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Estimating Aggregate Production Function with I(2) Capital Stock[1]

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Abstract

One of the most important features of estimating a production function is the presence of an I(2) capital stock series. Given the empirical regularity that the first difference of capital stock -i.e. investment- is an I(1) series, capital stock tends to have a double unit root. Using Ethiopian data from 1960/61 to 2001/02, we showed that the existence of cointegrating relationship is rejected under the I(1) analysis while the I(2) analysis fail to reject the existence of cointegrating relationship. This indicates the possibility of polynomial cointegration. We also argued that the polynomial cointegration can be motivated theoretical apart from being an empirical issue alone.

JEL Classification: **C32; E23**
Keywords: Production function, I(2) variable, cointegration

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1. Introduction

Specification and estimation of production function had been the workhouse of most economic theories. In a macro economics context, the growth literature *a la* the Solow model extensively employs aggregate production function and its parameters to come up with important conclusions. Among others, Mankiw et al (1992) used a Cobb-Douglas production function to test the implications of the Solow model while Easterly and Levin (2001) used it for their growth accounting analysis on the relative importance of total factor productivity visa vise total factor accumulation.

In cross country growth analysis, estimation of the Cobb-Douglas production function is fairly straight forward. Most of the empirical studies proxy capital by investment (scaled by GDP) and labor force by the economically active population and proceed to estimation either in cross section or panel framework. The problem of estimation, however, would crop-up when estimating a production function for a single country in the presence of stochastic trend in the time series variables. The problem would be serious as capital is a stock variable which invariably contain double unit root. In fact many applied macroeconomists in Africa do confront this problems when they attempt to formulated simple macro model for use in budget formulation and short run forecasting, say for use in the Medium Term Expenditure Framework (MTF) which is being widely employed in many Ministries of Finance Offices in Africa. This is at least our experience in Kenya and Ethiopia. The nature of the data in other African countries is not different and hence the problem could be found across countries in the continent (and elsewhere else). In this chapter we have attempted to address this applied problem.

In the presence of I(2) variable, the usual approach is to difference the I(2) series and employ the I(1) analysis on the differenced and the other I(1) variables. However, this restricts the possibility of having multi-cointegration relationships among the variables and hence imposes a priori restriction that there are only linear cointegrating relationships. Allowing for multi-cointegration or polynomial cointegration is a less restrictive description of the data that lets us treat different theoretically plausible relationships. This paper would, thus, employ an I(2) framework to address the issue of I(2)-ness in estimating aggregate production function. The method is illustrated using the Ethiopian data for the period 1960/61 to 2001/02.

2. The production function and data

Following the growth literature we considered a simple Cobb-Douglas production function[4] given as in equation (2.1) and linearized in equation (2.2).

$$Y = AK^{\alpha}L^{1-\alpha} \qquad \textbf{2.1}$$

$$\ln Y = \beta + \alpha \ln K + 1 - \alpha \ln L \qquad \textbf{2.2}$$

Where Y is total output; A is technological progress, K is total physical capital, L is the total labor force and β is logarithm of A.

Estimating the production function in [2] using time series data requires addressing the stochastic trends in the variables. If all the variables are integrated of order one- I(1)-, estimation can be proceeded by testing for the existence of a common trend among the variables. When it is the case that one or more of the variables are integrated of higher order, our cointegration test in I(1) framework may give a misleading result.

Figure 1 presents the levels and growth rates of GDP, capital and labor series used for our analysis. As can be seen from the figure, the smooth trend of capital stock and its trending growth rate suggest its I(2)-ness. The smooth trend of labor force also suggests that it may be an I(2) series. The growth rate of the labor force, as shown in the figure, does not show a strong trend reverting behavior which also imply that the labor force series might border I(2)-ness. On the other hand the GDP series shows an I(1) behavior with its growth rate being trend reverting. The univariate unit root tests conducted using the Pantula principle could not also reject that capital is an I(2) series and output is I(1). The case for the labor force is not conclusive. The DF statistic shows that labor force is an I(1) series while the ADF statistics could not reject the I(2) null[5].

At this juncture it may be necessary to say some about the nature of the data. We obtained GDP and gross capital formation from the national accounts compiled by Ministry of Finance and Economic Development. However, as frequent revision of the

[4] It should be noted that the preference for a CD production function doesn't imply that it is the best though it is a workhorse in the Solow model and the growth literature in general. Practioners can experiment with other practical functions such as the Constant Elasticity of Substitution (CES) and translog formulation.

[5] As one of the anonymous referees suggested, we also tested for trend stationarity and found that the de-trended series are nonstationary suggesting that the variables contain stochastic trend rather than deterministic one.

national accounts is prevalent, it is difficult to get reliable data that spans for the whole of the four decades. Specifically, the national accounts data from 1960/61 to 92/93 (referred as the old series) and from 1980/81 to 2000/01 (referred as the new series) are generated using different definitions. One way of addressing this problem of change in definitions of our dependent variable (GDP) is to introduce an impulse dummy in our regression. The alternative is to address the change in definition explicitly by looking at how it affected the series. Following the later method and comparing the old and new series of GDP reveals that the change in the definition seems to have a level effect leaving the growth rate somehow unaffected. In such a case we can fairly impose the growth rate of the old series on the new series and extrapolate the GDP series backward. We thus used the later procedure to adjust both the GDP and gross capital formation series of the national accounts.

Regarding capital stock, there is no estimate of the capital stock in the country. We generated the data for capital stock using the capital accumulation equation (where K_t is current capital stock and K_{t-1} lagged level of capital stock): $K_t = K_{t-1} + Investment - Depreciation$. As we don't also have the initial value of capital stock (K_{t-1}) we used an estimated incremental capital output ratio (ICRO) and generated K_{t-1} as: $K_{t-1} = ICRO * Output_{t-1}$.

The data for labor force is extracted from the World Bank's African Development Indicator CDROM (2005). This database compiles data from 1965 and hence we extrapolated the labor force series backward using exponential smoothing technique as our sample period goes back to 1960/61. The labor force series exhibited some unexpected trend. We could not explain the abrupt fall in the growth rate of labor force in 1970, 1977, 1993 and 1997. However, the retrenchment of labor force following the economic liberalization program and the HIV/AIDS epidemic could be plausible conjectures in explaining the sharp decline in the growth rate of labor force.
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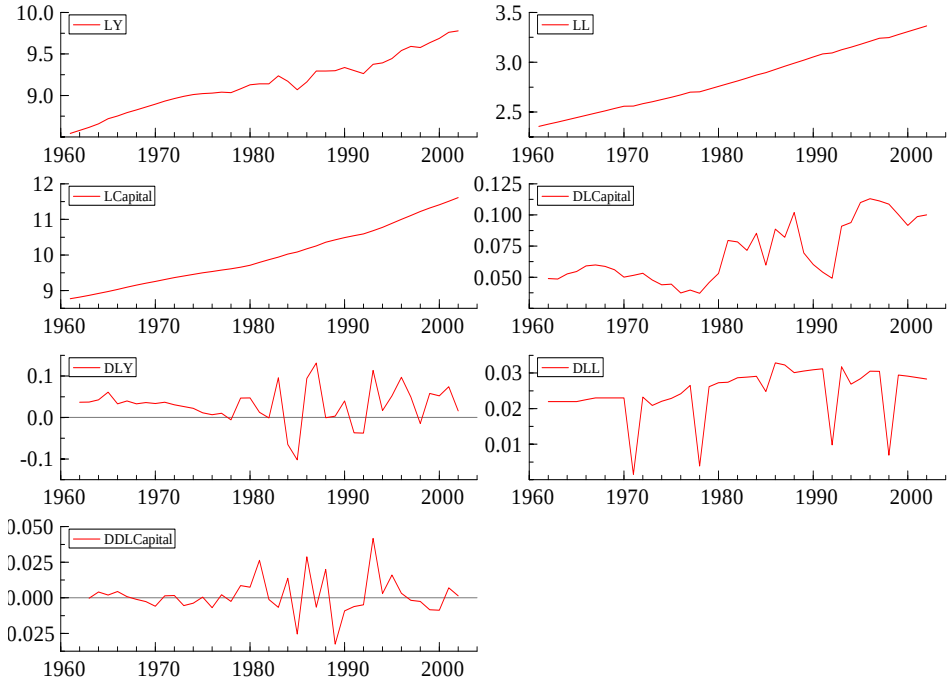
Figure 1



3. The econometric framework

The empirical analysis follows the Johansen (1995, 1997) multivariate cointegration framework based on a vector autoregressive process.

Consider the kth order VAR(k) of the form

$$\mathbf{x}_t = A_1\mathbf{x}_{t-1} + A_2\mathbf{x}_{t-2} + \ldots + A_p\mathbf{x}_{t-k} + \varepsilon_t \qquad \textbf{[3.1]}$$

where $\mathbf{x}_t$ is p x 1 vector of endogenous variables, A_i is p x p matrix of parameters, and $\varepsilon_t \sim IN(0, \sum)$

Upon repeated re-parameterization, equation (3.1) can be written as

$$\Delta \mathbf{x}_t = \sum_{i=1}^{p-1} \Gamma \Delta \mathbf{x}_{t-i} + \Pi \mathbf{x}_{t-p} + \varepsilon_t \qquad \textbf{[3.2]}$$

Where $\Gamma = -[I - \sum_{j=1}^{i} \mathbf{A}_j]$ and $\Pi = -[I - \sum_{i=1}^{p} \mathbf{A}_i]$

If the $\mathbf{x}_t$ vector is cointegrating, the **Π** vector will have a reduced rank (*r* <*p*) so that it can be factorized in to α and β matrices, both of dimension (*p x r*), where r is the rank of π which is the same as the cointegration rank, such that $\pi = \alpha\beta'$. The matrix α is the matrix of weights with which each cointegrating vector enters the *p* equations of the VAR while the matrix β is a matrix of long run coefficients or cointegrating parameters. In addition to this, for the system to generate I(1) process, $\alpha'_\perp \mathbf{\Gamma} \beta_\perp$, where $\alpha_\perp$ and $\beta_\perp$ are orthogonal complement matrices of α and *β*, (so that $\alpha'_\perp \alpha = \beta'_\perp \beta = 0$) needs to have a full rank (i.e., it has to be stationary)[6]. Otherwise, the system would be integrated of higher order. Thus, to account for I(2) system we need a reduced rank restriction on $\alpha'_\perp \mathbf{\Gamma} \beta_\perp$.

Following Johansen (1997) the I(2) model can be represented as

$$\Delta^2 X_t = \Pi X_{t-1} - \Gamma \Delta X_{t-1} + \sum_{i=1}^{k-2} \Psi_i \Delta^2 X_{t-1} + \varepsilon_t \qquad \textbf{[3.3]}$$

Where $\varepsilon_t \; is \; iid \; and \; \Psi_i = -\sum_{j=i+1}^{k-1} \Gamma_j$

As in the I(1) model assuming that the **Π** matrix has a reduced rank; and allowing the $\alpha'_\perp \mathbf{\Gamma} \beta_\perp$ to have a reduced rank to accommodate higher order of integration, we can analyze the I(2) system. With $\alpha'_\perp \mathbf{\Gamma} \beta_\perp$ having a reduced rank, it can be parameterized into *ξ* and *η* matrices. Thus, the joint pair of reduced rank conditions of the I(2) model can be stated as

$$\Pi = \alpha\beta' \qquad \alpha, \beta \; (p \; x \; r), \; r<p \qquad \textbf{[3.4]}$$

[6] Johanson (1988, 1991, 1995) has shown that the cointegrated VAR model can also be given by an alternative 'common stochastic trend' representation $X_t = C\sum_{i=1}^{t} \varepsilon_i + C(L)\varepsilon_t$ where C= $\beta_\perp(\alpha'_\perp \mathbf{\Gamma} \beta_\perp)^{-1}\alpha'_\perp$; β is px(p-r) dimension; $\beta'_\perp \beta = 0$ and rank($\beta_\perp \beta$)=p[C(L)] such that C(L)ε_i corresponds to a p-dimensional I(0) component. It can be shown that although X_t is p-dimensional, the vector series is driven by just p-r common stochastic I(1) trend $\sum_{i=1}^{t} \varepsilon \alpha'_\perp$ (see Haldrup, 1998:627)

$$\alpha_{\perp}^{'}\mathbf{\Gamma}\beta_{\perp} = \xi\eta^{'} \qquad \xi,\eta\ (p-r)\ X\ s,\ s<(p-r)$$

Johansen (1995, 1997) showed that the space spanned by the system can be decomposed into I(0), I(1) and I(2) trends. Three mutually orthogonal matrices β, β_1 and β_2, where

$$\beta_1 = \beta_{\perp}\left(\beta_{\perp}^{'}\beta_{\perp}\right)^{-1}\eta \quad and \quad \beta_2 = \beta_{\perp}\eta_{\perp}$$

divide the p-dimensional space into different cointegration relationships. The process can be described as:

$\beta_2^{'}X_t$ $p - r - s$ dimensional I(2) trend (where s<(p-r))

$\left(\beta,\beta_1\right)^{'}X_t$ I(1) relations that reduce the integration order from 2 to 1.

$\beta^{'}X_t - \delta\beta_2^{'}\Delta X_t$ I(0) polynomial cointegration result where $\delta = \bar{a}^{'}\Gamma\bar{\beta}_2$ of dimension r x $(p - r - s)$

The number of polynomial cointegrating relations cannot exceed the number of I(2) trends requiring that $r \geq p - r - s$.

The estimation procedure follows Johansen's (1995) two step procedure. The first step involves solving the reduced rank problem for the **Π** matrix for each value of $r = 0, \ldots p-1$. On the second stage, the estimated α and β will be used to solve the reduced rank regression problem associated with $\alpha'_{\perp}\mathbf{\Gamma}\beta_{\perp} = \xi\eta'$ which will be solved for $s = 0, 1, \ldots p-r-1$. At each step the trace statistics will be generated. On the first step, the trace statistics Q_r for a rank of **Π** equal r against the unrestricted rank p is computed. On the second step, the trace statistics conditional on the first step gives $Q_{r,s,}$ for a rank of $\alpha'_{\perp}\mathbf{\Gamma}\beta_{\perp}$ equal s against the unrestricted rank $p - r$. The sum of the two tests, $[S_{r,s}]$ gives a simultaneous test for the model $[H_{r,s}]$ against the unrestricted alternative. The model $[H_{r,s}]$ is rejected if$[H_{i,j}]$ is rejected for all for all $i < r$ *and* $j \leq s$.

4. Empirical results

The cointegration analysis is preceded by determining the data congruency of the VAR. Using the data from 1960/61 – 2001/02, VAR (2) appears to be a valid specification based on the Akaike Information Criterion. The restriction that 'lags higher than 2 are all zero' cannot also be rejected using F-statistics confirming the VAR (2) specification.

We first conducted an I(1) cointegration analysis using our VAR (2) specification. The result shows that output, capital and labor are not cointegrated implying that the variables do not have a stable relationship that leads to an I(0) relationship. That is, the I(2) variables might cointegrate as C(2,1) but they do not cointegrated with the I(1) variable leading to an I(1) residual. We proceed to an I(2) analysis to test for a possible polynomial cointegration.

Table 4.1: Testing cointegration in I(1) framework

		Trace test	[Prob]
	0	26.721	[0.111]
H_0: Rank≤	1	10.987	[0.216]
	2	0.43605	[0.509]

To identify the rank indices of the I(2) model , *r* and *s*, we used the trace statistics test, $S_{r,s}$ reported in Table 4.2. The test starts from the most restrictive model, $H_{0,0}$ in the upper left hand side and proceeds down the columns, from top left to bottom right, stopping at the first acceptance *a la* Pantula principle.

Table 4.2: I(2) test for the rank order

r		$S_{r,s}$		Q_r
0	92.308	58.883	44.007	44.005
	(0.0003)	*(0.0229)*	*(0.0404)*	*(0.0036)*
1		36.813	**18.363**	18.341
		(0.0495)	***0.3405***	*(0.0897)*
2			6.5354	6.5152
			(0.4273)	*(0.1594)*
p-r-s	3	2	1	0

† The (italics) figures are probabilities associated with the trace statistics

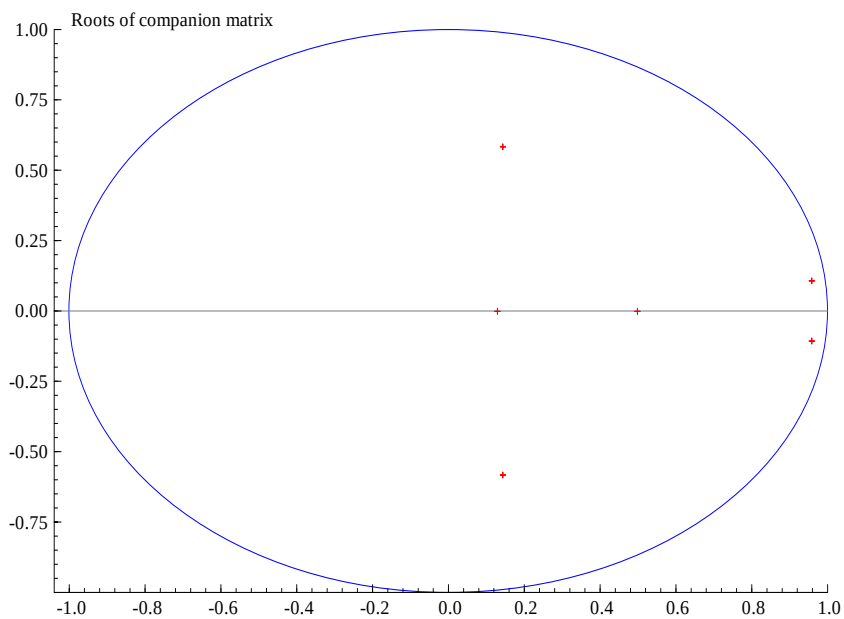
Our result shows that our first acceptance is when the number of I(2) trends in the system, *p-r-s=1* and *r=1*. Contrary to our I(1) analysis, we obtained one stable cointegrating relationship with one I(2) trend. The lack of cointegration in our I(1)

analysis is visa vise the presence of it in the I(2) analysis may suggest the presence of polynomial cointegration. That is the I(2) variables may cointegrate as C(2,1) which would further cointegrate with the change in the I(2) variable and the remaining I(1) variables. As the number of polynomial cointegration cannot exceed the number of I(2) trends = 1, the cointegrating relationship that we obtained would be due to the polynomial term in our I(2) cointegration analysis.

