The Green Revolution in Africa

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Contents

Why Can't We Transform Traditional Agriculture in Sub-Saharan Africa?

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There are growing world-wide concerns regarding the widespread and persistent or even worsening poverty and food insecurity in SSA. This is in sharp contrast to the experience in developing countries in Asia: Rice and wheat yields began to grow dramatically in the late 1960s, due to the development of fertilizer-responsive, high-yielding modern rice and wheat varieties (MVs), which is heralded as the Green Revolution. The question is why we failed to repeat the experience of the Asian Green Revolution in SSA. Based on case studies of NERICA rice in Uganda and "Organic Green Revolution" in Kenya, this article argues that a Green Revolution is possible in highlands of East Africa if proper support for research and extension is provided.

While population continues to grow rapidly in Sub-Saharan Africa (SSA), uncultivated land has been largely exhausted. Since the yield of food grain per unit of land has remained largely unchanged for more than several decades (figure 1), per capita food production in the region has been declining (figure 2). Therefore, there are growing worldwide concerns regarding the widespread and persistent or even worsening poverty and food shortages in SSA.

This is in sharp contrast to the experience in developing countries in Asia. Rice and wheat yields began to grow dramatically in the late 1960s, due to the development of fertilizer-responsive, high-yielding modern rice and wheat varieties (MVs), which is heralded as the "Green Revolution." Grain yield more than doubled and the per capita grain production significantly increased in tropical Asia over the last four decades.

The question is why we failed to repeat the Asian Green Revolution in SSA. This poses a serious challenge for development economists, because it is widely believed that Schultz (1964) provides an accurate characterization of traditional agriculture and proposes an appropriate prescription to transform it into a modern agricultural sector. This short article attempts to assess the relevance of the Schultz thesis for the development of agriculture in SSA.

The Relevance of Schultz Thesis

Schultz (1964) argues that changes in technology, such as better crop varieties and improved livestock, are the key to transforming traditional agriculture. Since farmers are supposed to be efficient in resource allocation, given the available technology used

over generations, agricultural extension does not play a significant role unless new profitable technologies are developed. Thus, he proposes that "most modern agricultural factors suited to a poor community must first be 'produced' by starting with established scientific and technical knowledge…" (p. 149). In other words, Schultz identifies new scientific knowledge created by investment in agricultural research as the main engine of agricultural growth, in addition to investment in the human capital of farmers. He also recognizes that public goods characterize a major part of the new science-based technology is characterized by public goods, so that public-sector agricultural research must play a major role.

The Green Revolution in Asia amply supported Schultz's thesis. Before the Green Revolution, the emphasis was on extending existing technologies, but not on generating new technology. Such a development strategy completely failed to transform Asian agriculture. Instead, the international agricultural research centers (IARCs), such as the International Rice Research Institute, developed high-yielding crop varieties, which led to a dramatic transformation of Asian agriculture since the mid-1960s. As Schultz (1964) predicted, farmers quickly adopted these highly profitable new varieties.

According to Evenson, unlike in Asia, "in many Sub-Saharan African countries the number of agricultural extension personnel far exceeds the numbers of agricultural scientists." This indicates that there is over-investment in extension, at least, relative to research in SSA.

Another important finding of Evenson is that the internal rate of return to research at IARCs is 68%, compared with 9% for national agricultural research systems in SSA. Research outputs at national agricultural research systems tend to be characterized by local public goods useful within the country.In contrast, research at IARCs tends to be oriented towards the development of international or regional public goods useful across country borders. Eveson's estimate of high returns to IARC research suggests that there is gross under-investment in international agricultural research in SSA. Considering that each country is relatively small in SSA, the role of IARCs is likely to be greater in this region than in Asia.

Appropriate Development Strategy for SSA

The Green Revolution bypassed unfavorable rainfed areas of Asia, which are subject to severe drought and flooding (David and Otsuka)The adoption rate of MVs of rice is about 70%, as of the early 2000s. In other words, agricultural research failed to develop profitable agricultural technologies for unfavorable areas, even in Asia. The low and unpredictable rainfall, coupled with the lack of irrigation facilities, means large areas of cropland in Sub-Saharan Africa are drought-prone unfavorable areas, which is a major constraint on agricultural growth in this region.

It is probably a mistake to identify the whole SSA region as being mired in traditional agriculture, where technology has been unchanged for centuries. Indeed, a number of

new cereal varieties have been developed and some have been widely adopted (Evenson and Gollin). Their impact on crop yields, however, is limited because fertilizer is not applied to maize, sorghum, and millet fields (Otsuka and Kalirajan 2005). Since improved varieties are generally fertilizer-intensive and, hence, high-yielding only when a substantial amount of fertilizer is applied, adoption of improved varieties has not had a significant impact on crop yields in SSA. This does not imply that African farmers do not know the effect of fertilizer application, as they apply it to commercial crops, such as tobacco and coffee. However, the inefficiency of agricultural marketing systems and market distortions in SSA mean chemical fertilizer prices are prohibitively high relative to crop prices.

Schultz (1978, p.6), a strong advocate of the Green Revolution, stated that, "What is needed are many Green Revolutions throughout low-income countries." He added that "They could be had, but they are presently suppressed by the lack of adequate incentives." He clearly recognizes the critical importance of unfavorable price distortions for farmers to adopt new technologies.

There are, however, at least two encouraging recent developments which strongly indicate that the two major constraints facing agriculture in SSA, i.e., drought-prone ecological conditions and high chemical fertilizer prices, can be overcome. The first case is the development and diffusion of upland NERICA rice (new rice for Africa), which has successfully been introduced in Uganda, among other countries. Because of the early maturity (i.e., growth period of 90-110 days compared with about 150 days for conventional varieties), NERICA can be grown within the rainy season in a normal year. In Uganda, there has been significant difference in the yield performance of NERICA between those farmers who have grown rice before and those who have not, since rice was not commonly grown in this country. At present, NERICA has become popular in Ugandan upland areas with no irrigation (Kijima, Sserunkuuma and Otsuka).

