Food Security, agricultural technology and policy – the case of maize in sub-Saharan Africa

Göran Djurfeldt and Rolf Larsson

Department of Sociology,

Lund University

*The authors are Professor and Senior Researcher at the Department of Sociology, Lund University Sweden. Rolf Larsson expired after tragic accident in October 2004.

**Contact phone +46 46 2228870 or +46 40 978890, fax +46 46 222 4794.

***Acknowledgements:

Data are drawn from a database collected in the course of the project ‘African food crisis – the relevance of Asian models’, carried out by scholars from Lund and Linköping Universities in collaboration with International Institute of Tropical Agriculture (IITA), Ibadan, Addis Ababa University, Nairobi University, Centre for Basic Research (CBR), Kampala, Sokoine Agricultural University, Morogoro, Centre for Social Research (CSR), University of Malawi, Zomba, Institute of Economic and Social Research, University of Zambia, Lusaka, Institute of Statistical Social and Economic Research (ISSER), Accra, Nigerian Institute of Social and Economic Research (NISER), Ibadan. The project is funded by Bank of Sweden Tercentenary Foundation and Sida. We are grateful to Michael Lipton and the participants several seminars at Lund University for constructive criticism.

Summary

This paper discusses food security and the African food crisis. By means of data from a survey of over 3000 farm households in eight sub-Saharan countries, the authors conclude that food security requires a broad integration of smallholders in the market. Subsistence orientation does not promote food security, while seed fertilizer technology does. Market integration of maize producers seems to be driven by the State, not by the market on its own. The diffusion of technology is stimulated by the market and is promoted by favourable macro policies, as reflected in policies of food import and in budget priorities.

Keywords:

Africa, Sub-Saharan Africa, food security, maize, government policies

Food Security, agricultural technology and policy – the case of maize in sub-Saharan Africa

This paper deals with the importance of agricultural policy and technology for farmers' food security and market integration. We draw on data recently collected in interviews with over 3000 farmers in eight sub-Saharan African countries. The results indicate that food production among African smallholders is highly responsive to increased use of seed fertilizer technology and to marketing opportunities for food crops. In the absence of a favourable macro environment promoting the use of inputs, however, the majority of farmers remain stuck in poverty and are barely able to meet their own food needs.

In the following we will use maize as an example to demonstrate the crucial role of the African state in providing the necessary macro conditions for realising the production potential inherent in increased technology adoption and increased commercialisation of staple production. This conclusion suggests that development options in African agriculture are different from those often surmised in the general development debate. Hence, we argue that policy makers in governments and among donors often work from assumptions that badly fit existing realities in African agriculture. We criticise a number of tendencies that recur in debates on agricultural development in sub-Saharan Africa. They are not internally consistent, and they seldom occur together, since they typically are associated with different types of actors.

(i) First, there is a tendency to overestimate the capacity of markets to drive agricultural development, including the diffusion of agricultural technology, while at the same time underestimating the capacity of African governments to do the same. This view is associated with authors of a neo-liberal leaning.

(ii) Second, there is a tendency to downplay the feasibility of ‘conventional’ technologies based on improved crop varieties and chemical fertiliser, while at the same time overestimating the impact and potential of alternative so called low input or pre-industrial technologies. One finds this view among many NGOs, especially those with a ‘green’ profile. It has had some influence also among donors, who promote so-called Low-External Input Agriculture (LEIA), as an alternative to what is sometimes dubbed ‘chemical’ agriculture, or conventional Green Revolution Technologies.

(iii) Third, there is tendency, which also is prevalent among actors in the NGO sector, i.e. to underestimate the importance of increased market integration for farmers’ food security. This is a bias that obviously is the opposite of the first one, in which markets are supposed to be the panacea for all social ills. By the proponents of this view, the market is seen to cause disease rather than to cure it.

It would be difficult to find somebody who would represent all views at the same time, although Madeley lies close to doing so (Madeley, 2002). He succeeds in being anti-State, anti-modernist in terms of agricultural technology and against markets, all at the same time. He could easily be dismissed where it not for the fact that his book, carrying a preface by the Director of the FAO, was prominently displayed at the FAO headquarters in Rome, during the summer 2002. This shows how well-spread the tendencies we are criticising in fact are, although they do not often appear all three at the same time and with the same person.

Our own position with regard to these issues can be summarised as being pro-State, in the sense that we think that States and governments need to drive agricultural development in matters relating to basic food security. To a large extent this is also a question of driving the development of agricultural markets, why there is no question of either the market or the State. Moreover, we think that pre-industrial farming technologies are inadequate to meet current and future challenges of poverty reduction and national food security. Finally, we believe that markets and market integration of smallholders are indispensable mechanisms for solving the African food crisis.[i]

Partly as a result of misdirected policies, stemming from assumptions such as those quoted above, agricultural growth in sub-Saharan Africa still lags behind that of population. As a result, food continues to be imported and poverty and food insecurity remain widespread. Few major donors and policy makers seriously consider domestic food markets as a potential engine of agricultural growth. This is strange given that these markets have been estimated to be worth 50 billion USD per year and that they are quickly growing. They are dwindling the markets for all other crops, new as well as traditional ones (Hazell, 2004). We will discuss the African food crisis by pointing at national import dependence as a major cause of food insecurity among farmers.

Ability to feed oneself from own production

This is a primarily a study of what we call *farmer's food security*. We define this as the ability of the farmer to feed herself and her family from own production of food grains or other staples. This is evidently only a part of the much larger and more complex concept of food security in general. At *national level*, food security concerns the provision of food for the non-agricultural (and largely urban) population as well. At *household* or *farm level*, food security can derive from sources other than own food production (e.g. production of so called export crops and/or from non-farm incomes). Given that the vast majority of African smallholders produce staple crops, farmer's food security often reduces to sufficient production of staples. As will be discussed, whether national food needs are met from imports or from domestic production has important bearings on food security at farm level.

Two corollaries of our definition of farmer's food security are that food insecure farmers who sell food grains, do so under distress, which is very common among African smallholders.

Another important corollary is that food secure farmers produce a surplus potentially for sale. Hence, our concept of farmers' food security is not in contradiction to but rather in correspondence with that of marketed surplus.