We first adopted the usual approach that tests cointegration among the differenced I(2) variable and other I(1) variables. We used VAR (2) specification and tested cointegration among output, labor and change in capital (investment). Our result shows that the null hypothesis of zero cointegration relationship is rejected in favor of one cointegration relationship. The moduli of the companion matrix are all within the unit circle as shown in the figure below. However, the existence of large roots close to 1 may indicate that there may be some unaccounted trend close to I(2).

Table 4.3:

		Trace Statistics	Prob
	0	65.674	[0.000] **
	1	21.302	[0.169]
H_0: Rank≤	2	8.2542	[0.238]



Given the problem of unaccounted I(2) trend and to allow for other type of relationship, we tried to identify the polynomial cointegration relationship. We tried to motivate the polynomial cointegration that the data exhibited theoretically. That is, the polynomial cointegration may indicate that output depends on the common trend of capital and labor (for instance capital labor ratio) and the new investment made. The I(2) capital stock may cointegrate with the near I(2) labor force- C(2,1) which may further cointegrate with the change in the I(2) variables- capital. Change in capital stock can be a theoretically valid candidate in forcing this relationship to cointegrate and hence it can be used as the polynomial cointegrating term.

To test the polynomial cointegration, we created a variable that captures the common trend of capital and labor as capital labor ratio - i.e. lnK – lnL. Using this variable along with output and change in capital stock, we run a cointegration test in I(1) framework and obtained one cointegrating relationship with the roots of the companion matrix being all within a unit circle. This is an interesting result in supporting the polynomial cointegration relationship. It also underscores the importance of I(2) analysis in motivating different theoretical relationships. Table 4.4 reports this result.

Once the cointegration relationship is established, the analysis can proceed using the I(1) framework. The long run relationships can be identified using the β vector with the adjustment coefficients contained in the α vector discussed in the previous section. Hypothesis testing can also be conducted in the I(1) framework using the LR test.

Table 4.4

		Trace Statistics	Prob
	0	63.990	[0.000] **
	1	25.398	[0.055]
H_0: *Rank*≤	2	8.3336	[0.232]

At this juncture, it is important to notice that the I(2) analysis is an important framework in detecting a polynomial cointegration relationship though the final analysis is based on an I(1) approach. As opposed to adopting the I(1) framework with the differenced I(2) variables, this approach is more flexible in allowing different types of relationships which are filtered out in the earlier approach.

5. Conclusion

We estimated a simple production function allowing for the presence of I(2) variables. We showed that, in the presence of I(2) capital stock for instance, the I(1) cointegration analysis rejected the presence of cointegration among the variables. However, the I(2) analysis showed the presence of one I(2) trend with a possible cointegration as the rank r=1. This can be attributed to the polynomial cointegration allowed in the I(2) analysis.

We also showed that the polynomial cointegration found in the data could also be motivated theoretically. Capital and labor may cointegrate as C(2,1) forming an I(1) capital labor ratio which along with investment (i.e. change in capital stock which is also the polynomial integration term) may give a stable relationship. This shows the importance of putting the problem in an I(2) framework to address the higher order integration and their relationship with the lower integration order.

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Aggregate Saving Behavior in Africa: A Review of the Theory and the Existing Evidence with a New Empirical Results[1]

Alemayehu Geda [2] and Haile Kebret [3]

Abstract

The objective of this paper is to review the theoretical and empirical literature on aggregate saving behavior and to examine the available evidence in order to draw lessons that are particularly relevant for African economies in general and Ethiopia in particular. It attempts to document the main theoretical linkages of saving to major macro-economic aggregates and the factors that determine saving at the micro-economic or household level, examine the existing empirical evidence, present a new estimated result conducted in the context of this study. The literature as well as the empirical finding in this study shows that saving is positively related to income level or growth, rate of investment, and short-run changes in terms of trade. On the other hand, more it is negatively related to macroeconomic instability, foreign aid, and age-dependency ratio.

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1. Introduction

1.1 An overview

Saving has always figured prominently in both theoretical analysis and policy design in both developed and developing economies. This prominence emanates from its assumed direct theoretical link to future economic growth and current expenditure levels via its link to consumption. Early theories of economic growth emphasized the role of saving as a source of capital accumulation and hence growth. Similarly the aggregate demand based theory of Keynesian economics also focused on aggregate expenditure which has a direct implication to saving. Due to their preoccupation with short-term macroeconomic adjustment and stabilization policies, the emphasis on saving was relatively neglected in the 1980s in many African countries. But the focus on economic growth and hence on saving seems to have resurfaced in the 1990s and after. This interest is partly due to the belief that one of the reasons for slow growth in Sub-Saharan Africa is the low rate of saving relative to other developing regions (Schmidt-Hbbel et al, 1996, Aryeetey and Udry, 1999). This is in particular true when one compares the level of domestic saving and investment (See Annex 1).

Saving could be examined in terms of its aggregate behavior or at a personal or household level. In addition to distinguishing the unit of analysis, it is also imperative that a distinction be made between saving behavior in developed and developing economies. As Deaton (1989) noted, there are many good reasons which indicate that factors that determine saving behavior in developing countries are likely to differ from that of developed countries. As will be discussed later, these differences include both macroeconomic aspects of saving (mainly related to institutional and policy issues) and microeconomic factors (such as family structure and type of asset-portfolios available for households in the two group of countries).

The objective of this article is to review the theoretical aspects of saving both at a macro-economic and micro-economic levels and examine the available evidence, including a new estimation made by the authors, in order to draw policy lessons that are particularly relevant for African economies in general Ethiopia in particular. The remainder of the paper is organized as follows: After examining measurement problems and saving trends in Sub-Saharan Africa, relative to other regions, in the remainder of this sub section, section two presents the theoretical determinants of saving. Section three reviews the empirical evidence by focusing mainly on Sub-Saharan Africa. Section four presents a new empirical result that we have estimated. Finally section five presents summary and the policy implications of the theory and the empirical evidence examined in the paper.

1.2 Measurement issues and saving trends in Sub-Saharan Africa (SSA)

It has to be noted from the outset that data problems in examining saving behavior both at the macro-economic and micro-economic levels, particularly in developing countries, are pervasive. For instance, at the macro-economic level, "saving is not measured directly but is the residual between two large magnitudes [GDP and consumption], each itself measured with errors (Deaton, 1989, p. 62)". Similarly, at the micro-economic level, "The standard household survey may well understate saving. The concept of income is itself extraordinarily complex, and most people in developing countries have little reason to distinguish between business and personal cash transactions" (ibid, p. 63). Aryeetey and Udry (1999) also note that in the case of Sub-Saharan Africa, non-financial assets (livestock, stocks of goods for trading, grain and farm inputs) dominate their asset portfolios which in essence are used to smooth out consumption over time. What is more, due to distortions in the trade sector that results in illegal capital outflow (via over-invoicing of imports and under-invoicing of exports, for instance), saving will be underestimated when calculated as the sum of trade and government surpluses and domestic investment (Deaton, 1989). Analysis of saving behavior in the absence of the above considerations therefore will make it inaccurate and in their presence complex.

With the above caveats in mind, using data from World Bank's 'African and World Development Indicators' growth and saving for Africa and other regions are summarized in Figures 1 to 3 and Annex 1. As can be seen in Figures 1, 2, and 3, GDP growth and Gross Domestic Saving as a share of GDP in Sub-Saharan Africa (SSA, henceforth) were very low. And the performance of the two aggregates had deteriorated sharply after the 1980s. The figures also show that the Asian countries' performance is the best both in terms of accelerating growth and capital formation.

The figures also indicate that within Africa, North African countries had a relatively higher saving rate through out the two decades although their saving rate has also declined after 1980, and recovered after the end of the 1990s.

Figure 1: GDP growth across the World (including Africa)

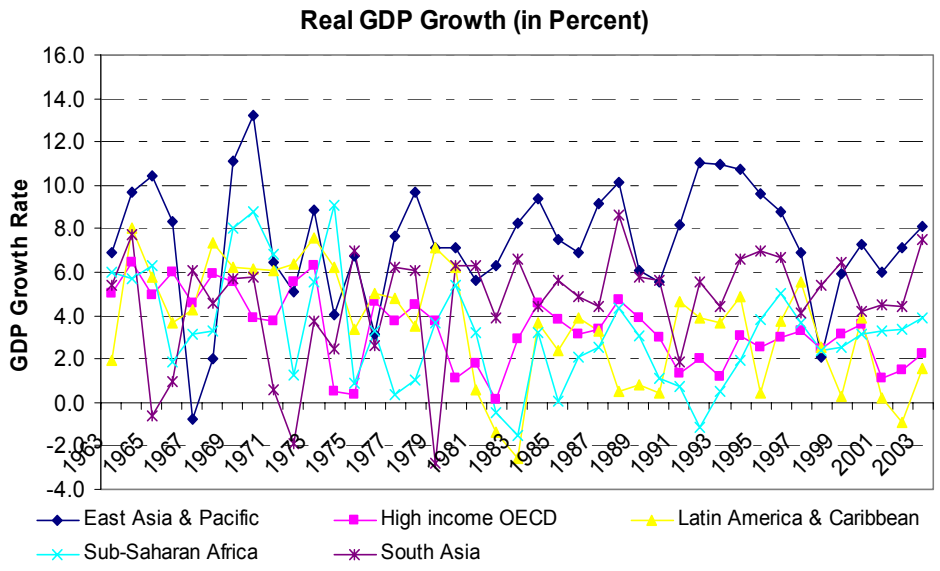


Figure 2: Growth domestic saving across the World (including Africa)

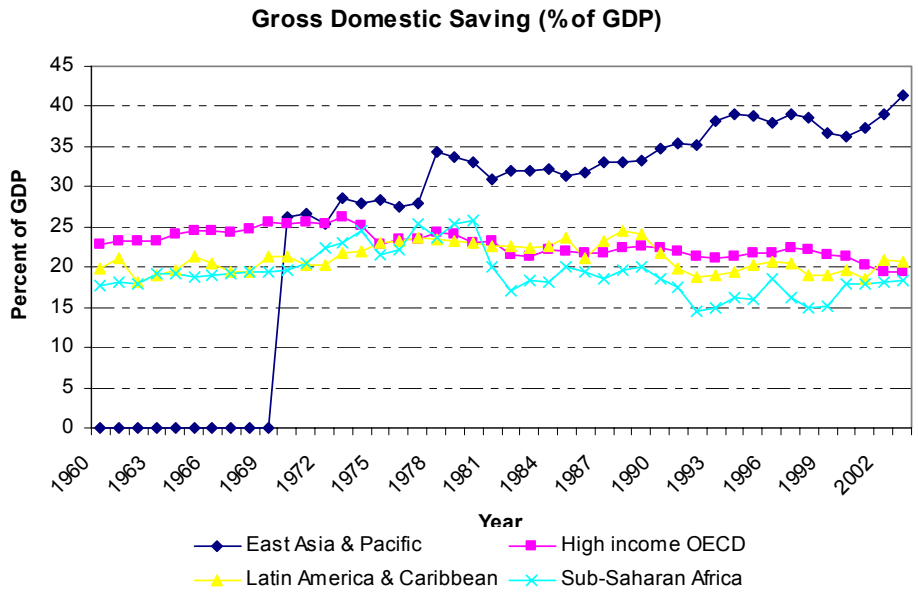
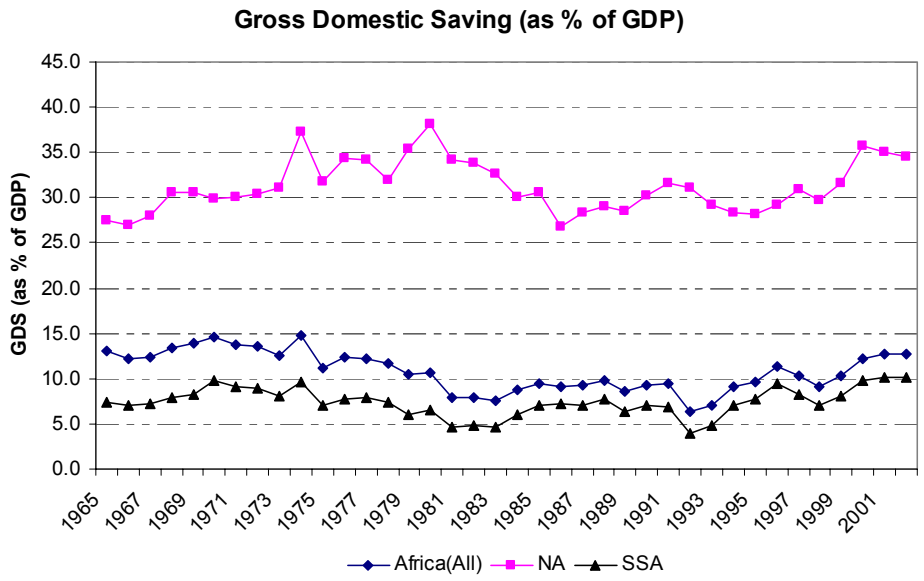


Figure 3: Growth domestic saving in Africa



2. Theoretical aspects of saving behavior

2.1 Saving and growth

Economic theory has maintained for long that saving or capital accumulation is the main determinant of economic growth, which can be understood as sustained long-term rise in income of a country. Lewis (1954, p. 155), among others noted, "central problem in the theory of economic development is to understand the process by which a community which was previously saving 4 or 5 per cent of its national income or less, converts itself into an economy where voluntary saving is running at about 12 to 15 per cent of national income or more". This belief implied that, first, saving is directly translated to investment and, second, saving is a prerequisite for economic growth.

Similarly, all the Neo-classical growth theories developed in the 1950s and 1960s also emphasized the importance of saving in the economic growth process. These emphases could be summarized in the following stylized facts: higher saving leads to higher investment, and higher investment leads to economic growth. The presumption of this reasoning is that, at least in a closed economy, *ex-post* domestic saving must equal *ex-post* domestic investment. And according to the above theories,

investment is directly related to output growth via the incremental capital output ratio (ICOR), at least during the transition to its steady state level or in the short-run. And the more recent endogenous growth theories go further by asserting that saving and investment (combined with technological progress and human capital) induce both short-term and long-term economic growth (Roemer, 1986, Lucas 1988). The implication of the above theories is that, as Schmidt-Hbbel et al, (1996, p. 91) noted, "saving is automatically translated into capital accumulation and thereby growth, and that this translation is simply the mechanism underlying the positive correlation between saving and growth that is observed in practice".

However, as will be discussed in the section on empirical evidence later, the consensus seems to be that only a small portion of cross-country growth differences could be explained by differences in investment ratios. And what is more, the direction of causality between investment and output growth and saving and output growth is far from clear (Schmidt Hebel et al, 1996, Elbadawi and Mwega, 1998). That is, while the correlation between the above variables is positive and mostly significant, the causation seems to run in both directions. For instance, Caroll and Weil (1994), argue that the positive correlation observed between saving and growth is partly due to the fact that growth precedes saving even under the assumption that saving is automatically translated into investment. Not incorporating this two-way causality between saving and growth would therefore overestimate the contributions of saving to growth. Such a finding makes the policy implication complex in that whether saving should be targeted to enhance growth or growth is the cause of saving.

In the case of SSA Elbadawi and Mwega (1998) argue that regardless of the direction of causation (i.e. even if saving follows economic growth), focusing on policies that enhance private saving is important for at least two reasons. First, even if saving is the result and not the cause of economic growth, empirical evidence suggests that sustaining a high rate of growth requires a high level of accumulation of capital which requires high level of saving. Second, due to SSA countries' limited external resources (limited ability to borrow from international capital markets and the conditionality imposed when borrowing from multilateral financial institutions), mobilizing national saving to maintain a high rate of investment and hence growth is essential.

