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Food Aid and the Disincentive Effect in Tanzania

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Food Aid and the Disincentive Effect in Tanzania

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Abstract. This study is a theoretical and empirical analysis of the economic impact of food aid on producer incentives in developing countries. The special focus is on the so-called disincentive hypothesis, which argues that food aid tends to lower food prices, reduce domestic production and thus worsen the country's economic problems. The aim is to assess how valid is this disincentive effect of food aid on the agricultural production. For the evaluation of the disincentive effect, empirical data from Tanzanian agriculture was collected, the data covering years 1971-1996. The theoretical models of agricultural production were developed reflecting the institutional circumstances in Tanzania.

The study starts with a review on the previous theoretical and empirical analyses of disincentive effect. A parametric market model for agricultural production with food aid is then formulated and analysed. Relative to the previous disincentive literature the theoretical model of agricultural production developed includes as a new element producer risk in the form of an uncertain crop price. Since Tanzanian food markets were divided into the official government controlled market and the illegal unofficial market, the supply model consists of a model for controlled markets with fixed prices and a model for unofficial markets with price risk. Based on the derived concepts of crop supply and market equilibrium, the disincentive hypothesis was tested with an econometric model of the market equilibrium in the unofficial market.

Empirical findings did not indicate a statistically significant disincentive effect on the maize production. Instead it turned out that a price effect dominated the disincentive effect in the unofficial markets, since in years of low domestic production food aid was channelled to official markets and the unofficial markets reacted with higher prices. The incompletely integrated markets accentuated the situation, the more reliable yields of the Southern Highlands did not reach the deficient Northern areas and food aid and commercial imports tended to remain at the coast and in Dar es Salaam.

Keywords: agricultural economics, food aid, food security, food policy, food production, production functions, econometric models, Tanzania

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Kirkkonummi, September 2001

Marja-Liisa Tapio-Biström

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1. Introduction

1.1. Background

Food aid has been given throughout the history. The primary motivation has been humanitarian, i.e., to reduce famine and suffering, but political motives have also always been in the background. The modern type of food aid started after the First World War, when around 6.2 million tons of food was shipped from the USA to Europe between 1919 and 1926. American food aid to Europe was primarily given to relieve distress, but a more political aim was also clearly spelled out: the use of food commodities as a weapon in the fight against Bolshevism. Later, this was to become one of the major influences upon the geographical distribution of food aid. Food aid was not only provision of relief supplies in cases of disasters; it became also a tool of economic and political policy planning (see Miller et al. 1981, for a detailed description of the development of food aid, and Clay 1985).

After the Second World War food aid became a regular feature of international development programmes. The Marshall Plan meant a massive transfer of resources, including food aid, from the USA mainly to Europe to rebuild the continent. Apart from humanitarian relief, the background motives included other aims, such as to put the major US trading partners back on their feet, to open up new markets for American products and to remove accumulated surplus food (Miller et al. 1981, 46).

In 1954 the basis for American food aid was laid with the enactment of the Public Law 480. The reason behind it was the huge grain surplus stocks which had accumulated in the USA. The declared aims of the new legislation were[1], apart from getting rid of surpluses, to open up new markets for American products, to decrease hunger and malnutrition and to use food aid as a lever to obtain important raw materials in short supply in the USA from developing countries. The leading role of the USA as food aid donor (around 90% of all food aid in the 1960s) has diminished with diminishing surpluses, and in the 1990s the EU has been the largest food aid donor.

Food aid policies and operations have changed greatly during the past fifty years. Food aid has become more and more diversified in terms of donors, commodities, and policy

[1] The preamble of the Agricultural Trade Development and Assistance Act of 1954 (Public Law 480, 83rd Congress) explicitly identifies the following as the objectives of the legislation: 1. To expand international trade; 2. To develop and expand export markets for the United States agricultural commodities; 3. To combat hunger and malnutrition; 4. To encourage economic development in the developing countries; 5. To promote in other ways the foreign policy of the United States.

objectives. In the 1950s and much of the 1960s, the United States was the dominant donor. With the establishment of the World Food Program (WFP), food aid became partly multilateral, especially from the 1970s onwards. With the signing of the Food Aid Convention in 1967, the number of donors increased substantially, making food aid much less dependent on one single donor.

During its history, food aid has been given to practically all developing countries of the world, but a major part has always been concentrated on a rather small number of recipients. In the 1950s and 1960s, during the dominance of PL 480 shipments, the recipients mirrored rather faithfully the political interests of the USA. Since then, food aid has become more diversified and scarce. There is a significant geographical shift from Asia to Africa. The growing emphasis of development motives at the background of food aid has resulted in increasing concentration of food aid on the least developed, the so-called low-income food-deficit countries. The diminishing surpluses as of the 1970s, together with the international food crisis in 1973-74, have led to an increased emphasis on the effectiveness and development effects of food aid. The food aid volume peaked in 1965 and 1966 with 18 million tons, diminished to 5.6 million tons by 1974, then grew rapidly to around 10 million tons annually, with the long time low of 6.6 million tons in 1997 (FAO, various years). Recently, as food aid has decreased, emergency aid has grown in prominence, while programme aid has markedly decreased.

Food aid is food given as grant or on concessional terms from a donor, which might be a government or an organisation, to a recipient, which might be a government or an organisation. Food aid can be divided into different categories:

1) Programme food aid is generally provided for the purpose of some sort of budget support to the recipient countries and is supplied in bulk for the government to sell.

2) Project food aid helps to satisfy minimum nutritional needs for the part of the population which does not normally have the capacity to do this, and is given to a target group through feeding programmes or food-for-work projects.

3) Relief food aid is delivered to victims of manmade or natural disasters.

4) PL 480 Title II food aid given by the USA is given to NGOs, and sold by them to finance development projects (see, for example, Singer et al. 1987 for a more detailed description).

Programme food aid is supplied in bulk to government stocks, reserves, silos, etc., and is used by the government just as it would use national production or commercial imports of the same commodity. This means that this kind of food aid is generally sold to the recipients or distributed through national relief schemes.

From an economic viewpoint, programme food aid functions in deficit years as an item which fills the gap between demand at existing prices and income levels, on one hand, and the normal available supply of food through domestic production, on the other hand. The economic impact of food aid is based on the fact that introduction of more grain into the market will decrease the price of grain. If food aid is sold in the open market at a market-clearing price, the price of cereals will fall. This means lower prices for local producers and cheaper food for local consumers. Decreasing price means that producers' profits will diminish which will lead to decreased production. This phenomenon is called the disincentive effect of food aid, and it was first presented by Schultz (1960). There is a considerable amount of controversial literature on the effects of programme food aid on the economies, and more specifically on agricultural production, of the recipient countries (see review articles by Singer 1978, Maxwell and Singer 1979, Clay and Singer 1982).

The possible economic impacts of food aid depend on the marketing policy and production structure of the recipient country. Economic impacts of food aid can be affected by government actions. Governments have tended to regard food markets as having such strategic importance as to call for different kinds of control mechanisms. The governments have several policy tools at their disposal for influencing the effects of food aid: 1) segmenting of markets; 2) stabilisation of prices; 3) using counterpart funds to establish a floor price or to subsidise input prices; or 4) using food aid as balance of payments support. Each of these may decrease the disincentive effect (Ibid. and Bremer-Fox and Bailey 1989 for a thorough discussion on policy choices).

A maximum positive consumption effect can be obtained by segmenting the market. When markets are segmented, some defined groups receive a limited or unlimited quantity of the goods in question, at less than the market price. This means providing cheap food for the lowest income groups by using special government shops, food coupons or other similar methods. This diminishes the overall disincentive effect by creating additional demand for food. The poorest people have a very high price and income elasticity of demand for food[2].

Stabilisation of prices can be attempted with the help of food aid (or commercial imports). Food aid can be used for establishing food reserve stocks[3]. These can alleviate price fluctuations and ease food access problems for people who are facing the risk of acute food insecurity. On the other hand, reserve stocks are expensive to

[2] In Tanzania the poorest 20% spent 74% of their income to food while the richest 20% spent 62%, the figure for the whole population being 68% (World Bank 1996, 79).

[3] This possibility has been used very little since the experiences have not been very encouraging. In Tanzania a grain reserve project was supported by a number of food aid donors and organisations between 1978 and 1982. The project was not successful, basically because of differences in interpretation between the government and donors regarding the purpose of the reserve. In addition, financial resources were not properly managed by the National Milling Corporation, which reduced its ability to replenish the reserve (WFP 1988, 11).

keep and difficult to manage. In a free market situation, the grain reserve should be run in a manner that does not disturb the markets.

The funds generated by local sales, the counterpart funds, are usually stipulated to be used for activities designed to increase agricultural production or rural incomes. Counterpart funds could also be used to balance the negative price disincentive effect by establishing a floor price for basic staple grains or by reducing production costs through subsidised inputs. The impact of such funds depends on the general development policy of the country, since they are entirely fungible. This means that the resources are available for any purpose, developmental or otherwise.

The quantity of counterpart funds is highest with sales at market clearing prices and lowest at segmented markets, where food aid is sold at subsidised prices for target groups. This implies a trade-off between the potential direct income effect and improved nutrition of the targeted poorest consumers, on one hand, and the financial support to the government, on the other hand.

At the opposite extreme from additional food aid, food aid can act as a substitute for commercial imports, and thus as a balance of payments support. In that case there cannot be any direct disincentive effect through the prices, since the total volume of food coming to the market does not change. The impact of this form of aid depends on what the government does with the saved foreign currency. The released resources could have positive macroeconomic effects if the government uses the resources to investments which decrease transaction costs. For example, an improved road network increases market integration, decreases transport costs and input prices. The foreign currency could, for example, be used to import other vital items like fuel, spare parts or agricultural inputs. Alternatively, the foreign currency could be used to reduce debts. This argument of the food aid proponents figures prominently in the discussion on the possible role of food aid in the African food crisis. (Clay 1986 has an excellent discussion on this problem, see also Clay and Singer 1982, Ezekiel 1989 and 1990, Fitzpatrick and Storey 1989. For a discussion on food aid in the African context, see World Bank and World Food Programme 1991.)

Paradoxically, using food aid as balance-of-payment support violates one of the basic rules of international food aid policy, the so-called Usual Marketing Requirements (UMR). Most donors impose a condition when granting food aid, requiring that it shall not replace normal commercial imports. The UMR is calculated as an average of the commercial imports of the preceding five years. Modifications can be made due to exceptional circumstances. In practice, implementation of the legislation has been flexible, although occasionally - even for low-income countries - a hard line is taken.

(See Deaton 1990 for a theoretical discussion on the effects of UMR on the recipient country’s food economy, and Dearde and Ackroyd 1989) [4].

1.2. The aims of the study

The most important theoretical discussion related to programme food aid has been its possible disincentive impact on agricultural production. Schultz (1960) raised the issue by stating that as food aid will increase the aggregate supply of grain in the market, prices will decrease and this will be a disincentive for domestic grain production. Khatkhate (1962) offered a counter-argument. He stressed that subsistence farmers would not react to a price incentive by marketing more.

It is possible to speculate that the subsistence type of production, with high risk for household food insecurity, might lead to a situation in which the farmers do not react to price incentives; i.e., there is a possibility of a negative price effect. In that case, there would be no disincentive effect due to food aid, since farmers would make their production decisions based on the presence of high risk and subsistence needs. Their grain production for markets would be additional income realised in good years, not the sole aim of the production. Or they would sell some grain to cover the most necessary money needs irrespective of the price. In this case they would, if necessary, restrict their household consumption even below the nutritional needs. This does not imply that farmers would not be sensitive for price relations between various crops.

Since then the disincentive issue has been debated without any definite conclusion by, for example, Mann (1967), Seevers (1968), Isenman and Singer (1977), Clay and Singer (1982), and Maxwell (1986a,b, 1991). The models developed have not incorporated the risk which farmers are facing in making their production decisions. Neither have the institutional aspects related to price and agricultural policy prevalent in many of the recipient countries been included into the models. Empirical studies have seldom been based on rigorous theoretical analysis.

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[4] Singer et al. (1987, 40) cite the case of Tanzania as an example. Some donors to Tanzania had specified balance-of-payment support as the purpose of their assistance. Since it was concluded that Tanzania had thus violated the UMR, Canada halted her food aid for 1982/83. It was resumed again in 1983/84, even though Tanzania had not met its UMR commitments that year due to lack of foreign exchange - so that food aid, in substituting for non-existent national cash, became financial aid. ”Though food aid has formed a part of the import structure, it should not be assumed that additional imports would or could exactly replace food aid. Tanzania's foreign exchange situation worsened after 1978, but its food aid requirements were also high and rose sharply in the late 1970s and early 1980s. If the food aid received in 1981/82 had actually been bought commercially, in addition to the amount spent on commercial imports, the total cost would have represented 30% of the aggregate non-oil foreign exchange availability in that year. This would have been equivalent to the combined value of that year's exports of sisal and cotton" (Singer et al. 1987, 41).

The hypothesis is that food aid has a price disincentive effect on maize production in Tanzania. The theoretical basis is conventional neo-classical farm production function and market equilibrium. To investigate the hypothesis the study progresses in three phases:

1) A model based on credible economic behaviour is developed to define the supply and demand in a grain market. Then market equilibrium is presented, and the impact of introducing food aid into the system is investigated.

2) The next step is to find such an empirical econometric specification representing the Tanzanian grain market system as would be consistent with the research problem. The study will develop a supply side two-market partial equilibrium model of maize production in Tanzania.

3) Then the model is applied to the data from Tanzania to investigate the impact of food aid on maize prices and supply, and the validity of the hypothesis.

The aim is, through the model developed in this study, to gain better understanding of the staple grain production in a subsistence oriented food system. This study will contribute to the knowledge of the interactions between food aid and domestic grain production. This information will be helpful in planning food aid actions. If it is possible to anticipate the likely impacts of food aid on the national food system, the modalities of food aid can be designed in a manner to minimise negative impacts.

The case study country Tanzania offers many interesting characteristics. It is a country which has been using extensive quantities of food aid during the period when grain markets were state controlled. On the other hand, the economic and grain market liberalisation processes have led to vastly diminished food aid.

Although Tanzania had been self-sufficient with food during the early years of its independence and even exported food in some years, the situation changed radically in the early 1970s. Tanzania developed a heavy dependence on programme food aid, and in some years, as much as 90% of imports were food aid. This was due to many external and internal circumstances, among them the oil crisis, war with Uganda, villagisation as well as government marketing and price policy. Because of the large quantities of food aid received, it is instructive to study its impact on the production and price levels of the major staple food, maize. Interestingly enough, the volume of food aid decreased rapidly as the grain market was liberalised, and has not reached the previous high levels, even in drought years.

A typical Tanzanian farmer is a peasant smallholder, and the peasant household is of a semi-subsistence kind. The dominant technology is rainfed hoe-cultivation. Since a major part of the agricultural work in Tanzania is done by women while men often hold the legal rights as the heads of the households, in this study the household is considered to be the minimum production unit and the peasant farmer is a representative of this unit. The division of responsibilities, decision-making power and labour within the peasant household is not considered here.

The strong element of subsistence production - some 70% of maize is used by households for their own consumption - offers interesting insight into the nature of peasant decision-making in presence of weak integration into the markets, high weather-related risks, unsupportive government policies and weak social security. Tanzania demonstrates many features which are common to countries in Sub-Saharan Africa. Thus some more general insight can also be gained from this kind of a study.

2. Review and synthesis of the previous literature

Although food aid has been given in its modern form since the Second World War and it is an established practice of international co-operation and has considerable economic value, there is very little scientific research done on it. The words of Cathie (1989) are still valid: "... there is no universally accepted method of assessing its (= food aid) role, its potential adverse effects and its potential contributions". Indeed, as this chapter shows, theoretical work has been limited and controversial. Although many countries have received food aid over a considerable period of time, there are very few empirical studies on the impact of food aid on the recipient economies.

This chapter lays the theoretical foundation for the study and reviews the research previously done on the subject. It presents the theoretical developments of the idea of food aid as a disincentive for domestic production in the recipient country, combined with efforts to develop analytical approaches for studying this impact. Then follows a formal theoretical presentation of the disincentive impact. This is done with an analytical market model for agricultural production in the presence of food aid. Then follows a short review of the most important empirical research so far done, with special reference to the very limited overall research effort on food aid in Sub-Saharan Africa.

2.1. Theoretical approach

This study develops a production function and a market equilibrium model based on the price theory of neo-classical economics (any standard reference contains the basic features, for example, Doll and Orazem 1984, Hirshleifer and Glazer 1992). A production function describes the technical relationship that transforms inputs (resources) into outputs (commodities). Traditionally, an agricultural production function consists of a certain number of inputs which together define the quantity of output produced. The assumption is that a production process can be accurately described by a certain number and combination of factors of production. The classical ingredients are land, labour, seeds and chemical fertilizers. Inputs can be classified as fixed or variable. In terms of the growing season, land can be considered as a fixed input while labour and fertilizers and the like are variable inputs. The classification of inputs into fixed and variable is rather arbitrary, since it depends entirely on the time perspective chosen. In the long run. all inputs can be considered as variable, but for the sake of simplicity, in a production function presented here, land is defined as a fixed input factor. The analytical relevance is attained by placing the production possibilities in the context of the goals of the farming family and the resource constraints of the individual farm.

The basic theory of farm production makes some important simplifications. The consumption side of the farm households is ignored, only one single goal, i.e., short-term profit maximisation is explored, and only one single decision-maker, the farmer, is permitted. Further, it is assumed that there is competition in the markets for farm inputs and outputs and there is unlimited working capital for the purchase of variable inputs.

The law of diminishing returns is fundamental to production economics. It states that as units of a variable input are added to units of one or more fixed inputs, after a point, each incremental unit of the variable input produces less and less additional outputs. For example, if incremental units of nitrogen fertilizer were applied to maize, after a point, each incremental unit of nitrogen fertilizer would produce less and less additional maize. If the fertilizer levels are still increased, at a certain point the effect will be toxic and the total physical product (TPP) starts declining.

The marginal physical product (MPP) refers to a change of output associated with an incremental change in the use of an input, while average physical product (APP) refers to average quantity of output produced per unit of input at each input level. By repeatedly differentiating a production function, it is possible to determine accurately the shape of the corresponding MPP function. The production function can be divided into three stages. Stage I begins at zero input level and continues to the point where APP is at its maximum and equal to MPP. Stage II begins where APP is maximum and ends where MPP is zero. Stage III is the range of input levels where MPP is negative and TPP is declining (Kay and Edwards 1994, 116-118).

To be economically feasible, agricultural production function must meet two conditions: the marginal physical product should be positive and declining. For the condition to be met, the production function should have a positive first derivate and negative second derivate, i.e., the response of output to increasing levels of the input(s) should be rising but at a decreasing rate.

The most efficient level of variable inputs depends on the relationship between the price of the input and the price of the output. The economically optimal level of the input is reached when the marginal value product of the input is equal to the price of the input. The economic optimum changes with the changing price ratio between the input and the output.

It is widely known that peasant households in developing countries face a high level of uncertainty. This uncertainty is more pervasive and serious than the one faced by the farmers in temperate zones. The variations in the climate are more unpredictable and tend to have more severe consequences for the crop yield. The markets are unstable with poor information and a number of other imperfections. The peasants are mostly so poor that their sheer lives depend on the crops produced and there are few other coping options available. This leads to modifications in the peasants' economic behaviour.

Current practice in the economic analysis of risk (a general introduction to the subject can be found in Ellis 1988, 80-100) is based on the subjective probabilities attached by farm decision-makers to the likelihood of occurrence of different events. The analysis of risk involves not just these probabilities, but also the way they enter economic decisions. Uncertainty refers in a descriptive sense to the character of the economic environment confronting peasant farm households. The environment contains a wide variety of uncertain events, to which the farmers will attach various degrees of risk, according to their subjective beliefs on the occurrence of such events (Ellis 1988, 83).

The concept of risk is firmly rooted in the economic concept of personal utility maximisation. In the case of subjective assessment of uncertain events the individual maximises expected utility. Empirical evidence quoted by Ellis (1988, 94) tend to confirm following aspects of peasant behaviour related to risk: peasants are risk aversive, and this results in sub-optimal resource allocation; many peasant communities follow cultivation practices, and choices of crops, designed to increase security rather than income; risk aversion declines as income rises.

Market demand is defined in terms of alternative quantities of a commodity that all consumers are willing and able to buy as price varies and as all other factors are held constant (Tomek and Robinson 1990, 14). Models of agricultural product price behaviour often assume a purely or perfectly competitive market structure. In practice, this is seldom the case with the main agricultural staples. In our empirical example from Tanzania, there where two markets for maize, one regulated by the government and the other purely competitive illegal market, where prices were determined by the forces of supply and demand.

An equilibrium price is the price at which quantity demanded equals quantity supplied. Actual prices approximate equilibrium prices in a purely competitive market. However, with imperfect information about current and expected economic conditions, actual transaction prices may deviate from the equilibrium level (Tomek and Robinson 1990, 82). The implicit assumption of most empirical studies is that an average of transaction prices (month, quarter or year) is equal to the equilibrium price.

The conventional supply-demand diagram describing equilibrium does not imply that price and quantity are constant in a purely competitive market. An equilibrium price is defined for a given static supply and demand function. In studying empirical phenomenon it is convenient to look at a series of static situations and compare them with each other. This is called comparative statics.

Another possible approach to analyse peasant production is based on models of household production. These models treat households simultaneously as production and consumption units. Thus it is possible to simultaneously study questions such as the level of farm production, the demand for farm inputs, consumption and supply of labour and how the behaviour of a household as a producer affects its behaviour as a consumer and supplier of labour and vice versa. These models, however, require detailed household level data which is not readily available and expensive and time consuming to produce**.** Because of the lack of data this study applies the conventional neo-classical production function which is based on the assumption of perfectly functioning markets. Market imperfections, however, will be taken into account in interpreting the results.

Peasant producers in developing countries like Tanzania face many more difficulties compared to their temperate zone farmer colleagues. Peasants are by definition in Ellis (1988, 4) farm households, with access to their means of livelihood in land, utilising mainly family labour in farm production, always located in a larger economic system, but fundamentally characterised by partial engagement in markets which tend to function with high degree of imperfection. Their temperate zone counterparts, the family farms, are integrated into markets. While these markets are often regulated, they possess many more features of fully working markets in accordance with the assumptions of the neo-classical economic theory. The partial integration into the market means that subsistence consumption is a central aspect of production. Peasants in developing countries are often very poor, food security is a central aim of the household and economic capacity is extremely limited. Although all rural households as a rule have land and cultivate food, there are also some households which are net food buyers. These households are especially vulnerable to incompletely functioning markets. The incomplete markets mean that low and uneven development of infrastructure acts as a hindrance for movements of both information and goods. Further capital markets are fragmentary or non-existent, variable production inputs may be irregularly available and a freehold market for land does not always exist (see, e.g., Ellis 1988, 9-12). Thus some of the assumptions used in neo-classical economic analysis do not hold in the case study example of Tanzania. However, in this study it is assumed that by using the tools of the neo-classical production function and the concept of market equilibrium it is possible to gain useful insight into the economics of staple food production and impact of food aid. The perfect market model is used here also to highlight indirectly the instances where the market functions imperfectly (see econometric analysis in Chapter 5).