Our survey deals mainly with four crops: maize, cassava, sorghum and rice, complemented in Ethiopia by teff and wheat. Operationally we define farmers as food secure if they produce more than 220 kg of grain or grain equivalents per consumption unit (CU).[ii] We note that as many as about 40 % of the farmers in our sample fail to attain that level, even in the best of the three years recorded in the survey (2000-2002) (see Table 1), and consequently are net buyers of basic food items. The data was collected in 2002, which was a drought year in several of our sample countries; hence the level of food security that year was even lower than indicated by our "best year" figures.

Production per consumption unit (CU) is not only remarkably low, but also highly variable and skewed. When sorting the respondents from low to high producers, production for the lowest 10 % is negligible while the highest 10 % produce a surplus exceeding two to three times their own consumption needs. While the absolute level of production is rather modest also for this relatively high performing group, it is worth looking into what factors account for the variation in production and make some households attain food security while others do not.

(Table 1 about here)

Analysis to be made

The question posed in this paper links up with above paragraph: What determines farmers' ability to produce enough for their own subsistence and on the top of that a surplus for the market?

Tacking on to the discussion in the introduction, more specifically we ask what is the role of:

i) pre-industrial technologies, i.e. manuring, crop rotation, fallowing, intercropping etc.;

ii) industrial-scientific inputs, i.e. seed, fertiliser, pesticides etc. ;

iii) markets and

iv) agricultural policies.

This will be done by controlling for the effects of a number of socio-economic variables at household level:

v) gender, age, educational level, household and farm size, wealth status etc.

Next we will discuss some methodological issues. From then on we will look at some of the production determinants at farm level before moving on to the macro factors and the issue of agricultural policy. The paper will close with a short concluding discussion.

Methodology and sample

Aiming to increase our understanding of the African food crisis, and the potential for overcoming it, the survey questionnaire was designed with reliability as a priority. We tried to ask farmers what they can reasonably be expected to be able to answer without too gross margins of error. This in turn means that we have not attempted to estimate for example labour input in terms of days, or prices (or shadow prices) of inputs. Thus we cannot calculate a production function, in a strict sense of the term for these farms, neither can we estimate total surplus production in monetary terms. The fact that we have kept to physical quantities rather than monetary values also implies that we can only with difficulty aggregate from crop to farm level. This strategy prevents us from performing some conventional types of analysis, for example of labour productivity. Hopefully, the data allow instead for giving fairly reliable estimates of some down-to-earth variables, like farmer's food security.

The project and survey methodology was designed from the assumption that the potential for intensification in food crop production is more likely to be found in areas that meet certain conditions in terms of average annual rainfall and access to markets (infrastructure) than in places that are peripheral in this respect. At the continental level, the sample consisted of eight Anglophone countries in what may be labelled Africa's "maize and cassava belt". Despite a clear potential for an agriculture-led development in these countries, they all face, albeit to a varying extent, problems with low agricultural performance, rural poverty and recurrent food shortages.

The household sample consisted of more than 3,000 households in more than 100 villages in 20 regions (Table 2). Also in this case, the multistage sampling design took account of the variation in the agricultural potential of the regions in which the households resided. This is illustrated by the graph (below) showing "agricultural dynamism" as a continuum, where "low" depicts low productivity potential following the aridity and remoteness to markets (Graph 1). At the other extreme, "high" refers to areas where ecological endowments and marketing infrastructure have combined to create some of the most dynamic and productive environments in Africa (examples are Mt Kilimanjaro in Tanzania, parts of the Kenyan highlands, areas surrounding the main cities, etc.).

Our intention has been to capture the dynamism in regions that are "above average" in terms of ecological and market endowments but excluding the most extreme cases in this regard. While the households sampled are not representative of farmers in rural Africa as a whole, the encircled area can nevertheless be said to be typical of the type of environment in which a majority of the smallholder population in sub-Saharan Africa reside, yet be sufficiently diverse as to yield information about crucial conditions responsible for farmer performance.

We believe that by addressing issues of productivity constraints where an apparent potential for agricultural improvement exist, valuable insights into the causal relationships governing agricultural development in sub-Saharan Africa can be gained. As stated earlier, the survey dealt with four major staple crops (maize, cassava, sorghum, rice).

(Graph 1 about here)

The sampling was thus a multistage one:

Stage 1. **Countries** (purposive sample) – Ethiopia, Ghana, Kenya, Malawi, Nigeria, Tanzania, Uganda and Zambia.

Stage 2. **Agro-ecological/market regions** (purposive sample), total 20.

Stage 3. **Villages** (purposive sample), total 103.

Stage 4. **Farmer households** (random sample), total 3,097.

A summary of characteristics of the sample is given in Table 2.

(Table 2 about here)

The farm households

The sampled households can be said to be typical of African family farms, which despite the presence in some countries of state farms or private estates constitute the backbone of the agrarian structure in SSA. Typical of the interviewed households is their generally small area under cultivation, both when measured totally and per crop (Table 3). Production is partly for subsistence, partly for sale. Fields are worked by family members mainly, with women performing the bulk of farm labour using simple hand tools. Locally, fields are prepared by ox drawn ploughs or by tractors.

(Table 3 about here)

Operationalization

Our survey unit is the farm, but seen with the eyes of a statistician, the farm is a multi-level unit. We define farmer's food security at the level of the farm, or rather of the farm household, for which production of subsistence or surplus is an aggregate of the individual crops grown on the farm. Crops are grown with different technologies, with different degrees of market orientation and they tend to be differently affected by agricultural policies. Hence it is no easy matter to aggregate from the level of individual crops to that of the farm and the household. For this reason and on the basis of its paramount position as a staple food and cash crop in most of sub-Saharan Africa, we have chosen to concentrate on maize. Although it is difficult to talk about food security in maize terms alone and even more difficult to pinpoint a specific production level of maize below which farmers are food insecure, it seems fair to argue that the pattern for maize is indicative of the problematic food situation in sub-Saharan Africa in general, as can be seen in Table 1. This means that we are operationalising food security at crop level, as *the production of maize per consumption unit*.

The use of pre-industrial technologies is captured in two binary variables, the first one indicating the use of either or both of farm yard and green manure (cf. Graph 2). The graph indicates that small farmers are more likely to use this technology and that usage gradually tapers off for bigger holdings, most likely due to labour constraints, since this is a labour intensive practice. The other variable captures in a similar fashion the use of intercropping, fallowing and crop rotation. As can be seen from the graph, most farmers use these methods, but the line tapers off somewhat as farms become larger.