The theoretical linkages of saving, investment and economic growth outlined above suggest that, first as noted earlier, the theories provide less clear direction for policy makers in that they do not provide a clear direction as to which should be targeted first (saving or growth). It is true that this does not diminish the importance of saving

for African countries for reasons appropriately stated by Elbadawi and Mwega (1998), above. But for designing an appropriate policy, it is likely to be useful to clearly identify the exact causative linkage in order to distinguish between what is an instrument and what is a target both in the short run and the long run. Second, at a theoretical level the determinants of saving and investment differ. Therefore, at a policy level the presumption that saving is directly translated to investment may not hold. Arguably, this is more likely to be the case in more recent years than before for at least two reasons: (i) due to the increase in availability of financial instruments not all saving is used for productive investment (but instead at least some of it may be diverted to what is called portfolio investment or speculative capital) purposes; and second, due to liberalization, the relationship between domestic saving and domestic investment incorporate an international dimension. That is, the net change in capital flow is what determines investment and not necessarily the level or rate of domestic saving. The average investment to GDP ratio of 17% vis-à-vis the average domestic saving to GDP ratio of about 6% for the period 1970-2003 in Ethiopia, which is largely true in most SSA countries, is a case in point.

2.2 Saving and consumption smoothing

Given that saving is a postponed consumption, saving has always been examined in relation to consumption smoothing behavior. This is because a decision by households or individuals to consume or save is a joint decision. This decision is the main determinant of national saving. The relationship between saving and consumption could be summed up in the predictions of the two popular models of consumption behavior - namely, the permanent income hypothesis and life cycle models of consumption. These two models are based on the premise that the motive for saving is to average out consumption over an infinite time horizon (the case of the permanent income hypothesis) or a finite time horizon with overlapping generations (in the case of life-cycle model). In general both theories predict that consumption is determined by life time resources rather than each period's income. This suggests that, in the absence of borrowing constraint, saving and dissaving is used as a mechanism to adjust the optimal consumption over the life time horizon.

In particular, the life cycle hypothesis postulates that saving (both to repay previous obligations and to finance expenditures during retirement) is made during productive years. This implies that the age structure of the population has a direct influence on aggregate saving such that a high dependency ratio will have a negative impact on saving (Elbadawi and Mwega, 1998, Masson et al, 1995, Birdsall et al, 1999). This is because, a decrease in the relative size of the working population decreases the

number of savers relative to dissavers (the young and the old). An increase in per capita income has the opposite effect. As Deaton (1989, p. 76) noted, "Per capita income growth has a similar effect (as a decrease in dependency ratio) because workers are saving on a larger scale than the retirees are dissaving". It is to be noted that this is the basis for the earlier discussed positive correlation usually observed between growth and saving.

The view that demographic factors affect saving is not however shared by all researchers. For instance, Koskela and Viren (1989), Kennickell (1990), and Caroll and Summers (1991) question the significance of age structure in determining saving behavior. Kennickell, and Caroll and Summers in particular argue that differences in age-consumption profiles are too small for demographic factors to significantly affect saving rates.

Regardless of the merits of the above theories in explaining the saving behavior in developed countries, the determinants of saving in developing countries are likely to differ in many significant ways. Deaton (1989) documents some of the features that may influence household saving behavior in developing countries. These features include: households in poor countries tend to be large and poor; the economy is dominated by agriculture; households face an uncertain income flow and have different demographic structure; and liquidity constraints are binding. Given these features, therefore, how households smooth consumption over time and decide on how much to save is likely to differ from the basic predictions of the above discussed inter-temporal models of consumption and saving behavior. In explaining the motives for saving in developing countries which exhibit the above features, Birdall et al. (1999) argue that since households operate in a multi-generational context the need to save for retirement is not important since adults expect that their children will support them during old age. Further, due to the uncertainty of income (say, owing to the volatility of agricultural output) such households may not be able to predict future income and hence plan consumption and saving over a long time horizon. Life cycle models which are based on an inter-temporal decision scheme are therefore likely to have little explanatory power in predicting the saving behavior in poor countries.

As more recent theories emphasize, the main motives for saving in poor income countries are likely to be for precautionary (against random decreases in income as short-run buffering) or to finance private investment since availability of credit for such purposes tend to be scarce. At a policy level, this implies that high rates of return on investment will encourage saving (Birdsall et al., 1999). This of course is only true if the rate of return on investment is higher than the rate of time preference. But as Birdsall et al. (1999) noted, given the subsistence nature of such economies, the rate

of time preference is relatively high since there are not many goods (luxuries, for instance) that could be removed from the consumption bundle. The above arguments suggest that, in addition to a concerted effort to provide access for credit facilities to increase investment, designing tax and other policies to ensure profitability of investment will therefore be required to encourage saving.

Further, a common consideration in the context of consumption smoothing and saving is the impact of interest rates on saving. Theoretically, the impact of the real interest rate on saving is ambiguous. This is because a change in interest rate implies both substitution and income effects. For instance, an increase an income implies that tomorrow's consumption becomes relatively cheaper (or the opportunity cost of current consumption increases) which in turn implies a positive impact on saving. On the other hand, given an increase in expected income (resulting from high interest rate income), it will lead to an increase in current consumption and therefore decrease current saving. The usual assumption is that the substitution effect dominates and therefore an increase in real interest rate (above the rate of time preference) will have a negative impact on consumption and a positive impact on saving. Even though as will be discussed in the empirical evidence section, its impact in the case of developing countries is very little if at all, many theories pay a significant attention to it as a determinant of saving.

In the context of developing countries, the most widely cited theory in this regard is the McKinnon (1973) and Shaw (1973) "financial repression" hypothesis. The main arguments of this hypothesis could simply put as follows: economic growth in developing countries is low because saving rates are low, and saving rates are low because official real interest rates are low. Implicit in this argument is that, saving is automatically translated to investment and economic growth is mainly determined by the rate of investment. It further assumes that private saving responds positively to real interest rate. The repression of the financial sector as reflected in low or negative real interest rates, therefore, hinders saving mobilization. Aryeetey and Udry (1999, p. 24) observed that, "Real interest rates are often generally low in most of SSA for a number reasons, including relatively high inflation and other indicators of macroeconomic instability,. as well as institutional factors that have often repressed interest rates".

If indeed the main obstacle to private saving mobilization is financial repression, the policy implication is clear. As has been incorporated in any typical structural reform package (usually sponsored by the Brettonwoods institutions), it takes the form of liberalization of the financial sector in order to offer positive deposit rate such that it encourages private saving. As Masson et al. (1995, p. 7) noted, "the effect of

liberalization on saving behavior can operate through at least two channels. First, financial development may provide outlets for financial saving, thereby raising saving rates..., a channel that has been emphasized in the development literature. The second aspect involves liberalization of consumer access to bank credit, as occurred in a number of industrial countries in the 1980s." As is well known, many financial reforms have been undertaken in many SSA countries in the 1980s and early 1990s. Despite such reforms however, real deposit rates have not significantly increased in many African countries as Aryeetey and Udry (1999) noted. According to the above authors (P. 24), "the real deposit rates have risen far slower than lending rates in many countries, including Ghana, Malawi, Tanzania, Uganda and Kenya. There are indications, however, that when there is some stability in macro-economic conditions and deposit rates rise, depositors react positively to such rises as happened in Ghana at the end of the 1980s and in Nigeria earlier." It has to be noted however, the evidence regarding the effect of real interest rate on saving is mixed at best. For instance, Giovannini (1985), Schmidt-Hebbel, Webb and Corsetti (1992) found no significant impact of real interest rate on saving, while Ogaki, Ostry, and Reinhart (1995) found positive effects that are small and very sensitive to income levels.

2.3 Saving and external sector

In the case of open economies, the determinants of saving are more complex. For instance, even *ex-post* saving may not equal investment as long as there is no constraint to capital flow across national boundaries. For instance, capital inflows in the form of concessional loans and foreign aid have an impact on national saving. As noted earlier, the usual rationale for granting aid or concessional loans has been to augment domestic saving. But if instead, as many researchers (Elbadawi and Mwega, 1998, Dayal-Gulati and Thimann, 1997, Schmidt-Hebbel et al, 1996, and Masson et al, 1995, for instance noted), foreign aid is used to smooth out consumption instead of investment, it will have a crowding out effect on domestic saving. That is, foreign aid is a substitute and not complementary to national saving. Recent empirical evidence seems to support the crowding out effect of foreign aid on national saving than the complementarity hypothesis (For more details, see Dayal-Gulati and Thimann, 1997, Schmidt-Hebbel et al, 1996, Global Coalition (1993).

A related issue usually considered in the literature as influencing saving behavior is changes in terms of trade, otherwise known as the Harberger-Laursen-Metzler effect. At a theoretical level, this effect is examined in an inter-temporal optimization model. Accordingly, this theory predicts that a temporary improvement in terms of trade would lead to an increase in saving by increasing temporary income or wealth. But

the effect of permanent changes in terms of trade on saving is ambiguous (Dayal-Gulati and Thimann, 1997, Schmidt-Hebbel et al, 1996). Mwega (1997) argues that the effect of terms of trade is important in SSA countries due to their narrow export base and the price volatility of primary exports. He cites some evidence that this indeed was the case in Kenya in which coffee producing rural households were able to save about 60 per cent of their windfall during the 1976-1977 coffee boom.

2.4 Saving and macro-economic policies

In principle government policy could have a potentially significant influence on national saving either by directly increasing public saving or implementing policies that increase private saving. Such policies include, "revenue policy (tax structure, tax incentives), expenditure policy (transfers, income redistribution), and the degree of government saving," (Dayal-Gulati and Thimann, 1997, p. 7). Government policy directed at financial and pension reforms could also potentially affect private saving, in addition to the above routes through which government could influence national saving.

Whether public saving substitutes or complements private saving is not clear from the theoretical literature. As Mwega (1997) pointed out, in the absence of complete crowding out (Keynesian Assumption), public saving complements private saving; in the case of complete crowding out (Classical but particularly Ricardian equivalence) government budget balance (or public saving) has no effect on private saving. That is, according to the latter theories, the offset coefficient approaches unity. Though it is an empirical issue, due to the stringent assumptions of the Ricardian equivalence hypothesis (infinite planning horizon of households, no borrowing constraint etc), its relevance for a typical SSA county is likely to be limited. This implies that at least in the case of poor African countries, the effect of public saving on private saving is likely to be positive or Ricardian equivalence is unlikely to hold. As will be discussed later, the recent empirical literature is consistent with this observation. The main reason for the failure of the Ricardian equivalence to hold in developing countries is the prevalence of liquidity constraints (Masson et al, 1995).

In addition to fiscal deficits, governments could also potentially influence private saving by introducing tax incentives, as noted above. By raising the after-tax rate of return governments could in principle encourage private saving. But the final outcome on national saving is ambiguous because it decreases public saving and if the tax is selective it may lead to portfolio reshuffling to gain from the tax break thereby introducing distortions. The existing available literature seems to shed no light on this issue.

Similarly, whether direct income transfers and income redistribution positively affect total (national) saving or not is ambiguous at a theoretical level. That is unless the marginal propensity to save between low income groups on the one hand and between the government and the private sector on the other varies significantly, they may offset each other and hence have no impact on total saving.

Other government policies that may affect saving include financial reform, pension reform and macro-economic instability. Financial reform that results in an increase in interest rate is likely to encourage saving ala the McKinnon (1973) and Shaw (1973) argument.

Another potentially relevant determinant of saving is macro-economic instability. Since saving is an inter-temporal decision, how economic agents view the future real value of their wealth affects their saving decisions. For instance, inflation (the usual proxy for macro-economic instability) reduces the real value of financial assets. Therefore, inflation expectation could discourage saving and encourage consumption and/or lead to portfolio reshuffling away from financial assets.

3. Saving behavior in Africa: An overview of the empirical literature

There is a growing empirical literature that attempts to empirically examine the determinants of saving in developing countries. The rest of this paper is devoted to the review of such studies with an emphasis on SSA. To allow smooth flow of the review a thematic classification of the available evidence is made. Each of these themes is discussed below.

3.1 Macroeconomic based explanations

a) Economic growth

According to Elbadawi and Mwega (1998), there is a growing gap, compared to other regions, between saving and investment in SSA for the last three decades (Elbadawi and Mwega, 1998, p. 4; See also Annex 1). It is noted in many studies (See for instance Levine and Renelt (1992), De Long and Summer (1993) and King and Levine (1994) all cited in Elbadawi and Mwega (1998)) that investment is the most important determinant of growth. A neoclassical production function based estimation by Yonger (1994) has also find investment, not technological progress as such, being an important explanatory variable of growth in Southeast Asia (Elbadawi and Mwega 1998).

Growth is crucial in the determination of saving because investment, which is closely linked both with growth and saving (Mwega, 1997, p. 200) links saving to growth although the causality issue (i.e., whether saving causes growth or the other way round) is not yet settled. Carroll and Weil's (1994) based on their empirical findings noted that it is growth that cause changes in the saving rate. Similar result is also reported in Mason et al (1995). Most cross-country studies that include growth in real income as a determinant of saving, as Schimidt-Hebbel *et al* (1996) noted, report a strong positive effect of income on saving. Using per capita income and its growth, Mwega (1997) also reported a positive effect of growth for a sample of LDCs used in his model. When he estimated the model for a sample of African countries only growth is found to have a significant positive effect (his other income variables, per capita income and its square, seem to show problem of multicollinearity). Our result in section four below also confirms this. Elbadawi and Mwega's (1998) empirical study shows that saving rate significantly Granger-causes the investment rate although the relationship between saving rate and economic growth is non-significant. Other studies (Dooleey, Frankel and Mathieson 1987, Summers 1998, cited in Schmidt-Hebble *et al* 1996) find that there is a strong correlation between investment and saving both in developed and developing countries. However, growth is found to Granger-cause both saving and investment (Elbadawi and Mwega, 1998, p. 7). Similar result is also reported in the study by Carroll and Weil (1994).

Elbadawi and Mwega (1998) have also estimated a saving function both for a LDCs group and for SSA using different specifications (a pooled estimation with regional dummies, fixed-effect-based estimation and estimations based on GMM-IV). In the study for all LDCs, income and its growth have positive and significant effects on saving rate when the pooled model is used; with the fixed-effect model, however, they becomes statistically insignificant. When the model is estimated using the SSA data only, the effect of per capita income is found to be important (Elbadawi and Mwega, 1998, p. 19). Cross-country evidence also suggests that per capita income has a positive effect on saving rate. According to Deaton's (1990) survey, the literature on household saving in LDCs has almost uniformly found that saving will increase with 'permanent income' (See Bhall 1979, 1980 for India; Musgrave for Latin America; Muellbauer 1982 for Sri Lanka; Berancours 1971 for Chile' and Paxson 1989 for Thailand, all cited in Deaton 1990). This does not mean, however, that there is a strong link between saving and growth; similarly the evidence for good inter-temporal allocation by households is also weak (Deaton, 1990, pp. 86-87).

b) Macroeconomic instability and uncertainty

Despite the earlier outlined theoretical arguments, the evidence regarding the effect of macro-economic instability on saving is inconclusive at best. Macro-economic instability and uncertainty is found to affect private saving rate in Schmidt-Hebbel's (1994) work on explaining Africa's growth performance (See Elbadawi and Mwega, 1998, p. 12). For a sample of LDCs Masson *et al* (1995) found saving being negatively correlated with macroeconomic instability and uncertainty when inflation rate is used as proxy, although Edwards' (1995) result using Latin American countries is inconclusive (See Elbadawi and Mwega, 1998, p. 12; Mwega, 1997, p. 207). In Elbadawi and Mwega's study for a sample of LDCs, inflation is found to have statically significant negative effect in a pooled model while being insignificant in the fixed-effect model.

The empirical evidence of the effect of macro-economic instability on saving rate is therefore mixed. In SSA there is evidence that macroeconomic stability lead to a rise in deposit rates and depositors react positively to this rise as observed in Ghana and Nigeria (as noted by Nissanke an Aryeetey 1998, cited in Aryeetey and Udry, 1999, p. 24). But Mwega's (1997) result show that inflation has no significant effect. Our result in section four below also confirms this result.

3.2. Open economy aspects: Terms of trade and foreign aid

A widely used open-economy based variable for explaining saving in developing countries is foreign aid. The aid-saving debate is a well-documented issue in the aid literature. It goes back to the classic works of Griffin and his associates. Critics of Chenery and Strout's (1966) two-gap model (Griffin 1970, Griffin and Enos 1970, Weisskopf 1972), argued that foreign capital inflow (aid in particular) can be a substitute for saving and a large fraction of it is used for increasing consumption. Similar negative effect of aid on saving is also reported in the literature (Fry 1978, 1980; Giovannini, 1985; Schmidt-Hebbel, Webb and Corsetti, 1992).

Papanek (1972), on the other hand, argued that these critics took association (of low saving and high foreign capital inflow for common exogenous reasons) for causation. Boweles (1987) attempted to investigate the causality question using the 'Granger Causality' test. His analysis suggests that casual relationships are not universal and even in countries where it holds it is found to depend on the structure of aid (say, whether from bilateral and multilateral sources or not).

Gupta (1975) has used a simultaneous equation model that allows for both the direct and indirect effects of aid and suggested that the negative effect of capital inflow is grossly overestimated and the total (indirect and direct effects) may also be positive. His estimation of the saving function, however, shows a negative coefficient both with aid and foreign capital inflow in general.