2.2. The price disincentive effect in previous literature

The major scientific debate concerning the impact of programme food aid on recipient countries[5] is the disincentive debate. It began with an article by Schultz (1960), where he discussed the possible effects of Public Law 480 products upon the countries receiving them. He concluded that PL 480 increased the quantity of resources at the command of the recipient countries. To this extent the countries were better off. Whether these resources were used as additional food or as additional saving was an open question. But his main point was the economic impact of food aid on domestic agricultural production. Assuming that the interest of the recipient country is to expand agricultural production alongside with industrial development, there is a reason to be worried about the impact of food aid. Schultz (1960, 1029) presented a hypothetical case study of India. He assumed that food aid was a grant, the normal commercial imports continued as before, and there were no close substitutes in either production or consumption within the country. Presumably he also assumed that food markets were unregulated and food aid was programme food aid sold in the recipient country. Food aid represented 6% of India's domestic production of food. Provided that the price elasticity of demand for farm foods was no less than unity, a reduction of producer prices by 6% was implied. This would be partially offset by the income effects of the rise in real incomes associated with the food aid grants. This would mean that consumers were better off, but producers would be confronted with lower prices and also with an income effect reducing their consumption. That would give a wrong signal for agricultural producers - a disincentive to produce.

Schultz's argument was challenged by Khatkhate (1962). He represented the view that a fall in food prices is no cause of concern since, in largely subsistence oriented peasant economies, the majority of farmers respond to rising prices by marketing a smaller part of their production and consuming a larger part. The marketed surplus assumes the characteristics of a backward sloping supply curve. This view is based on observations from India[6] where subsistence farmers produced the maximum quantity with the available inputs, but this was barely enough for subsistence consumption. They had a fixed number of expenses which had to be covered, like taxes, debts and some consumption goods. Thus they marketed part of their production to cover the expenses, even if that meant that they could consume less than they needed (i.e., one could interpret that they are credit rationed[7]). However, rising prises meant that peasants had to sell less to earn the needed amount of money and they could retain more to household consumption. Thus the peasants behaved rationally but the overall

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[5]Ezekiel (1955) made a pilot study, the first scientific study on the impact of food aid on recipient country economies, about the impact of labour intensive projects on the Indian economy.

[6] The empirical observations are based on a study of Narain (1961) in which it was stated that the marketed surplus as a proportion of the value of produce declines up to the 10-15 acres size group and increases thereafter.

[7] Credit rationing is usually defined so that farmers were willing to borrow more but were not allowed to due to a credit ceiling imposed on them (Keeton 1979).

very low production levels in relation to household food and cash needs resulted in a backward sloping marketed supply curve. This theory relies on assumptions that the total acreage, labour, and other factors of production engaged in agriculture cannot expand in response to price or be able to shift to alternative agricultural commodities when relative prices change. According to Khatkhate the peasants were acting rationally by optimising their behaviour in relation to the consumption needs and obligations on the one hand and production possibilities on the other hand. The constraints for increased production were technical by nature.

However, Beringer (1963) and Falcon (1963) presented evidence already in 1963 on the shift of production as the relative prices of different commodities change. Their findings were confirmed by the review of Kern (1968). Thus, although the peasants were bound by credit rationing, they responded to prices by shifting the resources to produce commodities which were relatively more remunerative. Although the peasants' aggregate supply of a certain commodity responded to prices, the total level of agricultural production did not rise in the short run due to various production constraints.

These results were confirmed by Schultz in 1964 in his study ”Transforming Traditional Agriculture”, in which he presented his view of a rational but poor peasant[8]. The reasons for low productivity were technological constraints. The solution to this was agricultural research. Peasants were shown to be price conscious and price responsive within the technological constraints they were facing. This was shown by shifts in production between various crops as their relative prices changed. The view of Schultz of the rational but poor peasant induced in the 1970s a gradual shift in agricultural price policy of many countries. To increase food production, a shift in relative prices in favour of food crops could be made. This induced a shift in production towards more profitable crops; in this case food crops[9].

Fisher (1963) presented a theoretical development of Schultz's thesis. He was the first to make a graphical presentation of the disincentive impact of food aid on domestic production. From the graphical presentation of the price impact of food aid Fisher proceeded to show that the price impact was approximately given by the price elasticity of the domestic supply curve divided by the sum of domestic supply and demand price elasticities. In the simplified model Fisher did not take cross elasticities

[8] Ozanne (1999) summarises the theoretical discussion and available empirical evidence on peasant farmers supply response in a review article. The conclusion is that it is theoretically possible for the supply response to be negative. Empirical evidence does not, however, support this. But empirical evidence tends to confirm the preconceptions of the researchers, and thus Ozanne concludes : 'It should also be recognised that empirical results which do not have the "correct" sign tend to be rejected and therefore go unreported in academic publications. The weight of empirical evidence may therefore be misleading and economists and policy makers alike should be wary of accepting prevailing dogma unreservedly'.

[9] This theme is developed in Eicher and Staatz (1984).

between different products and substitution effects related to relative price increases into account.

Von Braun (1982) assessed the price dampening effect of food aid on wheat prices in Egypt with a model in which the disincentive effect of food aid was derived from the price flexibility and the price elasticity of supply concerning acreage and yield. The situation with very low levels of food aid was compared to a situation with high levels of food aid. The resulting demonstrated disincentive effect was comparatively marginal. The weakness of this partial attempt to quantify the disincentive effect, based as it was on only one product, wheat, could only be overcome in a complete dynamic model of the agriculture, and this would have to provide a consistent picture of the effects on competing product prices, the price level and the demand reaction.

Bezuneh et al. (1988) examined the effects of a particular type of food aid programme - food-for-work (FFW) - on agricultural production, income, capital investment, employment, and the mix of foods consumed by participants in a specific FFW project. They constructed a peasant-household-firm model (HFM) which incorporates a linear programming model on the production side and an almost ideal demand system on the consumption side. The theoretical HFM with FFW consists of five elements: (a) a household utility function; (b) an agricultural production function; (c) a time constraint; (d) a FFW production function; and (e) and an income constraint. They concluded that the potential impacts of FFW on output, employment, and consumption depend not only on the household time allocation in the short run but on the extent to which FFW increases the productivity of an idle or underemployed resource (labour). They also suggested that labour productivity effects could result from capital investment and nutritional effects (although nutrition effects on human capital accumulation were not explicitly included in the above model).

Hoffman et al. (1994) made a model in order to study the impact of food aid on food subsidies in recipient countries. They tested it empirically with data from ten countries. According to their results, food aid does not simply reduce developing country budget demands (and commercial imports) but it tends to induce increased food subsidies, thus increasing consumption. The data did not allow any definite conclusions on the effect on producers. That depends on the form of the subsidy programme. Thus they conclude that if food aid discourages domestic production, it is because producers are denied effective access to world markets due to transport costs, export taxes and other barriers. Food aid only relaxes the budgetary pressures promoting such impediments.

Whether the disincentive effect is operative seems to be an open question given the mixed evidence (Mann 1967, Seevers 1968, and Maxwell 1986b). After giving a formal presentation of the disincentive effect in the following section 2.3., we will proceed by presenting the relevant existing empirical research on the disincentive effect and the research conducted on the impact of food aid in Sub-Saharan Africa in section 2.4.

2.3. The disincentive effect revisited

To lay a firm economic basis for the interpretation of the disincentive effect and for the study of the impact of food aid on grain production, a formal analytical market equilibrium model without and with imports is presented. This will allow us to study the presented arguments in a consistent form. The model is a typical market model where consumers' demand for agricultural products, supplied by the farmers, and the equilibrium price and quantity are determined by the intersection of demand and supply curves. In the model, the effect of food aid is a positive shift in aggregate supply.

A. Consumer demand

Let us assume that the preferences of a representative consumer define a quasilinear utility function. This function is linear in terms of composite commodity consumption and concave in terms of grain consumption. Hence,

[1] $$u(x,z) = u(x) + z\ ,$$

where u = utility, x = the quantity of grain and z = other consumables.

Moreover, we assume that the concave part, $u(x)$, is quadratic so that the demand function will be linear for diagrammatic purposes.

[2] $$u(x) = (\alpha - \tfrac{1}{2}\beta x)x\ ,$$

which yields a linear demand curve (α and β are positive and describe the preferences of the consumer).

The consumer's budget constraint is

[3] $$px + qz = m$$

where m = usable income, p = price of grain and q = price of other consumables.

The problem of the representative consumer is to choose the quantities of x and z so as to maximise [1] subject to [3].

It is convenient to solve [3] for z, to obtain a free maximisation problem instead of a constrained one.

[4] $$z = \frac{m - px}{q}$$

Using [4] for z and recalling [1] gives the following maximisation problem

[5] $$\underset{\{x\}}{\text{Max}}\, u[x, z] = (\alpha - 1/2\beta x)x + \left(\frac{m - px}{q}\right).$$

The optimal quantity for grain production is obtained by choosing x so as to maximise [5]. This gives us the following first order condition:

[6] $$u_x = \alpha - \beta x - \frac{p}{q} = 0 .$$

The second order condition is negative, as required for the optimum

[7] $$u_{xx} = -\beta < 0 .$$

We can solve [6] for optimal consumption, i.e., demand for grain x^d from the first order condition to yield

[8] $$x^d = \frac{\alpha}{\beta} - \frac{p}{\beta q} .$$

Let us denote for convenience $\frac{\alpha}{\beta} = a > 0$ and $\frac{1}{\beta} = b > 0$. Hence, a is the shift parameter of demand and b is the price sensitivity parameter of demand, i.e., b is the slope of the demand curve.

Now we can rewrite the demand function [8] as

[9] $$x^d = a - \frac{b}{q} p .$$

This shows that the demand of grain is linear and depends positively on the shift parameter and negatively on the relative price, indicated by the sensitivity parameter.

Finally, let us note $\frac{p}{q} = p^*$ meaning relative or real price of grain and we can write

[10] $$x^d = a - bp^* .$$

Now we can calculate the comparative statics of grain demand by differentiating x^d with respect to p and q in order to study the impact of changing prices of grain and other consumables on the demand of grain.

[11a] $$\mathrm{x}_{\mathrm{p}}^{\mathrm{d}} = -\frac{1}{\beta q} < 0$$

[11b] $x_q^d = \frac{b}{q^2} p > 0$

Hence, when grain price increases, demand decreases, but when the price of composite commodity increases, the demand of grain increases.

Thus we can write

[12] $x^d = x^d(\underset{-}{p}, \underset{+}{q})$

B. Supply

Let us assume that the producers maximise their net revenue from agricultural production. Let $c(x)$ denote production costs[10] and we can write the revenue maximisation equation for producers as follows:

[13] $Max\pi = px - c(x)$,

where π = net revenue, p = grain price, x = grain quantity, and c = production costs.

Assume next that the production costs $c(x)$ are quadratic, i.e., $c = (f + 1/2ex)x$. The farmer's problem is to choose x (the produced grain quantity) to maximise revenue

[14] $Max\pi = px - (f + 1/2ex)x$,

where f gives the intercept of the marginal cost function and e is its slope.

Differentiating [14] with respect to x gives us the first order condition

[15] $\pi_x = p - f - ex = 0$.

The second order condition is negative as required for the optimum

[16] $\pi_{xx} = -e < 0$.

According to [15], at the farmer's optimum, marginal revenue from production equals marginal costs. We can solve x^s to get the quantity of grain supplied as a function of price and cost factors.

[17] $x^s = \frac{p - f}{e} = -\frac{f}{e} + \frac{p}{e}$

[10] Usually one formulates the farmer's profit maximisation as a problem of choosing factors of production. As is well known, cost function exhibits the properties of production function so that this is an equivalent to the production function approach.

We denote $-\frac{f}{e} = \gamma$ and $\frac{1}{e} = \varepsilon$ and can then express the supply function of grain as

[18] $$x^s = \gamma + \varepsilon p \,,$$

where γ is the shift parameter and ε is the price sensitivity parameter.

The comparative statics of grain supply can be calculated by differentiating [15] with respect to p, e and f in order to study the impact of changes in grain price and fixed and changing costs on the supply of grain. We obtain the following total differential $dp - df - edx - xde = 0$ and further

[19a] $$\frac{dx}{dp} = x_p^s = \frac{1}{e} > 0 \,,$$

[19b] $$\frac{dx}{de} = x_e^s = -\frac{p-f}{e^2} < 0 \,,$$

[19c] $$\frac{dx}{df} = x_f^s = -\frac{1}{e} < 0 \,.$$

Higher grain price increases production, while higher costs decrease production.

Thus we can write

[20] $$x^s = x^s(\underset{+}{p}, \underset{-}{c})$$

C. Market equilibrium on a competitive market

The grain market is assumed to be competitive so that each economic agent takes the market price as given. To get the equilibrium price of grain, we set supply equal to demand

[21] $x^s = x^d$, which using [17] and [8] gives

[22] $$\frac{p-f}{e} = \frac{\alpha q - p}{\beta q} \,.$$

Thus we get the equilibrium price of grain

[23] $$p^* = \frac{q(\alpha e + \beta f)}{(\beta q + e)} \,.$$

Using this in either [8] or [17] produces the equilibrium quantity of grain

[24] $$x^* = \frac{\alpha q - f}{\beta q + e} \,.$$

Now we can calculate the comparative statics of market equilibrium by differentiating p^* and x^* with respect to q in order to study the impact of changes in the relative prices of grain and other consumables on the equilibrium price and quantity of grain produced domestically. We differentiate [23] and [24] with respect to q to see how higher price of a composite commodity affects the demand for grain:

[25a] $$p_q^* = \frac{(\alpha e + \beta f)e}{(\beta q + e)^2} > 0$$

[25b] $$x_q^* = \frac{\alpha(e + f)}{(\beta q + e)^2} > 0.$$

Hence, the impact of the increasing price of other consumables on market equilibrium is that both the equilibrium price and quantity of grain demanded increases. This is as expected, i.e., demand shifts to grain due to higher price of the composite commodity. The aforementioned situation can be presented in a graphical form as in Figure 2.1.

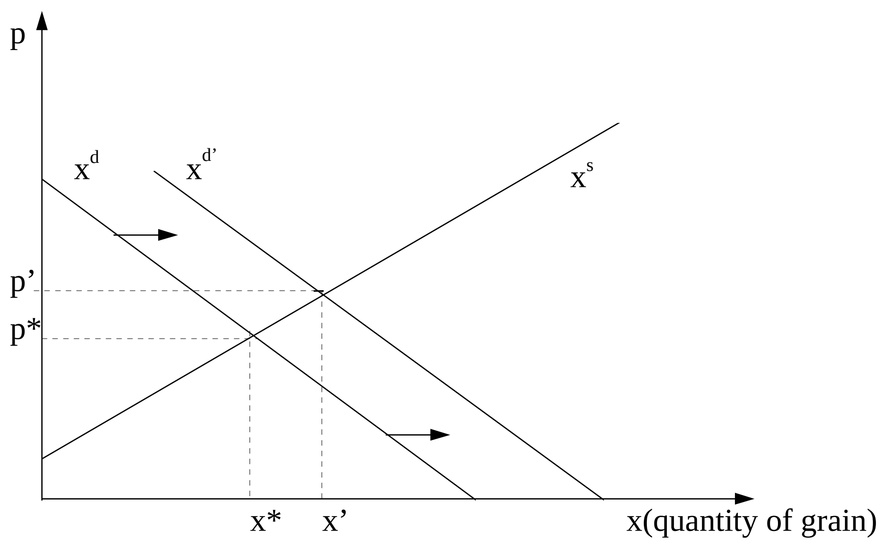

Figure 2.1. The original equilibrium x^* and comparative statics.

The original equilibrium is given by p^*, x^*. When q increases and thus the relative price of grain decreases, i.e., the grain becomes relatively cheaper when the price of other commodities rises, the demand curve of grain shifts outwards. The overall demand shifts from other commodities to grain. Thus a new equilibrium is created with higher production and price for grain.

The overall level of prices depends on consumer preferences and the production technology (cost terms). Consumer preferences change over time due to, for example, urbanisation, increased international trade, and social values associated with certain types of foods. Technical change, according to Ellis (1988, 213), means a reduction in the quantity of resources required to produce a given output; or alternatively, more output for the same level of resources. Changes in consumption preferences and technology will shift the demand and supply curves.

D. Market equilibrium with food aid

Assume now that the government imports a quantity of I of the agricultural commodity as food aid. Let us assume that I is a perfect substitute for x and it is sold in the same market as x so that the consumer cannot distinguish the origin of the commodity. We can solve the market equilibrium by equating domestic production and food aid to domestic demand.

[26] $$x^s + I = x^d$$

This can be written in accordance with equation [22] as

[27] $$\frac{p-f}{e} + I = \frac{\alpha q - p}{\beta q}$$

Now we can solve the equilibrium price with food aid

[28] $$\hat{p} = \frac{q(\alpha e + \beta f)}{\beta q + e} - \frac{\beta q e I}{\beta q + e}$$

Comparing equilibrium prices without food aid [23] and with food aid [28], we can see that the introduction of food aid reduces the equilibrium price, as the difference between prices is positive

[29] $$p^* - \hat{p} = \frac{\beta q e I}{\beta q + e} > 0\,.$$

Using [29] in either x^s or x^d produces the equilibrium quantity of grain with food aid

[30] $$\hat{x} = \frac{\alpha q - f}{\beta q + e} - \frac{\beta q I}{\beta q + e}$$

Comparing equilibrium quantities of domestic grain production without food aid [24] and with food aid [30], we can see that the introduction of food aid decreases the equilibrium quantity, as the difference between quantities is positive.

[31] $$x^* - \hat{x} = \frac{\beta q I}{\beta q + e} > 0\,.$$

The introduction of food aid into the grain market decreases the price of domestic grain and the quantity of domestic grain produced. This is illustrated in Figure 2.2.

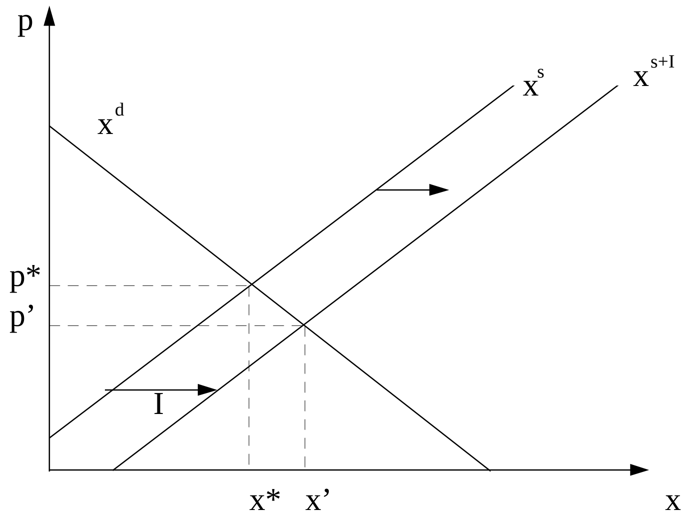

Figure 2.2. The impact of food aid on grain price and domestic production.

Now we can calculate the comparative statics of market equilibrium by differentiating $\hat{x}$ and $\hat{q}$ with respect to I in order to study the impact of changes in grain food aid on the equilibrium price of grain and quantity of grain produced domestically.

[32a] $$\hat{p}_I = -\frac{b\beta q}{\beta q + b} < 0$$

[32b] $$\hat{x}_I = -\frac{\beta q}{\beta q + b} < 0$$

The result shows us that increasing grain food aid will reduce both the grain price and the quantity of grain produced domestically.

The above developed market model shows the rationality of the Schultz's hypothesis, confirming that increased quantity of grain in the market due to food aid will decrease the equilibrium price and the quantity supplied domestically. Conventional production analysis does not, however, give any support to Kathakhate's hypothesis of backward sloping marketed production curve. This possibility remains open and will be subject to empirical testing later on. Fisher's amendment concerning the amount of decrease in domestic supply depends on the availability of reliable elasticity figures.

2.4. Empirical research

The market model suggests that empirical analyses of the disincentive effect should be based on the following reduced form equations.

[33a] $x = x(p, q, w, r, I)$

[33b] $p = p(x, q, w, r, I)$ [11].

In this section, keeping the above equations as a base, empirical studies are briefly assessed. There are only a few empirical studies on the interaction between food aid and the recipient economy[12]; for the discussion on the disincentive impact relevant references are Fisher (1963), Mann (1967) and Seevers (1968).

Mann (1967), in an effort to quantify the impact of imports of cereals under PL 480 on the prices and domestic supply of cereals in India, constructs an econometric model encompassing six simultaneous equations. He builds on Fisher's (1963) work, which was based on the assumption that this impact depends on the price elasticity of demand and of domestic supply as well as on the ratio of total demand to domestic supply.

Mann's model includes (1) a supply equation; (2) a demand equation; (3) an income-generating equation; (4) a commercial imports equation; (5) a withdrawal from stocks equation; and (6) a market clearing identity. The responses of prices and domestic supply of cereals to a change in PL 480 imports of cereals are examined in terms of a unit shock, which is not sustained. That is, the imports under PL 480 are increased by one pound per capita during year 0, and then reduced to the original level during year

[11] Notice that we have used input prices w and r instead of c to describe the variety of production costs. This is justified theoretically due to the properties of production technology and the cost function.

[12] A major empirical study by the Michigan State University on the impact of PL 480 shipments on the Colombian economy was made in the early 1960s (Goering 1962, Goering and De Witt 1963). This deepened the understanding of the different possible effects of food aid on the recipient economy over and above the possible simple effect on domestic grain prices. This study introduced most of the major themes related to the impacts of programme food aid on the recipient country's economy. They used statistical analysis of macroeconomic and price data without trying to formalise their presentation. Their conclusion was that in the case of Colombia the prerequisites for a positive impact were in place. In a situation where there was a shortage of foreign exchange and food production lagged behind the population growth, PL 480 permitted increased food imports at a time when balance of payment conditions dictated conservatism in exchange expenditure.

1. The effects of this change are embodied in various multipliers. His results support the view that the food aid under PL 480 lowers the price of cereals and reduces domestic production of cereals. However, there is a net contribution to consumption, since the reduction in production is less than the quantity of food aid received.

Seevers (1968) studied the price-output effect by comparing various combinations of possible supply and demand elasticities along with plausible values for other parameters in a hypothetical country, the aim being to evaluate the likely magnitude of the disincentive effect. He developed Fisher’s model by incorporating variables for commercial imports, population, real income and government investment on food production. He also used the ratio of shipments to quantity demanded (total utilisation) rather than the ratio to domestic production.

Seevers’s model assumed that the cross-elasticity with other consumption items was zero. Further, subsistence consumption of farmers was treated as a part of total demand and consequently domestic supply represents total supply rather than marketed surplus. The result was an equation telling the percentage change in domestic grain supply arising from a one per cent change in food aid's contribution to total output, i.e., the food aid elasticity of supply.

Seevers proceeded by calculating the price and output effects of PL 480 shipments based on various levels of elasticity. According to him the impact of population growth, even if demand increases somewhat less than the population in proportion, means that surprisingly small population increases counteract disincentive effects of increased food aid shipments. Further, a similar analysis of commercial imports leads to the conclusions that there will be strong pressure to diminish commercial imports and this will diminish the disincentive effect. The pressure, under government control of imports, is to divert foreign exchange to other pressing needs; for private importers the lower domestic prices will reduce the profitability of imports. The use of food aid as import substitution is very common indeed, as concluded by Maxwell and Singer (1979).

When applying the aforementioned model to India, Seevers obtained following estimates: the price-output effect of one per cent increase relative to total utilisation (this is equal to an about 20% change in actual food aid shipments) would be a 1.58% decrease in prices inducing a 0.40% decrease in domestic production[13].

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[13] Seevers also takes up the related economic effects, which need to be considered when evaluating the impact of food aid, namely the impact on consumption levels, income distribution and resource allocation. His calculations for India imply that, if no import substitution occurs, the amount of food available will increase due to food aid shipments and the net effect will be a modest improvement in overall nutrition. If the food can be channelled to segments of population, in which it will increase short and long-run labour productivity, there will be a national income effect. But lower prices and less output together decrease money incomes to domestic producers by more than either one evaluated alone (the

The existing empirical research is mostly rather old and mainly concerned with Asia, India, in particular. Empirical research related to Sub-Saharan Africa is rare. The main empirical research on the impact of food aid in the food systems in Sub-Saharan Africa, including Stevens (1979), Cathie and Dick (1987), Maxwell (1986a, b, c, 1991), Mellor and Ezekiel (1987) and Tschirley et al. (1996), are reviewed below.

