific indicators for infrastructure and other communication networks (i.e. road type, access to phone, access to government training facilities) are not used in the analysis. Future research should take into account these factors since the use of these specifics may provided more detailed results for specific regional and national policy design.

References

Abdulai, Awudu, and Anna CroleRees. 2001. Determinants of Income Diversification amongst Rural Households in Southern Mali. *Food Policy,* 26, 4, 437-52.

Barrett, Christopher B., Mesfin Bezuneh, and Abdillahi Aboud. 2001. Income Diversification, Poverty Traps and Policy Shocks in Cote d'Ivoire and Kenya. *Food Policy,* 26, 4, 367-84.

Barrett, Christopher B., Tom Reardon, and Patrick Webb. 2001a. Nonfarm Income Diversification and Household Livelihood Strategies in Rural Africa: Concepts, Dynamics, and Policy Implications. *Food Policy,* 26, 4, 315-31.

Berg, Marrit van den, and Girma Earo Kumbi. 2006. Poverty and the rural nonfarm economy in Oromia, Ethiopia. *Agricultural Economics*, 35, s3, 469-475.

Bevan, Phillipa and Alula Pankhurst. 1996. *Ethiopia Village Sociological Survey Reports.* Oxford: Centre for the Study of African Economies.

Block, S., and Patrick Webb. 2001. The Dynamics of Livelihood Diversification in Post-famine Ethiopia. *Food Policy,* 26, 4, 333-50.

Bryceson, Deborah F. 1999. African Rural Labour, Income Diversification and Livelihood Approaches: A Long-Term Development Perspective. *Review of African Political Economy,* 26, 80, 171-89.

Carswell, Grace. 2002. Livelihood Diversification: Increasing in Importance or Increasingly Recognized? Evidence from Southern Ethiopia. *Journal of International Development,* 14, 6, 789-804.

de Janvry, Alain. 1994. Farm-Nonfarm Synergies in Africa: Discussion. *American Journal of Agricultural Economics,* 76, 5, 1183-85.

Deininger, Klaus, and Pedro Olinto. 2001. Rural Nonfarm Employment and Income Diversification in Colombia. *World Development,* 29, 3, 455-65.

Delgado, Christopher L., and Ammar Siamwalla. 1999. Rural Economy and Farm Income Diversification in Developing Countries. Food security, diversification and resource management: Refocusing the role of agriculture? In the *Proceedings of the Twenty-third International Conference of Agricultural Economists*, Sacramento, California, 126-143.

Dercon, Stefan, and Pramila Krishnan. 1996. Income Portfolios in Rural Ethiopia and Tanzania: Choices and Constraints. *Journal of Development Studies*, 32, 6, 850-75.

Ellis, Frank. 2000. *Rural Livelihoods and Diversity in Developing Countries.* New York: Oxford University Press.

_______. 1998. Household Strategies and Rural Livelihood Diversification. *Journal of Development Studies*, 35, 1, 1-38

Escobal, Javier. 2001. The Determinants of Nonfarm Income Diversification in Rural Peru. *World Development,* 29, 3, 497-508.

Holden, Stein, Bekele Shiferaw, and John Pender. 2004. Non-farm income, household welfare, and sustainable land management in a less-favored area in the Ethiopian Highlands. *Food Policy*, 29, 369-392.

Kijima, Yoko, Toyoma Mastumoto, and Takashi Yamano. 2006. Nonfarm employment, agriculture, and poverty dynamics: evidence from rural Uganda. *Agricultural Economics*, 35, s3, 459-467.

Lanjouw, Peter. 2001. Nonfarm Employment and Poverty in Rural El Salvador. *World Development*, 29, 3, 529-547.

_______. 2000. Rural Non-agricultural Employment and Poverty in Latin America: Evidence from Ecuador and El Salvador. In López, R., and A. Valdés, *Rural Poverty in Latin America*. Saint Martin's Press: New York, 99-119.

Lanjouw, Jean O., and Peter Lanjouw. 2001. The Rural Non-farm Sector: Issues and Evidence from Developing Countries. *Agricultural Economics,* 26, 1, 1-23.

Lanjouw, Peter, and Jean O. Lanjouw. 1999. *Rural Nonfarm Employment: A Survey*. The World Bank, Policy Research Working Paper Series: 1463.

Lanjouw, Peter, Jaime Quizon, and Robert Sparrow. 2001. Non-agricultural Earnings in Peri-urban Areas of Tanzania: Evidence from Household Survey Data. *Food Policy*, 26, 4, 385-403.

Lemi, Adugna. 2009. Trade liberalization and change in poverty status in Ethiopia: What are the links? University of Massachusetts Boston, Boston, MA, *Working Paper # 12*.

Mastsumoto, Tomoya, Yoko Kijima, and Takashi Yamano. 2006. The role of local nonfarm activities and migration in reducing poverty: evidence from Ethiopia, Kanya, and Uganda. *Agricultural Economics*, 35, s3, 449-458.

Nawata, Kazumitsu and Nobuko Nagase. 1996. Estimation of sample selection bias models. *Econometric Reviews,* 15, 4, 387-400.

Reardon, Thomas. 1997. Using Evidence of Household Income Diversification to Inform Study of the Rural Nonfarm Labor Market in Africa. *World Development,* 25, 5, 735-47.

Reardon, Thomas, Christopher Delgado, and Peter Matlon. 1992. Determinants and Effects of Income Diversification amongst Farm Households in Burkina Faso. *Journal of Development Studies,* 28, 2, 264-96.

Reardon, Thomas, Eric Crawford, and Valerie Kelly. 1994. Links between Nonfarm Income and Farm Investment in African Households: Adding the Capital Market Perspective. *American Journal of Agricultural Economics,* 76, 5, 1172-76.

Reardon, Thomas, Julio A. Berdegue, and German Escobar. 2001. Rural Nonfarm Employment and Incomes in Latin America: Overview and Policy Implications. *World Development* 29, 3, 395-409.

Ruben, Ruerd, and Marrit van den Berg. 2001. Nonfarm Employment and Poverty Alleviation of Rural Farm Households in Honduras. *World Development*, 29, 3, 549-60.

Sicular, Terry 1986. Using A Farm-Household Model to Analyze Labor Allocation on a Chinese Collective Farm. In Inderjit J. Singh, Lyn Squire and John Strauss (eds.), *Agricultural Household Models—Extensions, Applications and Policy.* Baltimore: The Johns Hopkins University Press.

Smith D.R., Gordon A., Meadows K., Zwick K. 2001. Livelihood diversification in Uganda: Patterns and determinants of change across two rural districts. *Food Policy*, 26, 4, 421-435.

Strauss, John. 1986. Appendix: The Theory and Comparative Statics of Agricultural Household Models: A General Approach. In Inderjit J. Singh, Lyn Squire and John Strauss (eds.), *Agricultural Household Models—Extensions, Applications and Policy.* Baltimore: The Johns Hopkins University Press.

Woldenhanna, T., and Arie Oskam. 2001. Income Diversification and Entry Barriers: Evidence from the Tigray Region of Northern Ethiopia. *Food Policy*, 26, 4, 351-65.

Yunez-Naude, Antonio, and J. E. Taylor. 2001. The Determinants of Nonfarm Activities and Incomes of Rural Households in Mexico, with Emphasis on Education. *World Development,* 29, 3, 561-72.

ANNEX

Table A.1: Off-farm Participation Rate by Region and Year

Worked on someone else land or other employment?		**Tigray**	**Amhara**	**Oromia**	**SNNP***	**Total**
1994						
Yes	Count	105	120	172	118	515
	% of Row	20.4%	23.3%	33.4%	22.9%	100.0%
	% within Region	70.9%	25.0%	42.6%	26.5%	34.9%
	% of Total	7.1%	8.1%	11.6%	8.0%	34.9%
No	Count	43	360	232	327	962
	% of Row	4.5%	37.4%	24.1%	34.0%	100.0%
	% within Region	29.1%	75.0%	57.4%	73.5%	65.1%
	% of Total	2.9%	24.4%	15.7%	22.1%	65.1%
Total	Count	148	480	404	445	1477
	% of Row	10.0%	32.5%	27.4%	30.1%	100.0%
	% of Total	10.0%	32.5%	27.4%	30.1%	100.0%
1997						
Yes	Count	28	109	91	116	344
	% of Row	8.1%	31.7%	26.5%	33.7%	100.0%
	% within Region	18.7%	23.3%	22.5%	26.6%	23.6%
	% of Total	1.9%	7.5%	6.2%	8.0%	23.6%
No	Count	122	359	313	320	1114
	% of Row	11.0%	32.2%	28.1%	28.7%	100.0%
	% within Region	81.3%	76.7%	77.5%	73.4%	76.4%
	% of Total	8.4%	24.6%	21.5%	21.9%	76.4%
Total	Count	150	468	404	436	1458
	% of Row	10.3%	32.1%	27.7%	29.9%	100.0%
	% of Total	10.3%	32.1%	27.7%	29.9%	100.0%

*Southern Nations, Nationalities, and People (SNNP)

Table A.2: Reasons for Not Participating in Off-farm Activities by Region and Year

1994		**Tigray**	**Amhara**	**Oromia**	**SNNP***	**Total**
No employment opportunities	Count	23	254	225	210	712
	% of Row	3.2%	35.7%	31.6%	29.5%	100.0%
	% within Region	38.3%	53.1%	62.5%	51.2%	54.4%
	% of Total	1.8%	19.4%	17.2%	16.1%	54.4%
Needed on farm	Count	6	133	86	121	346
	% of Row	1.7%	38.4%	24.9%	35.0%	100.0%
	% within Region	10.0%	27.8%	23.9%	29.5%	26.5%
	% of Total	0.5%	10.2%	6.6%	9.3%	26.5%
Job too far away	Count	1	4	7	19	31
	% of Row	3.2%	12.9%	22.6%	61.3%	100.0%
	% within Region	1.7%	.8%	1.9%	4.6%	2.4%
	% of Total	0.1%	0.3%	0.5%	1.5%	2.4%
Wages too low for kind of job	Count		9	1	12	22
	% of Row		40.9%	4.5%	54.5%	100.0%
	% within Region		1.9%	.3%	2.9%	1.7%
	% of Total		0.7%	0.1%	0.9%	1.7%
Taboo	Count	21	51		12	84
	% of Row	25.0%	60.7%		14.3%	100.0%
	% within Region	35.0%	10.7%		2.9%	6.4%
	% of Total	1.6%	3.9%		0.9%	6.4%
Other**	Count	9	27	41	36	113
	% of Row	8.0%	23.9%	36.3%	31.9%	100.0%
	% within Region	15.0%	5.6%	11.4%	8.8%	8.6%
	% of Total	0.7%	2.1%	3.1%	2.8%	8.6%
Total	Count	60	478	360	410	1308
	% of Total	4.6%	36.5%	27.5%	31.3%	100.0%
1997						
No employment opportunities	Count	18	115	113	69	315
	% of Row	5.7%	36.5%	35.9%	21.9%	100.0%
	% within Region	27.7%	31.0%	60.4%	37.1%	38.9%
	% of Total	2.2%	14.2%	14.0%	8.5%	38.9%
Needed on farm	Count	10	177	59	80	326
	% of Row	3.1%	54.3%	18.1%	24.5%	100.0%
	% within Region	15.4%	47.7%	31.6%	43.0%	40.3%
	% of Total	1.2%	21.9%	7.3%	9.9%	40.3%
Job too far away	Count	11	10	2	2	25
	% of Row	44.0%	40.0%	8.0%	8.0%	100.0%
	% within Region	16.9%	2.7%	1.1%	1.1%	3.1%
	% of Total	1.4%	1.2%	.2%	.2%	3.1%
Wages too low for kind of job	Count	2	5		6	13
	% of Row	15.4%	38.5%		46.2%	100.0%
	% within Region	3.1%	1.3%		3.2%	1.6%
	% of Total	.2%	.6%		.7%	1.6%
Other**	Count	24	64	13	29	130
	% of Row	18.5%	49.2%	10.0%	22.3%	100.0%
	% within Region	36.9%	17.3%	7.0%	15.6%	16.1%
	% of Total	3.0%	7.9%	1.6%	3.6%	16.1%
Total	Count	65	371	187	186	809
	% of Total	8.0%	45.9%	23.1%	23.0%	100.0%

*Southern Nations, Nationalities, and People (SNNP), ** Other includes health issues, lack of skill, old age, child care (nursing) and others.