Gupta (1987), however, reported the most extreme result of positive effect of foreign inflow on saving (Gupta, 1987). Giovannini (1983) found that coefficients on foreign saving for developing countries have mixed signs and are insignificant in regression equations. In a rather careful study which attempted to clean biases in the data, Boone (1994) found that the marginal propensity to consume out of aid (MPC) for ninety-seven developing countries where aid accounts less than 15% of the GNP is found to be close to one. When 15 small island SSA countries, where aid accounts for more than 15% of GNP, are included in the sample the MPC drops to 0.45 – suggesting lack of fungibility in small economies (Boone, 1994). Levy (1988) and World Bank (1994), also reported that about 40% of foreign aid goes into consumption.

In the context of SSA, Elbadawi and Mwega's (1998) work shows that the foreign aid ratio significantly Granger-causes a reduction in saving rate (the effect from saving to aid being insignificant). For a sample of LDCs and using the pooled model they found negative and significant effect of aid on saving; this significant effect, however, disappeared when a fixed-effect model is fitted to the data. In SSA the Global Coalition for Africa (1993), claims a negative and significant effect of foreign aid on domestic saving. Summarizing such evidence Shmidt-Hebbel *et al* (1994) noted that the empirical results do widely vary depending on difference in sample, model specification, estimation method as well as the extent of fungibility of the foreign resources (Mwega, 1997, p. 208). This 'aid-saving debate' has been carried for nearly three decades and is still an unsettled issue (see White, 1992, for an excellent survey).

Another open-economy based variable widely used in the empirical literature is the terms of trade (ToT). The ToT, through what is called the Harberger (1950) and Lursen-Metzler (1950) effect is expected to have a positive effect on private saving, especially when the improvement in ToT is transitory. Some empirical studies confirmed this hypothesis (See Ostry and Reinhart (1992), Bevan *et al* (1992), and Azam (1995)). The widely cited work of Bevan *et al* (1992) on Kenya noted that 60% of proceeds from the Kenyan coffee boom in the mid-1970s is saved. This is largely related to the fact that such incomes are windfalls which result from fluctuation in commodity prices (Deaton 1990). In Elbadawi and Mwega's (1998) study a growth in

the ToT has a positive and significant effect on saving rate. However, in Masson *et al* (1995) the ToT is found to be statistically insignificant. An extreme result of negative ToT effect is reported in Mwega's (1997) study.

3.3 Macro-economic policy issues

a) Fiscal policy

Corbo and Schmidt-Hebbel (1991 cited in Mwega 1997), Mwega (1997) and Elbadawi and Mwega (1998) have used public saving as explanatory variable in their saving equation. For the sample of LDCs they found negative and statistically significant effect of public saving on private saving. On the other hand, government consumption is found to have a positive and significant effect in Mwega's (1997) and Elbadawi and Mwega's (1998) studies.

One way of augmenting public saving is through taxes. It is argued that this situation brings about what is called the Ricardian Equivalence. Most empirical studies for industrial countries reject the Ricardian equivalence. Studies for developing countries also dismiss it in its pure form and agree that public saving offsets some private saving (Haque and Monties 1989; Corbo and Schmidt-Hebble *et al* 1991; Easterly Rodgigues and Schmidt-Hebble *et al* 1994; Edwards 1995, all cited in Schmidt-Hebble *et al* (1996) and Masson et al (1995)). These results show that public saving is an effective tool in raising national saving (Schmidt-Hebble *et al,* 1996, p. 99).

A related fiscal issue is the impact of public investment on private investment and hence saving, and if saving and investment have positive relationship. Serven and Solimano (1993), have examined the impact of public investment on private investment in developing countries and reported a positive and significant correlation in the panel data of developing counties, as well as in separate studies of Latin America and East Asia. Similar positive effect is reported for Africa in Alemayehu (2002). What the empirical evidence suggests about the impact of public investment is that different types of public investment are likely to have different kinds of effect. Empirically, such examination shows that infrastructural investment generally has a positive impact while investment by public enterprise do compete with private investment (See Easterly and Rebelo (1993) cited in Schmidt-Hebble *et al* (1996)).

Another fiscal policy noted in the literature is the impact of taxes. As was noted earlier, in Kenya during the coffee boom of the mid 1970s, the government did not tax farmers and hence farmers converted most of the windfall into saving (Bevan et al

1987). As noted by Deaton (1990), however, what happened in Cote d'Ivorie is the opposite policy and all the wind-fall gains accrued to the government.

b) Financial and monetary policies

An important macro-policy variable widely cited in the literature (in particular in what is called the financial repression school of Mackinnon (1973) and Shaw (1973)) is the real interest rate. On their empirical study Gelb (1989), Fry (1988) and Mackinnon (1991) cited in Elbadawi and Mwega (1998)) found real interest rate being positively and significantly correlated with economic growth. This contrasts with Masson *et al's* (1995), and Giovannini's (1983, 1985), among others' finding that interest rate does not explain saving. Mwega (1997) has found similar result for SSA. The use of nominal or real interest rate does not change the result either (Deaton, 1990, p. 88).

Ogaki, Ostry and Reinhart (1995) find positive interest rate effects that vary with income but are still small. For a sample of LDCs, Elbadawi and Mwega (1998) found this variable having a positive and significant effect in the pooled model. It turned out to be insignificant in the fixed-effect model, however (while the spread become significant in the fixed effect model). The fixed-effect model using the data of SSA shows that the real interest rate had a positive and statistically significant effect on saving. Similar result of sensitivity of interest rate effect to model specification is reported by Blinder and Deaton (1985), cited in Deaton (1990). Other studies of saving in SSA have come up with inconclusive evidence of how interest rate influences saving (See Mwega et al 1990; Oshikoya 1992 and Azam 1996 all cited in Aryeetey and Udry 1999).

Giovannini (1985) examined the effect of expected real interest rate on consumption growth on eighteen developing countries. He noted some non-zero effect in five (India, Jamaica, Greece, Myanmar, and Turkey) and no effect in the other thirteen (Argentina, Brazil, Colombia, Indonesia, Kenya, Korea, Malaysia, Mexico, Philippines, Portugal, Singapore, Taiwan and Thailand).

Another financial variable widely used in the literature is the degree of financial depth which is usually proxied by M2 to GDP ratio. In Masson *et al* (1995) study which used cross-country regression of 64 developing countries, broad money is found to be statistically insignificant. In Elabadawi and Mwega's (1998) empirical study this variable is found to be non-significant for a sample of LDCs. Mwega (1997) also reported similar result for SSA. However, in Elabadawi and Mwega's (1998) study, it turned out to have significant positive effect when the fixed-effect model is used. Similar result is reported by Edwards (1995), both for developed and developing

countries (See also Schmidt-Hebbel *et al,* 1996, p. 103, and Mwega (1997)). On the other hand, Corbo and Schmidt-Hebbel (1991), Schmidt-Hebbel, Webb and Coosetti (1992), report negative effect of broad money on saving. Domestic credit, used as proxy for financial constraint, on the other hand is found to have significant negative effect (its potency increasing with the fixed-effect model).

The issue of credit is worth examining. It can be argued that if households are able to borrow, they may finance high return investment by borrowing rather than saving (See Birdsall *et al*, 1999). The interesting empirical question then is whether poor households are credit-constrained or not? The evidence in Deaton (1992) shows that 25 to 40% of rural households surveyed in the Cote d'Ivoire and Ghana had outstanding loans. Surveys carried out in Nigeria, Pakistan, Kenya and Tanzania indicate that 65 to 90% of households borrowed at some point during a twelve months period – most loans in these surveys being for one cropping season (Udry 1993, Alderman and Garcia 1993 and Kimuyu 1994, all cited in Birdsall *et al*, 1999). This evidence suggests that borrowing is a constraint and may limit high level of investment although it may encourage own saving. Gavin *et al* (1997), cited in Birdsall *et al*, (1999), actually found that for Latin America financial deregulation has reduced savings by eliminating credit constraint. This result is in sharp contrast with findings that noted borrowing constraints have significant and positive effect on private and national saving (See Jappelli and Pagaon (1994); Easterly, Rodriguez and Shcmidt-Hebbel 1994, all cited in Schmidt-Hebbel *et al,* 1996, p. 101). This result, however, depends on the variables used. Jappelli and Pagaon 1994 for instance found significant negative effect when loan-to-asset value ratio is used; Edwards (1995) showed negative, though not significant, effect of consumer credit on private saving (See Schmidt-Hebbel *et al,* 1996, p. 103). Mwega (1997) also reported that domestic credit has no significant coefficient both for his LDC sample and for SSA. Our result in section four confirms this latter finding. Birdsall *et al* (1999) further argued, the rise in saving rate in some Asian countries such as Korea and Taiwan (and in Kenya's Central province before the late 1950s) is largely attributed to an improvement in agricultural investment opportunities to which credit constrained households, according to them, would respond by increasing labor supply, lowering consumption and increasing saving (Birdsall *et al*, 1999, pp. 12-13).

3.4 Demographic factors

Many studies about domestic saving in LDCs emphasize the effect of demographic factors. For a sample of LDCs, Elbadawi and Mwega (1998) used two demographic variables: the young-age dependency ratio and urbanization. In the pooled model

both variables have negative and statistically significant effects. This result becomes insignificant, however, when the fixed effect model is used. Comparing their estimation for LDCs with that of SSA, they noted, for SSA the dependency ratio emerged as the most important and robust contributor to the performance of high performing Asian economies relative to SSA. The dependency ratio has negative contribution especially in middle income SSA (Mwega, 1997, p. 214; Elbadawi and Mwega, 1998, p. 19). Masson et al (1995) find that demographic factors have significant negative effect for all but middle income LDCs. Others (See Harrigan, 1995, cited in Mwega 1997) noted that empirical evidence is conflicting and has not resolved the issue. Mwega (1997) reported that adverse effect of high dependency ratio on private saving appears to have little support for the sample of his LDCs.

Deaton (1989) has shown that for developing countries actual age-composition profiles are not consistent with the predictions of life-cycle theories, thereby undermining the empirical importance of the mechanism. The weakness of the life-cycle model in developing countries is also noted by Collins (1991) based on a sample of ten developing countries (See Aryeetey and Udry, 1999)

3.5 Institutional issues

According to Birdsall *et al* (1999), in some Asian countries (in Korea in particular - as opposed, say, to Brazil), public policy – which contributed to high quality, strong demand for labor and low income inequality – generated powerful incentive for the poor to invest in their children and to work more to finance that investment (Birdsall *et al*, 1999, p. 14-15).

Similarly, institutional measures, such as financial liberalization, by easing credit constraint causes a temporary stimulus to consumption. Empirical evidence in countries that have liberalized, access to consumer credit generally supports this view (See Jappelli and Pagano 1989; Bayoumi 1993; Lehmussaari 1990 and Ostry and Levy 1994 cited in Masson *et al*, 1995).

Ikhide (1996, cited in Aryeetey and Udry 1999) argues that institutional and structural constraints to saving are the major reasons for weak saving mobilization in Africa. This is compounded, he argues, by low presence of formal institutions. Extension of commercial bank branches to rural areas in five African countries covered in his study turned out to have the strongest effect on savings. Nissanke and Aryeetey (1998 cited in Aryeetey and Udry 1999) have also suggested that the fragmented nature of financial

markets in Africa tend to increase the transaction cost of moving from one segment to the other and hence could act as a disincentive for saving mobilization in Africa.

One predominant institutional feature of saving in Africa is the importance of informal saving. Deaton (1989) suggested that saving in such set up is intended to smooth consumption. Aryeetey and Udry (1999) though agree with this notion emphasize that most studies of fund utilization by such association shows that the funds are usually spent on consumer durables and for providing working capital (Miracle *et al,* 1980; Aryeetey and Gckel, 1991; Chpeta and Mkandawire, 1991, all cited in Aryeetey and Udry 1999). This informal financial sector is important because the available evidence indicate that the value of formal sector financial assets is less than half of the financial assets held by households in Africa although financial asset in general is relatively a small component of the portfolio asset held by households (See Aryeetey and Udry, 1999, p. 13).

Another structural/institutional feature noted to be important in the African context is the transport cost. Aryeetey and Gockel (1991), cited in Aryeetey and Udry 1999) have note that an average travel time of over an hour is required to reach a bank in rural Northern Ghana and the cost to such travel is about the equivalent of the prevailing minimum wage. This suggests that the incentive to save could easily be offset by the transport cost as long as the cost exceeds the return on saving. Webster and Fdler (1995 cited in Aryeetey and Udry 1999) attributed the relatively low scale of a number of microfinance arrangements in West Africa in part to the spare population in many of the rural area they serve in the Sahel - indicating that the location where access to credit is provided is important. Having the theoretical and empirical evidence discussed thus far, we have attempted our version of an empirical model in the next section.

4. New empirical results

In this section, we have attempted to offer a new empirical result. We have attempted to fit a number of models to the cross section and time series African data of the 1990-1998. To carry out the cross section analysis the following familiar formulation is followed. We have specified the modes as equation [4.1] and in matrix form as in [4.1a],

$$Y_{it} = \alpha + \beta_2 X_{2it} + \beta_3 X_{3it} + ... + \beta_k X_{kit} + u_{it} \qquad \textbf{[4.1]}$$

$$y = \begin{bmatrix} i & X \end{bmatrix} \begin{bmatrix} \alpha \\ \beta \end{bmatrix} + u \qquad \textbf{[4.1a]}$$

Where:

$$y_i = \begin{bmatrix} Y_{i1} \\ . \\ . \\ Y_{im} \end{bmatrix} \quad X_i = \begin{bmatrix} X_{2i1} & X_{3i1} \ldots X_{ki1} \\ \ldots\ldots\ldots\ldots\ldots\ldots & \\ X_{2im} & X_{3im} \ldots X_{kim} \end{bmatrix} \quad u_i = \begin{bmatrix} u_{i1} \\ . \\ . \\ u_{im} \end{bmatrix}$$

Y_{it} is the dependent variables, saving, for unit i in period t , I- 1…p and t = 1..m
X_{jit} is the j_{th} explanatory variable for country (unit) i j= 2,…k
u is nX1 is the Guassian error term

We will consider p (p=39) units indexed by i =1,…p. and m (3) time periods indexed by t= 1,…m giving as n=mn sample points.

The estimated results of the model above are given in Tables 4.1 and 4.2. Having the basic model specified above a number of its variants are estimated by allowing different assumptions, such as common intercept and slope in Model I, intercept varying over the cross section units while maintaining common slope in Model II (fixed-effect model), and varying intercepts and common slope for all, with differential intercepts merged with the disturbance term, in model III (the random-effect model) (See Johnston 1984, Griffith et al 1993 and Baltagi 1995).

The modes are estimated using average values for 1990-92, 1993-95, 1996-98. Model I is also estimated for the year 1998 only (termed Model Ia). The data are from World Bank, African Development Indicators. Two versions of the estimated models are given in Table 4.1 and Table 4.2. The difference between the two tables being the inclusion (and exclusion) of the income variable in Table 4.1 (and Table 4.2). The income data is excluded in the version reported in Table 4.2 because (i) the estimated results are found to be sensitive when income is included, and second (ii) since the dependent variable, saving, is defined as ratio of income(GDP), the latter's inclusion as regressor gives spurious correlation. We opted for the model results reported in Table 4.2 although we offered Table 4.1 for completeness. We have complemented the cross-section result by estimating saving function for 10 individual African countries for which we have data the result of which is reported in Table 4.3.

Table 4.1: Cross section results of different models for SSA: Dependent variables gross domestic saving as % of GDP (including income as regressor)

Regressors	Model using average for 1990-92, 1993-95, 1996-98			Model I: Common Effect (Ia)
	Model I Common Effect	Model II Fixed Effect	Model III Random Effect (Error Component)	for 1998 only
Constant	-31.92		4.2508	2.717
	(-1.60)		(0.21)	(0.06)
AgeDepP	34.25	11.5855	10.8969	31.03
	(1.98)	0.45	(0.58)	(0.75)
CPII	0.0007	-0.0030	-0.0014	0.0038
	(0.36)	(-1.43)	(-0.86)	(1.84)
CrPrP	-0.0001	-6.26E-05	-7.32E-05	-0.0004
	(-1.00)	(-0.81)	(-0.99)	(-0.04)
CABP	0.6035	0.5612	0.5205	0.5544
	(5.18)	(3.33)	(4.23)	(1.21)
DISBP	0.3633	0.0166	0.1171	-0.7211
	(1.43)	(0.08)	(0.62)	(-1.53)
CgP	0.1150	0.3898	0.2185	-0.7569
	(0.64)	(1.18)	(0.99)	(-1.75)
TOTI	0.0360	-0.0664	-0.0537	-0.1249
	(1.00)	(-1.32)	(-1.19)	(-0.92)
M2GDPR	-0.0629	--0.5715	-0.2373	-0.0911
	(-0.60)	(-2.22)	(-1.77)	(-0.44)
Percapita income	0.0173	-0.0007	0.0142	0.0213
	(4.27)	(-0.07)	(3.25)	(1.56)
Percapita income^2	-1.95E-06	7.56E-08	-1.57E-06	-2.79E-06
	(-2.61)	(0.06)	(-2.10)	(-1.11)
Observation	96	96	96	25
Adjusted R^2	0.61	0.87	0.87	0.72
F-test	15.76	73.34		7.1
t-values in brackets				

Countries (39 Sub-Saharan Countries):
Angola Benin Botswana Burkina Faso Burundi Cameroon Cape Verde Central African Republic Chad Comoros Congo, Rep. Cote d'Ivoire Equatorial Guinea Ethiopia Gabon Gambia, The Ghana Guinea Guinea-Bissau Kenya Lesotho Madagascar Malawi Mali Mauritania Mauritius Mozambique Namibia Niger Nigeria Rwanda Senegal Sierra Leone Swaziland Tanzania Togo Uganda Zambia Zimbabwe

Variables Used:
AgeDep = Age Dependency Ration
CPII= Consumer Price Index (given as index)
CrPrP = Private Credit as percentage of total credit
CABp= Current Account Balance (deficit), net official capital grants, as percent of GDP
DisbL = Disbursement of loan, long term and short term including IMF in current US $
DisbP = Disbursement of loan, long term and short term including IMF, as % of GDP.
Cgp= General government consumption as % of GDP
Sp=Gross (total) Domestic Saving as % of GDP
TOTI= Terms of trade (1995=100)
M2GDPR= M2 to GDP Ration, in percent
Data Source: World Bank, African Database (2000).