(Graph 2 about here)

Our data on the use of chemical fertiliser are fraught with reliability problems. Most farmers probably responded reliably to the question if they used fertilisers or not, but when asked about quantities used, estimates tended to be very imprecise. We have avoided this problem by simply using a binary variable: use or non-use of fertiliser. We have noted elsewhere (Larsson, 2005) that the use of industrial inputs is surprisingly high and in the graph the line starts out around forty per cent for the smallest holdings, reaching nearly 90 per cent for the biggest size-classes.

Studying the individual contribution of fertiliser, improved seeds and pesticides, Larsson has shown that they contribute positively to yields, with fertiliser ranking highest (Larsson, 2005). Note, however, that hybrids or improved seeds (HYVs) used alone only marginally improve yields. Unlike traditional varieties, HYVs respond very well to chemical fertiliser (and organic fertiliser) but yield little without these complementary inputs. For simplicity of analysis, we are using chemical fertiliser as a proxy for industrial inputs.

Use of animal or tractor ploughing is both an indicator of the scale of farm operations and a sign of more efficient land preparation that often goes together with higher rates of industrial inputs. Its use increases almost monotonically with the size of holding.

In accordance with the methodology explained earlier, the local research teams ranked the surveyed villages with respect to a number of market and agro-ecological criteria that corresponded with the dynamism continuum outlined in Graph 1. Since market and agro-ecological endowments tend to come together, probably because high-potential areas attract infrastructure investments, the relative rank of a village is an indication, albeit a crude one, of the market conditions facing farmers in that village. Based on the informed but *subjective* judgement of the local researchers, the surveyed villages were categorised as low, medium or good potential. In the subsequent analysis, we are comparing villages of medium and good potential with those of low potential.

Model 1: Technology use and commercialisation

We will start with a simple multiple regression model (Table 4), in which we introduce indicators of technology use and market conditions.[iii] The results tend to corroborate our contentions about the positive effects of industrial technologies and of market integration on farmers' food security, which we will discuss below.

Looking at the results in Table 4, we note that all β-factors except one of the indicators of pre-industrial inputs are statistically significant at below 0.01 level.

Looking first at the use of crop rotation, intercropping and fallowing, we note a negative correlation, significant at 5% level, with production of maize per consumption unit. This can be taken to mean that farmers using these methods tend to be less food secure. Farmers' using manure, on the other hand, tend to have higher food security than those who don't.

Regarding crop rotation, intercropping and fallowing, it is evident that in many parts of sub-Saharan Africa, these traditional methods are not sufficient on their own to ensure food security, even in a good year. Fallow periods are getting progressively shortened as population pressure increases and, for various reasons, the scarcity of land goes up. Too short a period of fallowing is not enough to restore the fertility of the soil, which thus deteriorates. While crop rotation as well as intercropping including nitrogen fixing crops could be a remedy to the exhaustion of the soil, our results indicate that on their own these measures are not adequate. Moreover, intercropped maize does not yield as much per unit of land, as mono-cropped maize. The whole idea of intercropping is to maximize the yield of the field as a whole, not the yield of a single crop in the mix.

(Table 4 about here)

Looking at the use of manure, on the other hand, we get a brighter view of the potential contribution of pre-industrial technology. However, the β-factor for manure is only a third of that for chemical fertilizer, indicating that there are limits to the effects of this method of fertilisation. Using farm-yard manure presupposes the ownership of livestock, or the availability of manure in the market (Boesen, 2000). Poor farmers are likely to have limited access to both. Also, applying compost and green manure often represent labour-intensive methods of increasing production. On this score too, many farmers are handicapped. The AIDS pandemic contributes to increasing the labour crisis in African agriculture and thus it limits the scope of labour intensive methods of intensification.

Tractor or oxen ploughing shows a completely different picture. It removes labour bottlenecks in land preparation, and as the high β-value indicates, farmers who use these techniques are much more likely to be food secure (and surplus producers too) than colleagues who do not (Binswanger and Pingali, 1987). Ownership of oxen moreover gives easier access to manure and thus indirectly promotes food security. Again, availability of traction is obviously constrained by farmers' resources and many of the poor are thus excluded from plough agriculture.

As expected, the use of industrial inputs apparently contributes positively to food security. Farmers who use chemical fertiliser (and certified seeds and pesticides) have substantially higher production than those who don't. Next to traction, this is what contributes most to explaining the variance in food security, outdistancing the use of manure, fallowing, crop rotation and intercropping.

Finally we see that market integration, as indicated by the two last 'dynamics' variables in Table 4, is significantly related to food security. Villages with good and medium agro-market potential have higher maize production and thus tend to have higher food security than those who have low potential and infrastructure. This would seem to strengthen a hypothesis that market integration promotes food security, rather than the other way round.

Checking the results against background variables

Based on Model 1, there appears to be a strong case in favour of policies that would increase farmers' market integration and the use of industrial inputs. Before the above results can be taken at face value, however, they need to be checked against underlying or spurious factors. In the model the detailed results of which are not included here, a couple of such control variables have been included. They are by no means exhaustive but nevertheless account for a great deal of the variation in production that derive from factors other than technology and market, such as differences in the resources commanded by the households. One obvious control variable at household level is *area under maize*, which quite expectedly heavily influences production. We have further included *maize specialisation* to control for the fact that farmers often tend specialise on one or a few crops, a circumstance that can be assumed to influence the production and income profile of the farm. Hence, farmers specialising in other crops than maize are less likely to be surplus producers of maize than the specialists in this crop, but this does not necessarily imply that they are less food secure. The same goes for households having their main sources of income from non-agricultural sources. Being a maize specialist, expressed here as a binary variable, is to have more than half of the farm area under maize and to have maize as the major income source. Also this variable is highly significant in the model.

Although not elaborated in the model, some further comments in relation to background variables are in place.[iv] As is well known, women perform much of the labour in African agriculture and many farms and households are also managed or headed by women.

Women farmers are discriminated against in a number of ways and differences in food security can at least partly be attributed to differences in gender (Larsson, 2005). The effect of gender on production, however, is mainly indirect and conditioned by farm size (and labour), meaning that as female farmers generally have less of these resources than men do, they tend to more frequently face problems of food security. Thus the lower production of female farmers seems to be more related to inequality in access to other resources than to technology as such.

In a similar fashion, wealth indicators such as “area under maize” reflect much of the general conditions under which the majority of farmers in SSA produce and sell staple crops. It is evident that wealthy farmers and farmers with large maize farms have higher chances of being surplus producers, probably because they can better afford industrial inputs and more easily manage the risks of commercial production. Consequently, as was demonstrated in Graph 2, the use of yield- and production-increasing technology (including traction facility) is partly correlated with and conditioned by farm size.