Table A.3: Descriptive Statistics of the variables used in estimation by year

Description	1994		1997	
	N	Mean	N	Mean
Age of household head (years)	1476	46.42	1469	44.88
Female headed dummy	1476	0.23	1469	0.23
Dependency ratio	1476	0.34	1425	0.39
Adult equivalent	1476	4.77	1469	5.58
Value of agricultural tools (in birr)	1476	30.91	1469	36.89
Area of total land owned (in hectare)	1476	1.95	1469	1.64
Ratio of area of land rented in	1346	0.09	1281	0.064
Value of livestock (in birr)	1476	960.35	1469	1033.51
Value of *meher* crops (in birr)	1476	1113.20	1469	2926.62
Value of *belg* crops (in birr)	1476	281.50	1469	456.65
Dummy for *meher* sale	1317	0.46	1317	0.64
Dummy for *belg* sale	1317	0.20	1317	0.21
Quality of land	1476	1.38	1469	0.92
Number of crops harvested	1476	5.21	1469	6.02

Table A.4: Timing of activities and of the surveys

Region	Survey site	Location	Main Harvest	Survey Round : Time of Interview				
				1989	**Round1 1994**	**Round 2 1994-95**	**Round 3 1995**	**Round 4 1997**
1	Haresaw	Tigray	October-November		June-July	January	March	June
1	Geblen	Tigray	October-November		June-July	January	March	June
3	Dinki	N. Shoa	December	March April	March-April	November	January	October, November
3	Debre Berhan	N.Shoa	November-December	March-April	March-April	October	March	June - August
3	Yetmen	Gojjam	November-December		March-April	October	March	September, October
3	Shumsha	S.Wollo	October-December		June-July	December-January	May	October, November
4	Sirbana Godeti	Shoa	November-December		March-April	November	March	June, July
4	Adele Keke	Hararghe	November-December	November-December	May-June	October	April	October, November
4	Koro-degaga	Arssi	October-November	November-December	May-June	November-December	May- June	June, July
4	Turfe Kechemane	S.Shoa	December		March-April	September-October	March- April	September, October
7	Imdibir	Shoa (Gurage)	October-December		March-April	October	March	June, July
7	Aze Deboa	Shoa (Kembata)	October-November		March-April	September-October	March	September, October
8	Addado	Sidamo (Dilla)	December-January		March-April	January	March	June, July
9	Gara Godo	Sidamo (Wolayta)	August-December	March	March-May	October	March	June, July
9	Doma	Gama Gofa	September-December	May-June	April-May	December-January	May-June	November

Source: Bevan and Pankhurst (1996).

A COMPARISON OF ALTERNATIVE ESTIMATORS OF MACRO-ECONOMIC MODEL OF ETHIOPIA[1]

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Abstract

During the past 5 decades a number of econometric techniques were developed and applied to a variety of econometric relationships to deal with the problem of single equation estimation as well as simultaneous equations bias. These days, such methods have very wide applications especially in more developed countries. However, there has been very little attempt to apply these techniques to empirical relationships describing the macro-economic sector of developing countries in general and Ethiopia in particular. In this study, a small macro-econometric model of Ethiopia is used to identify the best estimation techniques that will produce accurate forecast of the economy of Ethiopia. Six econometric methods were considered. The prediction accuracy of these estimators was examined using time series data covering the period 1970 to 2004. The results indicated that considerable gain in forecasting accuracy can be achieved by using 2SLSAUT01 and 2SLSAUT02 than simple ordinary least squares or two stage least squares to estimate macro-economic models.

Key Words: Econometric Techniques, Econometric Models, Ethiopia, Prediction

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1. Introduction

One of the major challenges that face many African governments is the lack of well-trained Professionals capable of preparing consistent short- to medium-term plans or a comprehensive long-term planning framework. Moreover, over the past years, a number of factors including instability and poor governance have created a time inconsistency problem in policy making in a number of African countries. However, it is expected that the recent trend towards the adoption of poverty reduction strategies that are consistent with overall macro-economic plans will require professionals who can develop and/or use short to longer-term planning frameworks adapted to their economies. Building and updating macro-econometric models require forecasting and planning experts, particularly in the ministries of finance, planning and economic development. In addition budgeting and planning exercises require forecasting major macro-economic variables for at least three to five years. Without such forecasts, the preparation of a country's resource envelope through annual budgets or what is commonly known as 'Medium Term Expenditure Framework – MTEF' would be a difficult task. Forecasting models are a crucial planning instrument. We can use an econometric model to describe how an economy works, and predict future growth rates or carry out simulations to determine how much investment is needed in order to achieve the Millennium Development Goals. Recent budgetary practices in most African countries demand forecasting the government resource envelope three to five years ahead. The invariant coefficients of the equations in a macro-econometric model are estimated from observed data with econometric methods. However, the Ministry of Finance and Economic Development of Ethiopia did not use any of these estimation techniques; rather it uses prior information and experience to fix the values of the parameters for forecasting purposes. But, there are more formal ways of estimating the model than by adjusting coefficient terms for forecasting purposes. The purpose of this study, therefore, is to fill this gap of identifying the best estimation techniques that will produce accurate forecast.

2. Macroeconometric modeling in Ethiopia

A comprehensive survey of African macro models by Harris in the mid 1980s and other recent reviews (see Alemayehu 2002, Alemayehu and Daniel 2004) show that macro modelling in Africa is still in its infancy (Harris, 1985)[4]. Although the development of macroeconomic models has reached a stage were a number of models are now being used on regular basis for forecasting purposes, Ethiopia no

[4] This section relies on Alemayehu and Daniel (2004).

longer uses its direct planning approach to manage its economy. On the other hand, the government has no other instrument of economic management either. Thus, the government lacks a macro model that could have facilitated macroeconomic policy analysis for a long period of time. This problem was severe when the effects of proposed policies are not tractable by simple reasoning alone. Nowadays, few models are emerging which contribute towards such end, a detail of which is given as under.

Asmerom and Kocklaeuner (1985) constructed a supply side macroeconometric model for Ethiopia. As sited in Daniel (2001), the supply side of the model disaggregates GDP by the production sectors: agriculture, other commodities, construction and distributive service and other services. From the expenditure side, the consumption function (for both private and public), sectorial investment functions, export and import functions are specified. The export function is disaggregated in to coffee and non-coffee and imports are also disaggregated in to capital goods, intermediate goods, consumption goods, fuel, and service imports. Savings are disaggregated in to private and public and specified accordingly. Finally, the saving and the trade gap equations, assuming the trade gap is binding, close the model. The model is fairly disaggregated. But the sectorial equations are not interconnected to capture the simultaneity in the system and hence an exogenous shock in one variable would fail to have any impact on the rest of the system. Moreover, because of the absence of price equation, the effect of any disequilibrium between aggregate demand and supply would completely spills-over to the foreign balance and hence it over or under estimates the foreign exchange gap.

Lemma (1993) also constructed a macroeconometric model for Ethiopia. As sited in Daniel (2001), the model has 53 equations (of which 14 are behavioural and the rest 39 are identities) with four major blocks: production sector and investment block, foreign trade block, public finance block and the price block. The model is essentially supply driven and has two productive sectors-agriculture and non- agriculture. The agricultural sector is related to the real relative price the farmers receive, the supply of manufactured goods to the farming sector and other exogenous variables like rainfall. The value added in the non-agricultural sector is specified as a function of the level of monetary investment. The aggregate level of investment, in turn, is a function of major source of funding such as government savings, credit from banking system and foreign capital inflow. The foreign trade block contains three export supply functions (private export functions for pulse and hide; and public coffee export functions) and two import demand functions (capital goods import and raw material imports, and consumers good import is assumed exogenous). The government sector consists of two behavioural government revenue functions (direct and indirect taxes revenue function and import tax function) and an identity export tax revenue function.

The government current expenditure and export tax rates are treated as policy instruments. Finally, the price block identifies two price equations based on consumer price index (CPI) and industrial sector price deflator. The change in CPI is related to excess domestic demand (a pure monetarist formulation) and rate of inflation for imported goods. Price in the industrial sector follows a mark-up rule and is indexed to the CPI in the structuralist tradition. The model, by large, describes the structural and institutional peculiarities of the Ethiopian economy and its policy-making institutions of the socialist era (post 1974/75). However, a significant part of the data(10 observations out of 18) used for the period of pre-1974/75 which cannot be described by the above explained model due to a clear institutional and structural differences between the two periods. In addition to this, some of the assumptions in which the model rested constrained the wider use of the model. For instance, the exogeneity assumption on government current expenditure and agricultural price is questionable. In the case where the economy is for external shocks such as war, drought and terms of trade fluctuations, the exogeneity assumption on government recurrent expenditure will not be a fair assumption. Moreover, to the extent that peasants in Ethiopia had been marketing a considerable part of their produce (after fulfilling the levied quota by Agricultural Marketing Corporation) in the flexible price market, treating agricultural price as purely exogenous is not acceptable. The exclusion of the monetary sector and the formulation of CPI equation can also stand in the negative side of the model. Above all, the result of the model suffers from simultaneity bias as each equation in the model is estimated by OLS.

Daniel (2001) also constructed a macroeconometric model for Ethiopia. The model is set up in aggregate demand and supply framework. The model has 30 equations of which 14 are behavioural and the rest are identities and technical relationships. As sited in Daniel (2001) this model is designed to capture the peculiar structure of the Ethiopian economy such as its supply-constrained nature. Thus, total output is disaggregated into agricultural and non-agricultural (industry, services and other distributional activities) sectors. Moreover, the economy is characterized by a general capacity under utilization, and an attempt is made to capture this phenomenon. On the demand side, private and public consumption and private investment functions are specified. Public investment is assumed to be exogenous. The domestic demand for imports (disaggregated into consumption, intermediate and raw material imports) and foreign demand for export are included on the demand side. The monetary sector comprises a money demand equation and an endogenously money supply equation. The latter is believed to capture the monetization of deficit. Price and the real exchange equations are specified as endogenous in the model.

3. The estimators

There are various econometric methods with which we may obtain estimates of the parameters of macroeconometric models[5]. However, we will consider only the most appropriate estimation methods which may be classified in two main groups, single equation and system-equation techniques. As their names indicate, the main difference between these system estimation methods relates to the information content of the estimator. Another important difference is that single equation estimation techniques involve estimation of the stochastic equations one at a time while system estimation methods all the stochastic equations are estimated simultaneously.

Six estimators are considered. The "least squares method" is the starting point for econometric methods. Each estimator is first used to estimate the twelve stochastic equations of the model. The reduced form of the model is then solved for each set of estimates, and within-sample predictions (both static and dynamic) of the endogenous variables of the model are generated over the sample period. The estimators are compared in terms of the accuracy of the within-sample predictions.
The general model to be estimated is

$$AY + BX = U \qquad \textbf{(1)}$$

where **Y** is an hxT matrix of endogenous variables, **X** is k x T matrix of predetermined (both exogenous and lagged endogenous) variables, **U** is an h x T matrix of error terms, and **A** and **B** are h x h and h x k coefficient matrices respectively.

T is the number of observations. The i^{th} equation of the model will be written as

$$y_i = -A_iY_i - B_iX_i + u_i, \qquad \textbf{(2)}$$
$$i=1, 2, 3\dots h,$$

where y_i is a 1 x T vector of values of y_{it} (at time t=1,…,T), Y_i is an h_i x T matrix of endogenous variables (other than y_i) included in the i-th equation, X_i is a k_i x T matrix of predetermined variables included in the i-th equation, u_i is a 1 x T vector of error terms, and A_i and B_i are 1 x h_i and 1 x k_i vectors of coefficients corresponding to the relevant elements of A and B respectively.

The error terms in U are assumed to follow a second-order auto-regressive process:[6]

[5] A model is a group of structural equations describing relationships between economic phenomenon.
[6] The process in (3) can easily be generalized to higher-order processes, but that will not be done here since only processes up to second order are considered in the empirical work.

$$U = R^{(1)}U_{-1} + R^{(2)}U_{-2} + E, \qquad \textbf{(3)}$$

where the R matrices are hxh coefficient matrices, E is an hxT matrix of error terms, and the subscripts denote lagged values of the terms of U. The error terms in E are assumed to have zero expected values, to be contemporaneously correlated but not serially correlated, and to be uncorrelated in the limit with the predetermined, lagged predetermined, and lagged endogenous variables.

Many estimators could have been considered, but in order to limit the size and cost of this study, the following six estimators were chosen as some of the more important ones to consider.

Ordinary least squares (OLS)

The first estimator considered was ordinary least squares applied to each equation of (2).

Two-stage least squares (2SLS)

The second estimator considered was two-stage least squares applied to each equation of (2). Two-stage least squares produce consistent estimates if and only if the error term u_i in (2) is not serially correlated or if there is no lagged endogenous variable in X. With a large sample size, all of the variables in X should be used as regressors in the first-stage regression for each equation. In practice, however, it is usually necessary to use only a subset of variables in X as regressors or to use only certain linear combinations of all of the variables in X as regressors. A necessary condition for 2SLS to produce consistent estimates is that the included predetermined variables in the equation being estimated be in the set of regressors. Otherwise there is no guarantee that 2SLS will produce consistent estimates even if the error term is not serially correlated or if there are no lagged endogenous variables among the predetermined variables. For this study, therefore, the variables in X_i were always included in the set of regressors when the i^{th} equation of (2) was estimated by 2SLS.

Ordinary least squares plus first-order serial correlation (OLSAUTO1)

The third estimator considered accounts for first-order serial correlation of the error term u_i in (2), but not for simultaneous-equations bias. The estimator is based on the assumption that the error term in each equation is first-order serially correlated:

$$u_i = r_{ii}^{(1)}u_{i-1} + e_i\,, \qquad i=1,2, \ldots,h, \qquad \textbf{(4)}$$

which means that $R^{(1)}$ in (3) is assumed to be a diagonal matrix and $R^{(2)}$ in (3) to be zero.