The work of Stevens (1979) is the most comprehensive, covering four countries: Botswana, Lesotho, Upper Volta (now Burkina Faso) and Tunisia. He studied programme and project food aid and their impacts on nutrition, consumer prices and agricultural production, taking into account both direct and indirect effects. Unfortunately, the collected data was not sufficiently coherent or reliable to form the basis for an economic model to simulate the effects of food aid. The methodology adopted was, therefore, pragmatic and related to the type and quality of data available. This has resulted in the "creation of a mosaic of small chunks of data". Stevens (1979, 20) comments this approach by saying that in practice, this is how decisions are made on a wide range of issues in LDCs with poor statistics. Stevens did not get any unambiguous results on any of the subjects studied. He concludes: ”Food aid is unlikely to have a negative effect and may well have a positive impact, if supplied in good time and in the form of locally acceptable commodities to a food deficit country, with energetic agricultural development policies and as a part of a broader package of measures designed to assist a poverty-oriented development strategy. It is likely to have a negative impact, if supplied under the opposite circumstances. Since most recipients fall somewhere in between these two extremes, the decision whether or not to provide food aid will depend on delicate judgement” (Stevens 1979, 208-209).

There is one effort of food aid analysis based on a general equilibrium model. Cathie and Dick (1987) have done this in relation to the Botswanian economy. Its key behavioural equations were derived from the production and utility theory. Equilibrium equations emphasise the importance of relative prices and substitution prospects in explaining trade flows and the composition of domestic economic activity. The model was centred on a social accounting matrix flow system (SAM), which included commodity and factor flows, as well as income distribution between the government, regions and households. It thus allowed the tracing of the effects of drought, changes in

assumption here being that there are no alternative uses available for the inputs, no shifts to other products can be made); higher prices of items purchased by producers will cause the real incomes to decline somewhat more than money incomes. However, Seevers does not discuss the positive impact of decreased grain prices on consumers. The effect of food aid shipments on resource use is the last point Seevers makes. Three different effects can be isolated conceptually. The displaced resources can be shifted to other enterprises. Indeed, a shift of resources to some desirable alternatives may be consistent with the policies of a country lacking comparative advantage in food grain production and requiring more export crop production to earn more foreign exchange. Secondly, there is the possibility to save foreign exchange by replacing commercial imports with food aid. Thirdly, the sales proceeds from food aid sales are in effect a tax to producers. This tax can be invested into necessary development efforts and it could bring unused resources into production. Thus Seevers sees beyond the simple disincentive effect and looks at the domestic resources released as development possibilities.

international commodity prices and capital flows on the patterns of domestic economic activity and household income and consumption position, and showed the distributional consequences of alternative policy responses. In this analysis food security was defined as a deviation from trend consumption (Cathie 1989, and Cathie and Dick 1987). This is the only formal analysis of food aid in any Sub-Saharan African country. The problem with this kind of approach is that the technique is very data intensive. It is expensive to build this kind of models and highly qualified professionals must be available.

The results of this analysis of food aid in Botswana indicate that the single major source of instability facing the economy of Botswana is crop production. Food aid, with a standard deviation of some 85.28 per cent, is the highest single source of instability to the economy. Food aid has been neither stable nor counter-cyclical. The main forms of food aid to Botswana have been direct feeding programmes. The continuous supply of food aid has developed a dependency syndrome in Botswana, with periodic drought reinforcing the continuation of food aid supplies. For some 20 years as much as 50 per cent of the population has depended upon food aid, with few signs of self-sustained improvement, although the overall growth of the economy has been quite satisfactory, mainly due to the development of the diamond industry. According to the model, a food price stabilisation policy has the worst impact on the food consumption of the poor households. Further, if these stocks encourage inappropriate price policies in agriculture, the economic growth will be retarded (Cathie 1989, and Cathie and Dick 1987).

Maxwell (1986a, b, c, 1991) developed a pragmatic practical approach to study the possible disincentive effects of food aid and applied it to two case studies, Senegal and Ethiopia. The approach was based on a series of scenarios of possible disincentive effects both at the macro and the microlevel, on prices, policies, food habits and labour. These impacts were operationalised as a series of indicators, which were relevant prices with a variance, usually about ±15% of the average. According to Maxwell, there were no signs of price disincentive effect in Senegal. In Ethiopia no major disincentives were found at the macro level, which is quite natural because the amount of programme food aid in relation to domestic production was negligible. But the association of food aid with a substantial wheat subsidy gave rise to a concern. At the micro level there were signs of an emerging price-disincentive.

In the late 1980s the World Bank sponsored a large study ‘Managing Agricultural Development in Africa’ (MADIA), in which agricultural development constraints and possibilities were studied. It also included two studies concerning food aid (Mellor and Ezekiel 1987, and Mellor and Pandya-Lorch 1990). Mellor and Ezekiel (1987) examined the role of food aid in Kenya, Tanzania, Senegal and Cameroon, and the policies and programmes of different donors, namely USAID, Canada, EEC and World Food Programme (WFP). The study compared the food policies and the use of food aid and the developments in the food aid policies of various donors towards the case study countries. Mellor and Pandya-Lorch (1990, 7) concluded that ‘MADIA countries (the four countries mentioned above plus Nigeria and Malawi) illustrate four major features of food aid practice: substantial support of favourable development policies (Kenya); substantial support of unfavourable development policies (Tanzania); support of food supplies in the face of unfavourable weather and a difficult environment (Senegal); and grossly inadequate use of food aid to redress extreme poverty (Malawi).

Bezuneh et al. (1988) applied their household firm model (see Chapter 2.2., 20) empirically on a food-for-work (FFW) project in the Baringo district, Kenya where they conducted a survey. The results of the linear programming model indicate that net returns for representative farm households with FFW were 52% higher than for those without FFW. According to their study, FFW increased own-farm production, income, and employment in this food deficit, labour surplus area. However, in this example food aid was given directly to the recipient households as a compensation for work done in a development project and thus the results cannot be compared with the effects of programme food aid which acts through price impacts in the market.

In the 1990s the Michigan State University has conducted an intensive research activity in Mozambique (Weber et al. 1992, Tschirley et al. 1992, Tschirley et al. 1996, Donovan 1996, Tschirley 1997). A major question has been the impact of yellow maize food aid on the production and markets of domestic white maize. Interestingly enough, the assumption that yellow maize would act as an inferior good did not hold. The consumer behaviour was much more complex than that, the different types of flour having a decisive role. Empirical evidence was presented showing that retail prices of both white and yellow maize fluctuated with commercial yellow maize food aid shipments. It also was suggested that the instability in yellow maize prices, caused by irregular food aid arrivals, was transmitted to the white maize market (Tschirley et al. 1996).

In conclusion the evidence so far presented suggests that any disincentive effect depends on the details of the local economy and on how the food aid and related programmes are managed. When considering the practical applicability of the models for studying the disincentive effect developed earlier and described in section 2.1, there is scope for further development. The general equilibrium model is demanding to build. There is a need for an analytical approach, which uses easily available parameters, is technically easy to apply but is analytically rigorous enough. The next chapter proceeds in developing a model for analysing the impact of food aid on staple food prices of the recipient country. The model is a two-market model to reflect the circumstances of the case study country, Tanzania. The same kinds of policies have been in use in many other Sub-Saharan African countries.

3. Theoretical Model of Agricultural Production

3.1. Tanzanian food markets

This section develops a theoretical model of agricultural production with a specific focus on the institutional features of Tanzanian economy. During the 1970s and the '80s until 1986 the markets of agricultural products were divided into the official government controlled markets and the unofficial 'grey economy market'. The farmers could sell their agricultural products in the official market at a given, announced price, while the price formation in the grey economy market was based on the interaction between demand and supply.

At independence Tanzania reformed the staple food marketing system[14]. During the colonial period private traders of Asian origin had dominated the grain trade. This had created ill feelings among the population, especially in drought years, as grain prices rose. The state grain company, National Agricultural Products Board (NAPB), was established. All commercial quantities (exceeding 360 kg) had to be sold to the Board. Produce buying agents under the Board were regional marketing co-operatives and the prices were pan-territorial. Many of the co-operatives proved economically nonviable and business practices left much to desire. The marketing problems during the 1960s were related to gluts rather than shortages. Despite the fact that peasants were growing increasing quantities of cash crops as planned in the country's rural development strategy, there were no serious food shortages during the 1960s. The early 1970s saw marked changes in the overall national food security situation. Simultaneously as the massive villagisation programme was launched in 1973, co-operatives were abolished and the National Milling Corporation (NMC) was given the role of national grain monopoly. A one-tire food marketing system with NMC acting as the buyer directly from villages was established. An exceptional drought in 1973-75 lead to massive import needs and a price policy change. An adjustment of price relations between food and non-food crops in favour of food crops was made. This lead to a shift in production towards food crops indicating the price responsiveness of the peasants (but possibly also the distrust of peasants towards state cash-crop marketing monopolies). The resulting state controlled food marketing system proved to perform inefficiently and with the passing years developed into a heavy fiscal burden to the economy. The

[14] The newly independent nations of Africa tended to regard food markets as being too precious to be left to the market forces and private sector interests. The Tanzanian agricultural policy after independence was based on the view that the peasants were not responsive to prices. Smallholder peasants were thought to have a fairly low target level of income. Once this was reached, there were no incentives to produce more. Since it was thought that traditional peasants' main aim was to satisfy basic subsistence needs and not much else, market incentives were not considered to stimulate agricultural production (Amani and Ndulu 1987, 4, Lundahl and Ndulu 1987, 193, Eriksson 1993, 9).

official consumer prices were subsidised. This lead to heavy losses for the NMC, which had to apply the politically determined prices. When setting prices the government did not base the decisions on economic calculations but rather aimed at keeping the consumer prices of basic staples at a low enough level to avoid pressure on wage levels. The official marketing system was unable to collect necessary quantities of grain from producers to feed their traditional clients. The country had to rely on large-scale imports of basic staples, which were mainly in the form of food aid, to feed the main urban centres (Bryceson, Seppälä & Tapio-Biström 1998). This peculiar institutional system grew out of the political visions of the newly independent countries in Africa aiming at the national control of resources.

The structural adjustment process was commenced in Tanzania in the middle of the 1980s. One of the main elements was the gradual liberalisation of grain markets. By the early 1990s this process was completed. The role of the state was restricted to running the Strategic Grain Reserve.

In what follows, farmers' supply reaction in different markets is investigated with a model consisting of a controlled market supply model with fixed prices and an unofficial market supply model with price risk. This will illuminate the choices available for the Tanzanian peasant producers. It will also form the basis of understanding the past food aid policy and the impact of food aid on domestic production in a quite typical Sub-Saharan African food economy.

3.2. Production for the controlled grain markets

In the controlled markets the farmers sell to the parastatal firm, National Milling Corporation, for a price which is fixed, announced before the planting season and pan-territorial. This means that the producer price is the same on the controlled outlets all over the country, and thus the price contains an implicit transport subsidy for the areas which are located far away from the main consumption and deficit areas. This diminishes the risks of production, since an important element of income formation is known in advance[15].

[15] This brings a spatial element to agricultural production since official price may be more favourable in areas which are far from the food deficit areas and major markets. It will be tackled by introducing transportation costs in the analysis of farmers' behaviour in the open markets. Of course, the impact of weather on grain production, especially with the predominantly rainfed cultivation technology of Tanzania, is of major importance. But since its impact is the same for all producers in a certain area, the variation of weather has been abstracted away in the model. However, in the empirical implementation also the impact of weather is controlled.

Assume that the agricultural production function depends on two inputs, labour and external inputs which in the empirical part is taken to be chemical fertilizers.

[34] $$Q = f(l,k)$$

It is assumed that the production function is concave with $f_l > 0, f_k > 0$ and $f_{ll} < 0, f_{kk} < 0$, so that it reflects the law of diminishing returns. The cross-derivate is $f_{kl} > 0$, indicating that the inputs are complements, i.e., increasing the use of external inputs increases the marginal productivity of labour[16].

The peasant household is assumed to maximise net revenue from agricultural production. The revenue from agriculture depends on the produced quantity (Q) and the fixed price (P) deduced with production costs. Land is here regarded as a fixed factor. Further, the land is assumed not to be leased, and to be cleared by inputs of labour. Land is thus a fixed factor of production and implicitly included in the factor labour, since the amount of land is dependent on the available labour input in the predominant hoe-cultivation technology. In what follows, the wage of labour is w and the price of other inputs is r. Given these assumptions the profit function is given in equation [35].

[35] $$\pi = PQ - wl - rk ,$$

where P = Fixed price

Q = Produced quantity

w = Labour price

l = Labour use

r = External input costs

k = External input use

The farmer chooses the amount of labour and capital so as to maximise the profits

[36a] $$\pi_l = Pf_l - w = 0$$

[16]Alternatively one could assume that inputs are substitutes, i.e., that the cross derivate is negative $f_{kl} < 0$ implying that increasing the use of external inputs means less need of manual labour for the production of a certain quantity and thus diminishing labour input. This is presented in Appendix 1.

[36b] $\pi_k = Pf_k - r = 0$.

At the optimum the use of both inputs is increased to the point where the value of marginal product equals price, i.e., $Pf_l = w$ and $Pf_k = r$.

The second order conditions are given in [37a]-[37c]. They are valid due to the assumption of the concavity of the production function.

[37a] $\pi_{ll} = Pf_{ll} < 0$

[37b] $\pi_{kk} = Pf_{kk} < 0$

[37c] $\Delta = \pi_{ll}\pi_{kk} - (\pi_{kl})^2 > 0$,

Δ is the determinant of Hessian matrix and $\pi_{kl} = \pi_{lk} = Pf_{kl} > 0$.

Given that the second order conditions hold, the first order conditions implicitly define optimal l^*, k^* (and Q^*). Comparative statics are used to investigate what kind of impact a change in any one of the exogenous variables has on the endogenous variables l (labour use) and k (external input use).

The effect of an increase in the price of the food grain, on the input levels is given by

[38a] $k_P = -\Delta^{-1}\{ \pi_{ll} f_k - \pi_{lk} f_l \} > 0$

[38b] $l_P = -\Delta^{-1}\{ \pi_{kk} f_l - \pi_{lk} f_k \} > 0$

Thus, an increase in the grain price increases both capital and labour use. This is in accordance with the general theory of production, which indicates that higher price boosts input use. Higher price means that it becomes profitable to invest more on the production of the particular commodity[17].

The effect of an increase in the price of labour on the use of external inputs and labour is as follows:

[17] This holds true provided that there are no restricting factors affecting the price response. There could be a market failure in certain areas or a lack of availability of inputs or a lack of credit for the purchase of inputs.

[39a] $k_w = -\Delta^{-1}\{\pi_{lk}\} < 0$

[39b] $l_w = \Delta^{-1}\{\pi_{kk}\} < 0$

An increase in the wage of labour decreases the use of both inputs[18]. The increased labour price means that the production costs per unit of production increase. Thus the profits are maximised at a lower level of production.

The effect of an increase in the external inputs costs on the use of these and labour is as follows:

[40a] $k_r = \Delta^{-1}\{\pi_{ll}\} < 0$

[40b] $l_r = \Delta^{-1}\{\pi_{kl}\} < 0$

The interpretation is analogous to the above.

How about the comparative statics of output supply? One can express the optimal output as

[41] $Q^* = f(k^*, l^*) = f[k(P,r,w), l(P,r,w)] = f(P,r,w)$.

Differentiating Eq. [41] with respect to end price P and applying the chain rule of differentiation yields

[42] $$\frac{\partial Q^*}{\partial P} = Q_P = \frac{\partial f}{\partial k}\frac{\partial k^*}{\partial P} + \frac{\partial f}{\partial l}\frac{\partial l^*}{\partial P}$$

As defined above, $\frac{\partial f}{\partial k} = f_k$ and $\frac{\partial f}{\partial l} = f_l$. Let us also denote $\frac{\partial k^*}{\partial P} = k_{P,}$ $\frac{\partial l^*}{\partial P} = l_P$, to indicate that they give the comparative static effects of end price on inputs. Hence, we get

[43] $Q_p = f_k k_P + f_l l_P > 0$.

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[18] If inputs were substitutes, $k_w > 0$ as π_{lk} would be negative and other cases analogous.

Hence, higher end price boasts output supply.

Differentiating Eq. [41] in terms of wage yields

[44] $$Q_w = f_k k_w + f_l l_w < 0.$$

This indicates that higher input price decreases output supply.

Finally, differentiating Eq. [41] in terms of input price yields

[45] $$Q_r = f_k k_r + f_l l_r < 0,$$

with the same interpretation as above[19].

Thus the qualitative effects of production can be expressed as follows

[46] $$Q = Q(\underset{+}{P}, \underset{-}{r}, \underset{-}{w})$$

All the impacts are conventional. Increasing price increases production, and when input prices increase it is no longer equally profitable to produce as much as earlier and the level of production decreases. Thus also the use of external inputs decreases.

3.3. Production for the unofficial grain markets

Consider next the farmer who has the option to sell to two markets, either in the official market demonstrated above or in the unofficial[20] markets, which Maliyamkono and Bagachwa (1990) call the second economy. In the unofficial markets the producer faces a risk which is non-existent in the official markets: the price is not known when the planting decisions are made. Of course, there is some previous experience of the functioning of the grain markets and some idea of the price level in the two markets. Thus, the expected price must be higher than the government price, forming an

[19] Notice that if inputs were substitutes, the output supply effect Q_w and Q_r would be a priori ambiguous.

[20] The unofficial markets were illegal, and sometimes more and sometimes less tolerated, but one always can assume higher transaction costs in the unofficial markets owing to their illegal nature.

incentive to the producers and compensating for the risks involved. Because unofficial trade incorporates transport costs, which is not the case with official markets and pan-territorial prices, the expected revenue from selling in unofficial markets is the higher the closer the producer is to the market. When the distance to the market increases and transportation cost increases, there will finally be a distance after which the farmer does not make positive profit. In those areas the official markets are the only alternative.

Stochastic profit can be expressed as

[47] $$\tilde{\pi} = (\tilde{p} - c) f(k,l) - wl - rk ,$$

where $\tilde{p}$ is random price and c is unit transport cost, the other symbols being the same as in the previous model[21].

In the presence of uncertainty, one has to make assumptions concerning how the farmer relates her/his activities to risk. This analysis is based on the hypothesis of maximisation of the expected utility. To facilitate the analysis three further assumptions are made: 1) the price of the cereals is normally distributed; 2) the preferences of the farmers can be described by an exponential utility function; and 3) risk aversion is assumed to be constant. These assumptions have the advantage that the stochastic value of farmers' profit can be expressed in terms of its mean and variance. This allows for mean-variance analysis, which is a convenient tool for analysing risk bearing behaviour, as it condenses the risk into two terms, the mean and the variance of profits[22].

As is well known, making the assumption of normally distributed yields in agriculture has been subject to a continuous debate. Interestingly, by making a large comparison of empirical studies, Just and Weninger showed in a recent study (1999) that one cannot invalidate this assumption on the basis of this data. Their conclusion was that there is no conclusive evidence for or against the normality assumption. Therefore, this study makes the normality assumption, which makes the analysis much more simple and transparent.

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[21] Notice that P refers to the price in the official market, while p to that in the unofficial market.

[22] The assumption at constant risk aversion means that a change in the income of the producer does not have any impact on her/his willingness to take risks. In real life, though, it could be expected that those with higher incomes would be willing and able to take higher risks (Newberry & Stiglitz 1981, 74). The assumption of constant risk-aversion makes the analysis more simple and transparent, because risk is nicely described by the variance term.

Hence the utility function of a representative farmer is

[48] $$EU = -e^{-A\pi},$$

where $A = EU'' / EU'$ is the measure of absolute risk aversion.

If $\tilde{p}$ is normally distributed, with mean $\overline{p}$ and constant variance of the price σ_p^2 [$p \approx (\overline{p}, \sigma_p^2)$], then the expected profit is:

[49] $$E(\pi) = \overline{\pi} = (\overline{p} - c) f(k,l) - wl - rk .$$

The variance of profit is:

[50] $$\sigma_\pi^2 = \sigma_p^2 Q^2$$

Thus combining [48] and [49] expected utility can be written

[51] $$EU = -e^{-A(\pi - ½ A\sigma_p^2 Q^2)}$$

Since ordinal preferences can be presented by any monotonic transformation (if $u(\cdot)$ represents preferences then $v(\cdot) = \log u(\cdot)$ represents the same preferences, see Varian 1995, 56), one can take logarithms of [51] so that the maximising expected utility of function [51] is equivalent to maximising R, when R is

[52] $$R = \pi - ½ A\sigma_\pi^2 .$$

From equations [49] and [51] follows that the farmer's problem is to choose the use of inputs k, l so as to maximise the expected profits, i.e.,

[53] $$R = (p - c) f(k,l) \ - wl - rk - ½ A\sigma_p^2 \left[f(k,l) \right]^2 .$$

The first order conditions for the maximisation of expected utility from farm income in the unofficial market model is

[54a] $$R_l = \frac{\partial \quad R}{\partial \quad l} = (p-c) f_l - w - A\sigma_p^2 f_l = 0$$

[54b] $$R_k = \frac{\partial \quad R}{\partial \quad k} = (p-c) f_k - r - A\sigma_p^2 f_k = 0$$

We denote $\overline{p} - c = \overline{p}^*$, and rewrite

[55a] $$R_l = \frac{\partial \quad R}{\partial \quad l} = \left[p^* - A\sigma_p^2\right] f_l - w = 0$$

[55b] $$R_k = \frac{\partial \quad R}{\partial \quad k} = \left[p^* - A\sigma_p^2\right] f_k - r = 0 \,,$$

where $(p^* - A\sigma_p^2)$ is the risk adjusted net price of grain

At the optimum, the use of both inputs is increased to the point where the value of marginal product equals the price of the input, i.e., $\left[p^* - A\sigma_p^2\right] f_l = w$ and $\left[p^* - A\sigma_p^2\right] f_k = r$.

The second order conditions are given in [56a]-[56c]. They hold due to the assumption of concavity of production function, meaning that increasing use of inputs will produce diminishing increases in production and the law of decreasing returns of inputs is valid.

[56a] $$R_{ll} = \left[p^* - A\sigma_p^2\right] f_{ll} < 0$$

[56b] $$R_{kk} = \left[p^* - A\sigma_p^2\right] f_{kk} < 0$$

[56c] $$\Delta = \begin{bmatrix} R_{ll} & R_{kl} \\ R_{lk} & R_{kk} \end{bmatrix} = R_{ll} R_{kk} - (R_{kl})^2 > 0$$

Δ is the determinant of Hessian matrix and $R_{kl} = R_{lk} = \left[p^* - A\sigma_p^2 f_{(k,l)}\right] f_{lk} - A\sigma_p^2 f_k \; f_l \;\; > 0$ by assumption, i.e., it is assumed that the direct effect dominates.

Given that the second order conditions hold, the first order conditions implicitly define l^*, k^* (and by input use Q^*).

Comparative statics is used to investigate what kind of impact a change in any one of the exogenous variables has on the endogenous variables l (labour use) and k (external input use).

The effect of an increase in the price of the final product, food grain, on the input levels is as follows:

[57a] $$k_{\bar{p}} = -\Delta^{-1}\{R_{ll}\, f_k - R_{lk}\, f_l\} > 0$$

[57b] $$l_{\bar{p}} = -\Delta^{-1}\{R_{kk}\, f_l - R_{lk}\, f_k\} > 0$$

Thus, an increase in grain price increases capital and labour use. This is in accordance with the general theory of production, which indicates that higher price boosts input use. Higher price means that it becomes profitable to invest more on the production of the particular commodity. This leads to increased aggregate production and increased production per unit of land, if there are no restricting factors affecting the price response.