However, it is also evident from Model 1 that regardless of area, technology has an independent effect on production. As is the case for female headed households, discrimination against the poor is not related to the technology as such but lies elsewhere, presumably in the macro conditions currently circumscribing smallholder production in SSA. This finding is in line with arguments raised by Lipton (Lipton and Longhurst, 1989) and which goes against scores of authors who have claimed that green revolution technologies are anti-poor and anti-women (e.g. Shiva, 1991).

Although not specified in the table, also age was found to be significantly associated with production, however, less strongly than for the mentioned variables and in a non-linear manner. In general, production tends to increase up to around the age of 40 or 50, after which it tends to go down. This pattern is rather expected given the normal evolvement of the life cycle (see e.g. Netting, 1993, ch. 2). However, age may also reflect shifts in policy over the life span of the individuals in the sample. We will come back to this aspect when discussing the effects of market liberalisation and structural adjustment in the macro section of the paper.

Similarly, our results show that the household dependency ratio is negatively correlated with production per consumption unit, and positively with the use of hired labour. This lends support to the view that labour availability is a crucial factor for the prospects of improving food security at household level, at a given kind and level of technology. Or seen another way, at a given access to labour, technology is the one factor that can make a difference for food security. Particularly for households with high dependency ratios, improving food security from own production seems to hinge on a technology that substantially increases returns to labour.

In sum, Model 1 tells us that access to industrial input technology and living in a village with a higher potential for market integration appear to have a positive and independent effect on food security as expressed in higher maize production per consumption unit. At the same time, the model reveals some of the problematic conditions under which the majority of households in SSA operate. In the present situation the food secure and surplus producing households are the wealthier and large-scale farmers who can afford to use industrial inputs, hire labour in farm operations and manage the market and others risks associated with expanded production. For the majority, consisting of resource and labour constrained households, often female headed, the present situation of a highly insecure institutional and market environment implies substantial risks in farming. This brings us to examine some of the macro dimensions of maize production in SSA.

Macro-level factors, dynamics in the maize sector

We have yet to introduce the factor of policy in the model in order to test the hypothesis about the relevance of agricultural policies to food security, as discussed in the introduction. To begin with we will point to some evidence of dynamism in the African maize sector based on a combination of survey data and qualitative macro level data collected in the course of fieldwork (Holmén, 2005).

We depart from the answers to a retrospective question asked in the survey: ‘Have your yields of maize increased or decreased since you started your farm?’ Aggregating the answers to this question to country level, we get an indicator of farm dynamics in each country. The higher the average rate of this variable, the more dynamic the national maize sector, we contend.

Despite the fact that our samples cannot be claimed to be nationally representative, yield and production estimates do not deviate much from national data, as Larsson has shown (Larsson, 2005). With the risk of over-generalising, we take the rates of intensification to roughly reflect those of the country as a whole. Admittedly, the long time span reflected in this question makes it a crude instrument for drawing conclusions on more recent policies. Nevertheless, as can be seen from Table 5, the way the countries are ranked does make some sense with respect to the developments in these countries over the last decade or so.

(Table 5 about here)

Of the eight countries surveyed, Nigeria stands out as quite dynamic and has an interesting agricultural policy, promoting national self-sufficiency in maize and other staples (Akande, 2005). Ghana ranks second, again not very surprising given the fairly good performance of the country since the inception of its Structural Adjustment Programme in 1983 (Seini and Nyanteng, 2005). Similarly, since the fall of the Derg Ethiopia has run an agricultural development programme, almost a copy cat of the Indian programme from the mid-60s. Its positive development abruptly ended with the drought in 2002, the year when our data were collected. Our figures from a village in the country’s maize belt reflect this positive development. It is too early, however, to tell if the positive development has resumed after

2002, although production figures seem promising (Mulat and Teketel, 2003, Mosley, 2003, Dercon, 2004).

At the lower end of the scale is Malawi, with its rampant poverty and galloping AIDS pandemic. Malawi's attempt at agricultural development through the starter pack programme seems to have had little impact, and the programme could not be sustained (Holmén, 2005). Zambia, over the last decades, has had a 'stop-and-go liberalisation' and erratic agrarian policies, making ground for sporadic jumps in production (Saasa, 2003). When we made our survey, most peasants claimed to have stagnated in terms of yields and area.

Kenya and Tanzania, finally, are middling in terms of their maize dynamics. In the case of Kenya, its maize revolution stagnated already in the 1970s and the dynamism in the national farm sector obviously lies elsewhere (Kosura and Karugia, 2005). Its southern neighbor Tanzania also ranks low in dynamism. Although it is not drawn into export of horti- and floriculture to the same extent as Kenya, farm dynamics in Tanzania seems to have occurred mainly outside the maize sector (Isinika *et al.*, 2005).

Obviously, it is a far shot from demonstrating that, going by our sample data, there are national differences in farm dynamics, to establishing that these are due to differences in agricultural policies in the countries concerned. In the following, however, we will attempt to do exactly that.

Macro-level factors promoting food security

Contending that macro-level factors impact on the chances for farmers to be food secure, it remains to show what these factors are. As discussed in the introduction, our hypothesis is that the agricultural policy of the state matters more than what is commonly assumed. We will proceed to demonstrate this by substituting our estimate of national maize sector dynamics with three indicators of policy.

The first indicator is the percentage of government expenditure going to agriculture. The second one is import dependence, or more precisely maize imports as a percentage of total food imports. This variable is causally correlated to production in two ways: on the one hand, low domestic production would promote imports (and possibly also food aid), but on the other hand, high imports (as well as food aid) may also deflate domestic maize prices, thus being a disincentive to production. We argue that the latter is currently important: Surplus maize is dumped on world markets, primarily by the US, keeping international prices at rock bottom (Oxfam, 2004). For many governments there is a permanent temptation to import grain, instead of producing it domestically, especially since many donors are urging them to do so.

We try to separate the effects of production on imports, from the causal relation running in the other direction, and which we are primarily interested in, by taking import dependence lagged, as the average for 1995 to 1999 (see the below table).

(Table 5 about here).

Admittedly, this is a crude way of controlling for the influence of production on imports, but it seems to be the only way of doing it.

In the case of the share of government expenditure going to agriculture, we have also tried to use lagged data (cf. note vii), on the basis that changes in policy will be take effect some time after implementation.