Under this assumption, equations (2) and (4) can be combined to yield:

$$y_i = r_{ii}^{(1)}y_{i-1} - A_iY_i + r_{ii}^{(1)}A_iY_{i-1} - B_iX_i + r_{ii}^{(1)}B_iX_{i-1} + e_i, \; i=1,2,..,h, \qquad \textbf{(5)}$$

Ignoring the fact that Y_i and e_i are correlated, equation (5) is a simple nonlinear equation in the coefficients $r_{ii}^{(1)}$, A_i and B_i and can be estimated by a variety of techniques. Two of the most techniques are the Cochrane-Orcutt iterative technique and the Hildreth-Lu scanning technique, but any standard technique for estimating nonlinear equations can be used. The technique used for this study was the Cochrane-Orcutt technique. This is because Cochrane-Orcutt technique converges to a stationary value (Sargan, 1964).

Two-stage least squares plus first-order serial correlation (2SLSAUTO1)

The fourth estimator considered is two-stage least squares applied to each equation of (5). This estimator accounts for both first-order serial correlation and simultaneous-equations bias and produces consistent estimates if $R^{(1)}$ is diagonal and $R^{(2)}$ is zero in (3). In this estimator the following variables must be included as regressors in the first stage regressions in order to ensure consistent estimates of equation (5): y_{i-1}, Y_{i-1}, X_i, and X_{i-1}. For this study, these variables were always included in the set of regressors. Any standard nonlinear technique can be used for the second-stage regression of equation (5), and the technique used in this study was the Cochrane-Orcutt technique.

Ordinary least squares plus first- and second-order serial correlation (OLSAUTO2)

The fifth estimator considered accounts for first- and second-order serial correlation of the error term u_i in (2), but not for simultaneous-equations bias. The estimator is based on the assumption that the error term in each equation is determined as:

$$u_i = r_{ii}^{(1)}u_{i-1} + r_{ii}^{(2)}u_{i-2} + e_i, \; i=1,2, \ldots,h, \qquad \textbf{(6)}$$

which means that $R^{(1)}$ and $R^{(2)}$ in (3) are assumed to be diagonal matrices. Under this assumption, equations (2) and (6) can be combined to yield:

$$y_i= r_{ii}^{(1)}y_{i-1}+r_{ii}^{(2)}y_{i-2} - A_iY_i+r_{ii}^{(1)}A_iY_{i-1} +r_{ii}^{(2)}A_iY_{i-2} - B_iX_i+r_{ii}^{(1)}B_iX_{i-1}+r_{ii}^{(2)}B_iX_{i-2} +e_i, \; i=1,2,..,h. \qquad \textbf{(7)}$$

Again, ignoring the fact that Yi and ei are correlated, equation (7) is a simple nonlinear equation in the coefficients $r_{ii}^{(1)}$, $r_{ii}^{(2)}$, A_i, and B_i, and can be estimated by a variety of techniques. The Cochrane-Orcutt technique can be extended in an obvious way to the second-order case, and the extended Cochrane-Orcutt technique was the one used in this study. The technique converged quite rapidly in almost all cases.

Two-stage least squares plus first-and second-order serial correlation (2SLSAUTO2)

The last estimator considered is two-stage least squares applied to each equation of (7). This estimator is an extension of the estimator discussed in (6) to the second-order case and produces consistent estimates if $R^{(1)}$ and $R^{(2)}$ are diagonal in (3). It is easy to show, following the analysis in (6), that the following variables must be included as regressors in the first-stage regressions in order to insure consistent estimates of equation (7): y_{i-1}, y_{i-2}, Y_{i-1}, Y_{i-2}, X_i, X_{i-1}, and X_{i-2}. For this study, these variables were always included in the set of regressors. The nonlinear technique used for the second-stage regressions was the extension of the Cochrane-Orcutt technique to the second-order case.

4. Specification of the model

The specification of the model in this study was based on Daniel (2001). This model was chosen because of the advantages that it avoids many of the problems observed on other models as mentioned in part II. The model is yearly and consists of thirty equations of which fourteen are structural, seven are identities and the rest are definitions and technical relationships. The fourteen components are private consumption, private investment, tax revenue, government expenditure, export, import of consumers' goods, intermediate import, agricultural production, non-agricultural production, capacity utilization rate, price, demand for real money balance, money supply and exchange rate.

Aggregate Demand

Aggregate demand for domestic output is the sum of domestic absorption and the trade balance.

$$Y = A + (X-Z) \quad 1 \qquad \textbf{(8)}$$

where A is domestic absorption and X and Z are export and import, respectively. Domestic absorption is in turn the sum of private consumption (C), investment (I) and government expenditure on domestic goods (G).

Private Consumption

The economic meaning of consumption is the using-up of economic resources so that they are not available in the future.

Consumption is specified as a function of income and price:

$$\text{Log } RC_{pt} = \beta_{10} + \beta_{11} P_t + \beta_{12} \log RCp_{t-1} + \beta_{13} \log RY_t + \beta_{14} \log RY_{t-1} \qquad \textbf{(9)}$$

where RCpt is real private consumption, P_t is the price level and RY is real income at a time t=1,…T.

Private Investment

Investment is defined as spending which is not for current consumption but for future consumption or to increase the capacity to produce in the future. In other words investment is total spending minus consumption. So investment in the macroeconomic sense is spending on factories and machinery, the development of new mines, increase in the herds of cattle, the building of roads, the building up of the national stock of maize, the building up of foreign exchange reserves and so on. It is specified as:

$$LogI_{pt} = \beta_{20}\Delta LogRY_t + \beta_{21} LogI_{gt} + \beta_{22} LogZ_t + \beta_{23} LogPB_t \qquad \textbf{(10)}$$

Where PB_t is level of public debt, Z_t is the level of imports; and I_{gt} is the first difference of government capital stock which is public investment expenditure.

Government Sector

The government sector is modeled from both the revenue and expenditure sides. From the revenue side, tax revenue is modeled as a function of total output and foreign financial flows and the non-tax revenue is assumed to be exogenous. The expenditure function is also explicitly specified to avoid using it as exogenous policy variable. Assuming expenditure as exogenous is not realistic in Ethiopia since the economy is vulnerable to external shocks such as increase in foreign inflation, foreign interest rate, and an increase or decrease in foreign financial flows.

Tax Revenue

There are many ways of meeting the cost of government services. In a modern economy, taxation is normally by far the most important way of providing resources to the government, but other methods do exist.

Tax revenue is defined to be a function of economic activity proxied by GDP (Y), level of foreign trade and foreign capital flow (F). This is given as

$$Log\ TR = \beta_{30} + \beta_{31} logRY_t + \beta_{32} log\ (X+Z) + \beta_{33} logF_t \text{ Where } \beta_{3i} > 0 \text{ and } i = 1\ldots3, \qquad \textbf{(11)}$$

Government Expenditure

In the national accounts, government consumption expenditure is defined to include spending by local authorities as well as by the central government, on the provision of services. The national accounting definition of government consumption spending excludes ‘transfer payments’. These include the payment of pensions, and subsidies to parastatal organizations. The reason for this distinction is that such transfer payments are not direct purchases of services and so should not be counted as part of the national income.

The government current expenditure (G) is assumed to be positively related to total revenue (TR) and foreign inflow (F). Foreign inflation rate, proxied by import price (p^m), is also included in the specification and expected to have a positive coefficient. The lagged value of G is also included to capture possible path-dependent nature of public expenditure:

$$\text{Log } G_t = \beta_{50} + \beta_{51} \log TR_t + \beta_{52} \log F_{t+} \beta_{53} \log P^m + \beta_{54} \log G_{t-1} \quad \textbf{(12)}$$

where $\beta_{5i} > 0$ for i = 1…4

The fiscal block of the model also obeys to the following identities:
Total government revenue (TGR) = TR + other government revenue (OGR)
Total government expenditure (TGE) = G + Capital expenditure (CE)
Fiscal deficit (FD) = TGE – TGR

The External Sector

Exports and Imports

Exports are goods and services that earn foreign exchange. Imports are goods and services that have to be paid for in foreign exchange.

Export

Export (X) is specified as a function of real exchange rate (RER), capacity utilization rate (CUR) and real income (RY) as:

$$\text{Log } X_t = \beta_{60} + \beta_{61} \log RER_t + \beta_{62} \log CUR_t + \beta_{63} \log RY_t \quad \textbf{(13)}$$

Where $\beta_{6i} > 0$ i = 1, 2 & 3

Import

The import function is disaggregated into two parts: consumers and intermediate goods.

$$\text{Log } Zcons_t = \beta_{70} + \beta_{71} \log RY_t + \beta_{72} \log RER_t + \beta_{73} \log R_{t-1} + \beta_{74} \log Zcons_{t-1} \quad \textbf{(14)}$$

where Zcons is import of consumer goods, RY_t is real income, RER is real exchange rate and R is total foreign exchange reserves.

$$\log Zrac_t = \beta_{80} + \beta_{81} \log RY_t + \beta_{82} \log RER_t + \beta_{83} \log R_{t-1} + \beta_{84} \log ZRac_{t-1} \qquad \textbf{(15)}$$

where Zrac is intermediate import (raw material and capital).

In both import equations lagged dependent variables used to show partial stock adjustment behavior.

Total import (Z) will then be the sum of consumer, intermediate other imports:

$$Z = Zcons + Zrac + Zother$$

External Sector Closure

The external sector is closed by the reserve flows identity in which the accumulation or de-accumulation of reserves take place. Except for the trade balance, the other components of the external sector are exogenous in the model. We will use the identities,

BOP = CA + Transfer payments + capital account balance + net errors and omissions

Change in Reserve = BOP + change in arrears + debt relief

Reserve $_{(t)}$ = Reserve $_{(t-1)}$ + Change in reserve $_{(t)}$

where BOP is the balance of payment and CA (current account) is given as the sum of trade balance + net services + net private transfer payments.

Aggregate Supply

Total production is disaggregated into agricultural and non-agricultural, the specification of each being informed by stylized facts about the economic structure of the country.

Agricultural Production

The agricultural production function is assumed to be positively related to labour in the agricultural sector, good rainfall, and relative price of agricultural products. The function is given as:

$$\text{Log } Yagr = \beta_{90} + \beta_{91} \log Lagr_t + \beta_{92} \log RF_{t-1} + \beta_{93} \log\left(\frac{P_{agr}}{P_{nagr}}\right)_t + \beta_{94} \log Yagr_{t-1} \qquad \textbf{(16)}$$

Where Yagr is agricultural GDP, Lagr is labour force in agricultural sector[7], RF is rainfall, and P_{agr}/P_{nagr} is the ratio of agricultural GDP deflator to non agricultural GDP deflator.

Non-Agricultural Production

The non-agricultural sector refers to both manufacturing and service sectors. Output in this sector is determined by labour, change in capital stock, intermediate import and capacity utilization. This production function is given as

$$\text{Log Ynagr} = \beta_{100} + \beta_{101} \log \text{Lnagr}_t + \beta_{102} \log\Delta K_t + \beta_{103} \log \text{Zrac}_t + \beta_{104} \log \text{CUR} \tag{17}$$

Where Lnagr is labour force in non-agricultural sector, ΔK_t is change in capital stock, Zrac is intermediate imports, and CUR is capacity utilization rate in the economy. The total production is given by:

$$RY = \text{Yagr} + \text{Ynagr}$$

Capacity Utilization Rate (CUR)

Capacity utilization is defined as actual to potential ratio. It is derived as a ratio of actual GDP to potential GDP. Capacity under utilization may refer to both the agricultural and the non-agricultural sectors. This in the agricultural sector could be due to drought (whose proxy is rainfall). In the non-agricultural sector the main cause of capacity under utilization is shortage of imported inputs. Thus, CUR can be assumed to depend on the level of imports, and rainfall.

$$\text{Log CUR}_t = \beta_{110} + \beta_{111} \log \text{RF}_{t-1} + \beta_{112} \log \text{Zrac} \tag{18}$$

$\beta_i > 0$ where i = 1 & 2; RF is rain fall and Zrac is intermediate imports.

Prices

The domestic price level is determined by the real excess demand (RED) over the supply in the domestic economy, excess money supply over the money demand (EMs), and import prices (P^m). In addition, capacity utilization rate (CUR) is also related to the rate of inflation which in turn is related to a mark-up pricing system common in many African industries. Thus, price is specified as:

$$P_t = \beta_{120} + \beta_{121} \text{EMs} + \beta_{122} \log \text{RED}_t + \beta_{123} \log \text{CUR}_t + \beta_{124} \log P^m \tag{19}$$

[7] The data for labour force is adjusted using the capacity utilization rate in the agricultural sector to proxy employed labour force in the sector since the data for employed labour force is not available.

Money Market

The money supply equation is partly endogenous from the side of the balance of payments and the fiscal deficit. Following the flow of funds approach, the domestic money supply (Ms) can be given as

$$Ms = (TGR\text{-}TGE) - G^{s}_{p} + DC_{p} + \Delta R \qquad \textbf{(20)}$$

where (TGR – TGE) is the budget deficit, G^{s}_{p} is net sales of government interest bearing assets to the non-bank private sector, DC_p is domestic credit to the private sector, ΔF is change in foreign financial flows, and ΔR is change in foreign exchange reserve.

The demand for real money balance (M/P) is positively related to real income (RY) and negatively related with the opportunity cost of holding money, and given as:

$$\text{Log}\,(M/P)_t = \beta_{140} + \beta_{141}\,\text{log}RY_t - \beta_{142}r_t + \beta_{143}\,\pi_t + \beta_{144}\text{log}(M/P)_{t-} \qquad \textbf{(21)}$$

Where r and π are interest rate and inflation rate, respectively, that are used to proxy the opportunity cost of holding money.