The result (see Tables 4.1 to 4.3) shows that the age-dependency ratio is found to be negative and statistically significant in all versions of the model. When income is included in the model (although income has positive coefficient), the age-dependency variable offers counter-intuitive positive sign. This perhaps points to the problem of having the denominator of the dependent variable as regressor in the same model. Another important variable found is the current account balance which is found to have statistically significant positive effect on saving in all version of the model. Similarly the M2/GDP ratio is found to be statistically significant in model I and II through the coefficients are counter-intuitive. The other variables (inflation, terms of trade, credit, government consumption and disbursement of loans) are found to be statistically insignificant.

When the saving equation is estimated for each of the ten African countries, income (and per capita income) have statistically positive coefficient in 6 (and 4) of the ten countries. The terms of trade is found to have a statistically significant value only for Senegal and Algeria. Inflation is statistically significant in 3 of the 10 countries. It has, however, the counter-intuitive positive, statically significant, coefficient for Cameroon and Cote d Ivory (while being negative for Ethiopia). The current account balance is found to have a statistically significant coefficient in 5 of the 10 cases while the M2/GDP ratio is significant only in 2 of the 10 cases (being positive for Ghana and negative for Kenya).

Table 4.2: Cross section results of different models for SSA: Dependent variables gross domestic saving as % of GDP (without the income variable)

Regressors	Model using average for 1990-92, 1993-95, 1996-98			Model I: Common Effect (Ia)
	Model I Common Effect	Model II Fixed Effect	Model III Random Effect (Error Component)	for 1998 only
Constant	43.04226		44.14390	92.9490
	(2.33)		(2.36)	(2.47)
AgeDepP	-37.47064	11.66366	-24.46440	-51.9893
	(-2.52)	(0.47)	(-1.40)	(-1.49)
CPII	0.000359	-0.003002	-0.001631	0.0048
	(0.16)	(-1.52)	(-0.98)	(1.98)
CrPrP	-1.31E-05	-6.25E-05	-7.08E-05	0.0012
	-0.10	(-0.82)	(-0.94)	(.011)
CABP	0.870314	0.557953	0.656281	1.1715
	(6.84)	(3.54)	(5.25)	(2.92)
DISBP	0.201326	0.016168	0.061758	-0.8525
	(0.67)	(0.08)	(0.32)	(-1.58)
CgP	0.650234	0.384125	0.538551	-0.1437
	(3.54)	(1.22)	(2.39)	(-0.35)
TOTI	0.033795	-0.066716	-0.070022	-0.1664
	(0.48)	(-1.36)	(-1.51)	(-1.05)
M2GDPR	-0.205340	-0.573986	-0.271377	-0.2415
	(-1.72)	(-2.36)	(-1.80)	(-1.03)
Observation	96	96	96	25
Adjusted R^2	0.61	0.88	0.87	0.73
F-test	15.76	97.84		10.1
t-values in brackets				

Table 4.3: Time-series based results for sample of countries: Dependent variables gross domestic saving as % of GDP)

Variables	Cameroon		Cote d'Ivoire		Ethiopia		Ghana		Kenya		Malawi		Nigeria		Senegal	
	Coeffi-cients	t-values	Coeffi-cients	t-values	Coeffi-cients	t-values	Coeffi-cients	t-values	Coeffi-cients	t-value	Coeffi-cients	t-value	Coeffi-cients	t-values	Coeffi-cients	t-values
Constant			29.85	(2.4)*	0.34	(8.0)*			24.1	(5.02)*			13.31	(3.4)*		
GDP	-2.5E-10	(-0.25)	15.54	(2.3)*	3.0E-055	(4.3)*	1.17E-09	(1.08)	-5.8E-10	(-077)	1.8E-08	(-4.2)*	1.0E-10	(0.58)	3.8E-09	(2.7)*
GDP/Pc	0.010	(0.78)	-0.012	(-2.72)*	-0.002	(-4.12)	-0.02	(-1.07	0.03	(1.9)**	0.19	(4.1)*	0.02	(1.4)	-0.03	(-2.9)*
TOT	0.036	(1.06)	2.76	(0.52)			0.04	(1.39)	0.05	(1.11)	0.01	(0.43)	-0.08	-1.72@	0.23	(8.0)*
INF	20.23	(1.9)**	55.05	(3.54)*	-0.21	(-2.4)*							1.88	(0.33)	12.1	(1.9)
CBA	0.09	(0.39			0.10	(0.31)	0.42	(2.6)*	0.56	(3.1)*	0.29	(2.3)*	0.54	(3.1)*	1.17	(6.6)*
M2GDP	48.01	(1.5)	-14.55	(-0.28)	0.05	(0.38)	35.6	(3.13)*	-38.3	(-1.8)**	20.9	(1.0)	29.6	(0.95)	19.1	(1.1)
n	27 (70-97)		31		33		31 (67-97)		31 (67-97)		31 (67-97)		30 (68-97		30 (68-97	
R2	0.38		0.59			0.71		0.39		0.30		0.57	0.47		0.81	
F-value	4.17*		7.1*			10.8*		5.9*		3.6*		8.7	5.4*		26.5*	

Table 4.3 Continued

Variables	North African Sample			
	Algeria		Egypt	
	Coeffi-cients	t-values	Coeffi-cients	t-values
Constant	31.8	(7.0)*		
GDP	13.34	(1.9)**	-9.06E-10	(-2.52)*
GDP/Pc	0.005	(2.6)*	0.06	(2.43)*
TOT	12.16	(3.0)*	0.01	(0.81)
INF	-13.9	(-0.81)		
CBA	-0.35	(-1.32)		
M2GDP	-10.21	(-1.42)	3.24	(0.53)
n	28		32 (1966-97)	
R2	0.50		0.27	
F-value	3.3*		4.8*	

5. Conclusions and policy implications

Having reviewed the determinants of saving and its linkages to various economic aggregates, the purpose of this section is to highlight the main conclusions of the theoretical and empirical evidence, including our estimated results, and to summarize their policy implications. We have also attempted to review what we know and what we do not know about saving behavior in Sub-Saharan Africa. The following points seem to emerge form the analysis.

To begin with the saving data, both at macro-economic and microeconomic levels, suffers from measurement problems. This measurement problem arises because at the macroeconomic level saving is measured as a residual of a residual, and at a micro-economic level the concept of saving, particularly in a rural based economy is complex. Hence the reliability of the data that has been used to date is questionable. This problem suggests that even when the models are correctly specified and estimated the inferences drawn from them may not be that reliable. This may partly explain the inconclusive, mixed and at times contrasting evidence found about the determinants of saving. The policy implication of this is, as is already done in few countries in Africa, encouraging household surveys based on clearly defined concepts of income, consumption and saving. Doing this in the context of a diversified portfolio of assets as observed both at the rural and urban households will help clear some of the confusions.

There is a high correlation between growth and saving. However the causality issue (whether saving causes growth or the other way round) is not yet settled. But, in general most studies seem to suggest that income growth influences saving as indicated by the statistically significant growth coefficient in saving equations. For a sample of African countries, growth is found to be the most important variable that has a significant positive effect on saving.

There is also a strong correlation between investment and saving both in developed and developing countries. Growth is found to Granger-cause both saving and investment. Many studies also noted that investment is the most important determinant of growth. In particular, it was noted that traditional theories emphasize that saving augments growth at least until the economy reaches the steady state or in the short-run; and more recent theories further suggest that saving is required to maintain a certain rate of growth even beyond the steady state. In SSA the existing empirical evidence shows that the saving rate significantly Granger-causes investment.

For developing countries in general saving is negatively correlated with macroeconomic instability and uncertainty. In SSA not many studies have been carried out to examine the issue. And the few studies that have been carried out suggest that the impact of

macroeconomic instability on saving is inconclusive. The Ricardian equivalence is rejected both for developed and developing countries. This suggests that the presumption that households smooth out consumption over a long time horizon, as suggested by the conventional theories of consumption, is unlikely to hold. Although there is conclusive evidence that households in developing countries (particularly those in SSA) are credit constraint, the effect of such borrowing constraint on saving is inconclusive. The real interest is generally found to be insignificant in terms of explaining saving in developing countries. However, the result could depend on model specification and the level of income of countries. The finding in SSA strongly supports the conclusion that real interest rates have little or no impact on saving.

Financial reform may increase the incentives to save, but its overall effect is not clear. In addition to the interest rate aspect of this, the availability of credit argument has yet to get supporting evidence that it augments saving. Financial depth, proxied by M2/GDP ratio, is found to be inconclusive both for developing countries in general as well as for a sample of SSA countries.

In developing countries, including those in SSA countries open-economy related variables in particular, foreign aid is found to have a statistically significant negative effect on domestic saving, with only few contrasting results. For developing countries in general and for SSA countries in particular, Terms of Trade (ToT) is found to have a statistically significant positive effect on saving particularly in the short-run, but its long-term effect is ambiguous.

Demographic and institutional factors are found to be important. The dependency ratio, both in developing countries in general and in SSA countries in particular, is found to have a statistically significant negative effect. This underscores the importance of placing an appropriate population policy to enhance saving rates. Addressing institutional (through sensible policies such as formalization of the informal sector), and structural problems (such as infrastructural provision and efficient and relevant education policy) is also noted in the empirical literature as influencing saving mobilization.

To Sum-up, the following variables are empirically found to be the most important determinants of saving in developing countries including those in SSA. Saving is positively related to income level or growth, rate of investment, and short-run changes in terms of trade. On the other hand, more often than not it is negatively related to macroeconomic instability, foreign aid, and age-dependency ratio. We hope the points raised thus far help to chart an appropriate policy to raise the level of saving.

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Annex 1

Table 1: Gross domestic investment as share of GDP (%)

	1990	1991	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
[East and Southern Africa]	17.0	16.4	15.1	15.8	17.6	18.3	18.9	17.0	18.1	17.3	17.1	17.0
[North Africa]	28.4	26.6	25.6	23.4	22.9	22.8	20.6	22.6	25.9	25.8	24.3	24.4
[West Africa]	15.1	17.7	16.6	18.1	18.7	17.7	16.8	18.8	21.7	20.4	18.4	20.5
[All Africa]	19.7	19.2	17.2	16.6	17.3	17.1	19.3	18.0	16.8	17.9	21.6	21.0
[Sub-Saharan Africa]	16.4	16.8	15.6	16.4	17.9	18.2	18.3	17.5	19.2	18.3	17.5	18.1
[Sub-Saharan Africa excl. South Africa]	15.9	16.9	16.3	17.3	18.9	18.3	18.9	18.2	21.0	19.9	18.8	19.9

Source: World Bank (2004), World Bank African Database CD-ROM.

Table 2: Gross domestic savings as share of GDP (%)

	1990	1991	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
[East and Southern Africa]	18.4	16.5	14.3	15.2	16.6	16.3	17.6	14.7	14.3	15.1	17.3	17.0
[North Africa]	22.3	24.5	23.0	20.0	18.0	17.9	19.1	21.3	19.8	21.8	25.1	24.9
[West Africa]	18.3	18.3	15.1	14.2	18.1	17.6	23.8	20.3	17.1	16.6	24.1	21.6
[All Africa]	19.7	19.2	17.2	16.6	17.3	17.1	19.3	18.0	16.8	17.9	21.6	21.0
[Sub-Saharan Africa]	18.4	17.0	14.6	14.9	17.0	16.7	19.4	16.3	15.1	15.6	19.4	18.4
[Sub-Saharan Africa excl. South Africa]	15.5	13.9	11.4	11.5	14.9	14.7	19.8	15.1	13.2	13.5	20.1	17.9

Source: World Bank (2004), World Bank African Database CD-ROM.

Diversification Across Crops and Land in Small-Holder Agriculture in Ethiopia: The Case of Shewa Administrative Region[1]

Shukri Ahmed[2]

Abstract

The opportunities available for consumption smoothing can be expected to influence the ways in which rural households respond to income risks and thereby impact on the degree of diversification and adoption of risky activities. By assuming that diversification is a risk reduction mechanism, this paper deals with the diversification across crops and plots in Ethiopian small-holder agriculture. Specifically, the incidence and levels of land fragmentation and cereal crop diversification is analyzed in relation to the households' consumption security provided by liquid asset stocks (livestock). It is hypothesized that more endowments, specifically in terms of livestock assets will lead to less diversification (more specialization). A four year rotating panel data from the "Rural Integrated Household Survey Program" of the Ethiopian Central Statistical Authority (CSA) collected during 1988 to 1991 in Shewa, Ethiopia is employed. Contrary to the expectation of a safer strategy, land fragmentation was found to have a positive relationship with the level of asset ownership (though insignificant) and land holdings. This result, coupled with the positive relationship between population density and fragmentation, and the absence of land markets in rural Ethiopia, suggests that farmers were supply constrained. When the rural population is growing faster than the number of off-farm jobs, agriculture is the only career option for many. As more people try to make a living from a limited land base, pressure to divide and sub-divide farms and fields will increase. This calls for measures to ease barriers to land transactions which may then induce greater consolidation of plots thereby setting in motion a wide range of social and economic benefits. It also calls for enhancing the attempts being made to facilitate the introduction of appropriate technology, to create off-farm employment, and to curb

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population growth. On the other hand, it was found that, apart from climatic and agronomic factors, there is a systematic bias towards more crop diversification as the level of asset ownership and land holdings decline. Households with higher levels of livestock asset ownership and/or farm size have relatively lower levels of crop diversification. Thus, households with the ability to bear more risk (through their asset position) are found to have greater concentration on fewer cereal crops. The traditionally developed strategy of closely integrating crop and livestock enterprises to buffer against uncertainty in peasant agriculture is under threat due to the ever expanding cultivation of crops into grazing land, feed shortages, and overgrazing of existing pasture. This limits the possibility of poorer households entering into livestock rearing and those who have already done so may be forced to give it up.

Keywords: Ethiopia, Smallholder agriculture, Risk response, Liquid assets, Land fragmentation, Crop diversification

1. Introduction

Ethiopia, one of the poorest countries in the world with very low per capita income (100 USD per annum in 2003) and high population growth rate (2.7 percent in 2003), has an enormous food and nutrition problems at its forefront. Agriculture is the main economic activity contributing about 45 percent of GDP with some 80 percent of the population earning a living directly or indirectly from it. The very low levels of agricultural growth and productivity coupled with the prevalent high population growth are, therefore, at the crux of the country's economic malaise. Among other things, the overwhelming dependence on rainfed agriculture, increasingly reduced access to land, declining farm size, and lack of basic infrastructure for intensive land use have undermined agricultural growth and productivity.

Since 1993, Ethiopia has embarked on a development strategy based on agricultural development-led industrialization (ADLI) which made agricultural growth central to overall economic development aimed at creating more favorable conditions for significant productivity improvements in the agricultural sector in general and small-holder agriculture in particular. The liberalization of the economy, the large increase in modern input availability, the drive to build rural roads and storage facilities have already created a favorable response from farmers in terms of increased productivity and marketed output.

Appropriate government economic policies and institutions are essential in creating a climate conducive to tackling the above mentioned problems. However, ultimately it is

the response of peasant farmers to these policies which will make the difference. The basis of peasant households' decision-making should be a critical factor in the formulation of agricultural policy in developing countries. If farmers operate efficiently, implying that profits are maximized, then incomes can only be increased by introducing improved methods of production. On the other hand if farmers do not act efficiently, it may be desirable to reallocate resources within traditional agriculture. So far, knowledge about the behavior and choice of activities on small farms in Ethiopia, what governs these choices, their resource constraints and their potential for the overall development of agriculture is limited. Such information is not only indispensable for general assessment and improvement of the well-being of the low-income families, but it is also essential for designing efficient agricultural and rural development projects.

The objective of this paper is to analyse whether resource-induced risk aversion hampers crop specialisation and land consolidation, thus worsening the relative - and possibly absolute - income position of poorer households. Asset ownership, in terms of livestock, as an insurance mechanism in Ethiopian peasant economy is examined. By assuming that diversification is a risk reduction mechanism, the relation is tested between the degree of diversification across space and crops, and the level of endowments, particularly livestock ownership in Ethiopia's predominantly subsistence peasant households. Specifically, the incidence and levels of land fragmentation and cereal crop diversification is analyzed in relation to the households' consumption security provided by liquid asset stocks (livestock), controlling for the possible effects of idiosyncratic differences, the direct inputs available (land, oxen and family size), the experience of the household head (proxied in terms of age), and rainfall.