A third macro variable used in the model below is the Gross National Income per capita (see Table 5 above). We use the GNI per capita to control for the level of economic development, which we expect to be related to the development of agriculture. The higher this level, the higher the level of specialisation of farmers and the lower we expect the subsistence production of grain on the part of non-grain growers. This implies that we expect a negative correlation between GNI and our dependent variable. With Mellor's famous dictum: "The faster agriculture grows, the faster its share of gross national production declines" (Mellor, 1995) and, we can add, *the less we expect its share of government budgets*.[v] As can be seen from Table 6 (Model 2), data support this. Moreover, we expect the share of government expenditure to be negatively related to Gross National Income, which is another reason for statistically controlling for its influence.

In the model, both import dependency and budget allocation to agriculture have a significant impact on production. In line with our argument above, it seems that a policy of food importation implies increased food insecurity, most likely by having a discouraging effect on production for the domestic market. In contrast, the higher the budget allocation to the agricultural sector, the higher the production per consumption unit. Unfortunately, we lack data about the details of agricultural funding. With such data, we would have been able to see what investments have been most effective in terms of food security. In a general sense, government spending affects areas such as agricultural research and extension, agricultural credit, infrastructure investments etc.

Finally, in the model we have brought in a policy variable that touches on the policy content and which has been the subject of much debate over the past decades, i.e. structural adjustment (SAP) and market liberalisation. In most of the countries included in the sample, market liberalisation gained momentum in the mid-1980s. Also this variable is positively related to production, meaning that households established in the period coinciding with or after the inception of liberalisation tend to have a higher production than those formed in the pre-SAP period. When controlling for age (not in the model), the effect of market liberalisation is reduced, suggesting that part of it actually is a reflection of younger households' higher ambitions and working capacity. Even so, SAP and liberalisation remains significant (at 0.05 level) suggesting a small but traceable impact on production from the various measures taken by governments (and donors) under the common label "market liberalisation".[vi]

(Table 6 about here)

Looking at the technology variables in the model, we note that the two indices of pre-industrial input remain either statistically insignificant or negative. This implies that government priorities seem unrelated to the use of pre-industrial technologies. To the extent that donors and NGOs have given weight to such technologies and inputs during the 90s, the effect is not visible in our data. On the other hand, government priorities seem to affect the adoption of industrial inputs (including traction) and, as already mentioned, market-integration of maize farmers. This is indicated by the *variance inflation factors* (VIF)

As can be seen in the table, high VIFs signal problems of collinearity between budget allocation and import dependence. This is easily controlled by removing either of the two variables. When we do, the remaining variable remains statistically significant. These tabulations, which are not reproduced here, indicate that the two variables, i.e. budget allocation and import dependency respectively, carry about the same weight as determinants of food security.

From the VIF-factors we can also see that there is a certain but harmless multicollinearity between the two policy indicators, on the one hand, and on the other, (i) agricultural potential, (ii) GNI per capita, (iii) area under maize, (iv) use of traction in ploughing, (v) use or non-use of manure and (vi) use of industrial inputs. Leaving the second factor aside, it is tempting to interpret the moderately inflated VIF-factors as indicating the routes through which policy impacts on production. This would indicate that, first of all, macro policies have more impact in well-endowed areas. Thus they stimulate the market integration of farmers by steering infrastructural investments to high- and medium-potential areas. Furthermore, they seem to be of more benefit to big farmers than to small ones. Moreover, they promote the use of traction possibly through the price of diesel and maybe also of machinery. By stimulating the use of industrial inputs finally, they put a disincentive on the (labour-intensive) use of manure, which may explain why the β-factor for this variable is not statistically significant in this model.

Conclusions

In the introduction to this paper we criticised three contradictory views tending to recur in the debate on food security and agricultural development in sub-Saharan Africa. To recapitulate they were: (i) the tendency to overestimate the capacity of markets on their own to drive agricultural development and to underestimate the capacity of African states to do so; (ii) the downplaying of the potential of conventional seed and fertiliser technology; and (iii) the underestimation of increased market integration of food crop farmers for their food security, (i.e. for what we call farmer's food security).

We can use Model 2 in Table 6 above to simulate a number of scenarios illuminating the implications of our findings. Starting with technology, our model implies:

1) With preindustrial inputs and no industrial ones, and with all other variables at the mean, a mean-sized farm is expected to produce about 140 kg of maize per CU. On the other hand, with industrial inputs and manure, and with all other variables at the mean, a farm is expected to produce 340 kg per CU, i.e. almost 2.5 times as much. This demonstrates the potential of 'conventional' industrial-input agriculture, as it is already practised by many African farmers. If food security were a human right, which unfortunately it is not, it appears more than negligent on the part of governments and donors not to avail themselves of the potentials of this technology.

2) It is illuminating to calculate predicted maize production per consumption unit, controlling for size of area:

(Graph 3 about here)

As can be seen from the graph, making industrial inputs available to smallholders is expected to have a dramatic effect on their food security, lifting all but the very smallest ones above the 220 kg of maize per consumption unit that we use as a reference. In fact, our results indicate that a maize area of 0.30 hectares would be enough to provide for farmers' food security, should the farmers make full use of industrial inputs.

The differences between the hypothetical curves in Graph 3 encapsulate much of the current dilemma of food crop production in SSA. Our data support the view that SAP and market liberalisation have had a positive effect on overall production, probably by improving conditions for private trade and transportation etc., changes that were noted by the surveyed farmers as an increasing number of market outlets.

Nevertheless, it is also evident that it is foremost the wealthy and large-scale farmers that have been able to take advantage of the improved market opportunities that have emerged in the wake of SAP. For the majority of smallholders, production with industrial inputs remains a risky undertaking with a non-attractive relationship between input and output prices, lack of foreseeable markets, non-availability of credit and poor negotiating capacity vis-à-vis traders of inputs and grain.

Despite assurances of being pro-poor and pro-food oriented, past policies have been neither. The large gap in for example yields between large and small holdings, stemming from their contrasting application of industrial inputs, is illustrative of this point (cf. Larsson, 2005).

3) Farming in an area which is well endowed in terms of its agro-ecological and market potential (which tend to go together) has obvious effects on farmers' food security. However, with the current state of technology and policy environment the differences are not dramatic (compare row 1 in the table below). Comparing the current state of affairs with a scenario

where, in low potential areas, no farmers use industrial inputs, where, in medium potential areas, 50 % of farmers do so and where all farmers in high areas use industrial inputs, we get an alternative scenario.