Exchange Rate

Since the nominal exchange rate had been fixed for long in the country (only being liberalized in the 1990s), we, rather chose to specify the real exchange rate (RER).

$$\text{Log}\,RER = \beta_{150} + \beta_{151}\,\text{log}TOT_t - \beta_{152}\text{log}(OPEN)_t + \beta_{153}\,\text{log}F_t + \beta_{154}\,EMs \qquad \textbf{(22)}$$

where TOT is terms of trade, OPEN = [(X+Z)/ Y] is the trade (export, X, & Import, Z) to GDP, Y, ratio; F is foreign financial flows, and EMs is excess money supply, measured as the difference between money supply and money demand.

Identities of the Model

ΔLogRY = LogRY - LogRY(-1)

RAD = RCp + RCONSg + RIp + RIg

RED = RAD - RY

FD = G + Ig - TR - NTR

TB = X – Z

INFLATION = LogP - LogP(-1)

$$TOT = \frac{P_X}{P_Z} x100$$

Dummy Variable Included in the Model

In regression analysis, a dummy variable (also known as indicator or bound variables) is one that takes the values 0 or 1 to indicate the absence or presence of some categorical effect that may be expected to shift the outcome. An attempt was made to improve the results by using dummy to the model. The dummy variable, Dmy, is included in the model to capture Ethiopia's pre- and post-revolutions period. It is a dummy policy change with value unity after 1992 and zero otherwise.

$$\text{i.e. Dmy} = \begin{cases} 1, \textit{ for post} - \textit{revolution years}, 1992 \\ 0, \textit{otherwise} \end{cases}$$

Thus the model contains fourteen structural equations in which the private consumption, private investment, tax revenue, government expenditure, export, consumers import, intermediate import, agricultural production, non-agricultural production, price, capacity utilization rate, money demand and real exchange rate are endogenous and the remaining including dummy variable are exogenous.

Table 1. The Fourteen Equation Model

Endogenous Variable	Predetermined Variables					
1. LogRCp	Const.	P	$LogRCp_{-1}$	LogRY	$LogRY_{-1}$	
2. $LogI_p$		∆LogRY	$LogI_g$	LogZ	LogPB	Dmy
3. LogTR	Const.	LogRY	Log(X+Z)	LogF		
4. LogG	Const.	LogTR	LogF	$logP^m$	$logG_{-1}$	
5. LogX	Const.	LogRER	LogCUR	logRY		
6. LogZcons	Const.	LogRY	LogRER	$LogR_{-1}$	$LogZcons_{-1}$	
7. LogZrac	Const.	logRY	LogRER	$LogR_{-1}$	$LogZRac_{-1}$	
8. LogYagr	Const.	LogLagr	$LogRF_{-1}$	$\log(\frac{P_{agr}}{P_{nagr}})$	$LogYagr_{-1}$	
9. LogYnagr	Const.	LogLnagr	Log∆K	LogZrac	LogCUR	
10.LogCUR	Const.	$LogRF_{-1}$	LogZRac			
11.P	Const.	EMs	LogRED	LogCUR	$logP^m$	
12.Log(M/P)	Const.	LogRY	r	Π	$Long(M/P)_{-1}$	
13.LogRER	Const.	LogTOT	Log(OPEN)	LogF	EMs	
14. Ms		TGR-TGE	$-G^s_p$	DCp	∆R	

(See Appendix A for symbols used and their definition and subscript -1 after a variable denotes the one year lagged value of the variable).

5. Individual equations estimation result

This section considers the OLS, the 2SLS, the OLSAUTO1, the 2SLSAUTO1, the OLSAUTO2, and 2SLSAUTO2 estimates of Ethiopian macroeconomic model. Data for these time-series analyses were obtained from various sources. All data represent January-December calendar year and annual time-series extending from 1970 to 2004, giving a total of thirty five observations and thereby provide empirical results to various equations in the model formulated in part three. The length of the sample period is determined by the availability of the relevant data. The basic data used for this study are available from the author on request. Combinations of econometric software packages used for empirical analysis of this study are EViews (version 3.1) and STATA (version 9). After confirming the stationarity of the variables at I(0) and I(1), different estimation techniques are applied to estimate the equations and estimation results of the model are summarized in Appendix C. The basic set of instrumental variables used for the two-stage least squares estimators are presented at the bottom of Appendix B.

6. Within-sample forecasting

For each sets of estimates, within-sample predictions of the twelve endogenous variables were generated for the period 1970-2004. Comparison of the estimators is carried out in the context of within-sample predictions. In principle, both within and outside sample (ex-post) forecasts must be used. However, for ex-post forecast to be worth while, the time paths must be reasonable length, about ten sample points as a minimum (Challen and Hagger, 1983). As a result of this long forecast period requirement, the ex-post forecast is not performed.

Two error measures were computed for each set of predictions: mean absolute percent error and Theil’s Inequality Coefficient. The mean absolute percent error (MAPE) and Theil’s Inequality coefficient (TIC) and its decompositions bias, variance and covariance proportions for private consumption equation is presented in Table 2 for each set of estimates. Generally, the basic conclusions reached for private consumption results also hold for the remaining variables.

Evaluation of the Forecasting Power of the Estimators

The accuracy of a forecasting method is determined by analyzing forecast errors experiences. The forecasting performance of the estimators is judged on the basis of the differences between predictions and realizations. The smaller the difference between the predictions and the actual values of the dependent variable is the better the forecasting performance of the estimator. The estimators will be compared in terms of the accuracy of the within-sample predictions. The within-sample forecasting performance of the whole system should be assessed using standard statistical tools such as Root Mean Squared Error, Mean Absolute Error, Mean Absolute Percent Error, and Theil's Inequality Coefficient. The first two forecast error statistics depend on the scale of the dependent variables; and the remaining two statistics are scale invariant (i.e. unit free). In most instances unit-free measures are preferable (Challen and Hagger, 1983). As a result Theil's inequality coefficient (TIC) and mean absolute percent error (MAPE) are used in this study. If the forecast is good, the mean absolute percent error and the Theil's inequality coefficient should be as small as possible. Theil's Inequality Coefficient (TIC) suggested by H.Theil is a measure of the fit of a forecast (H. Theil, 1996). It ranges between zero and one. When it is equal to zero it indicates that the forecast has a perfect fit. TIC=1 indicates a forecast just as accurate as one of "no change" ($\Delta y_t = 0$), and a value of TIC greater than one means that the prediction is less accurate than the simple prediction of no change (J. Kmenta, 1986). For all of the equations the results indicate that the Theil's inequality coefficient is close to zero for 2SLSAUT01 and 2SLSAUT02, implying that the forecast has a good fit in these two estimators than the rest. Theil's inequality coefficient can be decomposed into **Bias, Variance, and Covariance proportions** each showing a different source of forecast error:

- The bias proportion indicates how far the mean of the forecast is from the mean of the actual series.
- The variance proportion indicates how far the variation of the forecast is from the variation of the actual series.
- The covariance proportion measures the remaining unsystematic forecasting errors.

If the forecast is "good", the bias and variance proportions should be as small as possible so that most of the bias should be concentrated on the covariance proportions. On the basis of these aforementioned selection and evaluation criteria concluding remarks have been drawn.

The results in the forecast evaluation indicate that in most of the equations the conclusions reached from examining the mean absolute percent error results and Theil's Inequality Coefficient results are the same. The TIC for all equations is below 0.3 and has least value for 2SLSAUT01 and 2SLSAUT02. These figures are in the acceptable range since "TIC less than 0.3 or 0.4 are considered not to be unduly large" (Oshikoya, 1990:101). The results also indicate that the model has small values of the mean absolute percent error, the bias and variance proportions in the 2SLSAUT01 and 2SLSAUT02 than the other estimators, implying a good forecast can be achieved by these two estimators. The bias proportion is less than 1% for 2SLSAUT01 and 2SLSAUT02 in all equations. In most of the equations the variance proportion is well below 10% for 2SLSAUT01 and 2SLSAUT02. The result also shows that the bulk of forecast error is unsystematic and hence captured by the covariance proportion. The model reveals a good feature in terms of mean absolute percent error, Theil's inequality coefficient and its decompositions for 2SLSAUT01 and 2SLSAUT02 than the other estimators.

Higher mean absolute percent error (MAPE) is observed in capacity utilization rate equation, price equation, intermediate import equation, real exchange rate and investment function. This is a common feature for most macroeconometric models in the case of developing countries (Salvatore, 1989). For the MAPE measure in these equations, the OLS & 2SLS estimators continue to perform poorly relative to the others, but for the other four estimators the MAPE results are quite close.

The mean absolute percent error and Theil's Inequality Coefficient for the private consumption variable are presented in Table 2 for each set of estimates. The most striking feature of the mean absolute percent error and Theil's Inequality Coefficient results is perhaps the increased accuracy obtained from the 2SLSAUT01 and 2SLSAUT02 estimates for the predictions. The result in Table 2 also shows that the two stage least squares estimators perform on average better than their ordinary least squares counterparts, that the AUT01 estimators perform on average better than their no-serial correlation counterparts, and that the AUT02 estimators perform on average better than their AUT01 counterparts: 2SLS is better than OLS, 2SLSAUT01 is better than OLSAUT01, 2SLS02 is always better than OLSAUT02, OLSAUT01 is better than OLS, and 2SLS01 is better than 2SLS. The OLS & 2SLS estimators continue to perform poorly relative to the others, and mean absolute percent error and Theil's Inequality Coefficient results indicate that 2SLSAUT02 estimator can be considered as dominating all of the rest.

Table 2: Forecast Evaluation for Private Consumption

Estimator	Mean Absolute Percent Error	Theil's inequality coefficient	Bias proportion	Variance proportion	Covariance proportion
OLS	0.179479	0.001192	0.000020	0.021872	0.978108
2SLS	0.179465	0.001092	0.000000	0.021733	0.978267
OLSAUT01	0.166915	0.001050	0.000000	0.020479	0.979521
2SLSAUT01	0.158079	0.000985	0.000000	0.020001	0.979999
OLSAUT02	0.166888	0.001050	0.000000	0.017665	0.982335
2SLSAUT02	0.158072	0.000985	0.000000	0.017655	0.982345

7. Conclusions

This research work is an attempt to select the best and accurate estimator among various estimators which posses high power of predictability (forecasting power). The results in this section indicate that considerable gain in forecasting accuracy can be achieved by the use of more advanced estimation techniques. Certainly, accounting for first- and second-order serial correlation is important, and even more gain appears possible by using a two stage least squares techniques as opposed to its ordinary least squares counterpart. Moreover, the results do indicate that series attempts should be made to estimate models by techniques other than ordinary least squares or two-stage least squares. The results also indicate that considerable gain can be achieved by using 2SLSAUT01 and 2SLSAUT02 estimators. Although a multi-period forecast is not included in this study, the results give an indication of the relative usefulness of the various estimators for multi-period forecasting purposes.

8. Policy implications

Based on the finding of this study the following policy implications may be drawn.

- The main contribution of this study lies on the application of econometric methods to identify the best estimation techniques that will produce accurate forecast using macroeconomic model of Ethiopia. Although the model is capable in identifying the best estimation techniques that will produce accurate forecast, the model is in the aggregate form (i.e. further disaggregation is necessary), so it would be more interesting if the model is disaggregated in agricultural, industrial and service sectors. Inclusion of the labor market, disaggregating government expenditures by activities, and disaggregating the production activity in detail would give a better shape for the model. By doing this better performance could be highlighted.

- Technocrats in ministries of finance and economic development have to focus on the task of macroeconomic forecasting which is of increasing importance in the context of poverty reduction strategies and Medium Term Expenditure Framework-MTEF preparation. In addition to this, strengthening the existing practice of forecasting in Ethiopia is important by providing these technocrats with an applicable framework of modeling that emphasizes forecasting using familiar software such as STATA and EViews. Hence this study will eventually help the policy makers to develop a better understanding of the structure of the economy and how it works. This in turn can result in improved model building as well better policy formulation and forecasting using individual equations techniques and examines how they perform. We may be interested in forecasting the values of some variables either to assess how they respond to given policy changes or evaluate necessary policy responses to a given change in these variables. Generally the output of this research will help the relevant government institutions in designing and revising appropriate techniques for forecasting the economy of the country. Besides its use in budget preparation, policy analysis and simulation exercises, the study provides the foundation for building full-fledged macro model in Ethiopia and as a basis for further research.

Reference

Alemayehu Geda. 2002. *Finance and Trade in Africa: Macroeconomic Response in the World Economy Context.* London: Pallgarve-Macmillan.

Alemayehu Geda and Daniel Zerfu. 2004. A Review of Macro Modelling in Ethiopia: With Lessons form Published African Models. *MoFED Working Paper Series, WPs-01*, Addis Ababa.

Asemerom Kidane and Kocklaeuner, G. 1985. A Macroeconometric Model for Ethiopia: Specification, Estimation and Forecast and Control. *East African Economic Review.*

Challen, D. W. and Hagger, A. J. 1983. *Macroeconometric Systems: Construction, Validation and Application*. London: Macmillan Press.

Daniel Zerfu. 2001. Macroeconomic Policy Modeling for Ethiopia, Unpublished MA Thesis, Department of Economics, Addis Ababa University.