Although fertilizer is seldom applied, the average yield of NERICA is 2.2 tons per hectare, far exceeding the average upland rice yield of 1.0 ton per hectare in SSA. Clearly, NERICA has superior capacity to extract soil nutrients. Furthermore, the yield reaches more than 3 tons per hectare if it is planted after heavily fertilized export crop such as tobacco. The yield is also high if it is planted after legume crops which have the capacity to fix nitrogen. Thus, like rice MVs in Asia, NERICA is also likely to be a fertilizer-responsive, high-yielding variety. The yield effect, however, is unsustainable unless fertilizer is applied properly. It is noteworthy that the yield of NERICA is particularly high when chemical fertilizer is applied.

Another case pertains to what Otsuka and Yamano call the "Maize Green Revolution" in the highlands of Kenya. In this region, local cows have been gradually replaced by dairy cows which are cross-breeds between local and European cows. Since dairy cows are highly productive, it is profitable for farmers to stall-feed them by growing feed crops for the sake of increasing both milk and manure production. Because it is easy to collect manure from stalls, these farmers apply manure and compost, as well as

chemical fertilizer, to maize fields. According to table 2, the average yield of the improved hybrid varieties is 2.1 tons per hectare, 50% higher than local varieties. If we focus only on those farmers who adopt improved varieties and apply both chemical and organic fertilizer, the average yield amounts to nearly 3 tons per hectare. Manure is applied to both local and improved varieties, which is particularly conducive to restoration of depleted soils. This pattern of development is essentially no different from the Green Revolution in Asia, aside from the use of improved livestock.

Schultz (1964) often mentions the importance of improved livestock in his 1964 book, in addition to improved crop varieties, as a major source of technical change in agriculture. Also, the use of manure is reminiscent of the Agricultural Revolution in 18th century England, which was realized by the cultivation of feed crops, stall-feeding of cattle, and the application of manure to crop fields (Timmer). The Maize Green Revolution combines the desirable yield-enhancing features of the Agricultural Revolution (i.e., the use of manure) and the Asian Green Revolution (i.e., the use of improved fertilizer-responsive varieties), the two precedent revolutions in world agricultural history. To date, however, there has been little research on the cereal crop-dairy cow-feed crop interactions in IARCs.

Concluding Remarks

Given the increasing population pressure on limited cultivable areas in SSA, the optimum agricultural development strategy seems to be development of land-saving, yield-enhancing technology, as in Asia where agricultural land has been scarce (Hayami and Ruttan). Thus, in all likelihood, there is no alternative but for the Green Revolution type, yield-increasing technology that can transform Sub-Saharan agriculture (Otsuka and Kalirajan 2005, 2006).

Although chemical fertilizer is expensive in SSA, some yield gains can be achieved by substituting organic fertilizer. Needless to say, however, long-term solution requires improvement of chemical fertilizer marketing systems. Owing to the advancement of modern biological science, particularly in the field of genomics, the possibility of developing drought-resistant grain varieties suited for ecological conditions in SSA is much higher. As Schultz (1964) predicted four decades ago, since farmers are willing to adopt profitable new technologies, the real challenge is to invest in the appropriate agricultural research to generate truly profitable fertilizer-using, yield-enhancing technology for SSA.

[Question]
You mentioned that in Kenya you thought that the government takes no active part in productivity increases being realised. I was just wondering how big a constraint that is?

[Prof. Otsuka]
Kenya has a research system called Kenyan Agricultural Research Institute. It is one of the most high-level national agriculture programmes. Nonetheless, there is no research on farming systems. This is actually a common problem in Africa. Rice in Asia is very different from farming systems in Africa. In the case of Asia, particularly rice production, it is quite independent from other sectors in agriculture. In other words, to synthesise the picture, all farmers have to do is plant seeds and then purchase chemical fertiliser and then apply and then wait for a few months and then harvest. But in Africa there are a lot of interactions among maize, cows, agro-forestry (trees) and field crops. However, there is no integrated approach towards improving this farming system. In fact in eastern and southern Africa - actually it's not a national programme but there is the International Agricultural Research Centre which triggers the major changes in farming systems in the tropics.

The point I want to emphasis is in eastern and southern Africa there are two international outreach research centres. One is ILRI – International Livestock Research Institute - which looks at only cows. That is located in Nairobi. And also in Nairobi we have ICRAF which is concerned with agro-forestry alone. These two institutes do not work together.

The essence of the Green Revolution is breeding; breeding of the grains – rice and wheat in particular. But there is no breeding institute in eastern and southern Africa. How can we expect major innovations to take place? In western-central Africa we have WARDA – West African Rice Development Association - and IITA in Nigeria. Unfortunately they are not scientifically strong enough to realise major change; although, WARDA was successful in developing nerica. I admire that invention.

We need good partnerships between international centres which want to produce so-called international public goods: useful knowledge for wide areas. National programmes focus on certain specific areas while using the knowledge generated by international research centres. This kind of interaction is absolutely needed but that's missing in Africa.

[Question]

I have a few points. My research has been on perishable food-stuffs in southern Tanzania. One thing that struck me from my experience in east Africa is that people like to eat maize-based food and perhaps not rice. Do they want to eat rice in Africa? The second point is slightly anecdotal, when I was in Tanzania, I found many farmers who used chemical fertiliser and those who did not have access to local fertiliser were buying it from trading capital of Tanzania, Dar es Salaam. I was wondering where it came from and followed the marketing links and was surprised to find it was being imported from Japan. It was surprising that it would have to be imported from so far away.