The effect of an higher price variance, and thus an increasing risk on the use of labour and external inputs

[58a] $$k_{\sigma_p^2} = \Delta^{-1}\{Af\,[f_k R_{ll} - f_l R_{lk}]\} < 0$$

[58b] $$l_{\sigma_p^2} = \Delta^{-1}\{Af\,[f_l R_{kk} - f_k R_{lk}]\} < 0$$

The effect of increasing risk is that the use of both labour and external inputs decreases.

The effect of increasing labour price on the use of inputs is the following:

[59a] $$k_w = -\Delta^{-1}\{R_{lk}\} < 0$$

[59b] $$l_w = \Delta^{-1}\{R_{kk}\} < 0$$

Increasing labour costs lead to decreased use of fertilizers, since the two factors are complementary to each other, both inputs are needed for increased production. In this case increasing labour price means that production costs increase. This makes the production more expensive and decreases the level of optimal production which allows for maximal profits. The level of labour use decreases, as it becomes more expensive.

The effect of increasing external input costs on the use of labour and external inputs is as follows:

[60a] $$k_r = \Delta^{-1}\{R_{ll}\} < 0$$

[60b] $$l_r = -\Delta^{-1}\{R_{lk}\} < 0$$

Increasing external input price decreases the use of both labour and external inputs. When the price of fertilizers increases, the use of the complementary input, labour decreases. A higher fertilizer price makes the production more expensive and decreases the level of production at which profits are maximised. Thus the level of both labour use and external input use will decrease.

The effect of increasing transport costs on the use of labour and external inputs is as follows:

[61a] $$k_c = \Delta^{-1}\{R_{ll} f_k - R_{lk} f_l\} < 0$$

[61b] $$l_c = \Delta^{-1}\{- f_l R_{kk} + f_k R_{lk}\} < 0$$

Higher transport costs lower net revenue decreasing the input use.

The effect of an increase in risk aversion on the use of labour and external inputs is given by

[62a] $$k_A = \Delta^{-1}\sigma_p^2 f(k,l)\{R_{ll} f_k - R_{lk} f_l\} < 0$$

[62b] $$l_A = \Delta^{-1}\sigma_p^2 f(k,l\{- f_l R_{kk} + f_k R_{lk}\} < 0$$

Higher risk aversion works like higher risk: farmers become less willing to invest in agricultural production in order to avoid future risk.

Finally, by applying the comparative statics of input use, one can give the comparative statics of output supply in a general form as follows[23]

[63] $$Q = (\underset{+}{p}, \underset{-}{c}, \underset{-}{w}, \underset{-}{r}, \underset{-}{\sigma_p^2}, \underset{-}{A})$$

This means that the higher price of grain will increase its production, but higher input prices, transport costs and variance and risk aversion will decrease grain production.

3.4. Summing up the model specification

Thus we have presented two market supply models, one for official markets with controlled, predetermined prices and the other for unofficial markets, with market determined prices and price risk. Apart from the open market price and a variable for the price variance, the model for unofficial markets incorporates also a measure for risk aversion and transport costs. We have chosen two factors of production, labour and inputs, as the endogenous variables. In the models we have investigated the impact of changing exogenous variables on the use of endogenous variables and the consequences for produced quantities. The impacts have been found to be conventional, thus according to the models higher price of grain leads to increased production, while increases in the values of other exogenous factors of production will decrease grain production. Now we can proceed to the empirical application by presenting the available data.

[23] To solve the comparative statics of output supply insert the inputs as a function of exogenous parameters into production function $Q = f[k(p, c, w, r, \sigma_p^2, A), l(p, c, w, r, \sigma_p^2, A)]$ and apply the chain rule just like in the previous subsection, e.g. $Q_\theta = f_k k_\theta + f_l l_\theta$.

4. Tanzanian grain economy - data and analysis

The models in Chapter 3 were developed for any general agri-product. As for Tanzania, the most important marketed staple grain is maize, which is also a major article in food aid. While the quantity and price of maize are the dependant variables, explanatory variables are dictated by the models in Chapter 3. They include end prices, input prices, transport costs, price variability and risk aversion. Since there is no data available on risk aversion, it cannot be taken into the empirical model.

The material for this study has been collected during field visits to Tanzania in 1993, 1994/95 and 1996. The material consists of published and unpublished government records, published and unpublished material from donors, published research on Tanzania completed with discussions with Tanzanian government officials, researchers and representatives of major donor organisations.

The variables of the model are presented by first introducing the food aid and food imports statistics with comments on the major developments in the field. Then comes maize production statistics with a discussion on the reliability of the production data. This is followed by price information together with a discussion on the price policy of the Tanzanian government from 1970/71 onwards. The input costs of production are presented with fertilizer statistics followed by minimum wage and transport costs.

4.1. Food aid and net grain imports; maize and all cereals

The great variability of import need is typical for the Tanzanian food economy. This is especially true for the basic staple maize, which has been both imported and exported during the 25 years under study. Standard deviation for maize imports has been 102 000 tons. The figures for the other favoured staples, rice and wheat, are less dramatic, standard deviation for rice being 17 000 tons and for wheat 20 000 tons. Rice imports have been on an average 34 000 tons a year since 1967/68, major imports starting in 1974/75. Wheat imports have been between 1967/68 and 1995/96 on an average 40 000 tons a year (Table 4.1.).

Table 4.1. Food aid and food net grain imports; maize and all cereals (in '000 tons).

Year	Maize net imports	Maize food aid	Maize food aid as % of imports	All cereals net imports	All cereals food aid	All cereals food aid as % of imports
1970/71	-24	0	0	12	0	0
1971/72	63	5	8	109	5	5
1972/73	79	6	8	80	6	8
1973/74	291	6	2	447	11	2
1974/75	225	32	14	269	79	29
1975/76	107	27	25	189	93	49
1976/77	42	7	17	81	41	51
1977/78	34	34	100	124	97	78
1978/79	-49	0	0	70	82	117
1979/80	5	0	0	93	83	90
1980/81	275	87	32	389	187	48
1981/82	232	217	94	388	359	93
1982/83	123	106	86	182	155	85
1983/84	194	69	36	298	142	48
1984/85	129	18	14	198	62	31
1985/86	6	3	50	61	43	71
1986/87	94	9	10	231	91	39
1987/88	-91	0	0	-5	35	0
1988/89	-20	0	0	29	29	100
1989/90	-30	0	0	5	8	148
1990/91	-55	0	0	-9	0	0
1991/92	25	0	0	102	2	2
1992/93	7	7	100	102	26	26
1993/94	28	14	51	145	24	17
1994/95	65	44	69	149	54	36
1995/96	0	0	0	70	0	0
Sum	1755	691		3809	1714	
Mean	68	27	28	147	66	45
Variance	10402	2228	1163	15145	5965	1656
Standard deviation	102	47	34	123	77	41

Sources: From 1970 to 1985/86 MDB 1989, 22, from 1986/87 onwards Food Security Department files completed with Raikes 1988, 189, Table 8.6. For 1971/72-1972/73 Raikes gives total food aid as 8 tons, thus the maize food aid from MDB Review is taken as representing total food aid. Food aid in 1970/71 is assumed to be zero since total net imports are very low.

Note: All cereals: maize, rice and wheat

The trend in total grain imports during the last 25 years shows marked variability (Figure 4.1.). The total grain imports consist of both commercial and food aid imports. Maize has been both imported and exported over the years, while wheat and rice have been regularly imported commercially and also figured prominently as food aid. The correlation coefficient between total maize net imports and all cereal net imports is 0.96.

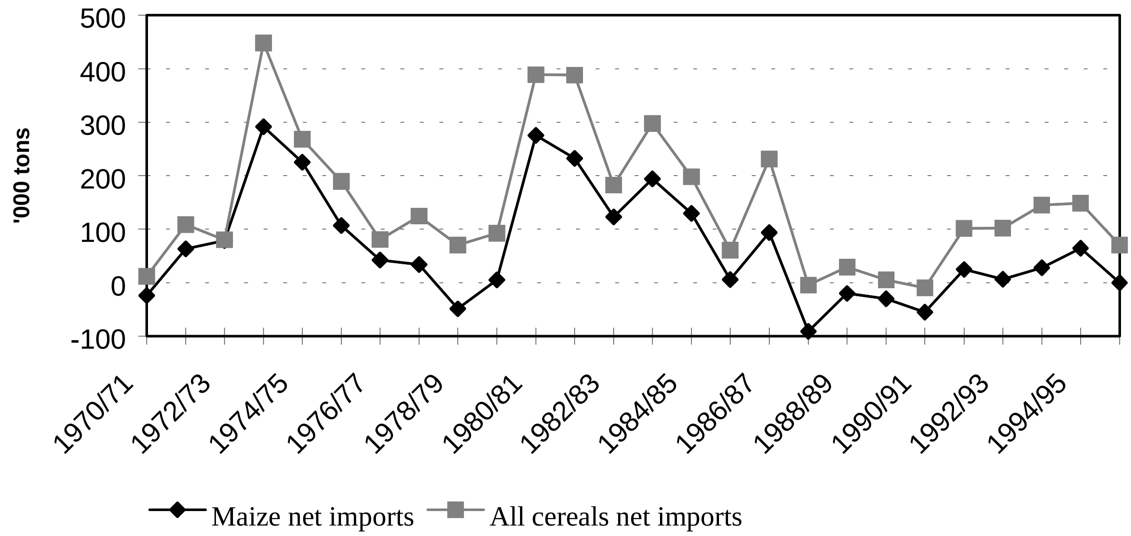

Figure 4.1. Net imports of all cereals (maize, rice and wheat) and maize in Tanzania 1970/71-1995/96.

The first peak in grain imports was in 1973/74 with total cereal imports of 450 000 tons. This is the all time high of the Tanzanian history. Maize imports were a record 300 000 tons at that time, which is also the highest figure in the history of Tanzania. Net cereal imports went down to 70 000 tons in 1978/79, at that time there were also maize exports of 50 000 tons. This first peak is related to the exceptional drought and to the disruption on production due to the villagisation programme[24].

Tanzania experienced a tight food supply situation throughout the years 1980/81. The commercial cereal requirements were estimated to be 500 000 tonnes (376 000 tons of maize and 124 000 tonnes of rice and wheat). The NMC managed to buy domestically only 174 000 tonnes of cereals. Thus there was a deficit of at least 350 000 tonnes of

[24] The Tanzanians rather tend to blame the unfavourable weather and oil price hike for high import needs but also the major reorganisation of production, following the villagisation process coupled with a creation of a monopsonic marketing structure, is correlated with rising import needs. Moving the rural population on a large scale and to a tight schedule must have meant practical problems as cultivation in new areas was initiated (see McHenry 1979 for evidence, and Bryceson 1990).

cereals that had to be offset through imports, in order to meet basic requirements and to maintain minimum levels of working stocks (MDB 1981).

The year 1980/81 was followed by 5 years of large cereal imports. Drought was the main cause of import needs of staple food grains but the link is not that simple. A continued need of imports was partly due to the structure of staple food markets in Tanzania. Although the NMC was supposed to be a grain monopoly, it did not provide for the food needs of the entire population wishing to buy food. The NMC's supplies of maize, rice and wheat were determined by the availability of marketed cereals and by the quantity of these commodities it was necessary to supply for the population groups, which were the NMC's primary clients. These were:

a) part of the population in areas of perennial rural deficits or extreme shortfalls, such as some districts in Dodoma and Shinyanga regions;

b) urban minimum wage earners and other urban poor people; especially in Dar es Salaam;

c) government institutions, such as educational institutions, the military, the government and parastatal employees, etc. This category received a great deal of the NMC's sales of rice and wheat as well as maize.

These groups had a certain minimum demand, which the government had to fill. If the NMC purchases were not adequate, imports were the only option, regardless of the food situation in the rest of the country. It is important to understand that total production, or even total marketed production, have only an indirect effect on imports. In those market circumstances it was the balance of the NMC's purchases and the demand the government felt must be met that determined the perception of import need (MDB 1986a, 13).

Actual imports were constrained by the foreign exchange availability and food aid availability. Maize imports in 1984/85 were substantially higher than those of the previous year, although still below the levels of the earlier 1980s. The government wanted to avoid the shortfalls in urban areas experienced in 1983 by importing significant quantities of commercially purchased maize from Thailand, altogether 120 000 tonnes. It is important to notice that 1983/84 production year did not have abnormally bad rains. Thus the continuing import-need in 1984/85 reflected the structural defects of the agricultural economy (MDB 1985, 24). At the same time, the access for food aid was decreasing. Maize received as food aid declined during three consecutive years (between 1981/82 and 1983/84). This was due to great needs in other parts of Africa, and growing scepticism of the donors vis-à-vis the real need for food aid in Tanzania. It is also significant that imported maize had a low price compared to the domestic price (ADAB 1984, Boucher and Dyck 1985).

Throughout the period from1980 to 1986, official domestic purchases of maize, rice and wheat were not sufficient to meet the demand from official consumer channels, so imports were a necessity. In the 1986/87 marketing season the Co-operative Unions and the NMC were suddenly faced with a completely new demand situation as far as maize was concerned. Following the gradual grain market liberalisation, a six-year spell of favourable weather started in 1986/87. The prices in the open markets fell drastically, in most markets the maize prices stabilised at a level below the official prices. As a result, official demand of maize fell back completely as even official institutions turned to the cheaper private markets. Thus the NMC had to export maize during four consecutive years, 90 800 tons in 1987/88 and another 19 800 tons in 1988/89, 30 000 tons in 1989/90, and 55 000 tons in 1990/91. Because of the relatively low export prices, this was done at a loss. The early 1990s saw some unfavourable production years. Grain imports were, however, notably low, compared to earlier import peaks during the government grain monopoly. All in all Tanzania has been a net importer of grain since 1970/71 every year except in 1987/88 and 1990/91 (Figure 4.2.).

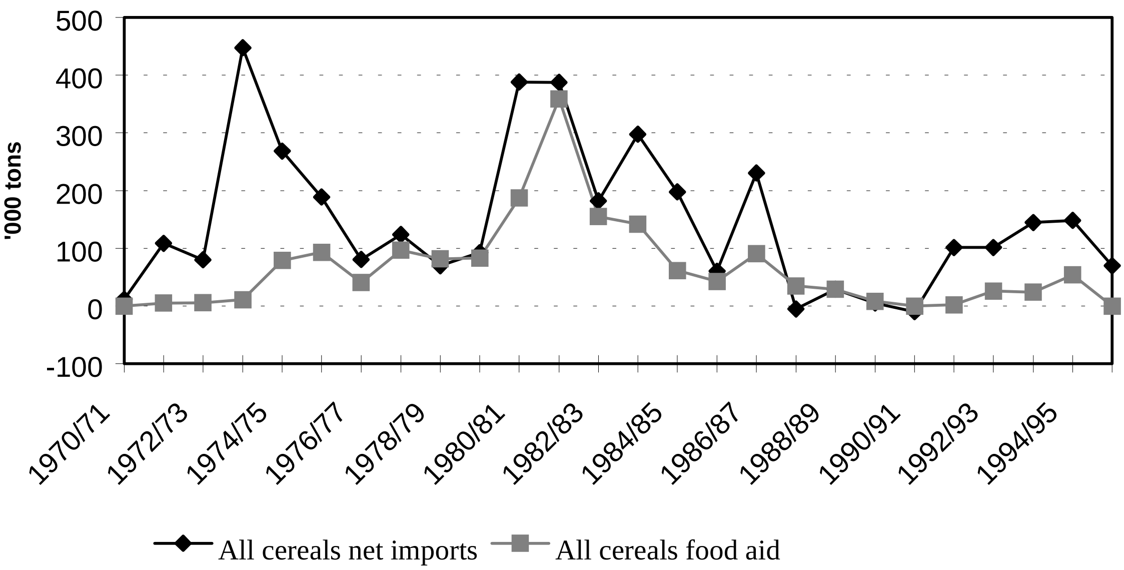

Figure 4.2. All cereals (maize, rice and wheat), net imports and food aid in Tanzania 1970/71-1995/96.

In this study it has not been possible to separate programme and emergency food aid since consistent time series are not available. But ”overall, the bulk of cereals aid has been programmed for sale through the public distribution system” (Clay and Benson 1987, 29), emergency food aid having only a minor share. Thus total food aid imports have been used as a basis for the calculations.

Food aid was given to a considerable extent for the first time in 1974/75 (79 000 tons) (there were some modest food aid imports in the early ‘60s). This was one year after the massive domestic cereal imports and shows the typical slow reactivity of food aid. Tanzania moved into a food import and food aid era from then on. Raikes (1988, 189) writes about a ‘ratchet effect’, meaning that food aid deliveries increase during emergencies and although they diminish afterwards, they remain well above the pre-emergency level. Food aid grew slowly after 1974/75, to reach its peak in 1981/82 with the massive 350 000 tons (including some 220 000 tons of maize). Then food aid came down to a very modest level in a few years time. The maize food aid was close to zero from 1984/85 onwards until the 45 000 tons delivered in 1994/95. All cereal food aid was very modest, being around zero from 1989/90 to 1991/92, then rising to around 50 000 tons in 1994/95 and coming back to zero again the next year.

Typical for the food aid to Tanzania has been an approximate one year lag in relation to changes in commercial imports. The other notable feature has been the large share of food aid from total imports from 1976/77 onwards all the way to the late ‘80s. This has meant considerable savings in foreign exchange, assuming that the same amounts would have been imported on commercial terms.

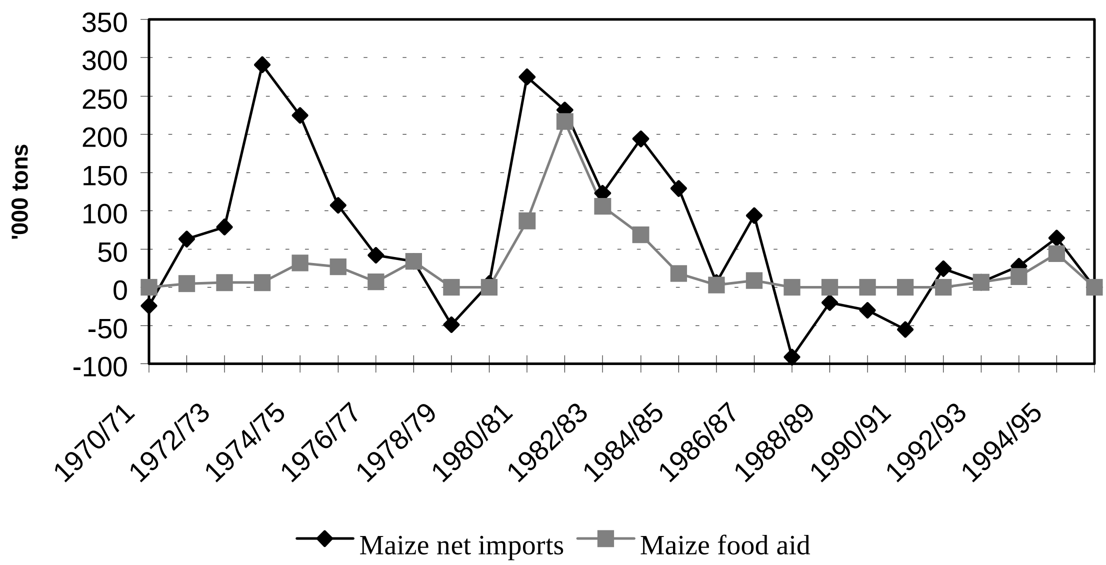

Figure 4.3. Net maize imports and food aid in Tanzania 1970/71-1995/96.

The maize imports show two distinct peak periods alternated by exports (Figure 4.3.). The commercial maize imports dominated in the mid-70s, while food aid played a very prominent role in the early ‘80s (from 1980/81 to 1982/83), levelling quickly down to zero, while commercial imports had two smaller peaks in 1983/84 and again in 1986/87. Considerable quantities of maize were exported in the late 1980s. The early 1990s were characterised by modest imports peaking in 1994/95 with 64 000 tons, around 70% of which was food aid.

Since 1970/71 the average yearly amount of food aid for all cereals has been 66 000 tons and the same for maize 27 000 tons. The total cereal food aid between 1970/71 and 1995/96 was 1.7 million tons, maize food aid accounting for about 0.7 million tons of the total. Although maize is by far the most favoured cereal[25], rice and wheat are much more common as food aid items, comprising 60 per cent of the total food aid.

The reason for this is that white maize, consumed in Tanzania, has very thin markets. It is not readily available as a food aid article. There is occasional surplus production mainly in South Africa, Argentina and China but these countries are not major food aid donors, and surplus white maize can be marketed commercially. Rice and especially wheat are common food aid crops, together with yellow maize; but yellow maize is not considered acceptable as food for human consumption in most parts of Sub-Saharan Africa[26]. Thus a majority food aid has been constituted by cereals other than maize. During many years, food aid has accounted for a major part of food imports, being close to 100 per cent in certain years; on an average food aid has comprised 41 per cent of total imports. For maize the respective figure has been 27.5 per cent.

4.2. Maize production

Maize is the favourite staple of the majority of Tanzanians and food security policy is tightly associated with the availability of maize. Maize is so much emphasised that it is useful to look at food production figures more generally (Table 4.2.).

From the point of view of the acreage, maize is the largest staple food crop, while cassava is the second, followed by pulses, sorghum and oilseeds/nuts. In production maize is clearly number two after bananas, cassava being as clearly number three. But from these three products, only maize is marketed, the other two being almost completely for subsistence consumption, expect for some local trade. This explains the importance of maize for food security policy, since it is the main commercial staple

[25] 60 per cent of staple food calories in the Tanzanian diet comes from maize, 10 per cent from rice and 1 per cent from wheat, see URT 1992, 23

[26] In Tanzania donated yellow maize has gone to a chicken food factory and local maize has been bought instead for food aid delivery (The Prime Minister's Office, personal communication). But there are experiences from both Zimbabwe and Mozambique during the 1990s of using yellow maize and signs of its gradual acceptance, see for example Tschirley et al. (1996).

grain, rice being the second in the mainly coastal urban markets. Wheat comes far behind (Figure 4.4.).

Table 4.2. Crop area and production statistics in Tanzania, 1988/89.

	Crop	Area 000 ha	Production 000 MT
Cereals	Maize	1 669	2 527
	Sorghum	476	405
	Millet	274	290
	Paddy	385	768
	Wheat	57	81
	Subtotal	2 861	4 071
Root Crops	Cassava	871	1 489
	Sweet potato	198	337
	Subtotal	1 069	1 826
Other Food	Pulses	526	383
	Oil seeds/nut	454	236
	Bananas	250	3 750
	Subtotal	1 230	4 369
Cash crops	Cotton	425	266
	Sisal	17	33
	Coffee	256	49
	Tea	12	16
	Tobacco	23	12
	Pyrethrum	n.d.	20
	Subtotal	733	396
TOTAL		5 901	

Source: Planning and Marketing Division, MoA, expect for banana, for which yield is estimated at 15 MT/ha (URT. 1992, 12 Table 1.) Since in the original table millet production was stated to be 29 000 tons, which is an obvious mistake, the figure 290 000 tons was used. This was confirmed from other MoA sources to be of correct magnitude. Note: Many food crops are inter-cropped, this further complicates the estimation of both area and yield figures.