(Table 7 about here)

In the alternative scenario, the medium potential areas would produce enough to make farmers food secure in maize, while the farmers in high potential areas would get a sizeable marketable surplus. Farmers in low potential areas would be less food secure than in the current scenario, because the alternative scenario assumes an unrealistically low use of industrial inputs. Overall maize production under this scenario would be around 220 kg, i.e. enough to cover the deficit in the low potential areas. Thus, the maize surplus in the high potential areas could be the basis for a linkage with the low potential ones– a linkage potentially benefiting both types of areas. A linkage of that type has been shown to be important in the Asian Green Revolution (for an overview see Mellor 1999 and for a critique, see Hart, 1998).

There is an obvious lack of realism in the above, since we are only accounting for maize. Our farmers already produce a sizeable marketable surplus of around 346 – 220 ≅ 130 kg of other grain and tubers. Under the alternative scenario, the marketable surplus deriving from increased maize production would increase to around 448 – 220 ≅ 230 kg. While the current surplus is enough to feed a non-farming population of slightly half the size of the farming one, under the alternative scenario our farmers would be able to feed a non-farming population slightly bigger than the farming one. In other words, our alternative scenario indicates that the sub-Saharan maize sector has the potential to feed also the urban population.

4) Looking at the policy environment, finally, we can compare a scenario where all countries have as high an import dependence as Kenya and as low a budget allocation as Ghana.

Assuming all other variables at their means, under this 'worst scenario', the predicted maize production per consumption unit would be 134 kg. The most favourable scenario would be to take the low import dependence of Nigeria and the high budget allocations of Ethiopia. Under such favourable circumstances, the predicted maize production would be 490 kg per CU, i.e. almost five times as high as under the worst scenario. Compared to the current situation, on the other hand, the most favourable policy scenario predicts a maize production almost three times the current level. This shows the potential of agricultural policies to alleviate the African food crisis.

The data we have collected and the analysis we have made support the following overall conclusions:

1) Food security in African maize production requires industrial and scientific inputs, so called local or traditional knowledge is not enough.
2) Furthermore, food security requires a broad integration of smallholders in the market. Subsistence orientation does not promote food security.
3) Market integration of maize producers seems to be driven by the State, not by the market on its own. The potential for increased market production of staples is high with state policies that take account of the constraints and market uncertainties currently facing the majority of smallholders.
4) The diffusion of technology is stimulated by the market and is promoted by favourable macro policies, as reflected in policies of food import and in budget priorities.

There are some clear lessons in this:

5) African governments giving priority to food security among farmers as well as in urban areas need to review their policies of food import and give high priority to

investments in agriculture and staple food production. The WTO gives room for the 49 Heavily Indebted Poor Countries (HIPC) to protect their domestic agriculture against dumping.

6) More use of industrial inputs and higher market integration require more secure and foreseeable production and market conditions at farm level. The only actor with the capacity to create such conditions is the State.

7) Donors cannot continue trying to bypass the State, but must work with African governments to influence their trade and agricultural policies.

References

Akande, T., The Role of State in the Nigerian Green Revolution, In Djurfeldt, G., H. Holmén, M. Jirström and R. Larsson (Eds.), *The African Food Crisis: Lessons from the Asian Green Revolution*, London: CABI 2005.

Binswanger, H. P. and P. L. Pingali, The Evolution of Farming Systems and Agricultural Technology in Sub-Saharan Africa., In Ruttan, W. W. and C. E. Pray (Eds.), *Policy for Agricultural Research*, Boulder, Col.: Westview Press 1987.

Boesen, J., The Masai Have Begun to Sell Their Cow Dung! African Farmers Are Trying to Avoid Soil Degradation in Many Ways, *Den Ny Verden,* 1, 2000,

Dercon, S., Growth and Shocks: Evidence from Rural Ethiopia, *Journal of Development Economics, 74* 2004, 309-329.

Hart, G., Regional Linkages in the Era of Liberalization: A Critique of the New Agrarian Optimism, *Development and Change, 29* 1998, 27-54.

Hazell, P., *The New Agenda for Pro-Poor Agricultural Development*, Washington D.C.: International Food Policy Research Institute, 2004.

Holmén, H., Food Crop Intensification and Macro Level Development, In Djurfeldt, G., H. Holmén, M. Jirström and R. Larsson (Eds.), *The African Food Crisis - Lessons from the Asian Green Revolution*, London: CABI 2005.

International Monetary Fund, Government Finance Statistics Yearbook, 2002.

Isinika, A., G. C. Ashimogo*, et al.*, Market Conditions, Infrastructure, Institutions and Agricultural Intensification in Tanzania since Independence, In Djurfeldt, G., H. Holmén, M. Jirström and R. Larsson (Eds.), *The African Food Crisis - Lessons from the Asian Green Revolution*, London: CABI 2005.

Kosura, W. and J. T. Karugia, Why the Early Promise for Rapid Increases in Maize Productivity in Kenya Was Not Sustained, In Djurfeldt, G., H. Holmén, M. Jirström and R. Larsson (Eds.), *The African Food Crisis - Lessons from the Asian Green Revolution*, London: CABI 2005.

Larsson, R., Crisis and Potential in Smallholder Food Production – Evidence from Micro Level, In Djurfeldt, G., H. Holmén, M. Jirström and R. Larsson (Eds.), *The African Food Crisis: Lessons from the Asian Green Revolution*, London: CABI 2005.

Lipton, M. and R. Longhurst, *New Seeds and Poor People*, Baltimore: Johns Hopkins University Press, 1989.

Madeley, J., *Food for All: The Need for a New Agriculture*, London ; New York: Zed Books, 2002.

Mellor, J.W., Faster, *More Equitable Growth – the Relation between Growth in Agriculture and Poverty Reduction*, Cambridge, MA: Abt Associates Inc., 1999.

Mellor, J. W., *Agriculture on the Road to Industrialization*, Baltimore and London: John Hopkins, 1995.

Mosley, P., *African Green Revolution - Asian Comparisons (Preliminary Title)*, Lund: Department of Sociology, 2003.

Mulat Demeke and Teketel Abebe, *Ethiopian Agriculture: Macro and Micro Perspective*, Department of Sociology, Lund University, 2003.

Netting, R. M., *Smallholders, Householders: Farm Families and the Ecology of Intensive, Sustainable Agriculture*, Stanford, Calif.: Stanford University Press, 1993.