Harris, J. 1985. A Survey of Macroeconomic Modelling in Africa' Paper presented to a meeting of the Eastern and Southern Africa Macroeconomic Research Network, December 7-13, Nairobi, Kenya.

Kementa, J. 1986. *Elements of Econometric*, second edition, Macmillian, New York. Second edition. Wiley, New York.

Lemma Mered. 1993. Modelling the Ethiopian Economy: Experience and Prospects (memo).

Oshikoya, T. W. 1990. *The Nigerian Economy: A Macroeconometric and Input-Output Model*, New York: PRAEGER.

Salvatore, D. 1989. *The Prototype Model*, *In African Development Prospects: A Policy Modelling Approach,* New York: Taylor and Francis.

Sargan, J. D. 1964. Wages and Prices in the United Kingdom: A Study in Econometric Methodology.

Theil, H. 1953. *Estimation and Simultaneous Correlation in Complete Equation Systems*, The Hague: Central Plan Bureau.

Appendix A : Definition of variables

CUR	Capacity utilization rate
Δ	Change
EMs	Excess money supply over money demand, measured as the difference between money supply and the estimated money supply.
F	Foreign financial flows (grants + loan and credits)
FD	Fiscal deficit
G	Government expenditure
Gsp	Net sales of government interest bearing assets to the non-bank private sector
Ig	Nominal government investment
ΔK	Change in capital stock –i.e gross fixed capital formation
Lagr	Labour force in agriculture
Lnagr	Labour in non-agricultural sector
Ms	Money supply
NS	Net service export
NTR	Government non-tax revenue
OGR	other government revenue
OPEN	Openness measured as export and imports as a ratio of GDP
PB	Public borrowing (domestic)
Pm	Import price
Pt	Price level measured by the CPI
Pagr/Pnagr	Price ratio of agricultural and nonagricultural product
π	Inflation rate
r	Real deposit interest rate
RAD	Real aggregate demand
RCONSg	Real government consumption
RCpt	Real private consumption expenditure
RED	Real excess demand
RER	Real exchange rate
RF	Rainfall
RIg	Real government investment expenditure
RIpt	Real private investment
RYt	Real output
TB	Trade balance
TGE	Total government expenditure
TGR	Total government revenue
TOT	Terms of trade
TR	Government tax revenue
X	Exports
Yagr	Agricultural output
Ynagr	Non-agricultural output
Z	Total imports
Zcons	Import of consumers' good
Zothers	Other imports (i.e. Z- Zcons –Zrac
Zrac	Import raw material and capital goods (intermediate imports)

Appendix B: Instrumental Variables used for 2SLS in each Equation in addition to those in the basic set

Dependent Variables	Estimator	Instrumental Variables
LogRCp	2SLS 2SLSAUT01 2SLSAUT02	LOGIg, LOGRF(-1), LOGΔK, LOGRED, LOGF, $LOGP^{m}$, LOGR(-1), r, ΔLOGRY, LOGLagr,LOGLnagr,LOGPB,LOGG(-1),LOGZCONS(-1), LOGZrac(-1), LOGYagr(-1), LOGOPEN, FD, NTR, π, TB, RIg, RAD, ΔR, DCp, G^{S}_{P}.
LogIp	2SLS 2SLSAUT01 2SLSAUT02	LOGRCp(-1), LOGRF(-1), LOGΔK, LOGRED, LOGRY, LOGF, $LOGP^{m}$, LOGR(-1), r, LOGLagr, LOGLnagr, LOGRY(-1), LOGG(-1), LOGZCONS(-1), LOGZrac(-1), LOGYagr(-1), LOGOPEN, FD, NTR, π, TB, RIg, RAD, ΔR, DCp, G^{S}_{P}.
LogTR	2SLS 2SLSAUT01 2SLSAUT02	LOGRCp(-1), LOGIg, LOGRF(-1), LOGΔK, LOGRED, $LOGP^{m}$, LOGR(-1), r, ΔLOGRY, LOGLagr, LOGLnagr, LOGRY(-1), LOGPB, LOGG(-1), LOGZCONS(-1), LOGZrac(-1), LOGYagr(-1), LOGOPEN, FD, NTR, π, TB, RIg, RAD, ΔR, DCp, G^{S}_{P}.
LogG	2SLS 2SLSAUT01 2SLSAUT02	LOGRCp(-1), LOGIg, LOGRF(-1), LOGΔK, LOGRED, LOGRY, LOGR(-1), r, ΔLOGRY, LOGLagr, LOGLnagr, LOGRY(-1), LOGPB, LOGZCONS(-1), LOGZrac(-1), LOGYagr(-1), LOGOPEN, FD, NTR, π, TB, RIg, RAD, ΔR, DCp, G^{S}_{P}.
LogX	2SLS 2SLSAUT01 2SLSAUT02	LOGRCp(-1), LOGIg, LOGRF(-1), LOGΔK, LOGRED, LOGF, $LOGP^{m}$, LOGR(-1), r, ΔLOGRY, LOGLagr, LOGLnagr, LOGRY(-1), LOGPB, LOGG(-1), LOGZCONS(-1), LOGZrac(-1), LOGYagr(-1), LOGOPEN, FD, NTR, π, TB, RIg, RAD, ΔR, DCp, G^{S}_{P}.
LogZcons	2SLS 2SLSAUT01 2SLSAUT02	LOGRCp(-1), LOGIg, LOGRF(-1), LOGΔK, LOGRED, LOGF, $LOGP^{m}$, r, ΔLOGRY, LOGLagr, LOGLnagr, LOGRY(-1), LOGPB, LOGG(-1), LOGZCONS(-1), LOGYagr(-1), LOGOPEN, FD, NTR, π, TB, RIg, RAD, ΔR, DCp, G^{S}_{P}.

LogZrac	2SLS 2SLSAUT01 2SLSAUT02	LOGRCp(-1), LOGIg, LOGRF(-1), LOGΔK, LOGRED, LOGF, LOGP^m, r, ΔLOGRY, LOGLagr, LOGLnagr, LOGRY(-1), LOGPB, LOGG(-1), LOGZCONS(-1), LOGYagr(-1), LOGOPEN, FD, NTR, π, TB, RIg, RAD, ΔR, DCp, $G^S{}_P$.
LogYagr	2SLS 2SLSAUT01 2SLSAUT02	LOGRCp(-1), LOGIg, LOGΔK, LOGRED, LOGRY, LOGF, LOGP^m, LOGR(-1), r, ΔLOGRY, LOGLnagr, LOGRY(-1), LOGPB, LOGG(-1), LOGZCONS(-1), LOGZrac(-1), LOGOPEN, FD, NTR, π, TB, RIg, RAD, ΔR, DCp, $G^S{}_P$.
LogYnagr	2SLS 2SLSAUT01 2SLSAUT02	LOGRCp(-1), LOGIg, LOGRF(-1), LOGRED, LOGRY, LOGF, LOGP^m, LOGR(-1), r, ΔLOGRY, LOGLagr, LOGRY(-1), LOGPB, LOGG(-1), LOGZCONS(-1), LOGZrac(-1), LOGYagr(-1), LOGOPEN, FD, NTR, π, TB, RIg, RAD, ΔR, DCp, $G^S{}_P$.
LogCUR	2SLS 2SLSAUT01 2SLSAUT02	LOGRCp(-1), LOGIg, LOGΔK, LOGRED, LOGRY, LOGF, LOGP^m, LOGR(-1), r, ΔLOGRY, LOGLagr, LOGLnagr, LOGRY(-1), LOGPB, LOGG(-1), LOGZCONS(-1), LOGZrac(-1), LOGYagr(-1), LOGOPEN, FD, NTR, π, TB, Rig, RAD, ΔR, DCp, $G^S{}_P$.
P	2SLS 2SLSAUT01 2SLSAUT02	LOGRCp(-1), LOGIg, LOGRF(-1), LOGΔK, LOGRY, LOGF, LOGR(-1), r, ΔLOGRY, LOGLagr, LOGLnagr, LOGRY(-1), LOGPB, LOGG(-1), LOGZCONS(-1), LOGZrac(-1), LOGYagr(-1), LOGOPEN, FD, NTR, π, TB, RIg, RAD, ΔR, DCp, $G^S{}_P$.
LogRER	2SLS 2SLSAUT01 2SLSAUT02	LOGRCp(-1), LOGIg, LOGRF(-1), LOGΔK, LOGRED, LOGRY, LOGP^m, LOGR(-1), r, ΔLOGRY, LOGLagr, LOGLnagr, LOGRY(-1), LOGPB, LOGG(-1), LOGZCONS(-1), LOGZrac(-1), LOGYagr(-1), FD, NTR, π, TB, Rig, RAD, ΔR, DCp, $G^S{}_P$.

Appendix C: Summary Results of Estimates

a. Estimates of the Model Using OLS Method

Regressors	Coefficient Estimates											
	Equation1 (LogRCp)	Equation2 (LogIP)	Equation3 (LogTR)	Equation4 (LogG)	Equation5 (LogX)	Equation6 (LogZcons)	Equation7 (LogZrac)	Equation8 (LogYagr)	Equation9 (LogYnagr)	Equation10 (LogP)	Equation11 (LogCUR)	Equation12 (LogRER)
Constant	2.4727*		-2.8016	1.3833	3.2210	10.4098**	4.9632	4.2510**	8.3979*	217.39	2.2712**	-0.1880
LogP	-0.0008**											
LogRCp(-1)	0.4662**											
LogRY	0.7166*		0.5927*		0.4094	-0.3645	-0.3515					
LogRY(-1)	0.41745*											
Δ LogRY		0.8505										
LogZrac		1.2593*									-0.0134	
LogPB		0.0104										
Log(X+Z)			0.2566***									
LogF			0.4057*	0.0390								0.0479***
LogTR				0.1060								
LogG(-1)				0.8300*								
LogPm				0.5485						375.2716*		
LogRER					3.7966*	0.2209	0.1709					
LogCUR					-1.0978				2.2898*	-3.6369		
LogR(-1)						-0.4991	0.0231					
LogZcons (-1)						0.8179*						
LogZrac (-1)							0.8279*		-0.5444			
LogLagr								0.2498***				
LogRF(-1)								0.0368			0.3065	
LogYagr(-1)								0.4001**				
LogRED										-87.6684*		
LogOPEN												0.1888*
LogLnagr									0.0397			
LogΔK									0.2261**			
Dmy	0.0739*	-0.3952*	0.1087***	0.0260	1.5409*	0.0994	0.1670	0.0373	-0.1901	43.6834*	0.0237	0.4726*
R^2=	0.9162	0.6812	0.9787	0.9828	0.9205	0.9749	0.9460	0.8355	0.5809	0.9436	0.0672	0.9743
DW=	2.001	1.9518	2.142	1.894	1.956	2.070	2.409	1.801	1.9233	1.846	1.605	1.804
F=	61.234	21.555	333.57	321.46	85.4461	217.80	98.06	36.831	7.8688	121.23	0.7309	378.993

* Significant at 1% level
** Significant at 5% level
*** Significant at 10% level

b. Estimates of the Model Using 2SLS Method

Regressors	Coefficient Estimates											
	Equation1 (LogRCp)	**Equation2 ($LogI_P$)**	**Equation3 (LogTR)**	**Equation4 (LogG)**	**Equation5 (LogX)**	**Equation6 (LogZcons)**	**Equation7 (LogZrac)**	**Equation8 (LogYagr)**	**Equation9 (LogYnagr)**	**Equation10 (LogP)**	**Equation11 (LogCUR)**	**Equation12 (LogRER)**
Constant	2.4710*		-2.8142	1.1958	-1.0713	9.5953**	5.8487*	4.2126*	6.1119*	212.954	0.6495*	-0.0640
LogP	- 0.0008**											
LogRCp(-1)	0.4679**											
LogRY	0.7161*		0.5951*		0.8423***	- 0.2567	-0.4809					
LogRY(-1)	0.4186*											
Δ LogRY		0.8587										
LogZrac		1.2393*									0.0074	
LogPB		-0.0289										
Log(X+Z)			0.2581***									
LogF			0.4027*	0.341**								-0.0347
LogTR				0.825*								
LogG(-1)				0.8590*								
$LogP^m$				-0.4605						386.5348*		
LogRER					2.8780*	- 0.0077	-0.4352					
LogCUR					0.5784				1.5835**	-1.6833		
LogR(-1)						- 0.5396***	0.0762					
LogZcons (-1)						0.8353*						
LogZrac (-1)							0.8132*		0.5512*			
LogLagr								0.2515***				
LogRF(-1)								0.0379			0.1543	
LogYagr(-1)								0.4022**				
LogRED										-89.3737*		
LogOPEN												0.1740**
LogLnagr									0.2957			
LogΔK									0.9824*			
Dmy	0.0735*	- 0.3906*	0.1086***	0.0285	1.0877*	0.1909	0.0563	0.0365	-0.1873**	43.4802*	0.0116	0.4800*
R^2=	0.9162	0.6813	0.9796	0.9838	0.9111	0.97507	0.9462	0.8355	0.5810	0.9456	0.0672	0.9686
DW=	2.0034	1.9379	2.1207	1.8930	2.3890	2.0950	2.3690	1.8040	1.9100	1.8500	1.8040	2.0690
F =	61.2405	21.378	359.85	353.75	76.8466	219.074	98.4742	36.82	8.0434	130.43	0.7206	319.202