My third point is, you showed us a picture of a beautiful Kenyan farmer. It seems to be a question of knowledge transfer. What would you recommend for research development but also outreach and perhaps what you would recommend JICA might do about it?

[Prof. Otsuka]
It is interesting that in Asia rice is inferior, meaning that as income goes up rice consumption declines. Particularly when urbanisation takes place,
Rice-consumption declines because it's troublesome to cook rice, particularly in the morning. In Africa it is said that with urbanisation rice consumption increases. It is easier to cook rice than gari and other foods. In fact, rice consumption has been increasing very significantly. In Japan on average we now eat around 65kg of rice per year. The maximum consumption of rice by Japanese was around 1960 when we ate as much as 130kgs. In the Philippines, in India, etc, the average is about 130kg now.

In Africa, according to statistics, rice consumption per year is now around 25kg. It used to be about 10kg per year in 1970. So consumption and production have been increasing rapidly. I started my research on Ugandan agriculture in 1994. Major uncultivated land in Africa is marsh land along the river bottom. Rice was not grown in 1964, but I dreamed…I imagined…maybe…some of this land may be converted to paddy fields. I visited there this year and I was very surprised that there are so many lowland rice fields. It has been expanding. Nerica rice is planted in 10,000 hectares. But there is one estimate that lowland rice production area is now 70,000 hectares (this does show on official statistics). Rice is becoming really, really important. And one child who talked to me said, 'I want to eat rice during Christmas.' They love rice. So I think rice consumption will increase. Rice research should be carried out seriously.

You are right, knowledge transfer is very important. But useful knowledge to be transferred is lacking. We need to conduct useful research first and then transfer it to farmers. The first thing we have to do is to generate new knowledge and then transfer it. This generation of research is still lacking- or weak at least. We really have to start research in the right direction.

Green Revolution in sub Saharan Africa: How Desirable and Feasible?

Professor Jonathan Kydd

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First I would like to say it is a great honour for me to be sitting on a platform with Professor Otsuka. I have been like you in the audience listening to him on a number of occasions in various places around the world. I have huge admiration for the way he wears his deep learning on the subjects and his knowledge of economics quite lightly and is able to tell vital and interesting stories to bring the very important issues through to a general audience. I'm not sure if I'm going to be able to follow that act but I would at least like to record my admiration for that act.

What I am going to do is take a somewhat different cut on the same subject and so the discussion at the end will be a rather interesting synthesis of these two different cuts. To indicate what my story is about before I get into the detail, the story really is first of all an as yet controversial reinterpretation of how the green revolution happened in Asia. Now, Prof Otsuka has very well set out what it was and why it was such a good thing. I am just going to give a somewhat different story emphasising different factors as to how it happened. And then - by accident, it's interesting that here, in a meeting sponsored by Japan - I'm going to be saying as I often do say, that Africa has in developing it's own policy framework a lot more to learn from Asia and probably ought to forgot a lot of the lessons that it's taught by Europe and more recently by the United States. Both of these are fairly controversial positions. I hope that therefore we can have a bit of controversy at the end of it. I've given myself a slightly different title but it's basically the same as the one announced. I came up with this after having read Professor's Otsuka's paper.

The starting points I think I can go through very quickly: agriculture is very important. A successful agricultural development strategy depends on, first of all, institutions. This is, in a sense, my own pet theme. Institutions meaning markets:

- Markets for the services for the provision of credit - Prof Otsuka very well set out the point that in Sub-Saharan Agriculture most farmers just are not using artificial fertiliser and that leaves the question as to how many really can be dependent on agro-forestry and animal manure?
- Markets for physical inputs of fertiliser
- Markets for information about technology and prices

Agriculture's linkages with other sectors are very important. Again, Professor Otsuka made the point that the Green Revolution had its impact on mass poverty reduction through not so much what it did to farming itself but what farming did to other sectors of the economy. In particular, the point that was made was the big reduction in food

prices as a consequence of the big increase in the availability of food. So, agriculture's linkages with other sectors of the economy are very important and I will say a bit more about these later.

And finally, there is a technology story. We've just heard a technology story and I am not, by and large, going to tell a technology story but I have to say that I buy very strongly into it. I too have been playing a minor role with a colleague of mine Andrew Daw who has been looking at nerica rice in Nigeria (work sponsored by the Sainsbury Family Trusts). And what we are coming up with is very exciting information as well. We can't really say much more about it except that we went there a bit sceptical and find that there is a lot more nerica around than the sceptics would have suggested. And again, as was said by Professor Otsuka, it's exciting that this sort of technology was generated in Africa by an institution that is part of the African public sector and by African scientists using their own methods. One of the questions I think we will be asking in two or three years or maybe even five years down the road is really how significant is all of this, but there is certainly a very interesting story there.

Let me say something about intellectual fashions in the treatment of agriculture. We went through a period from the end of WWII through to the 1970s where there was a period in which small-hold agriculture was not really taken very seriously by development economics of either the political right, the political left or the political centre. They felt that we needed to consolidate agriculture rapidly in large farms and concentrate on urban-based industrialisation. In the 1970s, at least in the economics literature, there was a counter-offensive: Professor Otsuka's paper mentioned Shultz, who got a Nobel Prize; Michael Lipton in this country; John Mellor in the United States; Shultz, I should also say, is an American. And the argument made was that small-hold agriculture actually does use resources efficiently; that it's capable of rapid growth and the Green Revolution evidence we've just heard I think validates that; and that it's capable of growth in both production of semi-subsistence staple crops – products that will then be consumed on the farm itself – and also products that will be sold off the farm (sometimes, of course, these are the same products). And this linkage point that I've already made, what agriculture does to the rest of the economy, was made strongly by these people.