This paper is expected to contribute to the understanding of the behavior of small-holder rural households and the empirical analysis and results are expected to benefit the on-going discussions on Ethiopian rural land policy that have a critical bearing on economic development and poverty reduction. It also highlights the importance of livestock in Ethiopian agriculture not only through their direct benefits in providing milk, meat and draught power but also in influencing the production decision of farmers through their role of being a security and buffer if and when income shocks occur. In the absence of adequate credit and insurance markets this role is very essential in peasant agriculture. It is particularly important, at this juncture, to understand this role because of the ever increasing transformation of grazing land into crop cultivation. This means that it is only a small number of households with large landholdings which are able to keep livestock, thereby concentrating innovative activities to these households. Without proper policies and adequate credit facilities

this may result in the development of poverty traps with permanently low incomes for the majority of rural households.

The analysis in this paper is based on agricultural household survey data for the years 1988-1991during which interventionist policies were in operation. The centrally planned policy environment within which the farmers were operating is no longer functional due to the change in government in 1991. The liberalization of the economy and the emphasis in agricultural growth since the current Ethiopian Government took power is having some positive impact on the resources available to peasant households, hence affecting the activity choices they make. However, the predominantly subsistence nature of the Ethiopian peasant sector, with limited participation in the market, and the overwhelming dependence on livestock as both productive input and store of wealth implies that, despite the data being relatively old, results and conclusions from this study have contemporary policy implications.

2. Literature review[3]

Economic theory rests on and takes as its starting point the assumption that each economic subject tries to maximize his individual gain, and that profit motivation governs the behavior of producers. Theoretical constructions based upon this assumption have been more successful in explaining the behavior of the non-agricultural sector of economies than that of the agricultural. This is more so in backward economies like Ethiopia where risk looms large and factor and product markets are, at best, imperfect. Risk has long been recognized as an important feature of the environment facing the farmer. A decision is said to be risky when its precise outcome is not known at the time when the decision must be taken. In farm management, such decisions are pervasive and often inescapable. Crops are planted without perfect knowledge of the weather or markets, unpredictable economic and political events may occur, yet a decision must be taken. This situation is particularly burdensome to the peasant farmers who, with their rudimentary technology, are faced with non-existent or imperfect credit, insurance and other factor markets. In order to investigate the impact of risk on decision making, a distinction is usually made between: 1) farmers' attitudes towards risk taking, i.e. the possibility that they are unwilling to take risks and to invest in risky but profitable activities, causing an overall

[3] For an extended review and discussion see Stefan Dercon 2004, *Risk, Insurance, and Poverty: A Review.* In Stefan Dercon (ed.), *Insurance Against Poverty* Oxford University Press. And Marcel Fafchamps 1999, *Rural poverty, risk and development.* FAO Economic and Social Development Paper 144.

underinvestment in agricultural inputs and misallocation of resources and/or; 2) the farmers' inability to invest in risky activities because of limited risk-taking capacity, leading to an unequal distribution of benefits derived from profitable activities, such as new technology, among the rich and poor strata of rural households. The latter, known as farmers' behavior towards risk, is the subject of this paper.

The volatility of states of nature, particularly in predominantly rainfed subsistence agriculture, can result in fluctuations in the income process which in turn results in consumption fluctuations. Such income uncertainties results in considerable welfare costs and is particularly burdensome to peasant households in poor countries like Ethiopia who, with their rudimentary technology, are faced with non-existent or imperfect credit, insurance and other factor markets. The standard theoretical and empirical analysis of the cost of risk and instability (Newbery and Stiglitz 1981) assumes incomplete markets: credit and insurance markets are absent. Their absence can be explained by problems of asymmetric information between lender and borrower, causing incentive problems such as moral hazard and adverse selection, as well as by the covariance of risks in agricultural societies that limit the scope for risk trading. Similar problems limit the use of community-based informal insurance systems (Townsend 1994, Alderman and Paxson 1992).

In the absence of these markets, rural households devise strategies to cope with income uncertainty. A common strategy is to alter the income risk they face through diversifying their income sources and skewing the risk distribution by focusing on low-risk income sources. Risk-averse households are willing to trade lower incomes for lower variability of incomes. They can achieve lower variability in incomes in a variety of ways: by diversifying crops and plots, using traditional and familiar inputs, finding employment off-farm, and through migration to other rural areas, or to the town.

The extent to which a household might choose lower but less variable income activities depends on its preferences towards risk, on the technology available and its ability to smooth consumption, given a particular level of income. The opportunities available for consumption smoothing can be expected to influence the ways in which households respond to income risks and thereby impact on the degree of diversification and adoption of risky activities. Where households have adequate means of risk diffusion, risk averse attitudes are not necessarily translated into risk averse behavior in the choice of income earning activities. Empirical studies in India found that the wealth of the household increased the riskiness of the portfolio of activities to which productive assets were allocated (Rosenzweig and Binswanger 1993) and also that liquidity constraints affected the degree of diversification and the adoption of risky activities (Morduch 1990).

Diversification across crops and fields probably represents the single most important weapon in the farmer's management arsenal to combat crop income instability (Walker et al 1983). Crop diversification is an important feature in the agricultural systems of less developed countries, where futures and insurance markets are not well developed. Small farms diversify to reduce costs associated with income variability. In this sense, crop diversification may be thought of as a form of portfolio management with the objective of minimizing income variation or of avoiding an absolute minimum income threshold. In this context, factors affecting the degree of crop diversity might include the farmer's wealth, the share of income which the farmer derives from crops as opposed to alternative sources of income, and access to consumption smoothing facilities such as insurance, or formal or informal credit facilities.

These traditional risk management actions are effective if they impart stability to net crop income and at the same time do not greatly reduce mean crop income. If diversification across land (land fragmentation) affords risk protection, then it will be privately more difficult and socially less desirable to enact consolidation reforms. Similarly, if crop diversification is effective there would be less incentive for farmers to participate in government-sponsored crop insurance programs.

Livestock is the traditional liquid store of wealth in highland Ethiopia. Many studies in Ethiopia have shown that the accumulation and depletion of livestock is mainly used in mitigating the consumption consequences of income fluctuations (Dessalegn 1987, Webb *et al*. 1992, Mohammed 1994, Dagnew 1994). Ninety five percent of the households in this study have mixed crop and livestock production. This is true for much of the highland parts of Ethiopia. The role of livestock is closely related to crop production and household consumption, providing draught power, milk and farmyard manure, supplementing crop income, and more importantly as a safety net for bad years.

It is important to note at this point that keeping livestock itself can also be risky. Disease, death, or thefts of animals are common. This may affect the role of livestock as a buffer, particularly if returns are covariate with crop income. However, the probability that these losses occur simultaneously with crop damage is not likely to be high or frequent except for extreme events such as drought and severe floods.

To summarize, it follows from the above discussion that income risk combined with credit constraints provide incentives for consumption smoothing through the use of liquid savings (livestock in this case). And it also follows that households with more livestock are willing to take more risks because of their ability to withstand the

consequences of income shocks. The opportunities that are available for consumption smoothing can be expected to influence the ways in which households respond to income risk (Alderman and Paxon 1992). In short, liquidity constraints affect the degree of diversification and the adoption of risky activities. This study aims to test for the above proposition in the Ethiopian context. Livestock as a store of wealth are expected to encourage increased concentration and limit diversification.

Land fragmentation

Agricultural land fragmentation - also known as pulverization (Clout 1972), morcellment (de Vries 1974), parcellisation (Roche 1956) - is the type of land ownership pattern where "a single farm consists of numerous discrete parcels, often scattered over a wide area" (Binns 1950). In other words it exists when a number of non-contiguous plots (or "parcels") of land are farmed as a single production unit. The existence of fragmented landholdings is an important feature in less-developed agricultural systems. The alleged costs of fragmentation include increased traveling time between fields (hence higher transport costs for inputs and outputs), negative externalities (such as reduced scope for irrigation and soil conserving investments as well as the loss of land for boundaries and access routes), and greater potential for disputes between neighbors.

In Ethiopia, some empirical studies suggest that the level of fragmentation is quite high given the small size of land holdings (Fassil 1980, Yohannes 1989). In the years prior to the 1975 land reform, one of the root causes of fragmentation of agricultural land was inheritance. Often, land areas of different fertility levels or located in different villages were shared among brothers and sisters. It was also possible for a married couple to obtain inheritance of land from parents of both husband and wife. In the regions where tenancy prevailed, it was often imperative for a tenant to cultivate parcels of land wherever they were available.

The land reform in 1975 put an end to the transfer of land through sale, lease, inheritance (except to minors and widows), or other means. [4] There is no other way of acquiring it except through peasant associations. But there is evidence suggesting that the magnitude of fragmentation has increased since the land reform in 1975. As Dessalegn noted "plot consolidation was not a goal in many peasant associations, the goal rather was equality as conceived by peasants. The distribution of land and the

[4] A good deal of research was carried out on the land issue in Ethiopia. For a recent work and bibliography see Tesfaye Teklu 2003, *Rural Lands and Evolving Tenure Arrangements in Ethiopia: Issues, Evidence and Policies*. FSS Discussion Paper No. 10, Forum for Social Studies, Addis Ababa.

curtailment of the free movement of people due to the land reform accentuated the problem of subdivision and fragmentation" (Dessalegn 1984 P.31). Land distribution was made to accommodate the landless, newly married couples, and increase in family size. These have become the main causes of fragmentation since the land reform (Dessalegn, 1984; Fassil 1980, Mengistu 1986). The 1975 land reform program in Ethiopia gave the opportunity to the poor and underprivileged to acquire land. However, it also transferred all land to public ownership, prohibiting all forms of private ownership, thereby replacing landlords by the state. [5]

The factors affecting agricultural land fragmentation can be broadly classified into socio-cultural, economic (operational), physical and political (King and Burton, 1982). The socio-cultural factors include increasing population pressure, shortage of gainful non-farm employment, and inheritance institutions which lead to the division of the land property among heirs (Igbozurike, 1970). Other socio-cultural factors include competition between different land use interests, deterioration or lack of marketing opportunities (assuming the farmer was able and willing to raise a saleable surplus by working a larger area), and absence of an effective agricultural education and extension services (Igbozurike, 1970).

Natural and man made features such as broken topography, railroads, highways and irrigation channels contribute to agricultural land fragmentation. The operational factors include the switch from an extensive to intensive tillage. Land fragmentation is also accentuated by land distribution schemes, as was the case in Ethiopia in the study period, which take land from the large and average land owners and divide it out among the landless and small peasant producers.

The above explanations of the factors affecting land fragmentation can, more formally, be classified into two broad categories (McPherson 1982, Bently 1987). The first, consisting of what can be described as "supply-side" explanations, treats fragmentation as an exogenous imposition on farmers. The second views fragmentation as primarily a choice variable for farmers and can therefore be described as "demand-side" explanations. Supply-side explanations invariably conclude that fragmentation has adverse effects on agricultural production. Demand-side explanations presume that farmers will, given free choice, choose levels of

[5] The current constitution of the Federal Democratic Republic of Ethiopia (1995), guarantees free access of land to rural households who seek and are able to cultivate in their place of residence. Such access through the official channel is conditional on proof of permanent physical residence, ability to farm continuously, and meet administrative dues and obligations. Qualified farmers have open-ended usufruct rights to land. These use rights are inheritable but the constitution bars any other forms of land transfer including land rental.

fragmentation that are beneficial. Imperfections in factor or commodity markets play a key role in both types of arguments.

Supply-side explanations of land fragmentation

Several factors have been widely cited as causing or contributing to involuntary fragmentation. The most frequently cited are partible inheritance and population pressure resulting in land scarcity (Anthony *et al.* 1979, Binns 1950, Holmberg and Dobyns 1969, World Bank 1978). Many authors argue that partible inheritance logically leads to fragmentation when farmers desire to provide each of several heirs with land of similar quality. Likewise extreme land scarcity may lead to fragmentation as farmers in quest of additional land will tend to accept any available parcel of land within reasonable distance of their house (Farmer 1960).

As McCloskey (1975) points out, the above mentioned factors explain why a young farmer might begin with fragmented holding but they do not explain the persistence of fragmentation in the face of economic incentives for consolidation. Such persistence indicates significant imperfections in the land market and it is claimed that land markets themselves are highly fragmented, with few willing sellers (Lipton 1968, Sargent 1952). Dorner (1977) cites multiple interests over parcels as restricting the potential supply of land, because unanimous agreement to sell is difficult to achieve. McKinnon (1973) stresses incomplete credit markets and the resulting inability of many farmers to finance land acquisitions.

Another supply-side factor is the breakdown of common property systems under the pressure of population growth. This breakdown has led to increased fragmentation in, for example, Kenya (King 1977) and Eastern Nigeria (Udo 1965). Rapid population growth in South Asia has, through inheritance, caused decreasing farm size and more fragmentation (Singh 1979). A number of authors have demonstrated that fragmentation in certain areas is a consequence of egalitarian objectives on the part of the communal authority (Dahlman 1980, Georgescu-Roegen 1969, Grigg 1970, Quiggin 1988). State laws that restrict land transactions also limit possibilities for land consolidation. Finally, nature itself may limit the boundaries of arable parcels (for example, waterways and wastelands) so that expansion of farm size requires the acquisition of separate pieces of land.

The supply-side explanations, while plausible, are not sufficient to explain fragmentation in all the areas in which it is found. First, even where land markets afford farmers opportunities for consolidation, fragmentation persists (for example, Rwanda and Ghana [Blarel *et al.* 1992]). Second, fragmentation has developed in the absence of land scarcity (for example, in areas of

Kenya, Zambia, and The Gambia [McPherson 1982]). Third, ancestors continue to bestow heirs with scattered holdings, a practice that would seemingly be halted if fragmentation was largely detrimental (Douglass 1969, Leach 1968). The argument that partible inheritance is designed for equity reasons runs into difficulty when it is observed that subdivision and fragmentation levels are eventually "checked" after reaching specific levels (noted in India by Hopper 1965, in Mexico by Downing 1977, and in Sri Lanka by Leach 1968). These facts suggest that other factors may be important in explaining fragmentation.

Demand-side explanations of land fragmentation

Demand-side explanations presume that the private benefits of fragmentation exceed its private costs. That fragmentation might benefit farmers follows from the realization that land is not homogenous. Parcels differ with respect to soil type, water retention capability, slope, altitude, and agro-climatic location. Recognizing this, Buck (1964) and Johnson and Barlow (1954) were among the first to note that by operating parcels in different locations, farmers are able to reduce risk by reducing the variance of total output and hence final consumption. This is partly because the scattering of parcels reduces the risk of total loss from flood, drought, fire, and other perils and also because farmers can more efficiently diversify their cropping mixtures across different growing conditions.[6] Other risk-spreading mechanisms, such as insurance, storage, or credit, also reduce variations in household consumption. Therefore, fragmentation for risk reduction should persist only if these alternatives are either not available or are more costly (Charlesworth 1983, Fenoaltea 1976, Ilbery 1984, Walker et al. 1983).

Another explanation for fragmentation was developed by Fenoaltea (1976) for medieval England. He argued that because of transaction costs in labor markets, the scattering of parcels enabled farmers to better fulfill their seasonal labor requirements and consequently to obtain higher yields. If the labor market does not work at all, labor supply is fixed by household size, and the need for temporally spreading labor requirements is great. Even if labor markets exist, the costs of supervision may induce farmers to scatter parcels and supervise a small number of workers at a time, rather than watch over a large number of hired workers on a consolidated holding at peak periods. This approach is most effective when different types of land are suitable for different crops (hence, when fragmentation facilitates crop diversification)

[6] The realisation of these advantages may require that the fragmented farms are scattered over a wide area. Studies in several parts of Ethiopia have shown that more than a quarter of fragmented parcels lie at a distance of more than 5 km from the dwellings (Fassil 1980, Yibeltal 1994).

or when different parcels of land offer sufficient diversity in climatic conditions that the same crop can be staggered over a wider range of planting dates.

Commodity market failures may also cause fragmentation to have a positive impact on productivity. When such failures occur, a subsistence mode may be adopted in which several products are raised for household consumption, rather than purchased with the proceeds of crop sales. If different land types or eco-zones are suitable for cultivating different crops, then the required diversity can best be obtained from fragmented landholding (Netting 1972).

3. Empirical approach

3.1 The setting and the data

The area considered in this study is Shewa, in central Ethiopia, divided into five regions during the study period (1988-1991).[7] The cultivated area under food crops in Shewa, accounted for almost 23 percent of that of Ethiopia (CSA 1987) and on average, cereals accounted for more than 90 percent of total cultivated area under annual crops. *Teff*, maize, wheat, sorghum, barley, are the most important crops in the region. These five cereals accounted for over 80 percent of all crop area. Livestock is an important component of the region's agriculture with rural households maintaining a few heads of livestock along with their farming practices. In this system, livestock provides draught power for cultivation, a source of additional income and self insurance, and home consumption. Available reports on regional estimates of livestock in the mixed agricultural (excluding nomadic) areas show that Shewa province had the highest proportion of livestock of all categories. In all about 26 percent of cattle, 28 percent of sheep, 21 percent of goats, and 33 percent of beasts of burden were found in the province (CSA 1984).