c. Estimates of the Model Using OSLSAUT01 Method

Regressors	Coefficient Estimates											
	Equation1 (LogRCp)	***Equation2 (LogI$_P$)***	***Equation3 (LogTR)***	***Equation4 (LogG)***	***Equation5 (LogX)***	***Equation6 (LogZcons)***	***Equation7 (LogZrac)***	***Equation8 (LogYagr)***	***Equation9 (LogYnagr)***	***Equation10 (LogP)***	***Equation11 (LogCUR)***	***Equation12 (LogRER)***
Constant	*2.402**		*-2.6038*	*1.8652*	*0.4243*	*10.7926***	*4.034*	*4.444*	*3.9214****	*-222.26*	*-0.0112*	*17.2355*
LogP	*-0.0006****											
LogRCp(-1)	*0.5418**											
LogRY	*0.7131**		*0.5894**		*0.6896*	*-0.3549*	*-0.2634*					
LogRY(-1)	*-0.4840***											
Δ LogRY		*0.9528***										
LogZrac		*0.0950*									*0.008*	
LogPB		*-1.0704**										
Log(X+Z)			*0.2153*									
LogF			*-0.4325**	*0.0610**								*0.0290*
LogTR				*0.1455***								
LogG(-1)				*0.7688**								
LogP^m				*0.7868*						*68.5760*		
LogRER					*3.334**	*-0.2626*	*-0.0688*					
LogCUR					*-0.6242*				*1.4324***	*-22.5534*		
LogR(-1)						*-0.5363****	*0.0278*					
LogZcons (-1)						*0.8043**						
LogZrac (-1)							*0.8906**		*0.0903*			
LogLagr								*0.2958**				
LogRF(-1)								*0.0447***			*0.029*	
LogYagr(-1)								*0.3463*				
LogRED										*-8.357*		
LogOPEN												*0.0655*
LogLnagr									*0.037*			
LogΔK									*0.7410**			
AR(1)	*-0.1817*	*0.8071**	*-0.1497*	*0.1705*	*0.2744*	*-0.1164*	*-0.3574****	*0.0964*	*0.9311*	*1.011**	*0.7716**	*0.9999**
AR(2)												
Dmy	*0.0635**	*-0.0325*	*0.1207**	*0.0282*	*1.3395**	*0.0739*	*0.1406*	*0.0368*	*-0.0844*	*5.7403****	*0.0047*	*0.3899**
R^2=	*0.9235*	*0.845*	*0.9790*	*0.9831*	*0.9286*	*0.9759*	*0.9481*	*0.8314*	*0.7686*	*0.991*	*0.536*	*0.995*
DW=	*2.004*	*2.340*	*1.980*	*2.050*	*2.174*	*2.056*	*1.824*	*1.837*	*2.276*	*1.86*	*1.70*	*1.89*
F=	*52.32*	*38.114*	*261.426*	*261.47*	*72.803*	*175.197*	*79.23*	*26.632*	*14.945*	*652.162*	*8.10*	*1500.5*

d. Estimates of the Model Using 2SLSAUT01 Method

Regressors	**Coefficient Estimates**											
	Equation1 (LogRCp)	Equation2 ($LogI_P$)	Equation3 (LogTR)	Equation4 (LogG)	Equation5 (LogX)	Equation6 (LogZcons)	Equation7 (LogZrac)	Equation8 (LogYagr)	Equation9 (LogYnagr)	Equation10 (LogP)	Equation11 (LogCUR)	Equation12 (LogRER)
Constant	2.4223*		-2.6106	1.8433	0.254	11.0745**	3.5308	4.4967	3.8913***	-224.26	-0.0291	1.1585
LogP	-0.0006***											
LogRCp(-1)	0.5376*											
LogRY	0.7127*		0.590*		0.6044	-0.3924	-0.1943					
LogRY(-1)	-0.4804**											
Δ LogRY		0.9546**										
LogZrac		0.1065									0.0052	
LogPB		-1.0600*										
Log(X+Z)			0.2155									
LogF			-0.4323*	0.0602*								0.0299
LogTR				0.148**								
LogG(-1)				0.7693*								
$LogP^m$				-0.7857						68.551		
LogRER					3.539*	-0.3466	-0.0668					
LogCUR					-0.8084				1.3632***	-22.2292		
LogR(-1)						-0.5224***	-0.0535					
LogZcons (-1)						0.7986*						
LogZrac (-1)							0.8987*		-0.0917			
LogLagr								0.2945**				
LogRF(-1)								0.0428***			0.0322	
LogYagr(-1)								0.3429				
LogRED										-8.2933		
LogOPEN												0.0668
LogLnagr									-0.028			
LogΔK									0.7462*			
AR(1)	-0.1782	0.8058*	-0.1480	0.1691	0.2839	-0.1131	-0.3652***	0.0985	0.9305*	1.0109*	0.7722*	0.9983*
AR(2)												
Dmy	0.0647*	-0.0392	0.1207**	0.0263	1.4354*	0.0387	0.1973	0.0376	-0.0894	5.7440***	0.0071	0.3925*
R^2=	0.9235	0.845	0.9790	0.9831	0.928	0.9758	0.9481	0.8314	0.7684	0.991	0.536	0.995
DW=	2.000	2.345	1.981	2.049	2.199	2.059	1.824	1.834	2.312	1.762	1.996	1.99
F=	52.36	38.118	261.425	261.45	72.928	175.04	79.14	26.644	14.861	652.60	8.095	1500.0

e. Estimates of the Model Using OLSAUT02 Method

Regressors	**Coefficient Estimates**											
	Equation1 (LogRCp)	Equation2 ($LogI_P$)	Equation3 (LogTR)	Equation4 (LogG)	Equation5 (LogX)	Equation6 (LogZcons)	Equation7 (LogZrac)	Equation8 (LogYagr)	Equation9 (LogYnagr)	Equation10 (LogP)	Equation11 (LogCUR)	Equation12 (LogRER)
Constant	2.2355*		-2.3994	4.0276**	-1.2105	11.867*	-2.7219	2.3372	3.1382	-10696.29	-0.0197	6.2932
LogP	-0.0004***											
LogRCp(-1)	0.7303*											
LogRY	0.7171*		0.5866*		0.8505	-0.3569	0.3064					
LogRY(-1)	-0.6588*											
Δ LogRY		0.5503										
LogZrac		0.3799									0.0072	
LogPB		-0.7992*										
Log(X+Z)			0.1595									
LogF			-0.4740*	0.0664								0.0224
LogTR				0.3676**								
LogG(-1)				0.4536**								
$LogP^m$				-1.4550***						60.418		
LogRER					3.1498*	-0.2050	-2.8388**					
LogCUR					0.4517				0.8435	-14.3822		
LogR(-1)						-0.6512**	0.8051***					
LogZcons (-1)						0.8185*						
LogZrac (-1)							-0.0642		0.0952			
LogLagr								0.1528**				
LogRF(-1)								0.0752***			0.0258	
LogYagr(-1)								0.6373*				
LogRED										-0.0913		
LogOPEN												0.0450
LogLnagr									0.0905			
LogΔK									0.8243*			
AR(1)	-0.5745**	0.4411***	-0.24980	0.4306	0.1719	-0.2994	0.5587	-0.0887	0.6261*	1.2566*	0.9084*	1.3114*
AR(2)	-0.4946***	0.3375	-0.1369	0.2233	0.1751	-0.3280	0.2684	-0.5485**	0.2981	-0.2564	-0.1958	-0.3119
Dmy	0.0522*	-0.0115	0.1327**	0.0503	1.2637*	0.0737	-0.7558	0.0232	-0.1342	3.6809	0.0083	0.3897*
R^2=	0.9323	0.853	0.9787	0.9834	0.932	0.9769	0.9581	0.8624	0.7859	0.992	0.549	0.9962
DW=	1.940	1.984	1.997	2.148	1.97	1.979	2.085	1.861	2.033	1.814	1.846	2.08
F=	47.193	30.186	199.09	211.965	59.606	145.58	78.41	26.11	13.111	522.09	6.331	1421.36

f. Estimates of the Model Using 2SLSAUT02 Method

Regressors	Coefficient Estimates											
	Equation1 (LogRCp)	Equation2 ($LogI_P$)	Equation3 (LogTR)	Equation4 (LogG)	Equation5 (LogX)	Equation6 (LogZcons)	Equation7 (LogZrac)	Equation8 (LogYagr)	Equation9 (LogYnagr)	Equation10 (LogP)	Equation11 (LogCUR)	Equation12 (LogRER)
Constant	2.2358*		-2.4069	3.9912**	0.3149	11.9055*	-2.4688	2.3682	3.1386	-12119.28	0.0321	1.2731
LogP	-0.0004***											
LogRCp(-1)	0.7302*											
LogRY	0.71698*		0.5865*		0.6971*	-0.3624	0.2841					
LogRY(-1)	-0.6586*											
Δ LogRY		0.5461*										
LogZrac		0.3873**									0.0034*	
LogPB		-0.7924*										
Log(X+Z)			0.1615									
LogF			-0.4728*	0.0657								-0.0230
LogTR				0.3695**								
LogG(-1)				0.4563**								
$LogP^m$				-1.4554***						60.6982*		
LogRER					3.4464***	-0.2169	-2.7057**					
LogCUR					-0.6475*				0.8249	-13.2639		
LogR(-1)						-0.6488**	0.7782***					
LogZcons (-1)						0.8178*						
LogZrac (-1)							-0.0311		0.0969*			
LogLagr								0.1525*				
LogRF(-1)								0.0741**			0.0301***	
LogYagr(-1)								0.6349***				
LogRED										-0.0379		
LogOPEN												0.0459
LogLnagr									0.0921			
LogΔK									0.8287*			
AR(1)	-0.4943**	0.438***	-0.2471	0.4262	0.1727	-0.2996	0.5327	-0.0865	0.6205*	1.2449*	0.9127	1.3116*
AR(2)	-0.5742***	0.340	-0.1327	0.22467	0.1426	-0.3273	0.2908	-0.5479	0.3035	-0.2447	-0.2016	-0.3140**
Dmy	0.0522*	-0.0134	0.1321**	0.0475	-1.4035	0.0687	-0.7021	0.0236	-0.1376	3.6746	0.0115	0.3913*
R^2=	0.9323	0.853	0.9787	0.9834	0.932	0.9770	0.9581	0.8624	0.7859	0.9917	0.549	0.9962
DW=	1.740	1.985	1.997	2.15	1.982	1.978	2.074	1.859	2.035	1.897	1.8476	2.07
F=	47.195	30.193	199.08	211.933	59.40	145.579	78.29	26.12	13.112	521.16	6.326	1421.26

ACHIEVING THE MDGs – A NOTE[1]

Naill Kishtany and Alemayehu Seyoum Taffesse[2]

Abstract

The material and symbolic importance of the MDG targets make it vital to assess the analytical coherence of the MDG "project". In this spirit, this note highlights complexities and difficulties of the MDG approach that policy makers should consider. It covers issues of measuring progress, and achieving and valuing outcomes; sustaining outcomes; devising policies during structural transformation; and implementing policies in a decentralised policy system. These discussions draw attention to some of the limitations of current methods of analysing the MDGs. A final section concludes.

[1] The bulk of this note was prepared for a report to UNICEF in 2004. In fact, its key elements were presented to a seminar at the UNECA even earlier (in early 2003, to be specific). We believe that it is relevant today to highlight the difficulties of the MDGs perspective. We thus made only very minor changes to the text.

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1. Introduction

The Millennium Development Goals (MDGs) are a set of internationally agreed targets that poor countries aspire to attain by 2015. The eight broad MDGs (as well as the corresponding targets and indicators) span poverty reduction, primary education, gender parity, child mortality, maternal mortality, reversal of diseases, environmental sustainability, and development cooperation.

The MDGs are fast becoming the touchstone for directing as well as assessing socio-economic progress across the developing world. Increasingly, country-level policy frameworks such as Poverty Reduction Strategies (PRSs) are linked to the MDG targets; estimates are now being made of the aid flows required to achieve the MDGs. Crucially, the MDGs can be a useful focal point for social and political dialogue and action in both poor and rich nations towards improving the lot of the poor around the globe.

The material and symbolic importance of these targets make it vital to assess the analytical coherence of the MDG "project". In this spirit, this note highlights complexities and difficulties of the MDG approach that policy makers should consider. Section two sets out an analytical framework for analysing the MDGs. The following four sections cover issues of measuring progress, and achieving and valuing outcomes; sustaining outcomes; devising policies during structural transformation; and implementing policies in a decentralised policy system. These discussions draw attention to limitations of current methods of analysing the MDGs. A final section concludes and proposes a more sophisticated and tractable approach to the MDGs.

2. Conceptualising the MDGs as a policy "problem"

The MDGs are a set of time-bound, multi-dimensional socio-economic goals almost all of which can in principle be translated into quantifiable targets and indicators[3] Development policy practitioners commonly believe that there are policy levers which governments can use to move countries towards achievement of these targets.

Ideally, the "solution" to a policy "problem" then consists of setting instruments' values so as to hit the targets, while allowing for institutional changes, uncertainty, and some learning. In mathematical terms, *Tinbergen's rule* states that well-defined solutions in a static framework require that the number of instruments equals or exceeds the

[3] There are eight overall goals some of which contain a number of specific targets. There are a total of 18 targets.

number of targets[4], (Tinbergen (1952)). But economies are dynamic not static systems; policy makers therefore seek to control the evolving system at a point in time (*point controllability*) and to influence its trajectory over time (*path controllability*). In this dynamic perspective, Tinbergen's rule no longer holds for point controllability because rates of change of instruments as well as their absolute levels can affect objective variables.