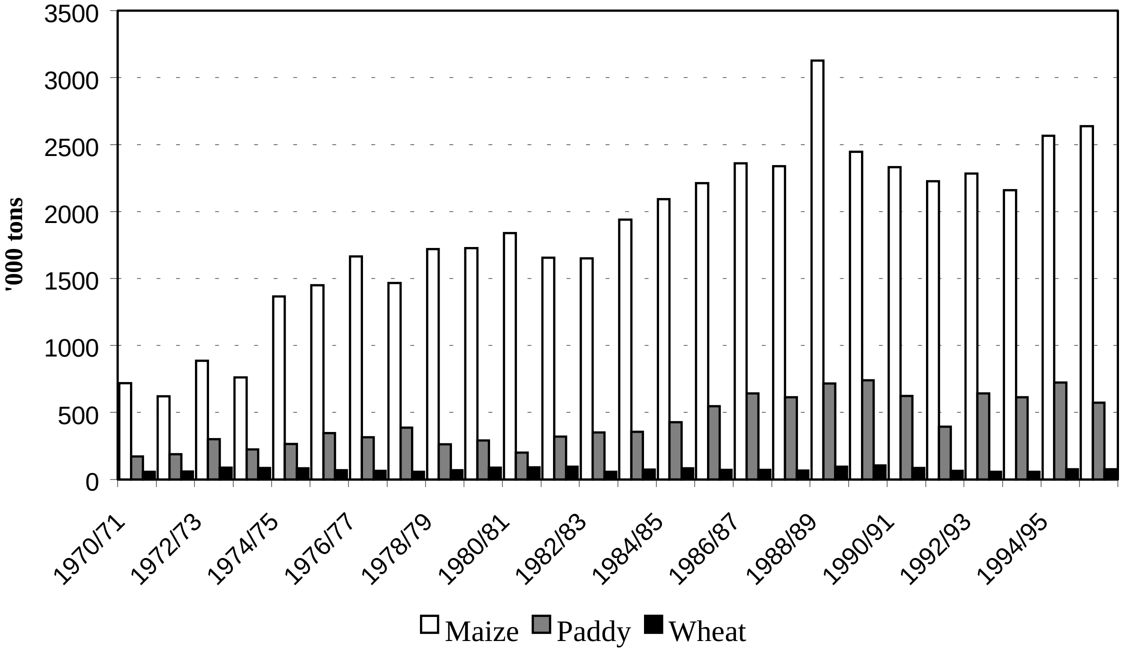

Figure 4.4. Preferred staple grain production in Tanzania: maize, paddy and wheat 1970/71-1995/96.

Even though marketable, a great share of Tanzanian maize production is subsistence oriented. In normal years it is estimated that around 75-80% of the produced maize is consumed by the producing peasant households (MDB 1986a, 1, MDB 1985, 1). Domestic production is of overwhelming volume compared to external trade (Figure 4.5). But due to the large share of subsistence use foreign trade has been of vital importance for the coastal urban areas, especially Dar es Salaam. The official production figures are shown in Table 4.3.[27]

[27] The national average yields for maize, paddy rice and wheat are 1.0, 1.2 and 2.5 MT/ha respectively. Regional averages vary for maize from 0.3 in Mtwara to 2.2 in Arusha; for paddy rice from 0.3 in Kagera to 3.0 in Arusha; and for wheat from 1.0 in Iringa to 3.7 in Kagera (Boucher and Dyck 1985, 26).

Table 4.3. Preferred cereal production in Tanzania, 1970/71-1995/96 ('000 tons).

Year	Maize	Paddy	Wheat
1970/71	719	171	57
1971/72	621	187	60
1972/73	887	301	88
1973/74	761	223	85
1974/75	1367	265	82
1975/76	1449	346	69
1976/77	1664	314	64
1977/78	1465	387	55
1978/79	1720	262	70
1979/80	1726	291	87
1980/81	1839	200	90
1981/82	1654	320	95
1982/83	1651	350	58
1983/84	1939	356	74
1984/85	2093	427	83
1985/86	2211	547	72
1986/87	2359	644	72
1987/88	2339	615	66
1988/89	3128	718	97
1989/90	2445	740	106
1990/91	2331	624	84
1991/92	2226	392	65
1992/93	2282	641	59
1993/94	2159	614	59
1994/95	2567	723	75
1995/96	2638	574	75

Sources: From 1970/71 to 1990/91 World Bank 1992, Appendix 2. The figures are based on various Ministry of Agriculture publications and from 1982/83 onwards on information from the Early Warning and Crop Monitoring Bureau, MoA. From 1991/92 onwards the figures came from the Food Security Department, MoA cited in MDB 1994, 5 and FAO 1996, 22.

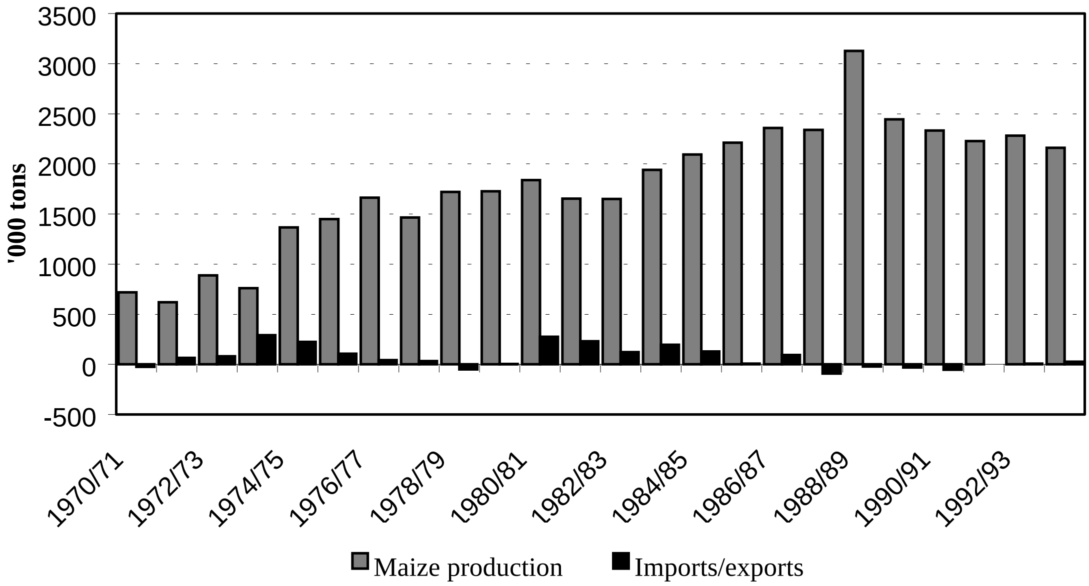

Figure 4.5. Maize: Production and net imports.

According to the official production statistics maize production grew slightly from the early 1960s onwards, oscillating between 457 000 tons and 887 000 tons from year to year reflecting population growth[28] and vagaries of weather. In 1974/75 the production figures jumped to a new level of 1 367 000 tons and continued to grow steadily, likewise reflecting the population growth and the changing weather conditions. The figures indicating a new production level suddenly reached in 1974/75 are hard to believe. There is no evidence of any such radical changes in production technology as would explain the fact that production figures almost doubled. This coincided with the villagisation programme, which lasted until 1976 and entailed the movement of the entire rural population into villages, causing considerable production disturbances. One cannot help thinking that the highly elevated production figures starting in 1974/75 are more a product of political expediency than real increase. This would mean that the whole production series is possibly at too high a level from 1974/5 onwards. This conclusion is reached also by van der Brink in the study of agricultural statistics in mainland Tanzania sponsored by the World Bank (World Bank 1992, 4)[29].

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[28] The Tanzanian agriculture is based on large rural population and subsistence-oriented hoe-cultivation. Since land is abundant in most parts of the country, growing population induces enlarged cultivated area with corresponding growth in the aggregate production.

[29] He gives an example of political formulation of statistics. Given the shortage of food after the 1974 drought, it was stipulated that each family should grow 2 acres of main staple crop. Additionally, each ‘able bodied’ person was supposed to cultivate a minimum of 2 acres of crops. Official area estimates often turned into arithmetic exercises, if the extension worker and Village Authorities simply multiplied the number of families by 2 and added the number of able bodied persons multiplied by 2 to obtain total acreage under main food crops.

From 1984/85 onwards the production was over 2 million tons annually, oscillating between 2100 000 and 2 663 000 tons. In 1988/89 there was a surprising jump to over 3 million tons. A MDB study (1986b) concluded that this high production figure must have been false and should be ignored. This conclusion was reached on the basis of price information which did not give any explanation for such an exceptional production figure. This conclusion is taken into account in the empirical model of this study, by using the average for the previous and the following year’s production as a proxy for the maize production in 1988/89.

The Tanzanian government has produced official food production statistics which show a doubling of the per capita food crop production over the period from 1966 to 1989. The validity of the official food production statistics has been convincingly questioned by Sarris and Brink (1993, Chapter 5). Various government agencies regularly publish regionally and nationally aggregated agricultural production data. The figures are not necessarily similar. The Bureau of Statistics produces its own agricultural statistics on food crops, derived from a nationally representative sample survey, undertaken by the bureau yearly from 1986/87 onwards. Earlier production figures were aggregates of local estimates. But for national accounts, the production estimates of the Early Warning and Crop Monitoring Bureau of the Ministry of Agriculture are used. These estimates are based on a physiological crop model that uses rainfall data and certain agronomic parameters. The yield estimates are combined with the area estimates from the agricultural extension agents, to obtain total production. There are several problems with this approach. The model is not regularly calibrated to objective production measurements in the field. And the whole exercise is based on the area estimates of extension agents, who do not employ any formal method for their estimates.

The second source of error during the government marketing monopoly was the need for political correctness. The estimates of extension agents were presented to village authorities who had an interest to present high production figures. The respective carrot was that high production was awarded, and the stick was that there were rules and bylaws stating minimum and compulsory areas for certain crops, established by the Rural Lands Act of 1973. According to Sarris and Brink (1993), there seems to be a consistent contradiction between the official estimates and survey estimates, caloric comparisons, price data, malnutrition rates, grain import figures, and information on structure and technology. Thus, independent survey estimates, import data, health statistics, estimates of parallel exports, open market price information, and changes in agricultural structure and technology seem to point, at best, to a slight increase in per capita production between 1966 and 1989. This means that the official aggregate production figures grossly overestimate the food production. Thus the puzzling 'calorie overhang', discovered by Yambi et al. (1990), would be an illusion. The expression was coined to express the fact that national food production was 60 per cent over the level of 2,300 kilocalories per person per day recommended by FAO and that at the same time 50 per cent of children were malnourished.

From the above it becomes amply evident that the production statistics are not reliable and can at best state something of the differences between various years but that the overall level since 1974/75 has probably been overestimated. The population has been growing at around 2.8% a year and urbanisation is still modest, thus it seems reasonable to assume a steadily growing trend for food production. In most places, there is still plenty of cultivable land available; thus production should be rather straightforwardly related to population growth. In rainfed cultivation systems like that of Tanzania, the weather has a decisive influence on the yield levels of any particular year at the local level. But on the national aggregate level, this influence is less marked. Tanzania is a huge geographic area, with many ecological zones and farming systems, and every year there are areas with exceptionally good and bad yields. The two rainfall systems, unimodal in the South and bimodal in the North, influence the national crop outcome to a great extent. The bimodal rains are more unreliable, leading to deficit years mainly when short rains fail. Thus national deficit years can be characterised by an unavailability of sufficient quantities of cereals in the northern part of the country. Cereal deficits are on the one hand local crop failures and on the other hand market failures, which means that grain from surplus areas cannot be moved to the deficit areas.

The low quality of production statistics is a problem from the point of view of this study, but the numbers presented above are the best available. From the manner the production data has been collected and from the discussion above it can be concluded that the data probably does reflect the annual variability to some extent but probably underestimates it. The data can also be misleading on the aggregate production level. The problems with data could bias the model so that it is more difficult to observe a disincentive effect.

4.3. Maize prices in Tanzania

The maize price statistics are much less problematic than those of maize production (Table 4.4.).

Table 4.4. Maize prices in Tanzania 1970/71-1996/97 (in TSh/kg).

Year	Official producer price	Open market consumer price	Real official producer price deflated by NCPI	Real open market price deflated by NCPI
1970/71	0,25	0,88	0,59	2,09
1971/72	0,24	0,96	0,54	2,18
1972/73	0,26	0,98	0,54	2,22
1973/74	0,33	1,08	0,63	1,89
1974/75	0,50	1,62	0,79	2,56
1975/76	0,75	1,82	0,94	2,29
1976/77	0,80	2,82	0,94	3,31
1977/78	0,85	3,14	0,89	3,3
1978/79	0,85	2,6	0,8	2,44
1979/80	1,00	2,92	0,83	2,43
1980/81	1,00	3,36	0,64	2,14
1981/82	1,50	4,86	0,76	2,47
1982/83	1,75	5,54	0,7	2,18
1983/84	2,20	9,2	0,68	2,85
1984/85	4,00	11,06	0,81	2,24
1985/86	5,25	9,34	0,9	1,6
1986/87	6,30	10,15	0,81	1,31
1987/88	8,20	14,42	0,81	1,43
1988/89	9,00	17,77	0,68	1,34
1989/90	11,00	19,53	0,66	1,17
1990/91	13,00	36,49	0,65	1,83
1991/92	30,00	50,63	1,23	2,08
1992/93		59,11		1,99
1993/94		62,01		1,69
1994/95		69,23		1,45
1995/96		90,01		1,41
1996/97		97,39		1,31
Sum	99,03	588,92	16,82	55,20
Mean	4,50	21,81	0,76	2,04
Standard dev.	6,71	28,66	0,16	0,57
Variance	45,05	821,44	0,02	0,32

Sources: Open market consumer prices 1965/66-1981/82 from eight markets, viz. Dar es Salaam, Arusha, Dodoma, Mbeya, Moshi, Musoma, Mwanza and Songea in Odegaard (1985); the price of 1982/83 is a simple average of around 25 markets; and the prices in 1983/84 -1996/97 are simple averages of around 31 markets (MDB files and Reviews from various years, World Bank, 1994b). Official prices are announced producer prices (MDB reviews, various years). Nominal prices are deflated with NCPI (Bank of Tanzania, 1994). 1996/97 index value is estimated from Dar es Salaam Consumer Price Index in Business Times, December 13-19, 1996.

Official price information is straightforward, since the yearly official prices were announced before each year's planting season. The open market prices are more problematic. Since grain trade was a government monopoly until the mid-1980s, when the markets were gradually liberalised, the open market trade was mostly illegal. No systematic information exists on the open market producer prices. Thus open market consumer prices are used as a proxy. The open market price data consists of simple means of the data collected in various localities of the country. There is no information of the quantities sold in different parts of the country. Thus it was not possible to construct any weighted average price figures.

For the first years from 1970/71 to 1981/82 the price data was collected from eight cities and towns, viz. Dar es Salaam, Arusha, Dodoma, Mbeya, Moshi, Musoma, Mwanza and Songea. These prices are taken from Odegaard (1985). It seems that this time series is the only price information available from that time period. From then on there is price information collected monthly by the Marketing Development Bureau of the Ministry of Agriculture. For 1982/83 the open market price used is an average of 25 markets and twelve months. From 1983/84 onwards the prices are similarly calculated using the price information from 31 markets (MDB Reviews, various years). The reliability of price information depends on the reliability of the persons collecting the data. Since there is no obvious vested interest in price data information, it should reflect fairly well the real situation. It is certainly a very much more reliable indicator of the maize market situation than the production figures. The real prices are calculated by deflating the nominal prices with the National Consumer Price Index (NCPI) (see Appendix 2.).

The relative value of agricultural producer prices has gone through distinct periods. In the 1960s and the early 1970s producer prices were not considered to be a useful policy tool. In money terms, the prices of major staple grains were increased slightly, if at all, and the real prices fell dramatically. Then came the supply problems of 1973/74 and 1974/75 related to drought and reorganisation of the agricultural production, i.e., the villagisation. To increase domestic marketed production, the nominal prices of staple food grains were increased sharply. This was combined with the introduction of attractive prices for the drought resistant food crops. At the same time several projects were initiated with an aim to increase the production and to improve the storage of grains[30]. The nominal official maize prices were increased by 56 per cent between 1973/74 and 1975/76. From then on the nominal prices were steadily increased (Figure 4.6.). The variance of the real unofficial price (0.32) is considerable compared to the variance of the real official price (0.02). The correlation between the real official and the real unofficial price is very low, 0.2.

[30]Ellis (1982 and 1983) and Ödegaard (1985) have analysed the price policy developments in Tanzania. See also Havnevik et al (1988, 65) and the MDB yearly reviews, different years.

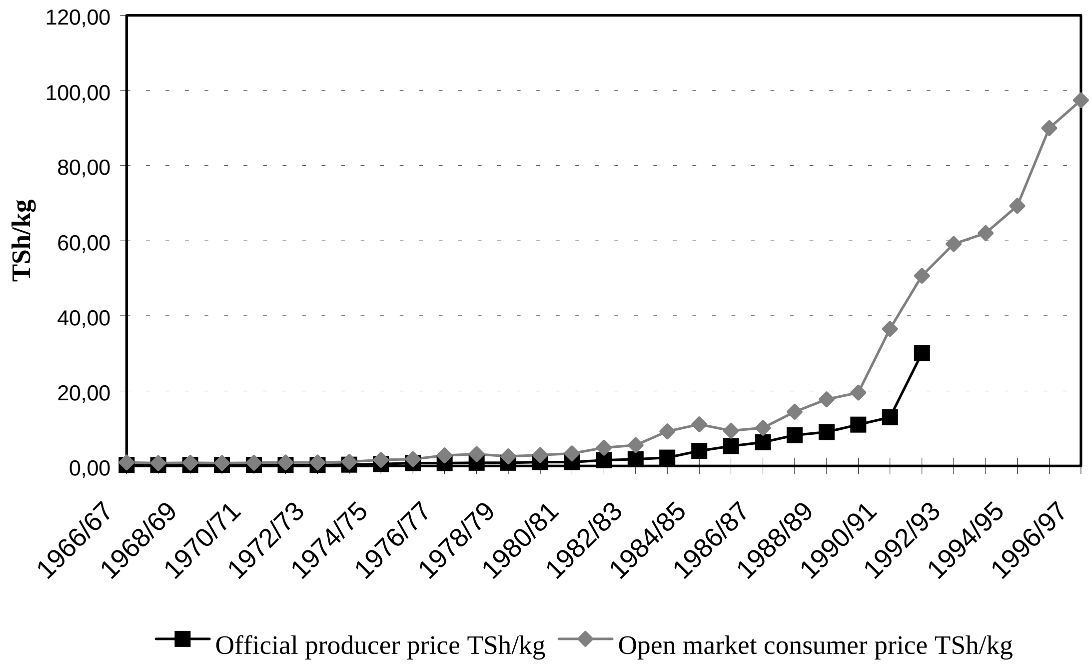

Figure 4.6. Nominal maize prices in Tanzania

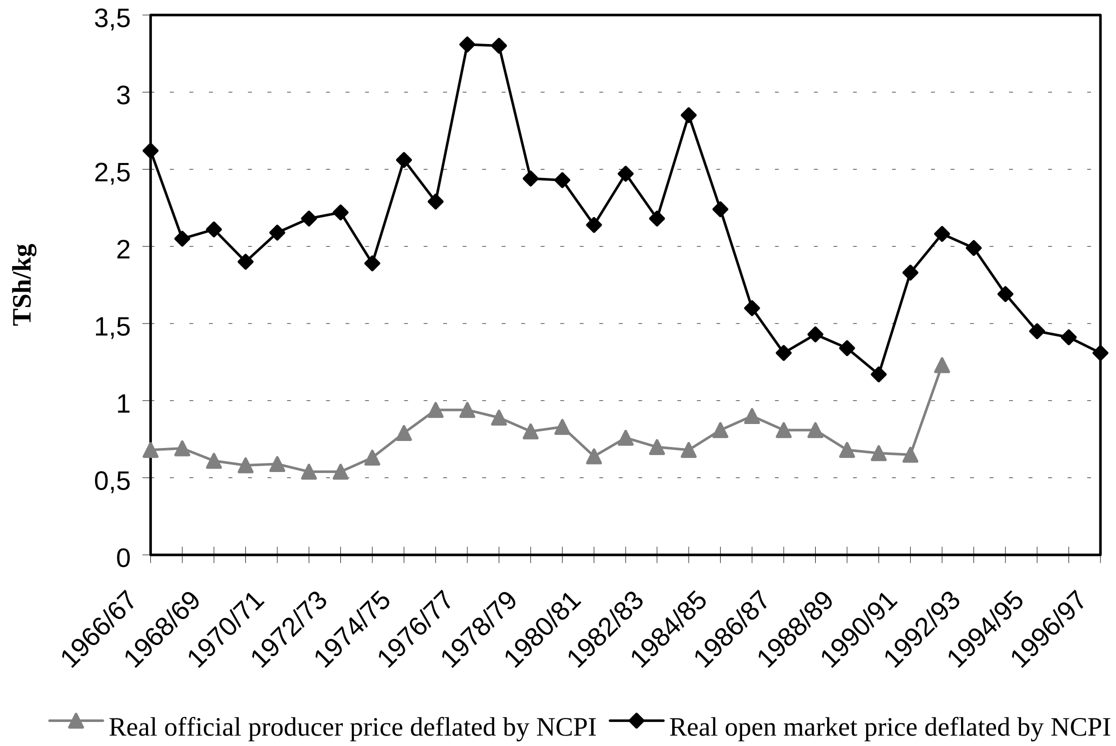

Figure 4.7. Real maize prices in Tanzania (Dec 1977=1).

Looking at the real prices the picture is different (Figure 4.7.). To obtain the real prices the nominal prices were deflated with the National Consumer Price Index (NCPI).

The real official producer prices rose between 1972/73 and 1975/6 by almost 50% from 0.54 to 0.94. The highest ever price level (except for the last official price of 1991/92) lasted two years. Then came a gradual decline in the real value, down to 0.64 in 1980/81. For some years the price level was even but the new food crisis of the early 1980s spurred the real official prices to rise up to 0.9 in 1985/86. Then the real value started declining again, going down to 0.65 by 1990/91. In the last year of official prices, 1991/92, the National Milling Corporation procurements had diminished to merely 10 000 tons, and thus the last high price of 1.23 was in practice unimportant.

The real parallel market prices have been fluctuating. From 1970/71 onwards the prices increased steadily to go dramatically down during the food crisis year of 1973/74, when the government imported massive amounts of cereals filling the market with official supplies. Then the prices increased again both in official and parallel markets. The all time high of the real parallel market consumer prices was in the years 1976/77 and 1977/78. After that the prices came down to peak again in the 1983/84 food shortage year. Then followed a steep decline during the years of market liberalisation and favourable weather on the second half of the 1980s. A general downward trend since 1983/84 was suddenly disturbed by considerable price rises in 1990/91. Although production estimates by the Food Security Unit did not indicate any significant production decreases, the MDB price and volume data indicated an apparent national food shortage. This induced the Strategic Grain Reserve to release nearly all of its maize stock, using the NMC for the distribution and selling of the grain. The maize prices continued at an elevated level until 1993/94. This might be due to the significantly higher maize prices in the neighbouring countries. The extent of unofficial exports is not known but it exists and might be significant.

Interestingly the prices went down during the marketing year 1994/95 following the unfavourable production year of 1993/94 when the short rains failed and the food security situation was considered to be alarming. This must mean either that there was a substantial substitution effect from other staples to compensate for the decreased supply of maize, or that the yield estimates were too low.

The correlation coefficient of open market maize prices and rainfall in Mwanza is -0.32, showing a weak negative correlation. Thus increased rainfall weakly correlates with decreased prices (see Chapter 4.7. for further details on the weather dummy).

In the process of liberalisation the seasonal fluctuations have decreased to a certain extent, due to increased long-term storage which evens out supply and prices over time

(MDB 1992, 39). Private traders were estimated to handle over 85% of the marketed food grains in 1993.