So this was a phase in development thinking in which it became quite fashionable to back agriculture. And we saw the institutions that – Prof Otsuka is the chairman of the board in one of these in the Philippines: IRI – the International Agricultural Research Institutions known as the CGIAR – were strongly backed with large amounts of international money. Subsequently they've struggled with trying to do the same things with less money [to Prof Otsuka] as I'm sure you know to your cost. We saw on the ground in a number of countries but introduced into Africa, the idea of integrated rural development; that aid agencies should finance governments to spend quite large sums of money in improving rural infrastructure, improving farmers' access to inputs with often state marketing boards that deliver inputs to farmers' doors, with forms of agricultural credit, and with agencies that bought agricultural output often at quite

stable prices. And then, in the last 15 or 20 years or so, we've seen a counter-reaction, particularly in Africa. Growing doubts about this thesis that small holder agriculture is efficient and that it has a key strategic role to play in growth and poverty reduction. The agriculture sceptics by getting itself closed down as quickly as possible. They wouldn't see it as the main engine for that growth but if anything an obstacle to that growth.

In literature on rural development, a strong emphasis on the non-farm rural economy. Worries that global trends which were quite supportive of the Green Revolution in the 1970s and 80s when world food prices were much higher and there was a real concern about food security in the world as a whole in aggregate, that these worries have gone away because world food prices in real terms are now very much lower.

Various other things have been happening structurally in the world economy affecting agricultures as well as other sectors. We're seeing concentrations in supply chains, particularly in commercial agriculture. Increasingly small numbers of large producers are producing stuff. Someone know to both of us because he is perhaps the most amusing member of our profession, an American called Tom Reardon, tells fantastic stories about how in Brazil if you want to be a supplier in an international or national supermarket chain, every 3 or 4 years the contracts are re-tendered and the buyers from supermarkets expect to deal with half the number of suppliers they dealt with in the last round. So there is this constant concentration going on with smaller – large but actually smaller - numbers of very intensive units tending to produce the high value agriculture around the world. This is a tendency, it is not a universal fact by any means yet.

We've got a very strong world-wide movement to liberalise markets affecting agricultures as well as everything else. And these approaches that I referred to which were fashionable in the 1970s which required a lot of government intervention, under intellectual attack and under often real practical attack by the World Bank as a consequence of policy conditionality attached to loans and sometimes, although this point is often exaggerated by WTO conditionality or WTO rules, basically, the poorest countries in the world are not really hugely constrained in their agricultural policy by WTO rules, although a lot of NGO lobbying might try to persuade you of the opposite.

Questions about if new technologies coming fast in to agriculture as it is into most other sections of the economy, can these small producers really absorb this new technology? Aren't there economies of scale? Aren't there major capital requirements? Is it realistic? Yes maybe we can help them form into co-operatives and farm organisations, but aren't there huge government problems in co-operatives which will mean that they will never be as nimble or commercially astute as a medium to big firm run by some smart entrepreneurs?

Another problem is dualism – that in so many of the poor countries and particularly in Africa we often have a small state or commercial agricultural sector and we often have

the great majority of farmers live in areas were they are practicing a form of semi-subsistence agriculture. Semi-sub in that they try to produce food for their own use and at the same time food to sell in the market often at the time they plant it they are not sure what it is for – if there is a surplus they will sell it and if there is not a surplus they will eat it all themselves. Or, if things are really desperate they will sell it even though they know they are going to be short later in the year because they need cash immediately.
And the circumstances of much semi-subsistence agriculture in SSA now are not very pretty. Again, we've been done a great service – well I have – by Professor Otsuka's series of statistics on yields in SSA. Those yields did not look particularly good. Yields per capita looked particularly unfavourable. They looked particularly unfavourable against a background of what has happened elsewhere in the world and against the background of so much aid that has gone in from the 1970s to support agriculture. Agriculture by and large in Africa at least until recently has been among the worst performing segments in the portfolio of the projects of the international aid donors. This is a generalisation of course, there are exceptions.

Now, the linkage story, perhaps there isn't time to go into in much detail, except to make the point that when small-holder agriculture grows, lots of other good things happen alongside it. It's the systemic contribution to poverty reduction. As we were walking towards this building we were discussing amongst ourselves and I think we had an agreement that as a historical moment the poverty reducing effect of the Green Revolution can be quite fleeting. We can debate how many years – but actually often quite a short period of time. But whilst it is happening, this process of intensification of small holder agriculture producing both subsistence crops and crops for the market, because it stimulates so many other sectors of the economy in the rural space and also in rural terms and adjacent urban space, it can have very powerful poverty reducing effects. So, it was incredibly helpful in what we now see as the great Indian success story. Can it be equally helpful in Africa?

Well, in the interests of time I will perhaps move ahead.

What are the options? Well, the slow progress we are seeing in Africa may be to do with the availability of appropriate technology. Undoubtably it is to some extent to do with that. Inappropriate genetic technologies. We've had some discussion as to organic technologies. There is a question of course as to how many farmers that's relevant to. I tend to work in Malawi, one of Africa's poorest countries, and actually livestock numbers in Malawi, never very great, are plummeting because of poverty and also because of insecurity and quarrels between people who are primarily live stock keepers and people who are primarily subsistence farmers. And there are very big animal health problems.

Is the problem that there is a lack of appropriate infrastructure for water? Well, undoubtably it is the case. Africa's Green Revolution, if it happens, will not look like the Asian Green Revolution because Africa has less water and different river systems.

It doesn't have what South Asia and East Asia have: these massive predictable floods every year into the plains coming from snow melting and predicable high rains in the mountains.

For me a key factor which I tend to stress in my work is lack of access to capital for the purchase of technology and by that I mean just the seasonal technology of the seeds and the fertiliser. Much of the reason why Africans don't produce fertiliser lies in the point that was made about the exceptionally high prices of fertiliser in the interior of Africa. But it is also the case that there is virtually complete financial market failure for the great majority if African peasant farmers. They cannot borrow money to finance their business. Micro-finance has not done much for agriculture because the micro-finance model is based on very short maturity loans, people establishing reputations and then the thing building up. Basically these people need to borrow for nine, ten, eleven months of the year and the micro-finance model doesn't work well with that. I say 'hasn't done much'; I'm not saying it hasn't done anything at all.