The household data used for analysis in this study are from the Ethiopian Central Statistical Authority (CSA). The CSA launched the “Rural Integrated Household

[7] The regional divisions of Ethiopia underwent several changes. Until 1987 there were 14 provinces of which Shewa was one. In 1988, with the formation of the Peoples Democratic Republic of Ethiopia (PDRE) by the former Military Regime, the provinces were devolved into regions and autonomous regions but most of the sub-divisions within provinces were still intact. For example Shewa was divided into 5 regions (North Shewa, South Shewa, East Shewa, West Shewa and Central or Addis Ababa). Currently, with the formation of the Federal Democratic Republic of Ethiopia, the country is divided into nine ethnically-based administrative regions and 2 chartered cities. Hence, the former Shewa province is divided between four of these newly formed regions.

Survey Program" (RIHSP) in 1980 with the objective of conducting sample surveys on a wide range of subjects in rural areas. The major part of this survey was the integrated food and agricultural statistics, while as part of the program the Authority conducted monthly surveys of retail and producers' prices in the rural areas for both crops and livestock and produced quarterly average prices. More than 20,000 households across the country were interviewed every year. From each zone (*Awraja)* a number of Peasant Associations (PAs) were selected at random and used for several years). [8] In all some 860 PAs were included in the sample (of which 170 were in Shewa). In each PA 25 households were selected by simple random sampling to conduct the survey.

The rainfall data are from the National Meteorological Services Authority. The data are reported on a monthly basis and are available for major towns throughout the province. For each PA in this study, data from the nearest meteorological station are employed. The unavailability of data on the distribution of rainfall within a month, which could be crucial for agricultural production, and for each PA calls for some caution in interpreting the empirical results.

3.2 Econometric method used

Most of the panel data models are based on the assumption that each cross-sectional unit is observed for the same time periods. However, in the context of sampling survey data from a population of households, the assumption of observing each of them over the same period is unrealistic. An alternative to this is to use a 'rotating sample' scheme. Rotation of a sample of households over time may deliberately be pursued by the data-collecting agency because the agency can neither force nor persuade a randomly selected individual to report more than once or twice (depending on how time consuming the reporting is). Thus the main purpose of rotating is to reduce the degree of non-response. The rotation principle also improves the quality of data collected by maintaining the representativeness of the sample, especially when the structure of the population is continuously changing.

The structure of the sample selection of individuals in a rotating design is as follows: Let all individuals in the population be numbered consecutively. The sample in period 1 consists of N_1 individuals. In period 2, a fraction, $m_{e1}(\sum m_{e1} \sum N_1)$ of the sample in

[8] Farmers are organized in peasant associations (PAs) within an officially demarcated physical area that does not exceed 800-hectare. The PAs were the basis for administering land-use directives from the government, administering and conserving public property and settling land cases.

period 1 is replaced by m_{i2} new individuals from the population. Thus the sample size in period 2 is $N_2=N_2-m_{e1}+m_{i2}$. In period 3 another fraction of the sample in the previous period, m_{e2} individuals ($\sum m_{e2} \sum N_2$) are replaced by m_{i3} new individuals and so on. The procedure of dropping m_{et-1} individuals selected in the previous period and replacing them by m_{it} individuals from the population (in period t) is called a rotating sampling. The total number of observations and individuals observed are $\sum_{t=1} N_t$ and $N_1 + \sum_{t=2} m_{it}$, respectively.

The sampling design outlined above generates several special cases. Firstly, the completely overlapping sample ($m_{it}=m_{et}=0$) where the units are observed in every period (the regular panel data case). Secondly, partly overlapping sample ($\sum m_{it}, m_{et} \sum N_t$). Thirdly, the incomplete non-overlapping sample ($m_{it}=m_{et}=N_t$), where the units are observed only once and the whole sample is replaced after one period. The data used here are of the second type where it is a partly overlapping sample.

Statistical methods developed for analyzing complete panel data can be extended in a straightforward manner to analyze rotating samples if the error terms are assumed to be independently distributed across cross-sectional units (Biorn *et al.* 1982, Hsiao 1986, Kumbhakar 1992). Apart from the minor modifications, the estimation technique is basically of the same form as for the complete panel data (Baltaji 1995).[9] The econometric estimation was carried out using LIMDEP computer package (Greene 1991) which has developed special estimation programs for rotating or incomplete panel data sets (unbalanced panel data).

Panel data sets for economic research possess several major advantages over conventional cross-sectional or time-series data sets. They usually give a large number of data points, increasing the degrees of freedom and reducing the collinearity among explanatory variables - hence improving the efficiency of econometric estimates. The problem, when using panel data to estimate a relationship, is to specify a model that will adequately allow for differences in behavior over cross-sectional units as well as any differences in behavior over time for a given cross-sectional unit. One of the early uses of panel data in economics was in the context of estimating production functions where allowance had to be made for unobserved effects specific to each production unit. This is referred to as the 'fixed effects' model and is given by:

[9] Panel data estimation techniques and their extension to rotating or incomplete panel data sets are discussed in Hsiao (1986) and Baltaji (1995).

$$y_{it} = \alpha_i + \beta' X_{it} + U_{it} \qquad i = 1,2, \ldots, N \quad t = 1,2,\ldots, T \qquad \textbf{[3.1]}$$

Where y_{it} is the output and X_{it} the vectors of inputs for the i-th farm in the t-th period; α_i captures the farm specific unobserved inputs assumed to be constant over time, and U_{it} is the error term with mean zero, $E(U_{it}) = 0$, and constant variance, $E(U_{it}^2) = \sigma_u^2$.[10]

The next important step was the 'random effects' model where α_i in equation (3.1) are treated as random variables just like U_{it}. Denoting $\bar{y}_i = \frac{1}{T} \sum y_{it}$ and $\bar{y} = \frac{1}{N} \sum \bar{y}_i$ it is possible to decompose the total sum of squares $T_{yy} = \sum (y_{it} - \bar{y})^2$ into two components as:

$$T_{yy} = \sum (y_{it} - \bar{y})^2 = \sum (y_{it} - \bar{y}_i)^2 + \sum (\bar{y}_i - \bar{y})^2 = W_{yy} + B_{yy}$$

W_{yy} measures within group variation, and B_{yy} measures between group variation in y. Using similar decomposition for all the variances and covariances, it is possible to get the estimator of β from equation (3.1) as $\hat{\beta} = W_{xx}^{-1} W_{xy}$. This is known as the 'within group estimator'. Assuming $\alpha_i \approx$ iid $(0, \sigma_\alpha^2)$ and $U_{it} \approx$ iid $(0, \sigma^2)$, the generalized least squares estimator of β is found in the random effects model as:

$$\hat{\beta}_{GLS} = (W_{xx} + \theta B_{xx})^{-1} (W_{xy} + \theta B_{xy}) \qquad \textbf{[3.2]}$$

where $\theta = \sigma^2 / (\sigma^2 + T\sigma_\alpha^2)$.

This is the same as using the ordinary least squares estimation with the transformed data:

$$y_{it} - \lambda \bar{y}_i \text{ and } X_{it} - \lambda \bar{X}_i \quad \text{where} \quad \lambda = 1 - \sqrt{\theta} \qquad \textbf{[3.3]}$$

An inevitable question is, which should be used? From a purely practical standpoint, the fixed effects approach is costly in terms of degrees of freedom lost, and in a wide, longitudinal data set, the random effects model has some intuitive appeal. On the other hand, the fixed effects approach has one considerable virtue. There is no

[10] In LIMDEP parameters for fixed effects are estimated as follows: a) estimate β in (1) by regression of $(y_{it} - \bar{y}_{i.})$ on $(X_{it} - \bar{X}_{i.})$ (with no constant term), b) estimate α_i with $\bar{y}_i - b' \bar{X}_i$. Estimates of the standard errors of a_is are obtained by : $\text{Est.Var}[a_i] = s^2/T + ' \bar{X}_{i.}' \text{Est.Var}[b]' \bar{X}_{i.}$. For rotating or incomplete data sets subscript t and T are replaced by t_i and T_i respectively, denoting the first and the last periods during which the ith individual was observed.

justification for treating the individual effects as uncorrelated with the other regressors, as is assumed in the random effects model. The random effects treatment, therefore, may suffer from the inconsistency due to omitted variables (Green 1993). Furthermore, the fixed effects specification will control for the risk preferences of individual households.

The fixed effects specification was used in this paper after the Hauseman test rejected the random effects specification (under the null hypothesis that the random effects model is the correct specification, the hypothesis that the error term and the explanatory variables are uncorrelated was tested).

4. Descriptive statistics

4.1 Description of land fragmentation in the surveyed households

In measuring fragmentation, most researchers use, as proxies, the number of fields per household (Evenson and Binswanger 1984) or the number of fields per unit area (Bardhan 1973). Both of these measures are usually highly correlated with farm size. To measure fragmentation properly, one needs information on three attributes: 1) the number of non-contiguous fields in the holding, 2) the area of each field, and 3) the location of each field with reference to every other field in the same holding and to the village homestead (Walker and Ryan 1990).

Data are available on the first two attributes for the surveyed households. Information on the number of non-contiguous fields per holding and the size of each field can be readily combined into a land fragmentation index by relying on measures of economic concentration or statistical diversity. In measuring fragmentation, the land fragmentation index is primarily used in this study. It is defined as one minus the Simpson index of diversity (Patil and Taillie 1982). The index F is calculated for each household i for cropping year t and represents one minus the sum of the squared proportional area of each field:

$$F_{it} = 1 - \sum (W_{ijt})^2$$

Where W_{ijt} equals the proportional area of parcel j to gross cropped area planted by household i in year t. The index equals zero for a holding containing one field,

approaches one for an extremely fragmented holding and, unlike the measures cited earlier, is independent of farm size (Walker and Ryan 1990).

Farm size, livestock asset and fragmentation[11]

Farms in Shewa are small and often fragmented. There is, however, some variation in the average farm size between the regions of Shewa as shown in Table 4.1. The average size is smallest in South Shewa while largest in East Shewa. The fragmentation index is found to be positively and significantly correlated with farm size in all regions of Shewa, with the highest correlation in East Shewa (0.461), and the lowest in South Shewa (0.241). In all regions, a higher level of fragmentation is associated with lower average parcel sizes.

Table 4.1 Shewa: Fragmentation and characteristics of surveyed households (1988-1991)

Regions of Shewa	Population Density (person/ha)*	Mean				Number of Observation
		Farm Size (ha)	**Number of parcels**	**Fragmentation Index**	**House hold size**	
North	0.95	1.08	3.20	0.51	5.22	962
Central	0.94	1.63	3.16	0.52	5.44	1,311
West	1.18	1.27	2.74	0.43	5.41	1,250
South	2.40	0.80	2.05	0.37	5.75	1,564
East	0.87	1.80	3.30	0.50	5.40	1,282
All	**1.33**	**1.31**	**2.83**	**0.47**	**5.47**	**6,369**

*The population density is based on *Woreda* (district) level data

Table 4.2, below, indicates that about 50 percent of households in Shewa had less than one hectare, with an average of around 0.6 ha. Both the number of parcels and the fragmentation index suggest that fragmentation increases with farm size, the larger land holdings are the more fragmented they are.

[11] "Livestock Asset" represents the total monetary value of livestock (cattle, sheep, goats, donkeys, mules, horses and camels) owned by each household.

Table 4.2 Shewa: Farm size and levels of fragmentation in surveyed households (1988-1991)

Category of Farm Size	% of Households	Mean		
		Farm Size (ha)	Number of Parcels	Fragmentation Index
Small Farms (less than one ha)	48.2	0.56	2.08	0.37
Medium Farms (one to two ha)	32.3	1.43	3.11	0.53
Large Farms (greater than two ha)	19.5	2.93	4.22	0.60
All	**100.0**	**1.31**	**2.83**	**0.47**

The same is true for the different asset size categories as shown in Table 4.3. The average number of parcels and the fragmentation index steadily increase for the higher asset ownership category. The above results taken together indicate that the level of household endowments in terms of farm size and asset ownership, if at all, have a positive relationship with the level of fragmentation. This is contrary to the idea that fragmentation is demand driven in response to the risky environment within which they operate.

Table 4.3 Shewa: Livestock and fragmentation in surveyed households (1988-1991)

Category of Livestock Ownership	**% of Households**	**Mean**		
		Livestock Value (Birr)*	**Number of Parcels**	**Fragmentation Index**
Small Farms (less than 1000 Birr)	40.9	451	2.45	0.41
Medium Farms (1000 to 2000 Birr)	32.7	1,457	2.91	0.49
Large Farms (Greater than 2000 Birr)	26.4	3,085	3.32	0.52
All	**100.0**	**1,541**	**2.83**	**0.47**

* The official exchange rate of the Ethiopian currency "Birr" was fixed under the former military government at Birr 2.07:US $1. Following the change in government, the official rate was initially devalued in October 1992 and followed a gradual devaluation since. At the beginning of 2006 the rate stood at about Birr9: US$1.

Population density and fragmentation

Population growth generally leads to further land fragmentation in rural areas (Blarel *et al*. 1992). Based on the review in earlier sections, it can be expected that fragmentation in areas of low population density will be driven primarily by demand. Demand in these areas, while originating from imperfections in the credit, labor, or

food markets, will depend on the extent of soil and agro-climatic diversity within the community and hence on the possibilities of diversifying into different crops. In regions where land is scarce, however, supply-side factors could also come into play, especially where land markets, as in Ethiopia, are almost non-existent to permit desired levels of farm consolidation. Other things being equal, it is expected that fragmentation is greater in more highly populated areas.

The data confirm a positive correlation between population density and the fragmentation index for most of the regions (North Shewa (0.28), Central Shewa (0.29), South Shewa (0.21), East Shewa (0.21)). West Shewa was the exception with a negative correlation of (-0.124). However, taken together, the population density for all observations in Shewa is positively correlated with fragmentation (0.14). A positive relation between population density and fragmentation together with the absence of land markets suggests that fragmentation is a supply constraint.

Table 4.4 Shewa: Percentage distribution of households by measures of fragmentation (1988-1991)

Measure	**Regions of Shewa**					
Fragmentation Index	North	Central	West	South	East	All
0.0-0.2	13.0	12.0	15.2	25.6	14.2	16.6
0.2-0.6	7.2	7.3	12.5	15.3	6.9	10.2
0.4-0.6	37.3	39.1	40.3	39.6	36.7	38.7
0.6-0.8	39.3	38.4	29.5	19.5	36.3	31.6
0.8-1.0	3.2	3.2	2.5	0.0	5.9	3.0
Mean*	0.51	0.52	0.43	0.37	0.50	0.47
Median*	0.57	0.58	0.49	0.44	0.58	0.50
Number of Parcels						
1	14.2	16.2	18.0	37.1	15.7	21.3
2-3	54.1	54.5	57.0	53.6	50.6	54.0
4-5	21.5	21.4	17.6	8.3	21.6	17.5
6-7	7.0	5.4	5.2	0.8	9.8	5.3
8 or more	3.2	2.3	2.4	0.1	2.4	1.8
Mean*	3.20	3.16	2.74	2.05	3.30	2.83
Median*	3.00	3.00	2.00	2.00	3.00	2.00
(Range)*	(1-18)	(1-16)	(1-16)	(1-11)	(1-17)	(1-14)

*Expressed in relevant units, not percentages.

However, the evidence reported in Table 4.1 and Table 4.4 indicates that farm holdings in West Shewa and South Shewa are the least fragmented while densely

populated. The median number of parcels is 2.0 each, and the median value of the fragmentation index is 0.49 and 0.44 respectively. On the other hand, Table 4.1 shows that the average *Woreda* population density of these two regions is 1.18 and 2.4 persons per hectare, respectively, showing that they are the most densely populated regions of Shewa. Furthermore, Table 4.4 shows that more than 37 percent of farmers in South Shewa operate only one parcel, while 90.7 percent operate three or fewer parcels. The fragmentation index is correspondingly low.

If farm fragmentation in the highly populated regions is not purely driven by supply, then its prevalence may not reduce average productivity of land. Moreover, the effect on productivity will depend on the degree of heterogeneity in soil and agro-climatic conditions, and hence the possibilities for efficient crop diversification or the staggering of labor tasks.

4.2 Description of crop diversification in the surveyed households

The concept of crop diversity is illusory because it incorporates two distinct ideas. First, crop diversity is assumed to increase with the number of different crops. In the case of Ethiopia, farms may be expected to have large number of different crops, particularly in the homestead gardens. However, a second concept relates to the relative importance of each crop in production. A more diversified farm is one which does not depend too heavily on any single crop.

The measure of crop diversification which evaluates the number of crops produced and the evenness of production share across crops is entitled the *diversification index (C).* This index is similar to the fragmentation index used in the previous section, except in this case area under each crop is used as the numerator. It is defined as:

$$C = 1 - \sum ((a_i)^2/A^2)$$

where a_i = area devoted to a particular crop in a given year, and
A = total annual cultivated area (equal to the sum of all cropped areas in each season).