But for many policy purposes—including the MDGs—path controllability is the measure of success: policy makers want not just the instantaneous achievement of targets but that these are sustained over time and arrived at by a path that strays as little as possible from politically and economically acceptable values of instruments and objectives. Path controllability, a stricter requirement than point controllability, in many cases does in fact require that the number of instruments equals or exceeds the number of targets (Petit (1990)). For a set of instruments and objectives this is in part conditional on a given structure of the economy, known outcome targets, and well-defined instruments. In practice, most policy problems do not meet the conditions for straightforward solution for the following reasons:

Available policy levers and feasible values:-

1. The number of objectives often exceeds the number of available instruments. This means that a "solution" does not exist in a static system or for path controllability in a dynamic system.
2. There may be more than one solution when the number of instruments exceeds the number of targets.
3. Even if a solution does exist, the values of the instruments needed to achieve it may be politically or technically infeasible.

Interdependencies:-

4. Some objectives may be related. They may be complementary, or they may be contradictory and raise policy trade-offs.
5. Some instruments may be related. Again, they may be complementary or contradictory.
6. Different instruments may be controlled by different policy institutions leading to problems of coordination and conflict.

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[4] More precisely, the number of *linearly independent* instruments must be equal or greater than the number of *linearly independent* targets (Petit (1990)).

Causality, information and uncertainty:-

7. There may be uncertainty about the relationships between instruments and objectives, or even about what the instruments are.
8. Some variables may be either instruments or objectives depending on the context or level of analysis (and whether analysis takes a static or dynamic perspective).
9. Information on the actual values of instruments and targets may be imperfect.
10. The structure of the economy may change over time. It may be affected by movements in instruments and target variables. In turn, as it evolves the extent to which (1)-(9) hold may change.

All of these problems are likely to bedevil progress on the MDG project. [5] In particular, they complicate attempts to *measure progress* towards and devise strategies for *achievement of the targets*; they also bring to the fore problems of *valuing outcomes* in multi-dimensional space (section three). They raise issues about the *sustainability* of outcomes (section four). In addition, they highlight complexities in devising policies during *structural change* where *uncertainty* and *learning effects* are critical (section five). Finally, they show the importance of *coordination* between different policy institutions (section six).

3. Measuring progress and achieving outcomes

In a static perspective, points (1) and (3)-(5) may mean that not all targets are achievable at a certain date. If the number of MDG targets exceeds the number of instruments available, then governments may not have enough levers to reach all of the targets. The interdependencies defined in (4) and (5) complicate the picture: trade-offs may frustrate the simultaneous achievement of certain targets while complementarities could offset the problem of insufficient levers defined in point (1). Even if the problems identified in section two do not hold and we revert to an easily soluble policy problem, trade-offs may still be present if moving policy levers requires scarce resources: in this case if different instruments "compete" for resources, trade-offs will be generated at the level of outcomes. In the case of MDG achievement both of these kinds of interdependencies are relevant.

The interaction between levers and targets takes place over time; the static problems contained in (1)-(6) have dynamic counterparts. Points (1) and (3)-(5) mean that a desired path of objectives and instruments may not be feasible. (4)-(6) imply that there may be varying speeds of progress towards different targets. Point (8) adds to

[5] These problems are also likely to be significant for domestically-driven planning initiatives.

this, but in a dynamic sense suggests a further complexity in the achievement of multiple targets. Instruments and outcomes may need to be *sequenced* over time: certain values of instruments may be required for certain values of other instruments later on; the same may apply to outcomes. Whether variables are instruments or objectives then changes over time. There may be a complex, shifting pattern of variables' status as means or ends. Point (10) is an explicitly dynamic problem which reinforces this point; indeed, one would hope that the structure of the economy would change as development takes place (see section five).

Interdependencies: examples from the MDGs

Trade offs— The large number of targets in the MDGs reflects the now established view of development as a multi-dimensional process. This breadth means that the problem of interdependence is likely to bite. There may be direct trade-offs at the level of outcomes. For example, some aspects of environmental sustainability (Goal 7) could conflict with the eradication of extreme poverty and hunger (Goal 1) within certain time frames. This would be so if the livelihoods of some segments of the poor depend on the exploitation of natural resources such as forests or minerals in ways which conflict with the goal of long-term environmental sustainability.

There may also be trade offs between instruments leading to policy conflicts over outcomes. For example, economic growth is a key instrument for reaching a range of targets, including, for example, universal primary education (Goal 2), the achievement of which calls for considerable resources best generated through output expansion. Cutting poverty requires growth but can also be achieved by reducing inequality through redistributive policies; the relative effectiveness of these two routes depends on certain underlying structural parameters of the economy (Dagdeviren et. al. (2000)).

The relationship between these two instruments — growth and inequality reduction and/or redistribution — has been the subject of a long debate in economics. In the 20th century this was carried forward through the work of Simon Kuznets who argued for a positive relationship between growth and inequality, at least in the early stages of development (Kuznets (1966)). If this is so, then there could be a trade off between these two critical instruments; this could lead to trade offs at the level of the objectives mentioned.[6]

[6] More recently, a literature has emerged claiming a positive relationship between equality and growth, some of this based on analysis of the East Asian experience (Birdsall et. al. (1995); Alesina and Perotti (1994)). This has led to a new consensus which emphasises the growth-dampening effects of inequality. Nevertheless, the linkages between distribution and growth are complex and still little understood. Indeed, some have questioned the East Asian evidence purporting to show a positive relationship between equality and growth, arguing that many studies make cavalier use of inequality data (Moll (1992)).

Indirect trade-offs in outcomes because of competition for resources between instruments are present in the MDGs. The MDG targets reflect the expansion of policy from the narrow macroeconomic stability objectives of the 1980s into interventions designed to directly affect social outcomes in health, education, the environment and gender relations, all now common ingredients of PRSs. A range of instruments are used to improve results in these areas. Many of these are not directly contradictory, but nearly all call for considerable funds. This implies outcome trade offs in countries carrying out PRS-driven expenditures: these countries often have small resource bases, high fiscal deficits and external debt burdens, and necessarily finite inflows of concessionary finance. Here, difficult choices may need to be made between, for example, technology investments to improve environmental sustainability and hygiene programmes for mothers to bring about the targeted reduction in child mortality (Goal 4).

Complementarities— On the other hand, it is now recognised that many of the instruments and objectives contained in the MDGs are complementary. In the objectives, female education (part of Goal 3) reduces child mortality through better nutritional and caring practices by mothers as a result of enhanced literacy and skills. Improved maternal health (Goal 5) is also likely to help reduce child mortality. Clearly, reversing the spread of epidemics such as malaria and HIV/AIDS will cut mortality. In turn, better outcomes in education and gender equality should help to halt the spread of these diseases, particularly HIV/AIDS. Finally, better educational and health outcomes should reduce poverty, directly, by enhancing poor people's entitlements to essential services and indirectly, through poverty-reducing growth as emphasised in "new" growth theories.

Sequencing— This analysis suggests that the problem of sequencing will complicate achievement of the MDGs. In particular, the kinds of complementarities described may unfold over time as part of a complex cycle of socio-economic transition. For example, low inequality is now considered an important aspect of East Asia's spectacular socio-economic performance. One view of developmental success in East Asia sees both low inequality and good educational outcomes as the essential initial conditions for subsequent high growth and poverty reduction (see McMahon (1998 on education; Birdsall et. al. (1995 on inequality and education). Using our division of variables into MDG targets and policy levers, certain values of instruments (distribution patterns) and objectives (education) may have been pre-requisites for later values of both instruments (growth) and objectives (poverty reduction). At a more micro level, improving gender equality is likely to be a prerequisite for halting and reversing the spread of HIV/AIDS (part of Goal 6). Thus, some variables may start as objectives but later be instruments for the achievement of other objectives.

Measurement problems

We have seen how interdependencies complicate strategies for achieving the MDGs, here conceptualised as a mapping from instruments to objectives. Trade-offs and complementarities also mean that measuring progress towards the targets in terms of movements in the values of objectives and instruments may necessitate more sophisticated analytical frameworks than those currently used. Benchmarking methods in their simplest but common form measure progress by extrapolating past rates of change for each target individually to see if the country in question is "on course" (Devarajan et. al. (2002); Sahn and Stifel (2001)). Clearly this is a highly imperfect approach if interdependencies and sequencing requirements are present. In such situations, measurement needs to take into account of interdependencies at the level of both objectives and instruments to give a more comprehensive picture of countries' distance from the targets.

Measurement is also hampered by imperfect information about the actual values of instruments and variables (point (9)). This is especially so because the MDG targets encompass a broad range of variables, including "soft" social indicators. In addition, interdependencies mean that the data problems of certain targets and instruments may lead to difficulties in the assessment of related variables. Imperfections in data sets essential for measurement of MDG outcomes and instruments including those for income, inequality, poverty and health status are well known. Even for developed economies, data sets such as those for inequality need to be handled with caution (Atkinson and Brandolini (2001)); in poor countries where statistical capacity is limited this is even more critical (Srinivasan (1994)).

Valuing outcomes

"Progress" implies valuation; in multi-dimensional space this is not straightforward. If interdependencies—particularly trade offs—along with the requirements of sequencing mean that not all goals can be achieved simultaneously, then social weightings will be needed to arbitrate between targets. This suggests the need for a social welfare function defined across the targets with explicit weights assigned to each objective. How such weightings would be determined is a complicated political as well as economic problem outside of the scope of this paper.

However, if choices do need to be made it would be better to make them explicitly rather than by ad hoc means or in reaction to uncontrollable events. Current methods of assessment do not fully acknowledge this and fail to take a systematic social welfarist approach to the problem. Defining a social welfare function is a complex task but opens up solutions to many of the problems flowing from the MDGs' formulation as a set of fixed targets. This is discussed further in section seven.

4. Sustaining outcomes

Point (7) in its dynamic form frames the problem of *sustainability* when targets begin to be achieved. Sustainability is a kind of path controllability: policy makers at a minimum want the economy's trajectory to preserve the values of objective variables once targets are hit. But shifting policy levers requires resources; given the limited resource base of developing countries much of this will be in the form of external inflows, whether overseas development assistance or loans. What is the long term relationship between instruments and outcomes and how stable are shifts in their values? If a certain value of an instrument—partly achieved through an infusion of external funds—leads to the realisation of a target, how permanent is this state and what is required to sustain it? Does the value of the instrument need to be sustained to preserve achievement of the target? If so, for how long will aid be needed to sustain the value of the instrument?

This is important for two reasons. Firstly, movement towards the MDG targets is supposed to be equivalent to a shift towards a higher level of development. Historically, long term development in successful countries has been propelled by a self-sustaining process of internal transformation, even if external funds have acted as a catalyst or secondary engine. Successful development involves countries becoming self-sufficient in the sense of not requiring concessional aid to plug resource gaps. One would hope, therefore, that achievement of the MDGs on the basis of certain kinds of relationships between instruments and objectives is part of a self-sustaining development cycle and not merely the "artificial" attainment of targets through large financial inflows divorced from underlying processes of internal transformation. Secondly, there is a danger that once targets are achieved, donors' attention may turn elsewhere in the belief that development problems are "solved". Sustainability may be hard to achieve (Kremer and Miguel (2004)); if aid is required after the targets are met, then this needs to be made explicit.

Two of the MDGs relate to education and centre on rates of enrolment; they illustrate the problem of sustainability. Enrolment rates are determined by supply and demand factors. Supply relates to the number of schools and their distance from communities and is partly a function of resources allocated to the educational sector. Demand for schooling is influenced by the private rate of return to education determined by the difference in earnings of workers with varying levels of education. Clearly, then, educational outcomes are a function not just of provision, but also of the extent of income earning opportunities for skilled workers generated by economic growth and a changing sectoral composition of output. Studies have shown that the availability of schooling and state expenditure on education do not very well explain enrolment rates (Bredie and Beeharry (1998); Lavy (1996)).

Much analysis of the MDGs' educational targets focuses exclusively on the supply side and on the amount of state resources that need to be spent calculated on the basis of an educational unit cost and the number of students not enrolled (for an example see Devarajan et. al. (2002)). Given the importance of demand-side factors in educational outcomes, this bias raises questions regarding the sustainability of targets in the way that we have defined it. In Indonesia, for example, enrolment rates were boosted during the 1970s and 1980s by demand-side factors caused by fast economic growth, and by an expansion of supply as a result of a large school-building programme. However, the economic crisis of the 1990s brought a sharp reversal in these gains. A similar trajectory was seen in Botswana when enrolment fell from a high level over the 1990s because of the HIV/AIDS crisis (Clemens (2004)).

Sustainability problems come in a slightly different guise in countries which have seen rapid rises in enrolment, but with significant deteriorations in quality as measured by the ratio of teachers to pupils, exam performance and repetition rates (see World Bank (2002) for evidence on Uganda; World Bank (2003) on Rwanda). Here, though, if enrolment outcomes are adjusted for quality, it may be that many of these countries have not made significant gains. But increasing enrolment through lowering quality may still raise issues of sustainability in our meaning of the term if declining quality reduces the private returns to education thereby choking off demand for schooling.