In retrospect it seems that the producer price policy was rather an outcome of overall policy concerns than a deliberate consequent effort. The main reasons for the decreasing real value of producer prices were the escalating marketing costs and the failure to take inflation into account in the pre-growing seasons determined prices. The price increases after food crisis appear to be rather “a reflex action to national crisis than a premeditated component of coherent strategy“ (Ellis 1982, 269).

The amount of staple grains sold through unofficial markets can be estimated only very roughly[31]. The Tanzanian view presented by the MDB (1983, 1) estimates that 80% of the maize and 50% of the rice yield are consumed in the farm. Of the marketed 20% of maize, 5% is sold through official channels and the remaining 15% through unofficial markets. In deficit years the informal market channels are increasingly used by the producers, while in surplus years most of the maize can be sold to the NMC (MDB 1981, 7). The average second economy staple grain prices have been consistently higher than official prices, except in 1987/88 and the four following years onwards. For example, in early 1984 the unofficial maize price was four times the official price of maize.

In 1981, when the economic crisis was clearly manifest and the fiscal resources of the government were very limited, a price reform was initiated. Pan-territorial prices were demolished and replaced with a dual price system which gave premium prices for the areas particularly well suited for maize production. Unfortunately only purely ecological considerations were taken into account in the design of the new price system. Since the transport costs were not considered, the higher prices were paid in the most remote surplus producing areas of the Southern Highlands. With the growing prominence of the parallel markets, the official producer prices became in fact floor prices. Official procurement became increasingly concentrated to the Southern Highlands where this price reflected the true price, while the other areas supplied the parallel markets where prices were much higher. According to Bryceson (1993, 73) Rukwa, Ruvuma and Mbeya of the Southern Highlands accounted for only 12% of the NMC purchases in 1978/79, but by 1982/83 they represented 52% of the total.

The grain market liberalisation meant that a competitive, multi-channel marketing system emerged. At the same time, the official marketing channel fell into a decline

[31]According to Maliyamkono and Bagachwa (1990, 76-77), estimates vary considerably. Usually the amount retained for home consumption is estimated at around 70 to 85% of the yield (see Temu 1984 and Odegaard 1985). In normal years 70 to 75% of the marketed surplus is channelled to informal markets. However, when the harvest is bad, the proportion of maize sold unofficially may rise to well over 90% while in years of bumper harvest, as in 1977/78, it may fall below 50%. But considerably lower figures are also presented, like Bevan et al. (1988).

during 1990/91 and 1991/92. Crop purchases by the NMC and the co-operatives became negligible. But the state is not completely absent from the grain market. The Strategic Grain Reserve emerged as a significant player in the food grain markets, following its role in helping to ameliorate the worst effects of the 1990/91 maize price rise, by releasing over 100 000 tonnes of maize stocks (MDB 1991). The SGR bought a similar amount of maize in 1991/92. The SGR bought and sold at fixed pan-territorial prices until the 1994/95 season when it started to experiment with tendering. (MDB 1994, 13).

4.4. Fertilizer use and price

The use of fertilizers has been and still is very modest in Tanzania. The figures for the total fertilizer use and the weighted average price in current prices and deflated by the National Consumer Price Index are shown in Table 4.5.

The use of fertilizers grew rapidly in the 1960s being 30 000 tons by the end of the decade, and further until 1975, when it was 70 000 tons. The latter was partly due to political enforcement. Bryceson (1990, 197) states that despite the villagisation and the agricultural development programmes of the government, the adoption of improved inputs by peasants was still very limited. Fertilizer distribution increased from 0.9 kg to 6.6. kg per rural resident between 1962 and 1980, boosted by a substantial fertilizer subsidy. According to Bryceson, a significant portion of the fertilizers, as well as of the improved seeds, went to the large-scale farming sector rather than to the peasant producers. By 1979-81 the fertilizer consumption had stagnated to 99 000 tons. The aggregate figures do not tell much, since the intensity of use is spatially highly varied. In 1980 75 per cent of the total went to six of the major maize surplus producing regions. Also crop specific use varied, with 45 per cent going to food crops, 18 per cent to tobacco and the remainder to other commercial crops (World Bank 1983, 120).

The 1986/87 Agricultural Sample survey of Tanzania indicated that about 14 per cent of farmers used chemical fertilizers, 27 per cent improved seeds, 12 per cent pesticides and 24 per cent farmyard manure (World Bank 1994a, 74).

Table 4.5. Fertilizer use and prices in Tanzania 1970/71-1995/96.

Year	Total fertilizer use in tons	The weighted aver. price (TSh/kg)	The real weighted average price (TSh/kg)
1970/71	31734	0,52	1,23
1971/72	35585	0,57	1,29
1972/73	47274	0,65	1,36
1973/74	56308	0,79	1,50
1974/75	60412	2,42	3,83
1975/76	69516	2,79	3,51
1976/77	54490	1,22	1,43
1977/78	71691	1,28	1,35
1978/79	81519	1,29	1,21
1979/80	95996	1,44	1,2
1980/81	108030	1,97	1,26
1981/82	94783	2,11	1,07
1982/83	80359	2,09	0,82
1983/84	88184	2,09	0,65
1984/85	98881	5,83	1,18
1985/86	116953	5,9	1,01
1986/87	123294	7,59	0,98
1987/88	139072	9,34	0,93
1988/89	113635	9,94	0,75
1989/90	123064	9,91	0,6
1990/91	132331	11,68	0,59
1991/92	146200	28,17	1,16
1992/93	n.d.	67,32	2,26
1993/94	53406	78,81	2,15
1994/95	115000	89,85	1,88
1995/96	120000	n.d.	n.d.
Sum	2257717	345,57	35,2
Average	90309	14	1
Standard dev.	32585,71	24,83	0,79
Variance	180,52	4,98	0,88

Sources for quantities: up to 1990/91 Shitundu (1995). Shitundu has used data from the Fertilizers Section in the Ministry of Agriculture, various MDB reports and Tanzanian Fertilizer Corporation. 1991/92 from World Bank (1994b). From 1993/94 onwards: Tanzania. Food Security Bulletin, (April/May 1994, June/July 1995, June/July 1996). Tanzania Crop Monitoring and Early Warning Unit. Ministry of Agriculture. Dar es Salaam. Sources for prices: Weighted average price calculated from Shitundu 1995, Appendix 1. Table 1. using price and quantity information of three fertilizer groups (SA/CAN/ASN other N;TSP/DAP/UREA;NPK). For 1991/92 and 1992/93 average change from the weighted average price of 1990/91 is used. The percentage of change is taken from Shitundu op.cit. table 2. For 1993/94 and 1994/95 prices are estimated using producer price indices: Fertilizer and pesticides 1993/94:117; 1994/95:114 (1992=100). Producer price index (Manufacturing sector) Quarterly Report 1995:3, Table 3. Bureau of Statistics. DSM.

In 1991 it was estimated that the yearly fertilizer use was 146 000 tons. By then over 70% of the fertilizers were used in the Southern Highlands, mainly for maize. Ten per cent went to Tabora and Ruvuma for tobacco production and the remainder was used for maize, tea, cotton and sometimes coffee (World Bank 1994a, 83). Between 1974 and 1991 fertilizer use grew at an annual rate of 3.4% per year (Ibid., 76). But the overall use is still very low and spatially highly diverging. Preliminary indications from the World Bank Study showed that input levels in the early 1990s averaged around 21 kg per hectare, which was well below the optimum level determined by research, but not necessarily far from the economic optimum in the very constrained smallholder context (Ibid., 75).

The fertilizer price is represented by a weighted average which is calculated using the price and the quantity information of three fertilizer groups, SA/CAN/ASN plus other N, TSP/DAP/UREA and NPK. The trends of current and real fertilizer price with comparisons to relevant maize prices are presented in Figures 4.8. and 4.9.

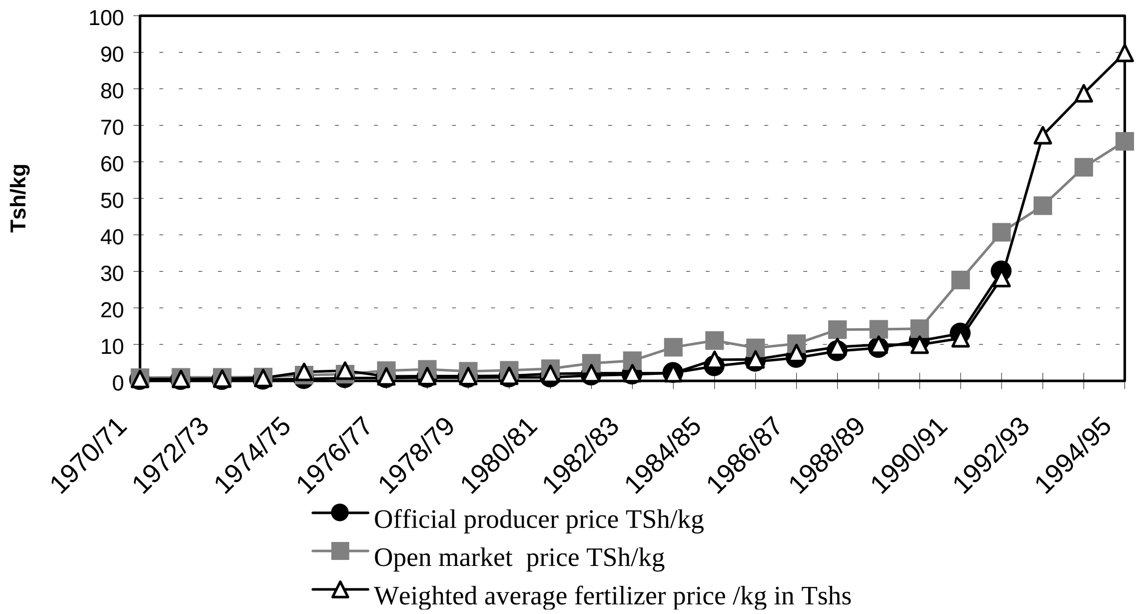

Figure 4.8. Maize and fertilizer prices 1970/71-1994/95.

Fertilizer prices closely follow the official maize price, being clearly higher in 1974/75 and 1975/76, even when compared to the open market price. Then again in the early 1990s the price of fertilizers increased very rapidly, becoming considerable higher that the maize price from 1992/93 onwards.

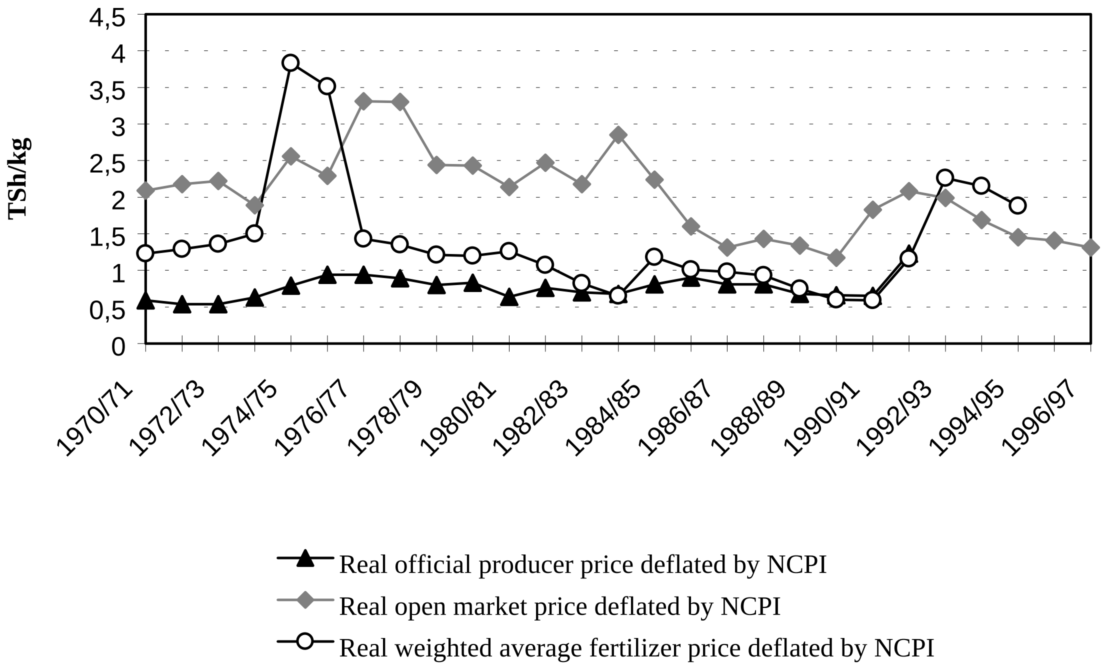

Figure 4.9. Real maize and fertilizer prices in Tanzania

The development of the real prices shows the price relationships more clearly. Fertilizer price shot to the skies after the first oil price hike in 1974/75 (Figure 4.9.). In 1976/77 the government initiated a fertilizer subsidy which reduced farm gate prices by around 50 per cent between 1976 and 1984. The fertilizer prices were also made pan-territorial through the introduction of a heavy transport subsidy. From 1976/77 onward, the real fertilizer prices went down until 1983/84, when a sudden increase of 45 per cent was followed by new decline until 1990/91. The explicit fertilizer subsidy ended in 1984 but repeated currency devaluations overtook the increases in the fertilizer selling prices permitted to the Tanzanian Fertilizer Corporation (TFC), so that by 1988/89 there was an implicit subsidy of up to 80 per cent (Ibid., 78). During 1989/90 and 1990/91 the average fertilizer prices were for the first time under the official maize producer price.

In late 1989 the government decided to phase out the fertilizer subsidy, starting in 1990/91 (70 per cent subsidy), and then reducing to 50, 40, 25 and zero per cent from 1994/95 onwards. The real fertilizer price started to increase dramatically from 1990/91 onwards, an average 85 per cent during that year, and 31-90 per cent in 1992/93 depending on type (Ibid., 78). Then the real price turned slowly down (Figure 4.9.). This might reflect increasing private imports, since import parity prices are lower than the production costs of the TFC.

4.5. Labour input

Minimum wage has been used as a proxy for labour input in agricultural production. Agricultural labour is used in only two per cent of farms, so this kind of agricultural labour market hardly exists in practice. The state farms employ labourers and in this study their wages are assumed to correspond to the minimum wage in government employment.

The real value of minimum wage increased from 1970 onwards up to 1975. After that a steady and steep decline set in continuing until 1983. From then on the real value of the minimum wage was stabilised, but started increasing again in 1993 (Table 4.6. and Figure 4.10.). Thus in the latter half of the 1980s the value of labour input was only a quarter of the highest value in 1974. This implies that it became subsequently less and less economically rational to work for a minimum wage.

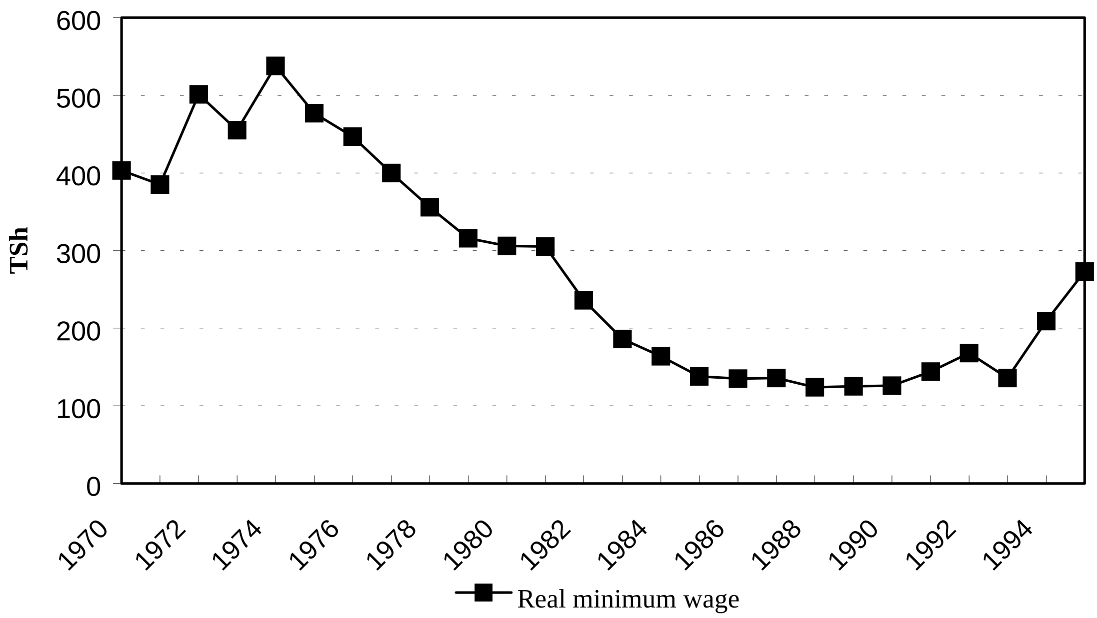

Figure 4.10. Real minimum wage, deflated by the NCPI.

Table 4.6 Current and real minimum wage in Tanzania

Year	Minimum wage (TSh)	Real minimum wage deflated by the NCPI (TSh)
1970	170	403
1971	170	385
1972	240	501
1973	240	455
1974	340	538
1975	380	477
1976	380	447
1977	380	400
1978	380	356
1979	380	316
1980	480	306
1981	600	305
1982	600	236
1983	600	186
1984	810	164
1985	810	138
1986	1045	135
1987	1370	136
1988	1645	124
1989	2075	125
1990	2500	126
1991	3500	144
1992	5000	168
1993	5000	136
1994	10000	209
1995	17500	273
Sum	57215	8749
Average	1907	292
Standard dev.	3556	132
Variance	60	11

Source: Selected Statistical Series 1951-1993. Bureau of Statistics, March 1995. Note: The real minimum wage was obtained by deflating the nominal wage with NCPI

4.6. Transport costs

Tanzania has a geography which places heavy demands on infrastructure development. The prime production areas of the Northern and Southern Highlands lay a thousand kilometres away from the main deficit areas, with highest population concentrations at the coast. The more reliable rains in the Southern Highlands secure a relatively steady surplus. In the Northern bimodal rainfall area the weather is much more prone to instability, leading to failed or decreased rainfall and decreased production in some years with regular irregularity. This leads to a need to move the surplus from the South to the North.

Transport is essential for functioning grain markets and it is definitely one of the bottlenecks for agricultural development in Tanzania. The country has a very low density of roads. Conditions for most rural roads are poor and transports both to and from villages are both difficult and costly. In many areas transports are largely restricted to the dry season. Private traders are often reluctant to operate in the rural areas because of excessive deterioration of vehicles (Tanzania 1987, 5).

Little maintenance work was undertaken on the road network during the 1970s and 1980s, and road surface quality deteriorated significantly. Since the initiation of the Economic Recovery Programme in 1986, the Tanzanian government and donors have worked together, to rebuild the road-network under the Integrated Roads Programmes (World Bank 1994a, 100).

The price rises of oil in the 1970s induced regulations for fuel conservation, restricting the use of vehicles and distribution of fuel. These restrictions were lifted in 1987, when it was felt that the increasing fuel prices, which were a consequence of large devaluations of the Tanzanian currency, would provide an adequate deterrent to the unnecessary use of petroleum products (Rutabanzibwa 1989/90, 43). In parallel with steps aimed at reducing fuel consumption by motor vehicles that were already in use, the government imposed restrictions on the importation of new vehicles (Ibid., 47). These restrictions were lifted with the establishment of the own imports scheme which meant that Tanzanians could use their foreign exchange for imports without any questions asked of the source of it (Tanzania 1987, 6).

Because of the constant shortage of fuel, tires and spare parts, the condition of the transport fleet deteriorated significantly until the market liberalisation process begun. The availability record for the public sector transport fleet was particularly poor. This was reflected in constant transport problems in moving grain and other agricultural products from surplus to deficit areas or to ports for export. The above facts of the transport system imply that there has been, and to a certain extent still is, a supply constraint for transport services in Tanzania.

Ramifications of the poor transport infrastructure were also seen in the input supply. The survey (cited in World Bank 1994a, 23) of six farming systems across the country concluded that improving supplies of inputs to farmers in areas of high to moderate natural potential is the single most important measure that can be taken in the short term to stimulate agriculture in Tanzania. In three out of six regions, the farmers interviewed expressed as their first priority the timely availability of appropriate inputs, this factor being more important than the respective price. This demonstrates the situation of excessive demand of fertilizers in relation to supply.

There are no consistent figures of transport costs for grain in Tanzania. Obviously, there are great regional differences related to distances, road conditions and vehicle availability. The following table 4.7. is based on available Marketing Development Bureau calculations which are used to determine the average share of transport costs in maize price. The cost trend is taken from the transport costs share of the National Consumer Price Index to reflect the trend in vehicle, fuel and maintenance costs.

There was a steady increase in transport costs from 1970 onwards so that around 1980 the transport costs were some 50 per cent higher than a decade earlier. Then came a steep decrease to just under the 1970 level, followed by a steep rise beginning in 1986, concurrent with the liberalisation of the economy. The growth of transport expenses seems to level off in the early 1990s to a level, which is two and a half times higher than the early 1970s level (Figure 4.11.).

Figure 4.11. Real transport costs, deflated by the consumer price index.

Table 4.7. Transport costs of grain in Tanzania

Year	Transport cost index	Average transp. cost (TSh/ton)	Real transp. Costs TSh/ton
1969	34	44	107
1970	36	46	109
1971	39	50	113
1972	46	59	123
1973	50	64	121
1974	75	96	152
1975	79	101	127
1976	92	118	139
1977	100	126	132
1978	132	170	159
1979	153	197	164
1980	199	256	163
1981	224	288	146
1982	253	325	128
1983	318	408	126
1984	338	434	88
1985	454	583	100
1986	554	712	92
1987	906	1468	146
1988	1 142	1850	140
1989	1 698	2750	165
1990	2 626	4253	214
1991	3 526	5711	235
1992	3 894	6307	212
1993	5 526	8950	244
1994	6 352	10288	215
Sum		45654	3861
Average		1755,92	149
Standard dev.		2848,68	42,56
Variance		53,37	6,52

Sources for transport cost index: Bank of Tanzania 1994; Bureau of Statistics1991; Bureau of Statistics 1996. Note: Transport cost index is the transport share of NCPI. Years 1969-76 represent the urban dwellers' transport cost index.
Sources for maize transport costs:
Weighted average transport cost for all regions/unions Tsh/ton

1978/79	211	Bryceson 1993, 73
1981/82	828	MDB 1981 Appendix 2.4.
1982/83	1036 (est.)	”
1983/84	n.d.	
1984/85	930	MDB 1986a, 57
1985/86	1200	MDB 1989, 51
1986/87	1600	
1987/88	2079	
1988/89	2420	
1989/90	2750	

Note: The average transport cost was calculated by using eight MDB figures for the ex-store NMC transport costs (1978/89-1982/83) and into-store transport costs for co-operative unions (1984/85 - 1989/90). The average transport cost from these figures was 12% of the open market maize price. Closest to this figure was the average transport cost for maize in year 1989/90: 2750 Tsh/ton. This was about 12% of the open market price and was used as a starting point and the cost series was calculated using the transport cost index part of the NCPI.

4.7. Weather

Since Tanzanian agriculture is rainfed, it was deemed necessary to study also the impact of weather on the supply of maize. In a rainfed agriculture production, drought or abnormally low precipitation usually explains variations and deficit years. Thus a weather dummy was incorporated into the models. The weather dummy was constructed using rainfall statistics. Different options for constructing the rainfall dummy were experimented with (see Appendix 3.).

Rainfall data has been collected from 12 stations around Tanzania regularly since late 1950s. The Bureau of Statistics publishes monthly rainfall figures, also indicating the number of rainy days. The first two dummies were constructed using the average of the yearly rainfall amounts from the 12 stations. This data was compared to the long-term average yearly rainfall. In the first case, rainfall 5% under the average was considered as a drought year while in the second case, 10% was used as the limit. In the first case, six years qualified as drought years, while only two years, i.e., 1970/71 and 1993/94 were classified as such in the second case. These dummies did not give any significant results. During the entire period looked at, the mean annual rainfall was never 15% lower than the average. This shows the variability of the Tanzanian ecology; it also reminds us that the years of drought never cover the entire country.