The diversification index varies between zero and one, with more diverse farms approaching one. Thus, for example, a farmer who produces only one crop would have an index value of zero, while the index of a farmer with an infinite number of crops, each covering the same area, would have an index value of one.

The average number of crops and level of diversification in all the regions of Shewa had a more or less similar pattern, ranging from 2.06 and 0.38 in Central Shewa to 2.75 and 0.45 in West Shewa respectively (Table 4.5). The reported correlation coefficients between crop diversification and fragmentation in Table 4.5 are all significant at the 1 percent level of significance. This may indicate that different parcels have different land types (slopes) or quality which are suitable for cultivating different crops. In particular, a household with more spatially separated fragments is more likely to have a higher level of diversification than a household with fewer parcels of land.

Table 4.5 Shewa: Percentage distribution of households by levels of crop diversification (1988-1991)

Measure	Regions of Shewa					All
Crop Diversification Index	**North**	**Central**	**West**	**South**	**East**	
0.0-0.2	17.5	19.8	11.8	14.0	15.1	15.5
0.2-0.6	11.4	8.2	8.7	10.8	11.4	10.1
0.4-0.6	56.4	57.0	55.3	51.6	55.8	55.0
0.6-0.8	13.6	14.4	22.2	22.7	17.0	18.4
0.8-1.0	1.0	0.5	2.1	0.9	0.7	1.0
Mean*	0.40	0.38	0.45	0.43	0.41	0.41
Median*	0.42	0.42	0.43	0.42	0.44	0.42
Number of Crops						
1	17.4	22.1	13.3	14.5	14.7	16.3
2-3	79.2	74.2	68.3	74.8	76.7	74.5
4-5	3.2	3.6	12.6	10.5	8.7	8.1
6 or more	0.0	0.0	5.8	0.2	0.0	1.0
Mean*	2.16	2.06	2.75	2.33	2.31	2.33
Median*	2.00	2.00	2.36	2.36	2.00	2.36
(Range)*	(1-4)	(1-5)	(1-8)	(1-6)	(1-5)	(1-8)
Correlation between Crop Diversification and Fragmentation	**0.49**	**0.39**	**0.37**	**0.45**	**0.53**	**0.41**

*Expressed in relevant units, not percentages.

Farm size, livestock asset ownership and crop diversification

Table 4.6 documents the percentage of households, number of crops and crop diversification index by farm size. The results suggest that both the number of crops and the index increase with increasing farm size though at a decreasing rate.

Table 4.6 Shewa: Farm size and levels of crop diversification (1988-1991)

Category of Farm Size	% of Households	Mean		
		Farm Size (ha)	Number of Crops	Crop Diversification Index
Small Farms (less than one ha)	48.2	0.56	2.07	0.37
Medium Farms (one to two ha)	32.3	1.43	2.51	0.46
Large Farms (greater than two ha)	19.5	2.93	2.75	0.49
All	**100.0**	**1.31**	**2.33**	**0.41**

On the other hand, in Table 4.7, the diversification index suggests that diversity declines after a certain level of livestock ownership. This result indicates that the share of area devoted to multiple crops is less evenly distributed at the higher level of ownership of livestock assets than at the lower ones. An explanation of this could be that farmers with a large enough asset ownership are more likely to grow some crops for the market, devoting more land to them, because they are less constrained by subsistence needs.

Table 4.7 Shewa: Livestock asset and crop diversification (1998-1991)

Category (Livestock Value)	% of Households	Mean		
		Livestock Value (Birr)	Number of Crops	Crop Diversification Index
Small Farms (less than 1000 Birr)	40.9	451	2.16	0.45
Medium Farms (1000 to 2000 Birr)	32.7	1,457	2.42	0.49
Large Farms (Greater than 2000 Birr)	26.4	3,085	2.43	0.38
All	**100.0**	**1,541**	**2.33**	**0.41**

5. Discussion of results

The estimating equations for land fragmentation and crop diversification are given below. For land fragmentation, the following linear fixed effects equation was used:[12]

[12] Logarithmic and semi-logarithmic type of functions were also estimated but the linear type was chosen because it had a better fit and all of the coefficients were more significant.

$$F_{it} = b_0 + b_1FARMSIZE_{it} + b_2OXEN_{it} + b_3ASSET_{it} + b_4AGE_{it} + b_5HHSIZE_{it} + b_6POPDEN_{kt} + \mathbf{b}_7V_i + \mathbf{b}_8T_t + e_{it} \quad \textbf{[5.1]}$$

where F_{it} is either the number of parcels or the fragmentation index of household i in year t; FARMSIZE is total farm size owned by a household (in hectares); OXEN is the number of oxen owned by a household; ASSET is the monetary value of livestock owned by each household (in '000 Birr); AGE is age of the household head; HHSIZE is the number of household members; POPDEN is population density for *Woreda* k in year t; V_i is a binary variable for each individual i; T_t is a binary variable for each year t; $b_0 – b_6$ are parameters and $\mathbf{b}_7$ and $\mathbf{b}_8$ are vectors of parameters to be estimated; and e_{it} is an error term.

Similarly, the determinants of crop diversification could be extended from the formulation given above. The main difference is the inclusion of the fragmentation index and the amount of sowing season rainfall as explanatory variables, and the exclusion of population density in the crop diversification equation. The inclusion of the fragmentation index is because the characteristics of different parcels may give rise to the cultivation of different crops. This gives rise to the problem of endogeniety because both crop diversification and land fragmentation are determined by the same household and village level variables. Therefore, the fitted value of fragmentation ($\hat{F}$) is used in the crop diversification equation which is given below:[13]

$$C_{it} = b_0 + b_1FARMSIZE_{it} + b_2OXEN_{it} + b_3ASSET_{it} + b_4AGE_{it} + b_5HHSIZE_{it} + b_6RF_{rt} + b_7\hat{F}_{it} + \mathbf{b}_8V_i + \mathbf{b}_9T_t + e_{it} \quad \textbf{[5.2]}$$

where C_{it} is either the number of crops or the diversification index of household i in year t; RF_{rt} is the amount of sowing season rainfall for *Woreda* r in year t; $\hat{F}_{it}$ is the fitted value of the fragmentation index. All others are defined above.

5.1 Explanatory variables and expected relationships:

- Farm size is the total operated area belonging to a household. It is one of the major factors differentiating households in terms of production. It is expected that households with larger farms are less diversified and specializing in limited

[13] The exclusion of population density was necessitated because the inclusion of the fitted value of fragmentation captures the effect of population pressure on crop diversity. The fitted value was derived without population density.

number of crops because of their ability to produce more than the families' needs which they can exchange for the products they did not produce.

- Oxen are the main source of traction power and therefore a significant input in agricultural production. This variable captures the technological differences that exist between the households. Therefore, households with more oxen are expected to have less diversified pattern of production.
- The asset variable is the monetary value (in thousand Birr) of all livestock owned by a household. This variable captures the insurance available to a household. Households with more asset value are expected to be less diversified because of their ability to absorb negative shocks if and when bad harvests are encountered.
- Family size is the total number of household members. It proxies the amount of labor available to a household. Due to lack of data no attempt was made to distinguish the consumer units from the work units. This creates a problem on the expected relationship between family size and diversification. If the dependency ratio is high, more food crops for household consumption are likely to dominate. And if the adult ratio is high, certain high value crops are likely to dominate.
- Age of the household head can be seen as a proxy for the experience and familiarity with some cultivation techniques. Older household heads are expected to be more conservative and risk averse. This means that age is expected to have a positive relationship with diversification.
- Population density is calculated at the *Woreda* level and proxies the pressure on land. It is expected that higher population density will encourage the sub-division of land and hence fragmentation.
- The amount of the sowing season rainfall is derived by simply adding the amount of rainfall for the months of April-July. These months encompass the sowing season for the different crops. One limitation of the rainfall variable is the lack of the rainfall distribution within a month. The rainfall distribution is important because most farmers change the land allocation to the different crops throughout the sowing season depending on the amount and distribution of rainfall. In any case, a higher amount of rainfall is expected to reduce the level of crop diversification because it means less risk.

5.2 Econometric results

Table 5.8 below presents the regression results for the fragmentation index and the number of parcels. The variation in fragmentation explained by the variables taken together is significant, as indicated by the F-statistics. However, none of the equations is very successful in explaining fragmentation by either measure as

indicated by adjusted R-squared of 0.16 and 0.19 (fixed effects) for the fragmentation index and the number of parcels respectively.

Although this is not uncommon for cross-section/panel data, the fixed effects specification did not improve much of the results indicating that unobserved household variables have little influence on the level of fragmentation. An example of such variables are managerial ability and risk preferences in a household. However, the joint significance test rejected the null hypothesis that the intercepts are homogeneous, thus rejecting the specification without fixed effects.

Table 5.8 Shewa: Determinants of land fragmentation (1988-1991)

Explanatory Variables	Dependent Variable			
	Fragmentation Index		Number of Parcels	
	without fixed effects	with fixed effects	without fixed effects	with fixed effects
FarmSize	0.09 (10.37)***	0.10 (8.21)***	0.18 (12.37)***	0.21 (11.89)***
Oxen	0.01 (1.41)	0.01 (1.37)	0.08 (1.47)	0.05 (1.21)
Livestock Asset	0.001 (0.98)	0.001 (1.28)	0.01 (1.08)	0.02 (1.56)
Age	- 0.004 (2.26)**	- 0.001 (3.39)***	- 0.003 (2.97)***	- 0.006 (5.23)***
Household Size	0.007 (1.85)*	0.005 (1.63)*	0.01 (1.69)*	0.03 (1.71)*
Population Density	0.07 (2.43)**	0.08 (3.39)***	0.15 (2.33)**	0.17 (4.68)***
T_2		-0.001 (0.23)		-0.02 (0.56)
T_3		0.002 (1.02)		0.01 (1.34)
T_4		0.001 (0.29)		0.01 (0.43)
Constant	0.34 (19.17)***	0.29 (10.13)***	1.99 (24.96)***	1.51 (9.28)***
AdjustedR^2	0.12	0.16	0.11	0.19
F-statistic	134.49***	156.98***	165.93***	172.14***
Joint-F Test	7.89***		9.45***	
N	6,369	6,369	6,369	6,369

Note: Figures in parentheses are t-statistics.
*** Significant at 1 percent ** significant at 5 percent * Significant at 10 percent
N = Number of observations

All considered variables, except for the age of the household head, have positive relationships with the level of fragmentation. The coefficients for farm size and population density are positive and statistically significant while for age it is negative and statistically significant. Population pressure is seen to be one of the main factors exacerbating fragmentation. On the other hand as farmers get older they tend to have less fragmented land which may indicate that their land is redistributed to new households or that younger farmers had no option but to accept more fragmented holdings. Household size is also significant (at 10 percent). This may indicate the relatively larger allocation of land (though fragmented) to larger families by the peasant associations. The other variables (oxen, and assets), though positive, are statistically insignificant. The time dummies are also insignificant indicating that the level of fragmentation did not change much in the years considered.

The positive significant effect related to farm size is unexpected as far as fragmentation is considered to be a risk management strategy and hence a choice variable. This result coupled with the insignificant effect of assets on the level of fragmentation indicates that households are supply constrained and have no control on the level of fragmentation they would like to have. The land holding and distribution pattern that was practiced during the study period may explain this result. Land was distributed in such a way that takes the different land types and qualities, in a peasant association, into consideration. This means that larger farm sizes can only be attained through additional parcels of land.

Table 5.9 presents the regression results for crop diversification. The introduction of fixed effects substantially raised the explanatory power of both equations (the adjusted R^2 rose to o.47 for the crop index and 0.38 for the number of crops equations). The joint-F test also rejected the homogeneity of the intrecept term. Most included variables are statistically significant and their level of significance rose with the fixed effects specification.

Significant positive effects can be observed on household size, and fragmentation for the crop index equation, while farm size is also positive and significant for the number of crops equation.[14] On the other hand, significant negative effects are observed for

[14] For comparison both equations were estimated without the fragmentation index as an explanatory variable. In both cases farm size became positive and significant, while assets became positive but not significant. The inclusion of the fragmentation index controls for cultivating different crops on different parcels of land due to differences of, say, soil quality.

farm size, number of oxen and the level of assets. The variables related to the age of the household head and amount of rainfall are not significant. However, as may be expected, the rainfall variable has negative effect on diversification.

Table 5.9 Shewa: Determinants of crop diversification (1988-1991)

Explanatory Variables	Dependent Variable			
	Crop Index		Number of Crops	
	without fixed effects	with fixed effects	without fixed effects	with fixed effects
Farm Size	-0.02	-0.01	0.21	0.25
	(2.61)**	(2.85)***	(3.72)***	(3.83)***
Oxen	-0.03	-0.02	-0.05	-0.05
	(3.88)***	(3.71)***	(2.15)**	(2.11)**
Livestock Asset	-0.05	-0.07	-0.02	-0.01
	(3.05)***	(3.22)***	(3.34)***	(3.58)***
Age	0.001	0.001	0.002	0.003
	(0.80)	(0.96)	(1.06)	(1.09)
Household Size	0.006	0.005	0.02	0.03
	(5.40)***	(5.02)***	(1.69)***	(3.78)***
Fragmentation	0.38	0.42	0.87	0.96
	(11.67)***	(12.39)***	(16.49)***	(17.26)***
Rainfall	-0.001	-0.001	-0.006	-0.005
	(1.23)	(1.33)	(1.07)	(1.27)
T_2		-0.004		0.01
		(1.32)		(0.98)
T_3		-0.01		0.02
		(1.72)*		(1.64)
T_4		-0.03		-0.01
		(2.05)**		(0.87)
Constant	0.15	0.11	1.24	1.07
	(10.19)***	(5.36)***	(20.64)***	(8.28)***
AdjustedR^2	0.22	0.47	0.17	0.38
F-statistic	152.95***	205.12***	116.17***	206.16***
Joint-F Test	11.52***		12.12***	
N	6,369	6,369	6,369	6,369

Note: Figures in parentheses are t-statistics.
*** Significant at 1 percent ** significant at 5 percent * Significant at 1 percent
N = Number of observations

It is interesting to note that both measures of crop diversification are positively and strongly influenced by the level of fragmentation. At the mean level of fragmentation, holdings have 48 percent more crop diversification than consolidated ones. The results on asset, farm size and oxen (in the crop index equation) are consistent with

the predictions: higher endowments discourage diversification (or encourage specialization) in crops. Even though larger farms tend to grow more crops, the proportion of area under the crops is less evenly distributed, meaning that certain crops get the lion's share.

The time dummies indicate an increasing and statistically significant decline in the crop diversification index, while the change in the number of crops is not significant. This means that farmers were less evenly allocating land to the different crops (allocating more land to some crops) in 1989-1991 compared to 1988 while not changing much the number of crops they were cultivating.

6. Conclusion

Results in this paper throw some light on land fragmentation and crop diversification, important features characterizing traditional farming systems. The results indicate that peasant households in Ethiopia produce many crops and cultivate fragmented holdings. The number of crops which farmers produce increases with farm size, but the crop diversification index declines with farm size because the distribution of land among crops becomes more skewed as farm size increases. This pattern implies that the larger the farms, the more land they allocate to fewer crops. Higher levels of livestock asset holdings are also associated with more specialization. By contrast, farmers with no or small level of assets allocate land more evenly, possibly to assure self-sufficiency first, because the risk of depending on and selling one crop to purchase another, where markets are poorly integrated, are greater than any gains from specialization. Rural households with limited sources of income and financial security will be forced to engage in higher degree of crop diversification.

The level of land fragmentation, on the other hand, increases with farm size and population density but does not seem to respond to the asset levels. These results, coupled with the non-existence of land markets in Ethiopia, imply that rural households are supply constrained. A higher level of fragmentation also leads to a more diversified cropping pattern. This can be beneficial for risk reduction, reducing peaks and troughs in labor demand and enhancing household food security and diversity. But the indication that fragmentation is a supply constraint implies that it may have adverse effects on productivity.

Measures are needed to reduce the costs of fragmentation on agricultural production. The ability of farmers to adjust optimally the extent of fragmentation (or consolidation)

of their holdings over time is limited due to the absence of land markets. When the rural population is growing faster than the number of off-farm jobs, agriculture is the only career option for many. As more people try to make a living from a limited land base, pressure to divide and sub-divide farms and fields will increase. This calls for measures to ease barriers to land transactions which may then induce greater consolidation of plots thereby setting in motion a wide range of social and economic benefits. It also calls for enhancing the attempts being made to facilitate the introduction of appropriate technology, to create off-farm employment, and to curb population growth.

The traditionally developed strategy of closely integrating crop and livestock enterprises to buffer against the uncertainty of rainfed crop production in the Ethiopian peasant agriculture is under threat due to the ever expanding cultivation of crops into grazing land, feed shortages, and overgrazing of existing pasture. This limits the possibility of poorer households entering into livestock rearing and those who have already done so may be forced to give it up. Countering the increasing severity of shortages in animal feed calls for strategic measures that should give due attention to the conservation of quality of those types of forage which grow on residual moisture. The promotion of deep rooting species would make forage available into the dry season without the need for supplementary irrigation. In the final analysis, an important means of reducing resource induced risk aversion is to increase the ability of farmers to take risks - for instance by improving credit facilities in rural areas, among other things.

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