Standard benchmarking approaches, which take little account of interactions between variables and therefore the underlying drivers of progress, fail to address the requirement of sustainability. These methods, being anchored in the MDGs' 2015 timeframe, use the criterion of point controllability. They would therefore give little warning of future reversals of the kinds discussed.

5. Structural transformation and "qualitative" policy design

So far analysis has been in terms of a "quantitative" policy problem: we have considered the relationships between instruments and targets while assuming that the underlying structure of the economy stays constant. But point (10) is important in developing countries where policy is typically aimed at changing deep structural parameters of the economy. Qualitative or structural policy focuses not on the values of target variables but on the relationship between variables (Eggertsson (1997)). It seeks to induce new relationships between existing instruments and targets and to activate new policy levers. These changes then require a revised quantitative policy because the evolving system needs to be managed on the basis of new parameters.

This distinction is relevant for developing countries seeking to reach the MDGs. Development is a process of structural transformation; following the Washington Consensus there is greater understanding of the broad range of structural changes needed for successful economic performance including at the level of markets, and in economic and political institutions (Stiglitz (1998)). So although the MDGs' set of fixed targets seems to point towards a qualitative policy problem, their achievement also requires attention to the qualitative aspects of policy. As economies move towards the MDG targets, structural shifts generate an ever-changing quantitative policy problem as new instruments and relationships come into play. This is related to the problem of sequencing discussed in section three: an evolving set of instruments may need to follow a certain time path if some are prerequisites for others.

To give some examples from the MDGs, gender empowerment may alter the functioning of labour markets, leading to shifts in the labour supply function as more women are able to work. This could lead to new relationships between growth, employment and poverty reduction. Institutional reform involves the emergence of new patterns of economic and political control which fundamentally change the operation of the economic system. An important component of this, governance reform – now a central part of developing countries' policy packages – is in part aimed at improving service delivery. Success in this area could change the relationship between public spending on health and education and outputs in these sectors. As countries reach certain stages of development, it is said that the decentralisation of some policy levers to regional governments can be good for government efficiency and service delivery. This is an example of a qualitative policy shift which gives rise to new instruments and relationships between instruments and objectives. Other important types of institutional change in developing countries are the transfer or sharper delineation of property rights and the formalisation of informal sectors of the economy, both of which may activate new instruments and bring new mappings between instruments and objectives.

The distinction between qualitative and quantitative policy shows just how complex the policy problem is for developing countries, especially in attaining a broad set of targets such as the MDGs. Structural changes often take place during times of political and social instability, common features of developing countries. Policy analysis therefore needs to take into account of political and social factors and likely conflict and contestation as new structures emerge, triggering new relationships between instruments and objectives.

Uncertainty and learning

Points (7), (9) and (10) are prominent in the MDG policy problem because of the importance of structural change in developing economies. When uncertainty exists over the parameters of the model describing the economy, policy decisions are dependent on the statistical distribution of these parameters. In this case we need to consider learning effects as instruments and objectives move over time; policy making then becomes a drawn out process of discovery.

In a situation of *passive learning*, policy makers' estimates of the economy's structural parameters change as new information emerges. Under *active learning*, this updating takes place as a direct result of policy makers' manipulation of instruments which allows them to discover more about the behaviour of the system (Kendrick, 2002; Petit 1990). Policy actions then have a dual purpose of bringing the economy closer to the desired path and reducing uncertainty about the operation of the system. Under active learning there may be a trade off between system performance and learning: certain policy actions may lead to a worse system performance at a point in time compared to others but yield better information about the operation of the economy, helping to give rise to better outcomes in the long run.

Active learning is critical if there is large uncertainty about the parameters of the economy or when the economy is going through structural change. Both come into play in the MDGs: there is clearly much uncertainty about the causal mechanisms of developing economies while development itself is a process through which the economy undergoes structural evolution equivalent to changes in underlying parameters. Important questions therefore surround the ability of governments to use new information to refine their policy making so as to move closer towards the MDGs. Critical parameters, new information on which may emerge as the economy moves through time, include the elasticity of poverty with respect to growth, the cost of increases in the HIV prevalence rate in terms of growth and the incremental effect of higher female educational levels on child mortality rates.

All of these will be important in finding a mapping from instruments to objectives to move more rapidly towards the goals. Making good use of such new information depends on the capacity of government institutions to analyse and act upon it. The process by which governments update their view of the economy because of new information is of great interest. In many developing countries processing capacity is limited and needs to be strengthened.

6. Decentralised policy and coordination problems

Point (6) further muddies the policy problem. Theoretical models and practical policy discussions often assume that policy levers are controlled by a single entity, normally the state. In practice, policy agency is dispersed among a set of institutions. Each of these institutions controls a sub-set of instruments linked to certain objectives. In this context an important issue is whether instruments and objectives can be "de-coupled" so that a particular instrument can be unambiguously assigned to an objective (Mundell (1962). If this is possible then each institution can implement its own policies and an overall solution be reached, subject to the other problems discussed above.

But here points (4) and (5) come back into play. Interdependencies will generate spillovers between institutions; the instruments and objectives of one institution may affect the values of those of another. The achievement of objectives therefore depends on coordination between different institutions. These considerations underlie the move in developing countries towards integrated, multi-sectoral policies on the basis of unified frameworks such as PRSs and Medium Term Expenditure Frameworks (MTEFs). The impetus towards donor budget support rather than project-based financing has come from a realisation that different policy areas interact and need to be considered as a coherent whole with all institutions operating under the same policy framework.

The MDGs illustrate this. The objective of halving poverty is connected to a set of instruments including those relating to macroeconomic performance. These include growth rates, inflation and the fiscal balance. Some of these levers are controlled by finance ministries and others by central banks. In turn, some of them affect objectives that come under the watch of other institutions. For example, important instruments for halting the spread of HIV/AIDS are controlled by health ministries, but the fiscal policies of finance ministries influence the amount of funds going into health and therefore have a direct impact on this goal. Similar considerations apply to many of the MDG targets. The optimal management of these kinds of spillovers require complex forms of coordination which will stretch the capacity of developing countries' bureaucracies.

7. Conclusions

The achievement of the broad set of precise, fixed targets embodied in the MDGs through the management of complex socio-economic systems raises doubts about the feasibility of the goals. Thinking about the MDGs in terms of instruments and objectives helps frame problems of target achievement, the measurement of progress and the valuation of outcomes all of which are difficult. We have also seen that sustainability of the targets is an issue which is inadequately addressed in current approaches. In addition, we argued that the need for coordination between different parts of countries' policy making systems will stretch the capacity of governments.

How useful are a set of ahistorical targets?

The issues of structural change discussed in section five expose the lack of historical context surrounding the MDGs. Most of the targets are expressed as rates of change in objective variables; two important ones – the achievement of universal primary education and the elimination of educational gender disparities – are in absolute levels. A remarkable feature of the MDGs is that the same quantitative targets are applied to all countries. Many of these countries are, however, at different stages of development. Structural change and sequencing are components of the concept of a stage of development. Countries at different stages have contrasting structural characteristics and patterns of relationships between instruments and objectives; in a dynamic perspective, certain socio-economic outcomes may be prerequisites for the transition to a more advanced stage.

None of this is taken into account of in the MDGs' absolute and universal targets. At first sight the targets seem to be a level playing field for assessing and comparing countries. In fact, that they do not explicitly account for the long term dynamics of structural change tilts the field towards those countries who have built up the critical mass of internal transformations necessary for developmental take off; countries which have yet to enter this virtuous cycle are at risk of being unjustly chided in the likely event that they fail to achieve many of the goals by 2015.

Taking a longer historical view underlines this point: in the 19th century when today's rich nations had educational enrolment rates similar to those of today's poor countries the evolution towards high enrolment was much slower than that seen in many developing countries in recent decades. This is even the case for some developing countries which are on course to "fail" on the educational targets (Clemens, 2004). Today's rich countries only made universal primary education an explicit development goal when they had higher income levels than today's poor countries and had nearly achieved universality. If the MDGs' educational targets had been applied to today's industrialised nations during their own early stages of development, they may well have missed the targets (for similar historical evidence on some of the other targets, see Clemens et. al., 2004).

The history of today's rich countries shows that development is a drawn out, uneven and contradictory process full of reversals and discontinuity. The MDGs, with their ambitious, linear and broad set of socio-economic goals belie this complexity; contemporary developed countries measured yesterday with today's MDG yardstick might well have been branded "failures".

References

Alesina, A. and Perotti, R. 1994. The Political Economy of Growth: A Critical Survey of the Recent Literature. *World Bank Economic Review,* Volume 8, Number 3

Atkinson, A. and Brandolini, A. 2001. Promise and Pitfalls in the Use of ‘Secondary’ Data Sets: Income Inequality in OECD Countries as a Case Study. *Journal of Economic Literature,* 39, 3

Birdsall, N., Ross, D. and Sabot, R. 1995. Inequality and Growth Reconsidered: Lessons from East Asia. *World Bank Economic Review* Volume 9, Number 3

Bredie, J. and Beeharry, G. 1998. School enrolment decline in Sub-Saharan Africa: Beyond the Supply Constraint. Discussion Paper 395, World Bank

Clemens, M. 2004. The Long Walk to School: International education goals in historical perspective. Working Paper Number 37, Center for Global Development

Clemens, M., Kenny, C., and Moss, T. 2004. The Trouble with the MDGs: Confronting Expectations of Aid and Development Success. Working Paper Number 40, Center for Global Development

Dagdeviren, H., van der Hoeven, R. and Weeks, J. 2000. Redistribution Does Matter: Growth and Redistribution for Poverty Reduction, *mimeo*.

Devarajan, S., Miller, J. and Swanson, V. 2002. Goals for Development: History Prospects and Costs, Policy Research Working Paper 2819, World Bank

Eggertsson, T. 1997. The Old Theory of Economic Policy and the New Institutionalism. *World Development*, Volume 25 Number 8

Elbers, Chirs , Jan Willem Gunning, and Bill Kinsey. March 2002. Convergence, Shocks, and Poverty: Micro Evidence on Growth under Uncertainty, *Tinbergen Institute Discussion Paper*, **TI 2002-035/2**, Tinbergen Institute.

Elbers, Chris, and Jan Willem Gunning. September 2003. Vulnerability in a Stochastic Dynamic Model, *Tinbergen Institute Discussion Paper*, **TI 2003-070/2**, Tinbergen Institute.

Elbers, Chris, Jan Willem Gunning, and Bill Kinsey. July 2003. Growth and Risk: Methodology and Micro Evidence, *Tinbergen Institute Discussion Paper*, **TI 2003-068/2**, Tinbergen Institute.

Fafchamps, Marcel. October 1999. *Rural Poverty, Risk, and Development*, Report Submitted to the Food and Agriculture Organization.

Geda, Alemayehu, and John Weeks. August 2003. Growth Instability among African Countries, *mimeo*.

Kendrick, David Andrew. 2002. *Stochastic Control for Economic Models*, Second Edition, Version 2.00. Available at http://eco.utexas.edu/faculty/Kendrick.

Kremer, M. and Miguel, E. 2004. The Illusion of Sustainability. Working Paper Number 35, Center for Global Development

Kuznets, S. 1966. *Modern Economic Growth: Rate, Structure and Spread*. Yale University Press

Lavy, V. 1996. School supply constraints and children’s educational outcomes in rural Ghana. *Journal of Development Economics*, 51: 291-314

Ligon, Ethan and Laura Schechter. 2004. Evaluating Different Approaches to Estimating Vulnerability. *mimeo*.

McMahon, W. 1998. Education and Growth in East Asia *Economics of Education Review* 17(2)

Moll, T. 1992. Mickey Mouse Numbers and Inequality Research in Developing Countries. *Journal of Development Studies,* Volume 28 Number 4

Mundell, R. 1962. The appropriate use of monetary and fiscal policy for internal and external stability. *IMF Staff Papers*, 9: 70-9.

Petit, M. 1990. *Control theory and dynamic games in economic policy analysis* Cambridge University Press

Sachs, Jeffrey D., John W. Mcarthur, Guido Schmidt-Traub, Margaret Kruk, Chandrika Bahadur, Michael Faye, and Gordon Mccord. 2004. Ending Africa's Poverty Trap, *Brookings Papers on Economic Activity,* **1: 2004**.

Sahn, D. and Stifel, D. 2001. Progress Toward the Millennium Development Goals in Africa, *mimeo*

Srinivasan, T. 1994. Data base for development analysis: An overview. *Journal of Development Economics* Volume 44, pp 3-27

Stiglitz, J. 1998. More Instruments and Broader Goals: Moving toward the Post-Washington Consensus. WIDER Annual Lectures 2

Taffesse, Alemayehu Seyoum and Alex de Waal. February 2005. *Child Survival during the 2002-03 Drought in Ethiopia*, A Report Prepared for the United Nations Children's Fund (UNICEF) Ethiopia.

Tinbergen, J. 1952. *On the Theory of Economic Policy* Amsterdam: North Holland.

World Bank. 2002. Achieving Universal Primary Education in Uganda: The 'Big Bang' Approach. *Education Notes*, Human Development Network

World Bank. 2003. Education in Rwanda: Rebalancing Resources to Accelerate Post-Conflict Development and Poverty Reduction. *Report Number 26038-RW*, Human Development Department, Africa Region.