There is very high risk aversion amongst poor people. Their vulnerability is so high that they have to avoid taking risks. They have to stick with what sort of worked last year and for us the critical thing is market failure. Market-failure I've talked about in credit markets. Often market failures in input markets in that fertiliser is often not available to buy even if people wanted to buy it. And produce markets over the recent years has become much more difficult. Average prices within them have fallen, which is of course good for poorer people, but they've become much more volatile. They've become more volatile because governments have been told and over time probably haven't had the resources – told to get out and haven't had the resources to stay in. And we're in a new paradigm in SSA where although governments do intervene in markets, they are not doing it with the approval of the international donors. There are interventions but they are in some ways behind the back of the donors and, of course, if they are done in that way then they are likely to be technically sub-optimal.

In the group that I work with in Imperial we have a three stage view of the process of agricultural transformation. First of all establishing basics; secondly, kick-starting markets; and thirdly, a phase when it is actually necessary to get government out. And the different stages are characterised by these points on the right of what you are looking at.

First of all you start with extensive low productivity agriculture. Secondly, you move to profitable intensive technology where wider uptake is inhibited by market failures of various sorts. And then finally you end up with something that is much more like agriculture being like a normal business. Being able to get access to its inputs and sell its outputs in reasonably un-government supported and non-intervened markets.

Our view is that the government is actually critical in the first few stages. In the first stage the government has to build roads, it has to put in place irrigation systems, it has to finance research much more generously than is the case at the moment, it has to put

extension in place; in many cases it also has to do a land reform. It also has to ensure that there are reliable local seasonable markets – that people get access to finance, get access to inputs, and get access to outputs. And then finally they have to ensure a transformation to effective private markets.

Actually, quite a lot of countries seem to have real problems with phase 2 and phase 3. You could argue that us lot here in the European Union, that we've got stuck somewhere between phase 2 and phase 3 and that we haven't managed to wean agriculture off the government. But one of the problems we find in Africa, is that a debate that is absolutely critical and sharp in Delhi, which would be, how does India in its transformation from phase 2 to phase 3 get the government out of agriculture, avoid the hugely wasteful interventions of the Food Corporation of India where there is a massive rodent feeding programme effectively. 'How do they do that?' is critical. But the problem is that there are far too many people arriving in Nairobi having listened to the Delhi debate, and think that the problem is to get the government out of agriculture in Africa. We actually unfortunately think it is needed although we also do agree very much with the point that was raised by one of the earlier speakers in reply to one of Professor Otsuka's points, and that is that the quality of government is declining and that makes one rather pessimistic if you believe that the quality of government is declining and you think that government is needed. We don't think that there is an easy way round to kick-start the market without going through a government process.

Given that that is our view, we've taken the database from IFPRI (a place where Professor Otsuka worked for some time) and they've got the best data-base on India. We've tried to reinterpret econometrically the Indian Green Revolution using our institutional story.

Bascially the numbers here: the lower the number the better. Basically, this represents a very good buy in terms of poverty reduction. It's an interesting story. Basically, what it says is that roads are always really potent ways on spending money on reducing poverty. Education, initially in pre-Green Revolution India, wasn't very good at reducing rural poverty. It becomes better but it's never as effective as roads.

Irrigation investment: never that good, although in recent years, awful, largely because of the subsidies locked into irrigation in India particularly electricity subsidies and so on. Irrigation subsidies: not so good. Fertisiliser subsidies: initially very potent but becoming less potent. Power subsidies: initially quite useful, subsequently a huge problem, as anybody who knows economic debates in India now knows. Credit subsidies: initially extremely potent. Research, which is what is pushed all the time, pretty good but actually not as good as credit subsidies at this early phase. Interesting…because if you listen to the to the standard policy advice from the World Bank it is, invest in a very limited number of public goods: research, extension, do not get the government into anything to do with intervening in markets. Our story here is: Asia or, at least more specifically, India's Green Revolution, had a lot more positive

government in its story, particularly at the early stages. I think that is a key lesson that Africa has to take on board and has to be put into the African debates.

Right, I haven't very much more time so I'll speed up and probably not cover all of this. One thing I would do, however, to give you an insight into how we think about these things in this group that I'm with at Imperial College is that we've been trying to focus on the real problems that farmers have in doing business in any part of the world. Here we have a modified version of a fairly standard economics story. Basically the black curve is a marginal revenue product curve. Basically it tells you the revenue you get from the marginal unit that you produce and sell into the market. The rather peculiar shaped sandwich might actually like a bit more like our chairman's geophysical lectures at this stage. The rather peculiar shaped sandwich is a story where the base in the sandwich is a technology story. It's about the business of transformation and growing crops. Everything else is about the costs people have in doing business. This is a framework derived from the New Institutional Economics. And, just to comment very briefly on the costs in this sandwich. First of all, at the bottom, or the second element in the sandwich, is what we call co-ordination costs and risks. Co-ordination is a critical issue in developing economies anywhere in the world but the market does it rather well, except for very big projects in countries such as the one we are in at the moment (in the UK). The market does not do such a good job very poor economies because of the problem of passive specitivity [?].

Let me give you one example. If I am going to invest in a sugar mill in a very poor country I am going need output for my sugar and I'm also going to need some more farmers to grow the sugar for me. Once I've made that investment, I'm vulnerable to the markets and I'm vulnerable to the small farmers who decide that my prices are not very good and they are not going to produce the sugar for me. So, I probably won't make the decision to invest in a sugar mill because I'm facing a very thin market. Basically the story is, if we hold hands and jump tog it will work; if we don't it won't work.