Oxfam, *The Rural Poverty Trap: Why Agricultural Trade Rules Need to Change and What Unctad XI Could Do About It*, London: Oxfam, 2004.

Saasa, O., *Agricultural Intensification in Zambia the Role of Policies and Policy Processes*, Lund: Department of Sociology, 2003.

Seini, W. and V. Nyanteng, The Structural Adjustment Programme and Smallholder Food Crop Production Intensification in Ghana., In Djurfeldt, G., H. Holmén, M. Jirström and R. Larsson (Eds.), *The African Food Crisis - the Relevance of the Asian Green Revolution*, London: CABI 2005.

Shiva, V., *The Violence of the Green Revolution : Third World Agriculture, Ecology and Politics*, London ; Atlantic Highlands, N.J.: Zed Books, 1991.

Sukhatme, P. V., Incidence of Protein Deficiency in Relation to Different Diets in India, *British Journal of Nutrition, 24* June, 1970, 477-487.

World Bank, *World Development Report 2004*, Washington, D.C.: The World Bank, 2004.

Tables

Table 1: Production of grain equivalents (kg) and maize per year and household consumption unit (pcu); mean, median, percentiles and standard deviation, best of three years.

Variable	*Mean*	*Median*	*10th percentile*	*90 th percentile*	*Standard Deviation*	*Per cent below 220 kg pcu*	*Total no. of cases*
Grain equivalent per consumption unit, kg.	441	278	60	933	612	41 %	2706
Maize per consumption unit, kg	288	170	38	630	380	59 %	2328

Note: Per cent missing cases 12.6 and 11.5 respectively. Source: own survey.

Table 2. Countries, number of regions, villages and farm households.

Country	*Ethiopia*	*Ghana*	*Kenya*	*Malawi*	*Nigeria*	*Tanzania*	*Uganda*	*Zambia*	*Total*
Regions	4	2	2	4	2	2	2	2	20
Villages	4	8	10	8	49	10	5	9	103
Households	322	416	298	400	495	403	320	443	3097
Female headed, per cent	5	17	43	40	12	20	14	24	22

Source: Own survey.

Table 3. Land under cultivation (total and per crop in ha) and percent of households cultivating, by type of crop.

	Total	*Maize*	*Cassava*	*Sorghum*	*Rice*	*Other food crops*	*Non-food crops*
Mean farm size, ha.	2.5	1.0	0.6	1.0	0.8	0.7	1.0
Median farm size, ha.	1.8	0.7	0.4	0.8	0.6	0.5	0.5
Households cultivating, per cent	100	85	40	23	25	81	37

Note: Per cent missing: 12.6 per cent. Source: Own survey.

Table 4. Farmers' food security regressed on use of technology and market conditions (Model 1).

Variable/factor	*Beta*	*Sign*
(Constant)	4.95	0.000
Chemical fertiliser (use/do not use)	0.29	0.000
Traction facility (yes/no)	0.29	0.000
Preindustrial input index 1: Animal or green manure (yes/no)	0.10	0.007
Preindustrial input index. 2: Crop rotation, intercropping, fallowing (yes/no)	-0.10	0.036
Medium agro-market potential	0.26	0.000
Good agro-market potential	0.32	0.000
Area under maize (acres), logged	0.62	0.000
Maize specialist (yes/no)	0.20	0.000

Note: R^2 = 0.42, no. of cases = 2078, per cent missing = 21.

Table 5. Rate of dynamism in maize sector, import dependence, budget allocation to agriculture and GNI per capita in selected countries.

Country	*Rate of dynamism*	*Import dependence*	*Budget allocation*	*GNI per capita*
Nigeria	0.76	0.02	1.62	780
Ghana	0.71	0.27	3.50	2000
Ethiopia	0.59	1.06	11.46	-
Tanzania	0.57	3.13	3.90	550
Uganda	0.44	7.39	4.17	1320
Kenya	0.43	14.01	3.75	990
Malawi	0.34	8.47	6.24	570
Zambia	0.34	17.79	4.70	770
Overall mean	0.50	1.65	4.26	982

Source of data: column 2: own survey; column 3: FAOSTAT; column 4: The percentage of government expenditure going to agriculture, forestry, fishing and hunting, which is the category found in IMF statistics (International Monetary Fund);[vii] column 5: Gross National Income in PPP USD (World Bank, 2004).

Table 6. Farmers' food security regressed on use of technology, commercialisation and background variables (Model 2).

Variable/factor	*β*	*Sig.*	*VIF*
(Constant)	6.057	.000	
Chemical fertiliser (use/do not use)	.270	.000	1.162
Traction facility (yes/no)	.541	.000	1.397
Preindustrial input index 1: Animal or green manure (yes/no)	.060	.169	1.269
Preindustrial input index 2: crop rotation, intercropping, fallowing (yes/no)	-.135	.015	1.058
Medium agro-market potential	.134	.005	1.548
Good agro-market potential	.193	.003	1.613
Area under maize (acres), logged	.525	.000	1.291
Maize specialist (yes/no)	.301	.000	1.246
SAP/market liberalization	.201	.000	1.074
Budget allocation for agriculture, logged	.553	.000	9.953
Import dependence, logged	-.111	.000	9.967
GNI per capita PPP USD, logged	-.275	.000	1.433

Note: R2 = 0.44, no. of cases = 2018, per cent missing = 23.

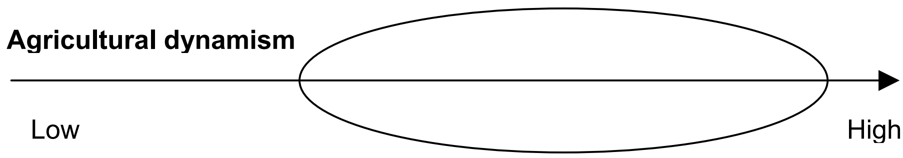
Table 7. Two scenarios for predicted mean maize production (kg) per consumption unit, by type of area.