Then a weather dummy was constructed from the rainfall statistics of Mwanza. It is the second largest town in Tanzania. Mwanza is situated in the Lake Victoria zone which has a bimodal rainfall pattern. The bimodal rainfall pattern is much more unreliable than the unimodal which is prevalent in the southern part of the country. Thus this dummy reflects the more unreliable rainfall of the northern part of the country. Drought years, marked with 0, were those with 15% or less rainfall than the long-term annual average rainfall. This weather dummy proved out to have satisfactory explanatory power and it was used in the estimations.

5. Empirical application to the Tanzanian maize economy

There are two basic ingredients in any econometric study – theory and data. The theoretical basis of the present work, neo-classical farm production theory and the concept of market equilibrium, was presented and discussed in Chapters 2 and 3. This analysis can be transformed into a testable form by constructing an econometric model. Econometric models are the most convenient way to summarise the theory relevant to the system under study for empirical measurement and testing. The model is specified – that is constructed and elaborated - in a way to appropriately represent the specific phenomena to be studied. Based on the data, presented in Chapter 4, relevant econometric techniques are used to measure and to test empirically certain relationships among economic variables.

The basic aim of this chapter is to study empirically whether the disincentive effect caused by food aid suggested by the theoretical analysis can be found in the data. First, however, we discuss the econometric approach used in this study in general terms (presentation is based on Dougherty 1992, Gujarati 1992, Maddala 1989, and Intriligator 1978). This is followed by the analysis of the two structural maize supply models for the regulated and open markets, respectively, to see how well they perform and to study which of them corresponds to the dominant way of production. Then we go on to investigate the reduced-form market equilibrium model and the impact of various parameters, especially food aid, on the amount of maize produced and its open market price.

5.1. Econometric approach

An econometric model is typically a stochastic model, i.e., an algebraic model that includes one or several random variables. The reason for using stochastic instead of deterministic models is that there are always unknown factors in economic relationships. Some relevant variables may have been omitted from the model; the equation may be miss-specified, in which case the particular functional form chosen, here linear, may be incorrect; even included variables may be measured subject to error; or further there may be basic randomness in the behaviour on the part of the actors. The stochastic terms can account for any or all of these considerations. Algebraically the stochastic nature of the relationship is usually represented by an additive stochastic disturbance term, which plays the role of a chance mechanism. The stochastic disturbance terms are unobservable random variables with certain assumed properties, e.g., means, variances and covariances. The use of stochastic disturbance terms in the model is the basis for the use of tools of statistical inference to estimate the parameters of the model.

The equations forming the original model are described as its structural equations and the equations that describe how endogenous variables are really determined are known as the reduced form equations. They are the equations that express the endogenous variables solely in terms of the exogenous variables and a disturbance term. When the structural equations include lagged endogenous variables as explanatory variables, the lagged variables are considered fixed and predetermined. In such a model the reduced form equations express the endogenous variables in terms of the predetermined variables, some of which are predetermined by virtue of being exogenous and some by virtue of relating to an earlier time period. The set of all reduced form equations is the reduced form which is used for both the analysis and the estimation of the model. The estimation of the reduced-form coefficients is usually also the first step in the estimation of the structural coefficients (Dougherty 1992, 323).

The purpose of the multiple linear regression model used in this work is to estimate how two or more variables are related. One variable, the dependent or endogenous variable, is determined by one or more explanatory or exogenous variables. Estimation of the regression facilitates the analysis of the separate effects of the explanatory variables which act together to influence the dependent variable. The estimated regression coefficients summarise quantitatively the effect of a change in any one explanatory variable on the value of the dependent variable.

There are several methods of estimation; the most common are least squares and maximum likelihood, both of which are used in this study. **The least square** method is based on the minimisation of the sum of squares of the residuals. The residuals can be interpreted as sample realisation of the stochastic disturbance term. The estimation results will not be correct, if four assumptions, the Gauss-Markov assumptions, concerning the stochastic disturbance term are not valid:

1. Each of the stochastic disturbance terms has a zero mean (disturbance assumption).
2. All stochastic disturbance terms have the same (finite) variance (homoscedasticity assumption).
3. Each pair of stochastic disturbance terms has a zero covariance (absence of serial correlation).
4. The disturbance term is independent of the explanatory variables.

In **the maximum likelihood** method specific assumptions are made of the form of distribution of the stochastic disturbance terms. Typically they are assumed to be distributed independently, identically and normally. The method gives maximum likelihood of observing the sample that was in fact observed. This is done by minimising the sum of square residuals. Thus least squares, under normality, maximise the likelihood of the sample.

The estimators should satisfy certain properties for the methods to function properly. These properties are tested to ensure that the estimators are correct. A first property of an estimator is linearity. A second property of an estimator is unbiasedness. This is satisfied if the expected value of the estimator is equal to the population characteristics. A third property is asymptotic unbiasedness, that is, as the sample size increases without a limit, the expected value of the estimator equals the true population value. A fourth property of an estimator is efficiency. A scalar estimator is at least as efficient as another if its mean square error is smaller than that of the others. A fifth property is the large-sample property of consistency; as the sample size increases without a limit, the probability of the estimator being identical to the true value approaches unity.

The Gauss-Markov theorem states the optimality properties of the least squares and maximum-likelihood estimators under the assumption of independent, identically and normally distributed stochastic disturbance terms. Under the BLUE assumptions estimators are the best linear unbiased estimators; i.e., the estimators have minimum variance within the class of linear unbiased estimators.

After the estimation of the model, it is tested. Diagnostic tests, or miss-specification tests, are designed to test the adequacy of the specification of the regression equation. The possible ways in which an equation might have been miss-specified include:

1. The set of regressors may be incomplete - some important variables may have been omitted.

2. The parameter vector may not be constant.

3. The functional form may be incorrect

4. One or more regressors may not be exogenous.

5. The error term may be autocorrelated.

6. The error term may be heteroscedastic.

7. The error term may be non-normally distributed.

If any specification error has been committed, the standard interpretation of the estimated equations is invalid in some way.

The regression explains only a certain proportion of the total variance. The coefficient of determination for a regression, R^2, is the measure of this. Thus R^2 is a measure of the explanatory power of the regression – in particular, how well the model, as estimated, fits the available data. If for example R^2 is 0.9, then 90% of the variance of the dependant variable is explained by the regression, with 10% left unexplained. Care must be taken when interpreting the meaning of R^2 when comparing two different regression equations. It is inappropriate to compare two regression equations with different number of explanatory variables or with a different dependable variable. R^2 values tend to be high with time-series data, where both the dependent and explanatory variables may reflect certain underlying time trends.

The F -test measures the explanatory power of the model and is calculated as follows:

$F = \dfrac{ESS/k}{RSS/(n-k-1)}$, where ESS is the explained sum of squares and RSS is the residual or unexplained sum of squares.

The null-hypothesis is that the model has no explanatory power. The better the model explains the phenomenon under study, the higher is the F -value. When the value is high enough, the null-hypothesis is rejected at a given level of significance.

A related test, the t-test, tests the hypothesis that one of the model coefficients is zero, i.e., it tests the hypothesis that the corresponding independent variable exerts no statistically significant linear influence on the dependent variable. The significance of the coefficient is determined by the ratio (t) of the estimated regression coefficient to its standard error. If the t ratio is low, the coefficient is not significant.

The Residual Sum of Squares (RSS) is the sum of the squared distance between the actual dependent variable and its estimated value. The Ordinary Least Squares method minimises the RSS . The RSS figures can be used when calculating F -tests.

Empirical econometrics faces various problems, of which several stem from the fact that certain assumptions of the Gauss-Markov theorem are not met. The least-square estimators are not necessarily the best linear unbiased estimators. Other problems involve the basic structure of the model. The model diagnostics are developed to assess the possible problems and the validity of the developed model in describing reality.

One assumption made within the standard regression model is that the error terms are mutually independent, so that there is no **autocorrelation**. Autocorrelation or serial correlation is a common problem in time-series econometrics. It means that the stochastic disturbance terms are not independent of one another. Autocorrelation is a typical problem when time-series data is used. A general cause of autocorrelation is miss-specification of the model, particularly the exclusion of relevant variables. The most important type of autocorrelation is first order linear serial correlation, namely the linear relationship between successive stochastic disturbance terms. The first order autocorrelation means that the error term at time *t* is correlated to the previous term at time *t-1*. Correspondingly the second order autocorrelation refers to the time period *t-2* (Gujarati 1992, 361). The presence of first order autocorrelation is tested by the Durbin-Watson test and AR 1-2 test is used to detect second order autocorrelation.

The Durbin-Watson test uses the d statistics, which is the ration of the sum of squares of successive differences of residuals to the sum of the squared residuals. Tables of significant values of the Durbin-Watson statistics are based on normally distributed disturbances and fixed explanatory variables. The tables give for a particular sample size n and a particular number of coefficients to be estimated k, lower and upper values for d, called dL and dU, representing bounds on the significance level for any set of explanatory variables. The test gives the positive and negative first order autocorrelations and the absence of autocorrelation. But between these, there are regions of indeterminacy in which the test fails. These are the cases of suspected positive autocorrelation (Dougherty 1992, 216-220).

Heteroscedasticity is the violation of the second Gauss-Markov condition stating that the variance of the disturbance term in each observation should be constant. The probability of the disturbance term reaching a given positive (or negative) value will be the same in all observations. This condition is known as homoscedasticity. If heteroscedasticity is present, the OLS estimators are inefficient and it could be possible to find other estimators, which have smaller variance for structural parameters. The second reason is that the estimators of the standard errors of the regression coefficients will be wrong, because they are computed on the assumption that the distribution of the disturbance term is homoscedastic (Dougherty 1992, 201-203). The appearance of heteroscedasticity in time-series models may be rationalised in some cases as a reflection of the way in which the variability of the dependent variable changes systematically over time. The variance of the error term at time t represents the uncertainty at that point in time; a larger variance of ε_t indicates more noise and uncertainty at time t that does a smaller variance. In some models it has been found useful to treat the variance of ε_t conditional of the information available at time *t*, as a function of previous errors. This is measured by the AutoRegressive Conditional Heteroscedastic (ARCH) test.

In addition to the Gauss-Markov conditions, it is usually assumed that the disturbance term is **normally** distributed, there is no skewness or asymmetry in the distribution, and no excess kurtosis.

The general linear model $Y = X\beta + \varepsilon$ is assumed to be linear in the regressors, and if the assumption of **linearity** is false, then any estimation of the model restricted by this assumption will lead to false inferences. This can be tested with the Regression Specification Error Test (RESET). It is computed by adding a parameter vector *Z*, which comprises of higher powers of the estimated value of the dependent variable $\hat{Y}$. This regression may be written as: $Y = X\beta + Z\gamma + \varepsilon$. A simple F-test with the hypothesis that $\gamma = 0$ is then a test to the linearity hypothesis.

If the RESET test rejects the hypothesis of linearity, it should be noted that no precise alternative functional form has been utilised as an alternative hypothesis. Moreover, a significant RESET statistic is not necessarily an indicator of a miss-specified functional form; for example, if there is a structural break in the relationship, this can also give rise to a significant RESET *F*-statistics (Darnell 1995, 346-347).

5.2. Econometric specification of supply equations in the maize production system

A table (Table 5.1.) is first presented listing and defining all the parameters used in the econometric models.

Table 5.1. Parameters and their definitions

Variable	Definition
Q	Quantity of maize produced
$\overline{p}$	Official price of
r	Outside input cost; average fertilizer price
w	Labour costs; minimum wage
D	Weather dummy based on the rainfall statistics of Mwanza town; a drought year marked with 0 is defined as having the annual amount of precipitation minus 15% or less than the long term annual average rainfall
$\tilde{p}$	Open market price of maize; the annual average of available information collected from various parts of the country
c	Transport cost calculated from average transport costs
σ_p^2	Variance of the open market price; the average squared deviation between the open market prices and their mean
A	Measure of absolute risk aversion,; not incorporated in the empirical calculations since it has not been possible to find a suitable means of measuring it
σ_{FA}^2	Variance of food aid; the average squared deviation between the annual amounts of food aid and their mean
I	Total grain imports, both food aid and commercial

Based on the qualitative properties of model [35] one can explain the quantity of maize produced for the market, Q by the official price $\overline{p}$ and the production costs represented by outside input costs r, average fertilizer price, and the price of labour input w, minimum wage. D is a weather dummy. The official market supply system can be presented as a log-linear function[32]

[64] $$\log Q = \alpha_0 + \alpha_1 \log \overline{p} + \alpha_2 \log r + \alpha_3 \log w + D + \varepsilon ,$$

where ε is the error term.

Analogously based on the qualitative properties of model [47], maize production for the market Q is explained by open market price $\tilde{p}$, fertilizer and labour prices and the weather dummy, and further by transport cost c and the variation of the open market price σ_p^2. The parameter A, which represents the measure of absolute risk aversion, is not incorporated in the empirical calculation, since it has not been possible to find a suitable means of measuring it. The open market supply system can be presented as a logarithmic function

[65]

$$\log Q = \beta_0 + \beta_1 \log \tilde{p} + \beta_2 \log c + \beta_3 \log r + \beta_4 \log w + \beta_5 \log \sigma_p^2 + \beta_6 \log A + D + \eta$$

where η is the error term[33].

The parameters were estimated using the Ordinary Least Square (OLS) method. In the open markets $\tilde{p}_{t-1}$ was used instead of $\tilde{p}$, since $\tilde{p}_{t-1}$ directs the decisions how much to sow at time t, i.e., the farmers base their decisions on the price of the previous season, which is the last price they have knowledge of at the time of the decision-making[34]. The results are shown in Table 5.2.

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[32] A log-linear function is used because it transforms the various parameters to a more comparable scale without changing their relative relationships.

[33] There is a possibility that some of the parameters in eq. [65] are endogenous. When prices are determined in a market setting, then the area planted will affect fertilizer and labour prices and Q itself will affect transport costs. However, in Tanzania, 75-80% of maize production is consumed by the peasant households. The area planted is, due to the prevalence of hoe-cultivation, directly related to the growing population as there is no land constraint to speak of. The variability of the Q is mainly due to the vagaries of the weather. Further fertilizer demand exceeds supply. Transport capacity is inadequate, thus in good harvest years the transport capacity is a bottleneck for well functioning grain markets. In this kind of setting the endogenity problem is not considered to be a serious issue.

[34] So-called adjustment factor (time lag) specification for supply.

Table 5.2. OLS estimates of the maize market system.

	Official market	Open market
Variable	log Q (t-probability)	log Q (t-probability)
Constant	15.60 (0.0000)	12.27 (0.0002)
log $\overline{p}$	1.02 (0.0015)	
log $\tilde{p}_{t-1}$		0.55 (0.0197)
log r	- 0.16 (0.3708)	0.31 (0.0470)
log w	- 0.43 (0.0088)	- 0.88 (0.0000)
log c		0.56 (0.0126)
log σ_p^2		1.12 (0.2759)
D	0.24 (0.0196)	0.11 (0.2759)
Diagnostics		
F	F (4,17) = 19.17 ($F_{0.01\%}$=4.67)	F (6,14) = 10.84 ($F_{0.01\%}$=4.46)
R^2	0.82	0.82
RSS	0.66	0.52
DW	1.55 (at 1 % D_L 0.57, D_U 1.63)	1.62 (at 1% D_L 0.26, D_U 2.35)
AR 1-2	F(2,15) = 0.98 [0.40]	F(2,12) = 1.24 [0.32]
ARCH	F(1,15) = 0.25 [0.62]	F(1,12) = 1.26 [0.28]
Normality	χ^2(2) = 0.5 [0.97]	χ^2(2) = 3.13 [0.21]
RESET	F(1,16) = 19.92 [0.0004]	F(1,13) = 19.36 [0.0007]

F is the significance of the whole equation statistic, R^2 is the goodness-of-fit statistic, RSS is Residual Sum of Squares, DW is the Durbin-Watson statistic for the first order autocorrelation, AR 1-2 tests for the second order residual autocorrelation, ARCH tests AutoRegressive Conditional Heteroscedasticity, Normality is a test for skewness and excess kurtosis of the errors, and RESET is Regression Specification Test. T-probabilities of the coefficient estimates are in parenthesis. All the estimations are performed by PC-Give version 8.10.

In the official price model goodness-of-fit is relatively good (R^2= 0.82) and the diagnostic tests are favourable, showing that the Gauss-Markov assumptions are met with the exception of some non-linearity. The non-linearity is not readily explained by the economic theory related to the properties of the components of the model. There is no evidence of any limiting values, which would change the reactions of the producers; thus the only plausible explanation is problems with the data set.

The signs of the estimated coefficients were as expected in the theoretical considerations. The logarithmic values for official price $\overline{p}$ and minimum wage w, which is the proxy for the price of the work input, were found to be statistically significant at the 1% level. The sign of official price was positive, showing the obvious connection of higher price with higher production. The negative sign of the minimum wage, which is in conformity with the model, tells that an increase in the price of the major production input will have a decreasing effect on production. The price of fertilizers did not have significance for the amount of maize produced. This can be explained by the low level of fertilizer use in relation to the total volume of maize production. The weather dummy using the 15% reduced average rainfall gave more significant results than the 10% dummy. Positive values in the model estimations tell that maize production is positively correlated with years when rainfall is more than minus 15% of average or higher. In years when rainfall is 15% less than the average the yields are negatively affected. In the official market model weather was significant at 5% level.

In the open market price model goodness-of-fit is likewise relatively good (R^2 = 0.82) and diagnostic tests are similar as the above. It is, however, shown by the *RESET*-test that all the exogenous parameters do not behave in all occasions in a linear fashion. Since the explanatory power is quite satisfactory, this is not considered to be a serious flaw. In the model all parameters were found to be significant, expect the weather dummy. The open market price was positive as the theory indicates and significant at 5% level. The price lagged by one year was used, because that is the latest price known to the farmers when making their production decisions. The interpretation is obvious: the higher the open market price, the higher the maize production. Thus both models show that Tanzanian peasants are price sensitive.

The price of labour is highly negatively correlated to production, as the theory would have it. The result is significant at the 1% level. Thus the higher the labour cost, the lower the production. Fertilizer price and transport costs are both significant at the 5% level. However, their sign is positive in opposition to the theoretical prediction of a negative sign, which would have meant that the higher the input costs the lower is the production. The apparent contradiction is explained by the specific circumstances of Tanzania. There seems to be serious lack of fertilizers (as well as other commercial inputs) and of transport services. Thus agricultural expansion associated with high fertilizer use leads to a situation in which a part of the demand for fertilizers is unmet. The inadequate transport fleet, fuel scarcity and inadequate and dilapidated road network turn transports to a significant bottleneck for grain marketing. This explains why high production is connected to higher prices for both fertilizers and transport services. Also the variability of the open market price is positively correlated to production, against the negative sign assumed by the theory. This can be understood by contemplating the structure of production in Tanzania. The majority of maize production, around 70%, is for subsistence use. Households are very much dependent on their subsistence production for their food security. There are very few possibilities for income generation outside agricultural production, especially in the South. Agricultural production is dependent on rainfall also for cash crop production and animal production. Thus the risk-bearing capacity is limited. Since maize production is rainfed, it is likely that at a local and regional level there is a drought at some places in any given year. This leads to risk-avoiding behaviour and increased production to secure the fulfilment of the minimum food needs of the peasant households also in bad years. The open market model did not show any significant value for the weather dummy. But when the weather dummy was left out, both the models showed problems with normality values, indicating that the changing rainfall pattern was significant in explaining the developments of maize production. This is probably because it helps to explain the behaviour of outliers.

To see which model is better in explaining the overall aggregate behaviour in agricultural production, the two models were compared by the non-nested encompassing test, suggested by Mizon and Richard (1986). It involves running model 1 with, as additional regressors, those variables from the competing model 2, which are not already accommodated in the first model, and testing their inclusion with F-statistics. This was done by testing a model containing all the variables from both of the competing models, the official market model and the open market model, with the F-test. This result was compared to the F-statistics of the two competing models.

The encompassing test was carried out by first estimating the joint model, including all the explanatory variables from both models

[66]
$$\log Q = \gamma_0 + \gamma_1 \log \bar{p} + \gamma_2 \log \tilde{p} + \gamma_3 \log c + \gamma_4 \log r + \gamma_5 \log w + \\ + \gamma_6 \log \sigma_p^2 + D + \psi$$

Then restrictions implied by alternative specifications were tested by means of F-test statistics. The results are reported in Table 5.3. The official market specification performed best but all showed significant F-values and the difference was not great between the different models. Hence, one can conclude that despite of the official policy with government grain marketing monopoly, open markets are relatively important for the economy. Moreover, the fact that both models perform so well demonstrates that the behaviour in the official and open market is surprisingly similar. This may be due to the fact that the government follows a market oriented policy when announcing the annual official price.

Table 5.3. The Mizon-Richard encompassing test (1986).

Model	Variables	F-statistics for linear restrictions
A	$\gamma_0, \gamma_1, \gamma_2, \gamma_3, \gamma_4, \gamma_5, \gamma_6, D$	F(5,15) = 11.50 (0.00)
B	$\gamma_0, \gamma_1, \gamma_4, \gamma_5, D$	F(4,17) = 19.17 (0.00)
C	$\gamma_0, \gamma_2, \gamma_3, \gamma_4, \gamma_5, \gamma_6, D$	F(6,14) = 10.84 (0.00)

5.3. Reduced-form market equilibrium model

Next we investigate the reduced-form market equilibrium model and the impact of various parameters, especially food aid, on the amount of maize produced and on its open market price.

At the equilibrium demand equals supply, hence both demand and supply specifications have to be analysed simultaneously. In simultaneous equation systems some of the independent variables in a regression are correlated with errors, and thus the fourth Gauss-Markov assumption is violated. In such a system there is a contemporaneous feedback between the endogenous variables of the system. Thus the OLS does not give unbiased and consistent estimates (Cuthbertson et al. 1992, 38).

There are several possible systems estimation techniques that can be applied when solving simultaneous equations. The most common are the full information maximum likelihood (FIML) and the three-stage least square methods. Systems estimation procedures estimate all the identified structural equations together as a set, instead of estimating the structural parameters of each equation separately. These systems methods are also called full information methods, because they utilise the information of all the zero restrictions in the entire system when estimating the structural parameters. Their major advantage is that, because they incorporate all of the available information into their estimates, they have a smaller asymptotic variance-covariance matrix than single equation estimators such as the two-stage least square do. But this also means that if the system is miss-specified, the estimates of all the structural parameters are affected.

In the maximum likelihood (ML) technique estimates of all the reduced-form parameters are created by maximising the likelihood function of the reduced-form disturbances, subject to zero restrictions on all the structural parameters of the system. It is based on the assumption of a particular probability distribution. The probability of observing a particular outcome is calculated. This generally depends on some unknown parameters. Given the data set we then choose those parameter estimates, which maximise the probability of the observed outcome. These parameter estimates are the maximum likelihood estimate of the unknown true parameter values (Cuthbertson et al. 1992. 46-47).

In the three stage least square (3SLS) method the instrumental variable approach is used first and this is followed by a generalised least square approach. The main difference between the results of FIML and 3SLS is that FIML is invariant to normalisation[35]. Thus the full information maximum likelihood (FIML) estimation method used in this study is the most efficient amongst all estimators for simultaneous equations.

In what follows, we give the reduced form at market equilibrium in terms of quantity and price, as given in equations [67a] and [67b]. The main issue is to study the disincentive effect, i.e., the effect of food aid on domestically produced quantities and price, but the effects of other variables are also of interest. As variables for studying the impact of food aid we choose the variance of food aid (σ^2_{FA}) and the amount of total imports (I); in the model the variable is lagged by one year to express the impact of imports on the production decisions the following year[36].