Now, the mechanisms for co-ordination we haven't time to discuss. Prof Otsuka studies actually in his work on industrial clusters in Africa. Those are often private autonomous mechanisms but also government mechanisms, in the early stages, we believe - somewhat unfashionably - are important.

Then another area that we concentrate on very strongly is the question of how people actually do business with each other. How do you make contracts? When you look at African agriculture or indeed agriculture in most parts of the world you find that by the standards of our part of the world, contracts are extremely non-standard. There is very often what is known as inter-locking. Let's say I'm a capitalist wanting to support cotton farming as a business. I will supply inputs used for cotton, I might help the people plough their farms, and they then have to grow the cotton and sell it to me at a pre-agreed price and I would cover my production costs and make a profit through paying them a price that is well below the market clearing price of the cotton.

That is just one example. But, essentially, what we have to do much more of in trying to get a Green Revolution in SSA is understanding how it is that people actually do business. And one of the problems with most neo-classical economists is that they believe writing business plans is somewhat below them. You know, that is business studies; economics is a much more refined and high level discipline. We tend to do it the other way around. If you can't write a business plan for something and show how it will work in the country then don't talk about it. I would say that here, when you get into this line of study, you find a very productive line of research which starts with the question of how do you do business in these very difficult circumstances? Where there is very low trust, extremely high risk of people defecting on the contracts, very poor government and enforcement of contracts, very poor information, highly volatile output markets… I could go on with the list.

The final element in the sandwich is government behaviour, rents and also behaviour by others. That is something which is quite strongly recognised by the current orthodoxy. The current orthodoxy is very strongly in favour of identifying rent seekers and bearing down on them. We would buy this as well.
Essentially what you get from this little diagram is that if you can compress this geological strata down then the low-level equilibrium trap, which is where we see most Sub-Saharan Africans being, moves out to the right. And there is also a better chance of the whole mountain being climbed and one getting out really to the right of this point D, where you have very much higher levels of production.

And so I must end now and I will leave you with an account of our story. Of course technology is important. It is absolutely critical. Of course expenditure on technology re is under-funded and we need more of it. Absolute common ground on that. If that were to happen and the new technology is taken up this green base to the diagram here would fall and production at the point of which the marginal cost and marginal revenue meet, where the profits are maximised, this will move out to the right and we will get much more production.

What we bring to the party – wrongly or rightly (there is a lot of debate on this) – is two things: one is this emphasis on how people do business, on the rent-seeking and on the role of government. And we do it in a sense of great humility of knowing that we are arguing a very difficult case which is at the early stage of development we actually want the government to do more when the government's capacity at the moment is actually declining.

Thank you.

[Question]
India was very well known for its state intervention and that state intervention clearly brought about the huge yields; but you are now saying that has gone too far and it's actually impeding further progress. What is the implication for Africa which is not unified and there is no one central state to intervene in that way?

[Prof. Kydd]
The implications are not good because you've got much smaller states, much weaker state capacity, you have huge constraints on trade within a region because of national borders which ought not to be there if you like. Certainly what we have been arguing for – and when we say this we find that many African scholars say 'yup, this is what we should be doing' - is for something like a common agricultural policy in the different regions of Africa. For example in southern or eastern Africa it might be possible for states to negotiate that agricultural policies including intervention in markets if there is going to be interventions in markets be centrally co-ordinated. There are a lot of potential benefits in this other than the much freer trade that could take place. One is that potentially difficult political issues can be taken out to the hands of national governments and handed to a super-national bureaucracy. People can then hate that bureaucracy and newspapers in the region can castigate that bur every day but it's performing a very useful function if it is run by technocrats who are able to make hard decisions.

[Follow-up Question]
There was an East-African Economic Union – or an attempt at one – and that failed dismally. Is there really any way forward?

Well there certainly is. In SSA at the moment there are attempts to revive old unions like this one and add a number to it. So, there are a lot of unions of various sorts and trade arrangements in place. The big challenge would be to get agricultural intervention into it. The tendency would be for states to say, 'Well, we can live with free-trade in shoes but we couldn't live with free trade in our basic staple crops.' And that's a key challenge, is to get over that point.

[Question]
You started off talking about institutions and the importance of information about technology and prices. One big change since I guess you started you work on this is the potential for information on communication technologies. Specifically in my work on market institutions and mobile phones in developing countries, the classical argument that always seems to be anecdotal and people are always talking about the potential to by-pass the middle man. I was wondering if you had any comments of this and how it might be improved?

Because of certain rent-seeking arrangements people have to physically go to see the person, perhaps the buyer in the urban centre, and that's the person who they will pay and so they can't really trust on the price anyway as he or she can say whatever price he/she wishes. So while you might have a phone to find out what the prices is in the whole sale market are, you've really got little alternative. Examples I've seen in West Africa are of a French company Alcatel who have been sending though SMS of what the prices are. You really need an outside source to be doing that. I don't think government is capable of doing that. What role do you see for these new technologies?

[Prof. Kydd]
I certainly agree with you that there's lots of interesting potential there. I speak with a degree of humility as I'm sure you know much more than me because you have been studying it. I wouldn't see very much a role for government in this. I think that most government market information systems in Africa have produced information that is too general and too late. People want to know: if I've got a load of potatoes, where can I sell it in the next few hours and what price will I get? I imagine enough competition will sort out who the crooks are and when you turn up at the market just don't go through with those quotes.

The one thing I would say is that the potential is very substantial. A few months ago in Malawi, which again as I mentioned is a very poor country, I saw an extremely interesting thing going on. The Malawi central bank has introduced something called the Malswitch card. Organisations that are buying produce from farmers find it extremely helpful to get farmers to sign up and get basic bank accounts, in this case with a unit organised by the central bank. Now, the reason for this is if you are a produce buyer in a poor country you incur enormous costs loading up a van with cash, taking that cash out into rural areas – you need to have two or three heavies on the van as well as the cash. This actually raises costs of doing business very substantially. What is tending to happen is that farmers can be paid in their Malswitch accounts and the accounts are accessed not through pin codes but simply by finger-print recognition.