	Type of area				
Scenario	Low potential	Medium potential	High potential	Total, maize only	Total, other staples included
Current state of technology and policy	156	179	188	173	346
Alternative scenario (see text)	123	218	370	221	448

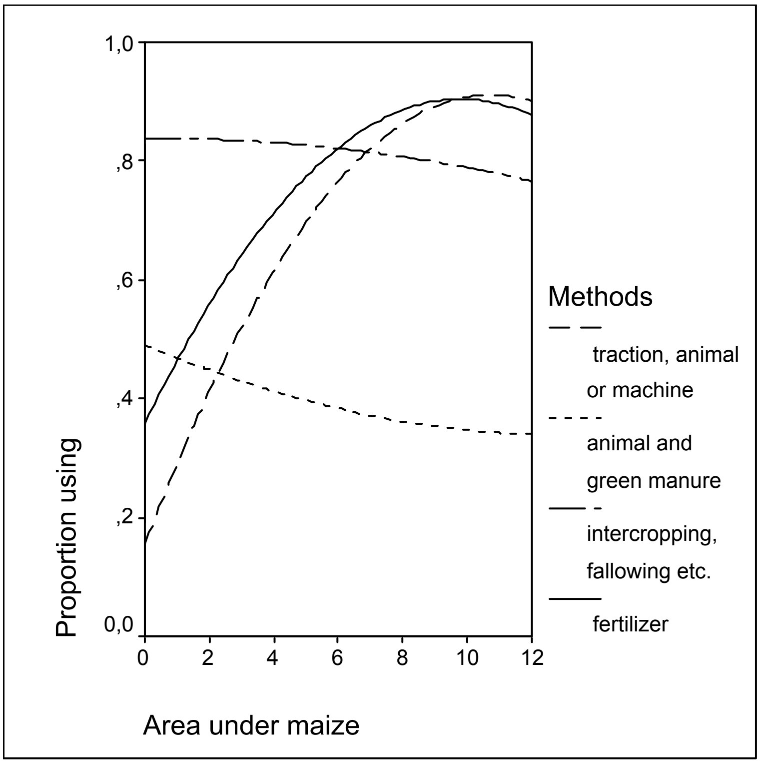
Note: Calculations from model 2. Source of data: Own survey.

Graphs

Graph 1. Sampling frame.

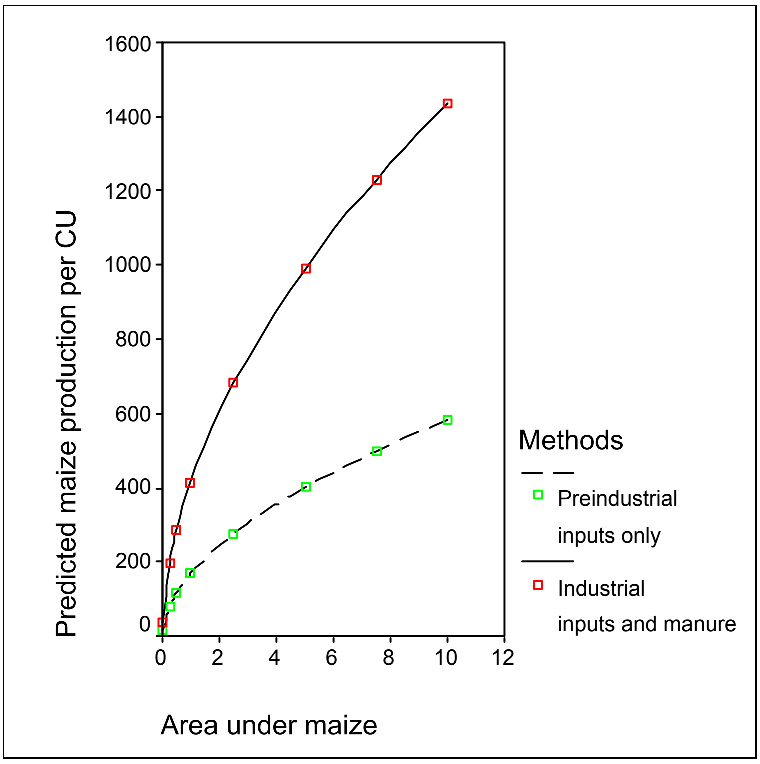


Graph 2. Probability for using various methods of cultivation by area under maize.[viii]



Source: Calculated from own survey data.

Graph 3. Predicted maize production per consumption unit by size of area under maize.



Note: Derived from Model 2 above. Source of data: Own survey.

Endnotes

---

[i] This is a major hypothesis of the project, which reinterprets the Green Revolution. Instead of the standard view, which sees the Green Revolution as driven by technology, we see it as *state-driven.*

[ii] In calculating grain equivalents, the following weights have been used: paddy 0.8 and cassava tubers 0.3. Consumption units: adults (15-60 years) 1.0; children (<15 years) 0.5: old (>60 years) 0.75. The figure 220 kg grain per consumption unit and year is taken from (Sukhatme, 1970) and indicates the approximate minimum food and calorie intake required to keep a person alive, corresponding to 2,200 kc or 600 grams of grain per day.

[iii] In terms of regression analysis, *production of maize per consumption unit* is likely to be a *heteroskedastic* variable. That is, as production increases, the variance among farms also increases. This heteroskedasticity is one reason why we use the natural logarithms of quantitative variables; it should increase the precision of the regression analysis. Another reason is that, given logarithmic independent variables, we get estimates of elasticities. In other words, β-factors can be taken to indicate how much a one per cent increase or decrease in a given independent variable is reflected in a corresponding increase or decrease in the dependent one. The other independent variables all vary between 0 and 1, making it easy to interpret the β-factors: when the independent variable increases from 0 to 1, the log of the dependent variable increases or decreases by the value given by the corresponding β-factors.

[iv] For simplicity and for reasons of space, the number of variables is deliberately kept down in the model. For a more elaborate model and discussion on how socio-economic factors influence production, see (Larsson, R, 2005).

[v] The share of agriculture in European Union budgets would contradict this generalization.

[vi] Discussing SAP and liberalisation in a continental sense is problematic due to the differences in content of policy between countries. Among common denominators are improved opportunities for private entrepreneurs (traders and transporters) and some improvements in the rural road infrastructure.

[vii] Nigeria and Tanzania are not members of the IMF, while Malawi only recently became a member. Data on Tanzania and Nigeria have been culled from national statistics. In the Nigerian case data are not exactly

comparable to those of the IMF. With the data we have access to, Nigeria appears to be giving less priority to agriculture than one would expect. Data bias in this case works against our hypothesis, rather than for it. In the case of Malawi data are from 2003-4 and thus not lagged. Data for Nigeria and Tanzania have been collected by Prof. Tunji Akande and Dr. Aida Isinika, to whom we are thankful

[viii] This graph has been derived from logistically regressing the relative chance of using a certain method on area and area squared. The curves have been drawn based on predicted values calculated from the regression equations.