The ATMs from which they can withdraw cash are remarkably wide spread. And here there are economies of scope with the running of petrol stations. If you run a petrol station you probably want to swipe cards because this is a very good way that owners of transfer vehicles making sure that their own staff don't steal too much because if you give them cash they will always exaggerate the mileage and so on. There is a very strong incentive to have the technology in petrol stations anyway: petrol stations handle a lot of money, petrol stations need two or three men with guns outside them at night to keep the physical product and any cash safe. Once you've done that you might as well go the whole way and become a general money transfer point at a petrol station. So, farmers can do that.

The next thing that is absolutely fascinating is, I mentioned that one of our key areas of our study is how people actually do business with each other. One of the problems in

doing business with anybody is your counter party may default on the contract and in SSA and in rural space, default is incredibly common. It's a huge risk and leap of faith. The credit default will be less easy if people are advanced money against their Malswitch card. The penalty is, if you become a long-term defaulter, your Malswitch card goes into deficit and is written off effectively and you will never be able to have another of these cards. Now, that is a big problem for many people as you will be un-banked if you fail. On the other hand, there may have to be a big stick and maybe quite a large number of people may have to fail and suffer through being ineligible for credit. There are very strong incentives to keeping yourself in good status with a Malswitch account. This is speculation and is all for the future.

Almost every time I go now to SSA – I'm going on Sunday again - I find exciting things in the mobile phone technology and related areas. It's worth saying that the petrol stations I've been talking about are mainly linked by mobile phones rather than fixed links.

[Question]
Does the high proportion of women in agriculture in any way affect the various forms of governmental intervention?

[Prof. Kydd]
I think the first thing to say is that the roles of women in agriculture and agricultural marketing varies enormously across the sub-continent. In West Africa agricultural marketing – with certain exceptions but particularly with local produce - is heavily feminised to the extent that it would be very difficult to be in the business if you are male. In other parts of SSA that is not true at all. I would say that that is the first point to be taken on board.

There is a quite a lot of literature that worries and I think worries appropriately about credit being advanced by certain agencies to male household heads who then gain power within households and then use that power in certain ways. I am myself not convinced that this is a first-order structural impediment to the kinds of things I am talking about. I'm sure it is a second-order structural impediment – various forms of discrimination against women. I suspect it's not a first-order impediment to agriculture intensification.

[Prof. Otsuka]
In Africa as well as in Asia, I think that women's status compared to men tends to be low so long as women are engaged in farming particularly in primitive farming which requires a lot of muscle work. Women's status tends to improve as women get engaged in non-farm activities.

Also, one of the cases I have seen in Ghana is that women's status improves as the demands of women's labour increases. In Ghana, traditionally only men owned the land but demand for cocoa cultivation increased and women's weeding activities became essential and now about one third of the land is owned by women in western Ghana.
So, demand for women's labour and shift of women's time to non-farm activities tend to strengthen women's status. That is my observation.

[Question]
You talked about chemical fertiliser and the use of chemical fertiliser and the difference it makes to yields. What is the main constraint in terms of the increased use of chemical fertiliser?

[Prof. Otsuka]

In my view it depends on the shape of the yield function. If there are varieties that are very responsive to the application of fertiliser, if the yield function looks like this (gestured with arms) farmers tend to apply more fertiliser. But if the yield function looks like this then there is less incentive. So there are two factors: lack of good varieties and high prices. Both result in the absence of fertiliser application.

But this does not mean that farmers do not know the impact of fertiliser application. He thinks that farmers are ignorant of use of fertiliser so he doesn't allocate the subsidy. But farmers do know the impact. In the case of tobacco, they apply fertiliser because they know the impact. Nonetheless, they know not to apply chemical fertiliser to nerica because it does not pay.

[Prof. Kydd]
I agree whole-heartedly with those two points – that it is to do with the yield curve and the price of fertiliser. It is also to do with the price of the product that is produced with the fertiliser which in many cases is very low and the volatility of the price of that product which imposes a high risks on those people who might borrow. And the particular take I tend to push in symposia is that for the great majority of Sub-Saharan African farmers there is just pure market failure in the credit market. So, unless you have cash prior to the season it is a pipe-dream which you can apply fertiliser. Most farmers don't have much cash because there are huge alternative demands for the cash in terms of basic consumables, medical expenses, even when there aren't formal school fees there are all sorts of expenses associated with children's schooling. That I think is a further constraint. The fundamental one is, is it profitable to apply fertiliser? If the answer is 'yes it is' then often the problem is that the farmers can finance it and so it doesn't happen.

[Prof. Otsuka]
I totally agree with you.

So, as you can see, I'm an optimist and Professor Kydd is not a pessimist but he is cautious. I'm here and he's here [gestures distance with hands]. So I need to explain why I'm here.

The reason is, in the 1950s, and even up to the 1960s, in Asia governments were very much corrupted. For example, Thailand was a paradise for corruption. In order to do something, private people always had to pay something to the government officials. The Market was not working at all – there was no credit market at all - and irrigation facilities were poorly built and the inflation rate was much lower. There was no strong national research programme or extension programme. Maybe except in India. India was relatively good. But not brilliant. So many things were missing. And then, as Professor Kydd appropriately raised in the beginning, how did the green revolution happen? Everything looked so bad. Market was not working – no national programme, no extension service, no credit market and irrigation was poorly built.

What happened was IRI produced modern varieties. That excited policy makers. President Johnson came from the US on the way to Vietnam. I've seen the film. He was so excited. He kept banging the table saying, 'This variety will change the world' and so on. Later, King of Thailand came. He got excited. I met him. I spoke to him about his memory of his visit to IRI in the late 1960s and he said he was so impressed. And then Bob McNamara came, and other leaders of the world came, and they were convinced that it was a promising change. Really, the seeds of change for the future. They supported investment of change in irrigation, improvement of national research system, extension programmes, and so on. In other words, the advent of new technology, increased rates of return to investing in research national programme, extension programmes, roads and so on and so forth. So, the advent of the really profitable miracle technologies triggers whole series of changes towards the improvement of farming systems in Asia.

The same thing is now happening in Uganda. I met the vice-president and he said even the president is excited. The president got re-elected last week I think. But anyway, he appointed the vice-president as the leader of the nerica dissemination programme. I met the vice-president – he is so excited about the future prospects of nerica. This kind of excitement of course changes policies towards defusing new profitable technologies in wider areas. So, I agree with Professor Kydd that market imperfections etc constrain the realisation of the green revolution to some extent, but I'm relatively optimistic because those constraints can be subject to change if we can develop really profitable technologies.

[Question]
There seems to be different stories here about technologies. First of all, I was wondering if both of you could elaborate? The way that I interpret what you are saying is that it was the technology that sparked the political will, which then sparked institutional changes and even changes in governance. What is the likelihood that we might be seeing some of the political will happening again but what is the likelihood that we are again going to see the changes in governance and institutions all stemming from these technologies especially when a lot of the technologies can be quite political and controversial?

[Prof. Otsuka]
We have failed to develop outstanding technologies for SSA importantly because of weather conditions – predictable and low rainfall. As Professor Kydd has shown, the return to research has been declining. I agree with that. IR8 was a major variety but the most important variety that was developed by IR36 which was released in 1976. The third major variety was IR64 developed in 1986. So, since 1986 to now, IRI has failed to develop major technologies. So the rate of return to research in IRI in the 1960s was very low.

But now, rates of return to research in IRI and other places are increasing owing to the dev of bio-technology and basic sciences. Earlier, for example, it was not possible to cross between cultivated varieties and wild rice. There is a lot of wild rice. Wild rice is like grass: without water it can grow and it's very strong against pests and diseases. If we can transfer genes that control those good things into cultivated rice we can develop varieties which are very strong against pest and diseases and which can be grown very will in conditions without much water. In fact that is happening. Scientists have already identified all the genes. What is missing is the knowledge of the function of each gene. But nonetheless scientists have broad ideas of the likely natural traits of every gene. Now, after crossing they can see if these genes have been transferred to the new variety. So using this kind of technology we have great chances to develop suitable technologies for drought areas.

In 2000, 20001, 2000, there has been a sharp decrease in funding for CGIR including IRI. The budget declined particularly because of the cut in funding from the Japanese government. Funding decreased by about 30%. What I was afraid of was that because of the declining budgeting conditions, the good researchers would leave and the poor researchers will stay. I was really afraid that IRI would lose the leading scientists. Very fortunately, that did not happen at all. The reason is that IRI is now an exciting place for research. That excitement, I think, prevented them from leaving. So I think the rate of return to research has increased now and that is another reason why I'm optimistic about the future of African farming.

[Chair]
I think it's time to draw this discussion to a close. I just wondered if Professor Kydd and Professor Otsuka would like to make some closing remarks?

[Prof. Kydd]
Well, yes if I may I'll just do it by answering that very interesting question I was asked there.

I think the point I'd make about - trying to grossly simplify the green revolution process in Asia - was that one had these, miracle varieties of wheat and rice, if you like, dropped into well-watered India and other parts of the world where behind this you had government although the government had been a little bit out of the story. But you had a long tradition going back many centuries of water management. You also had at the time in these counties a strong tradition of government intervening in the economy to help farmers overcome these critical market failures and to make sure the markets into which they were selling their products were not particularly volatile. That is counter to the current orthodoxy. So you then look at Africa and you find that the physical constraints are different. There is much less in the way of a strong tradition of water management. But there are some well-watered areas.

I think it's interesting that Professor Otsuka examples are from the highlands or Kenya and Uganda which are places in Africa where soils and water naturally are quite good. When you move to much of the rest of Africa where the majority of poor people live, these fundamental conditions are not there so I think that's why I'm somewhat more pessimistic. But I'm not hugely pessimistic. The story we are coming up, with from a position of scepticism, is that nerica rice is interesting. It's moving in Nigeria, which is a country which is characterised by very bad government and so you certainly can't say that the government making it happen in Nigeria; the government generally stops things happening in Nigeria.

We've talked about mobile phones and other technology. And of course we haven't really debated it here today but Professor Otsuka has continually reminded us of all this technological progress in the pipeline with potential for genetic modification and us not really knowing where this is going to take us. But I think there is a very well-grounded assumption that this will produce varieties that will grow in places where it is currently difficult to produce high yields with very poor soils and poor fertility.

I think I will finish by saying however by saying that my own guess about genetic modification is that it will be the bigger and more capitalised farmers who will grab and use technology first because amongst other things, there are huge amounts of private money going into the area and pitifully small amounts of public money.

[Prof. Otsuka]
I began my research on African funding systems in 1993. Before that I had never read any papers on Africa. I thought Asia and Africa were so different. When I saw a paper which is entitled something like 'Maize funding system in Nigeria', I just threw it away. I never read it. But that applies to African researchers too. I think that Professor Kydd is a good exception. Most African researchers don't study from Asia. But I don't think Asia and Africa are so different. There are a lot of similarities from which we should learn something.

If you are interested in African issues, don't look at Africa alone. You should look at Asia and Africa and maybe Latin America as well. There are a lot of similarities and we can learn a lot of lessons from the experience of Asia, some of which is certainly very useful for the development of Africa.