The market equilibrium combination $\{Q^*, \tilde{p}^*\}$ can be given as simultaneous system of following log-linear functions:

[67a]

$$\log Q^* = \alpha_0 + \alpha_1 \log \tilde{p} + \alpha_2 \log \bar{p} + \alpha_3 \log w + \alpha_4 \log r + \alpha_5 \log \sigma^2_{FA} + \alpha_6 \log I + \alpha_7 \log \sigma^2_p + D$$

[67b]

$$\log \tilde{p}^* = \beta_0 + \beta_1 \log Q + \beta_2 \log \bar{p} + \beta_3 \log w + \beta_4 \log r + \beta_5 \log \sigma^2_{FA} + \beta_6 \log I + \beta_7 \log \sigma^2_p + D$$

where φ and δ are error terms.

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[35] In the 3SLS the estimates are not invariant to the choice of normalisation. If the original equation were written differently, with a different choice of the normalised endogenous variable, the estimates from a finite sample would be different (Darnell 1994, 397-399).

[36]The total imports I represents both food aid and commercial imports. A model was first constructed separating commercial and food aid imports but the results did not have explanatory power. It seems clear that since the government uses food aid and commercial imports the same way, resorting to commercial imports when it has not been able to secure enough food aid to meet its obligations, they act in the market in similar manner and should be treated together.

According to the time structure of the model, maize production and open market maize price are determined simultaneously. Hence one cannot use $\tilde{p}$ as an explanatory variable in [67a] and Q as an explanatory variable in [67b]. Here we follow the common procedure and use lagged $\tilde{p}$ in [68a] and lagged Q in [68b][37] so that the actual equations to be estimated are:

[68a]
$$\log Q^* = \alpha_0 + \alpha_1 \log \tilde{p}_{t-1} + \alpha_2 \log \bar{p} + \alpha_3 \log w + \alpha_4 \log r + \alpha_5 \log \sigma^2_{FA} + \alpha_6 \log I_{t-1} + \alpha_7 \log \sigma^2_p + D + \varphi$$

[68b]
$$\log \tilde{p}^* = \beta_0 + \beta_1 \log Q_{t-1} + \beta_2 \log \bar{p} + \beta_3 \log w + \beta_4 \log r + \beta_5 \log \sigma^2_{FA} + \beta_6 \log I_{t-1} + \beta_7 \log \sigma^2_p + D + \delta$$

Because of simultaneity it is useful to apply the full information maximum likelihood (FIML) estimation procedure[38]. The results of the system of equations, together with some diagnostics, are presented in Table 5.4.

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[37] In reduced-form equations endogenous variables are expressed in terms of predetermined variables, some of which are predetermined by virtue of being exogenous and some by virtue of relating to an earlier time period. Thus in an equilibrium model, the one exogenous parameter that is used to explain the other, must be lagged by a year (see Dougherty 1992, 323).

[38] The estimations are made with PcFiml, which is designed for modelling multivariate time-series data for linear variables. The assumption of linearity is made, because it is rational to assume the simplest model as a basic assumption. If this performs satisfactorily, no more complicated models are needed.

Table 5.4. Reduced-form FIML estimation results for maize production and open market price equilibrium system

Reduced form equations, period 1971/72-1991/92		
Explanatory variable	log Q (*t*-probability)	log $\tilde{p}$ (*t*-probability)
Constant	16.37 (0.00)	10.66 (0.02)
$\log \tilde{p}_{t-1}$	- 0.22 (0.35)	
$\log \overline{p}$	1.07 (0.00)	1.14 (0.01)
$\log w$	- 0.36 (0.06)	0.46 (0.01)
$\log r$	- 0.15 (0.40)	- 0.46 (0.02)
$\log \sigma^2_{FA}$	0.01 (0.08)	0.009 (0.06)
$\log I_{t-1}$	0.03 (0.07)	0.03 (0.05)
$\log Q_{t-1}$		-0.38 (0.17)
D	0.21 (0.06)	-0.002 (0.98)
Diagnostics	For single equations	
AR 1-1	F(1,5) = 11.92 [0.02]	F(1,5) = 5.37 [0.07]
ARCH	F(1,4) = 0.02 [0.89]	F(1,4) = 0.10 [0.76]
Normality	χ^2(2) = 1.69 [0.43]	χ^2(2) = 2.14 [0.34]
Diagnostics	For both the single equations and the whole system	
AR 1-1	*F*(4,20) = 1.01 [0.43]	
Normality	χ^2(4,20) = 4.16 [0.38]	

AR 1-1 refers to the first order auto-correlation statistics, ARCH describes the heteroscedasticity statistics and Normality refers to the Jarqua-Bera normality test statistics. Second order autocorrelation and normality are calculated also for the whole system (see Doornik and Hansen 1994). The numbers in parenthesis for the parameter estimates are t probabilities and those for the diagnostics are the marginal significance levels (see Doornik and Hendry 1991).

The diagnostic performance of the system of equations is relatively good. The single-equation statistics for no heteroscedasticity and for normality show good performance, but instead there is some evidence for serial autocorrelation in the quantity equation. However, for the whole system (vector) tests for no autocorrelation and for normality can be accepted at the standard significance levels. Hence, we can go on in interpreting the parameter estimates.

We start the interpretation of the results with the disincentive effect. If it holds, one should have a negative coefficient for I_{t-1} in both quantity and price terms. This does not, however, show up. On the contrary, both coefficients are positive and the impact on open market price is statistically significant at the 5% level while quantity showed significance at the 7% level. This is contrary to the model. What accounts for this result?

In a situation of food aid being imported, the domestic production has not been able to supply the market with enough grain. The price effect dominates the disincentive effect due to the two-tier marketing system. The imports of food aid and commercial imports do not fill the gap created by a bad yield. Because official prices are fixed, production deficiencies are translated into increasing prices in the unofficial market. In deficit years more grain is marketed via unofficial channels than in normal years and consequently the NMC has relatively more difficulties in procuring enough grain as compared to normal years, thus the import need is proportionally higher than the total domestic production would indicate. Simultaneously farmers, who market to the unofficial market, get an income which is not as much lower as the yield decreases would indicate. Thus food imports signify inability of the NMC to buy from the domestic market due to decreased yield and also due to the fact that producers tend to choose unofficial marketing channels. The increased unofficial prices act as a positive signal for farmers to produce more.

Part of the phenomenon is also explained by the incomplete integration of markets. Obviously due to the dismal infrastructure and transport situation, the markets are not well integrated. When imports arrive, they are used for feeding the coastal urban areas. The inland deficits, which usually occur in the North at Lake Victoria zone, are not met by imports; thus this deficit increases the open market price. The open market is most active in the deficit areas inland. The coastal areas and especially the capital, Dar es Salaam, have traditionally been better served by the government grain monopoly, which of course, also has a monopoly for grain imports.

The variability of food aid imports showed no statistical significance in relation to the domestic maize production and to the unofficial maize price. (However, the variability of food aid imports showed positive significance at the 8% level in relation to the domestic maize production and at the 6% level in relation to the unofficial maize price). Variability of food aid is a sign of variability of production. The positive correlation could be interpreted as a risk-avoiding reaction from the part of the peasants. The insecurity of the market situation induces the subsistence producers to increase their production to increase household food security.

The variability of food aid imports in relation to the open maize price was almost significant at the 6% level and the sign was positive, i.e., the prices do not decrease with the variability of imports, as the theory would suggest. The relation to the amount of maize produced was also positive. This is related to the same market structure as explained above. Food aid amounts vary a lot and are highly unpredictable and seldom reach the inland deficit areas. Thus the impact of high food aid variability is to increase the open market price.

The equilibrium maize production model shows a strong positive relation between the official price and the amount of maize produced. This was as expected. However, the lagged open market price was not significant. Thus official price is a strong determinant of the production. Among the inputs, labour price turned out to be almost significant at a 6% marginal and had a negative sign as could be expected, indicating that high labour costs lower the production. Transport costs and the variability of the open market price were tested and showed no significance, and were accordingly dropped out of the model. The weather dummy was almost significant at the 6% level, showing the positive correlation between good weather and maize production.

The open market equilibrium price equation showed positive correlation between the official price and open market price with a 1% significance level. This is quite understandable, since both prices reflect the market situation; the official price seems to follow the developments of the open market price with a lag. The price of labour input was positive and significant at the 1% level, showing the theoretically correct relationship between high input and high produce prices. On the other hand, the sign of fertilizer price is negative and significant at the 2% level, against the theoretical expectations. This can be explained as previously: when production is high the demand for fertilizers is high, thus increasing the price, but high production means also lower price for the products, explaining the simultaneously increasing fertilizer price and decreasing produce price. Another explanation might be that the annual data is simply not as accurate as the growing season data, and the decisions are based on the prices at the beginning of the growing season. In the price equation the weather dummy did not show any impact.

6. Conclusions

This study analysed the economic impact of food aid on producer incentives theoretically and empirically. The aim of this study was to assess the validity of the so-called disincentive effect of food aid on the agricultural production in developing countries. Disincentive effect was postulated by Schulz (1960) who argued that by decreasing market prices foreign food aid deteriorates domestic agricultural production. This leads to a long-term reduction of agricultural production in developing countries. For the evaluation of the disincentive effect, empirical data from Tanzanian agriculture was collected, and the theoretical models of agricultural production were developed reflecting the institutional circumstances in Tanzania.

The study started with a review of previous theoretical and empirical analyses of the disincentive effect. Previous economic research on the disincentive effect based on rigorous theoretical analysis was found to be rare, as were the empirical applications based on economic theory. Therefore, a parametric market model for agricultural production with foreign food aid was formulated and analysed. The previous theoretical literature was discussed, interpreted and evaluated in the light of the qualitative results of the model presented in Chapter 3.

The next step was to develop a model of agricultural production reflecting the institutional features of Tanzania. The time period under study was from 1971 to 1996. For a large part of the period under discussion, Tanzania had a grain market policy in which the government had a market monopoly. This had led to the development of an unofficial market, as the case usually is with market systems based on a state monopoly. A gradual market liberalisation was begun in 1986 and completed in 1991. A theoretical model was developed presenting the farmers’ supply reaction. The model presented adds a new dimension to the past efforts of studying the disincentive effect by introducing the concept of risk into the model.

The farmers' supply behaviour in different markets was considered through a model consisting of the supply model of controlled markets with fixed prices and the supply model of unofficial markets with price risk. This illustrated the choices available for the peasant producers of Tanzania. In both models farmers choose the use of fertilizer and labour inputs so as to produce crops. Producing for the official market is by its nature deterministic, because the government announces the future price of the crop before the season. Comparative statics of input use in the deterministic model is conventional. When producing for unofficial markets farmers may get a higher price, but it is risky. Moreover, farmers have to carry the transportation costs of going into the markets. As for the ceteris paribus effects in the unofficial markets, higher expected price increases production, while higher price risk, measured by its variance, as well as higher transportation costs decrease production.

Empirical estimations for the agricultural supply function based on the official market model showed rather good performance, and all the signs of the determinants of agricultural supply functions were as predicted by the theory. The fertilizer price was not, however, significant. This indicates the well-known fact that fertilizer application levels in Tanzania are very low and thus fertilizer prices do not significantly influence the produced quantity of maize. The weather dummy turned out to be significant at a 5% level showing the importance of weather. Since the weather dummy was constructed by using the average rainfall of the Mwanza town meteorological station, the result indicates that the production of the Lake Victoria zone is negatively affected by annual rainfall which was 15% below the long-term average. This influences the total production figures of the country, indicating the importance of the unreliable short rains in the northern areas for the total production.

The open market model also performed quite well. The positive effect of the crop price on production confirms that peasants are price responsive. As predicted by the theory, higher wage levels reduce the use of labour in production. While both fertilizer prices and transport costs were significant, they were of the opposite sign as compared to the predictions of the model. The reasons can be found in the realities of the Tanzanian agricultural production system. There has been much less fertilizers available than farmers would have been willing to buy. This has meant that when farmers wanted to increase production and therefore demanded more inputs, the shortage of supply pushed the fertilizer prices up. This is clearly shown also in the World Bank enquiry of 1994 stating that farmers were more concerned about the availability and timeliness of fertilizer deliveries than about the price (World Bank 1994, 75). Likewise, the lack of transport capacity has been a bottleneck for grain marketing.

Contrary to the theoretical model, the open market price variance and maize production correlated negatively. This was explained by the production system of Tanzania. An overwhelming majority of producers are subsistence oriented food insecure peasants. 70 per cent of staple grain production is used for home consumption, up to 80 per cent in years with weather unfavourable to grain production. Malnutrition rates are very high, up to 60% of children under five years of age are undernourished. Food markets are not well integrated. There could be non-marketable over-production in the Southern Highlands, while northern regions experienced lack. In practice NMC could secure food through the official marketing system only for its customary clients, institutions and urban people at the coast areas, complemented with some emergency aid. This led to a strategy where staple food production for household use gained priority and risk minimisation was the most rational behaviour.

After having analysed empirically the supply functions, the focus was shifted onto the analysis of the unofficial market equilibrium in order to trace out whether disincentive effect of food aid can be found. The mere fact that the supply of the farmers was found to be empirically price responsive could indicate this. The econometric model of market equilibrium was based on the parametric market model in the presence of food aid, which was developed to describe the disincentive effect.

The market equilibrium model implies that price and quantity are determined simultaneously by the demand and supply augmented by the food aid. Consequently they cannot be analysed with the ordinary least square method. Therefore, a full information maximum likelihood (FIML) estimation procedure was used. In the simultaneous market equilibrium model the endogenous price is an explanatory variable in the quantity equation and vice versa. Therefore, in the estimation the price was lagged by one period in the quantity equation and quantity lagged by one period (one year) in the price equation.

The empirical estimation of the market equilibrium model showed that food aid did not have a statistically significant direct disincentive impact on staple production during the study period in Tanzania. Increased unofficial price was a positive signal for farmers to produce more. It was suggested that this was due to the structure of Tanzanian food economy. In the two-tier market system the price effect dominates the disincentive effect. Food aid and commercial imports, as well as the domestic procurements by the government were used in the official markets. Prices in unfavourable years are higher in unofficial markets and a larger share of production is sold unofficially. The incompletely integrated markets accentuate the situation. Bad years and food aid are related to dry conditions in the Lake Victoria zone as demonstrated by the weather dummy. The more reliable yields of Southern Highlands seldom reach the deficient northern areas, and food aid and commercial imports also tend to remain at the coast and in Dar es Salaam.

Politically food aid was part of the government strategy to secure important groups, i.e., urban citizens especially in the capital, with low price staple food and to avoid any direct famine situation in any part of the country. The official marketing system developed into a great financial burden and never worked satisfactorily either from the consumers’ or producers’ point of view. The official supply was too limited in relation to the consumer demand. The NMC paid late and sometimes never to the producers for their grain. The pan-territorial pricing induced a spatial production structure, which became extremely expensive due to high transport costs. During 1974/75-1984/85 Tanzania received food aid all the time, with two distinct peak periods in the mid-1970s and early 1980s. However, after the gradual market liberalisation from the mid-1980s onwards, the need for food aid decreased dramatically. At the same time major donors concluded that Tanzania was essentially a food self-sufficient country and decided to reduce their food aid to Tanzania drastically. After market liberalisation a spell of unfavourable weather during the early 1990s did not result in major increases in food aid. During the two-tier marketing system the government was very much dependent on food aid to keep up the official marketing monopoly. The economic situation of Tanzania was such that it would have been very difficult for the government to import commercially the quantities of grain received as food aid. The government grain monopoly was an inefficient and fiscally very costly mode of grain market organisation. It would hardly have been possible to keep it up without considerable financial support in the form of food aid. After the market liberalisation the need for large quantities of food aid vanished. There are no indications that the nutritional status of the populations would be any worse, nor better for that matter, as a result of liberalised grain markets and low food aid levels. Thus it could be stated that food aid partly supported an unsuccessful and economically unsound agricultural policy and that food aid acted as a policy disincentive in Tanzania. This conclusion has important implications for the donor policy. Food aid must be seen as a part of the food system and its impacts analysed accordingly.

An interesting point of view, which has been barely touched in this study or anywhere else, is the donor policy, both the policy of donors towards Tanzania and the policy of the Tanzanian government towards donors. There is considerable literature of the changing paradigms in food aid (see for example Singer et al. 1987, Clay and Stokke 1991). The perception of the role of food aid has changed markedly. Tanzania has been in a particular position among food aid recipients because it has received food aid from very many different donors. Thus there has not been a dominant donor whose policy would have been decisive. On the contrary, Tanzania has utilised the situation with its many donors to thrive an active food aid policy. This merits further study.

This study was one attempt to clarify the question whether food aid acts as a disincentive for domestic grain production. A more comprehensive understanding of Tanzania’s particular food system could be gained by studying the regional level. Spatial dimension is important in the Tanzanian food system due to the special features of the country’s geography. This necessitates collection of data of marketed quantities of grain in different parts of the country. The incomplete market integration due to the lacking and deteriorating infrastructure is an important element in the Tanzanian food system and should be dedicated more research attention. It has been empirically studied by Bryceson (1993) and Amani et al. (1992). The institutional issues related to credit availability, as well as land ownership and control are also important elements in understanding the Tanzanian food production and marketing system.

Since the grain market liberalisation now covers almost all countries in the Sub-Saharan Africa, future studies should analyse the impact of food aid in a free market situation. Most countries have still retained some kind of strategic grain reserve arrangements. It is imperative to understand how food aid influences the grain production and markets and how it should be used not to disturb the markets. This study forms one contribution for increased understanding of the interactions between food aid and the food system.

Summary

This study analysed the economic impact of food aid on producer incentives both theoretically and empirically. The aim of the study was to assess the validity of the so-called disincentive effect of food aid on the agricultural production in developing countries. Disincentive effect was postulated by Schulz (1960) who argued that by decreasing market prices foreign food aid deteriorates domestic agricultural production. This leads to a long-term reduction of agricultural production in developing countries. For the evaluation of the disincentive effect, empirical data from Tanzanian agriculture was collected, and the theoretical models of agricultural production were developed reflecting the institutional circumstances in Tanzania.

The study started with a review of previous theoretical and empirical analyses of the disincentive effect. Previous economic research on the disincentive effect based on rigorous theoretical analysis was found to be rare as were the empirical applications based on economic theory. Therefore, a parametric market model for agricultural production with foreign food aid was formulated and analysed. The previous theoretical literature was discussed, interpreted and evaluated in the light of the qualitative results of the model.

The next step was to develop a model of agricultural production reflecting the institutional features of Tanzania. The time period under study was from 1971 to 1996. For most of the period under discussion, Tanzania had a grain market policy in which the government had a market monopoly. This had led to the development of an unofficial market, as the case usually is with market systems based on a state monopoly. A gradual market liberalisation was begun in 1986 and completed in 1991. A theoretical model was developed to describe the farmers' production decisions in both official and unofficial markets. The model presented adds also a new dimension to the past efforts of studying the disincentive effect by introducing the concept of risk into the model.

The farmers' supply behaviour in different markets was considered through a model consisting of the supply model of controlled markets with fixed prices and the supply model of unofficial markets with price risk. This illustrated the choices available for the peasant producers of Tanzania. In both models farmers choose the use of fertilizer and labour inputs so as to produce crops. Producing for the official market is by its nature deterministic, because the government announces the future price of the crop before the season. Comparative statics of input use in the deterministic model is conventional. When producing for the unofficial markets the farmers may get a higher price, but it is risky. Moreover, farmers have to carry the transportation costs of going into the markets. As for the ceteris paribus effects in the unofficial markets, higher

expected price increases production, while higher price risk, measured by its variance, as well as higher transportation costs decrease production.

Empirical estimations for the agricultural supply function based on the official market model showed rather good performance, and all the signs of the parameters of agricultural supply functions were as predicted by the theory. The open market model also performed quite well. The positive effect of the crop price on production confirms that peasants are price responsive. As predicted by the theory, higher wage reduces the use of labour in production. While both fertilizer prices and transport costs were significant, they were of the opposite sign as compared to the predictions of the model. The reasons can be found in the realities of the Tanzanian agricultural production system. There has been much less fertilizers available than farmers would have been willing to buy. This has meant that when the farmers wanted to increase their production and therefore demanded more inputs, the shortage of supply pushed the fertilizer prices up. The lack of transport capacity has also been a bottleneck for grain marketing.

Contrary to the theoretical model, the open market price variance and maize production correlated negatively. This was explained by the production system of Tanzania. An overwhelming majority of producers are subsistence oriented food insecure peasants. 70 per cent of staple grain production is used for home consumption, up to 80 per cent in years with the weather unfavourable to grain production. Malnutrition rates are very high, up to 60% of children under five years of age are undernourished. Food markets are not well integrated. There could be non-marketable over-production in the Southern Highlands, while the northern regions experienced lack. In practice the state monopoly grain marketing organisation, the National Milling Corporation, could secure food through the official marketing system only for its customary clients, institutions and urban people at the coast areas, complemented with some emergency aid. This led to a strategy where staple food production for household use gained priority and risk minimisation was the most rational behaviour.

After having analysed the supply functions empirically, the focus was shifted onto the analysis of the unofficial market equilibrium in order to trace out whether the disincentive effect of food aid can be found. The mere fact that the supply of the farmers was found to be empirically price responsive could indicate this. The econometric model of market equilibrium was based on the parametric market model in the presence of food aid, which was developed to describe the disincentive effect.

The market equilibrium model implies that price and quantity are determined simultaneously by the demand and supply augmented by the food aid. Consequently they cannot be analysed econometrically with the ordinary least square method. Therefore, a full information maximum likelihood (FIML) estimation procedure was used.

The empirical estimation of market equilibrium model showed that food aid did not have a statistically significant direct disincentive impact on staple production during the study period in Tanzania. The higher unofficial price was a positive signal for farmers to produce more. It was suggested that this was due to the structure of the Tanzanian food economy. In the two-tier market system the price effect dominates the disincentive effect. Food aid and commercial imports, as well as the domestic procurements by the government were used in the official markets. Prices in unfavourable years are higher in unofficial markets and a larger share of production is sold unofficially. The incompletely integrated markets accentuate the situation. Bad years and food aid are related to dry conditions in the Lake Victoria zone as demonstrated by the weather dummy. The more reliable yields of the Southern Highlands seldom reach the deficient northern areas and food aid and commercial imports also tend to remain at the coast and in Dar es Salaam.

Politically food aid was part of the government strategy to secure important groups, i.e., urban citizens especially in the capital, with low price staple food and to avoid any direct famine situation in any part of the country. The official marketing system developed into a great financial burden and never worked satisfactorily either from the consumers’ or the producers’ point of view. It would hardly have been possible to keep it up without considerable financial support in the form of food aid. After the market liberalisation the need for large quantities of food aid vanished. There are no indications that the nutritional status of the populations would be any worse, nor better for that matter, as a result of liberalised grain markets and low food aid levels. Thus it could be stated that food aid partly supported an unsuccessful and economically unsound agricultural policy and that food aid acted as a policy disincentive in Tanzania. This conclusion has important implications for the donor policy. Food aid must be seen as a part of the food system and its impacts analysed accordingly.

Tiivistelmä

Tutkimuksessa analysoitiin ohjelmaperusteisen elintarvikeavun taloudellisia vaikutuksia tuottajien kannustimiin sekä teoreettisesti että empiirisesti. Ohjelmaperusteinen elintarvikeapu toimitetaan vastaanottajamaan hallitukselle myytäväksi edelleen kotimaan markkinoilla. Tutkimuksen päämääränä oli arvioida ns. elintarvikeavun negatiivista kannustinvaikutusta maataloustuotantoon kehitysmaissa. Hypoteesin negatiivisesta kannustinvaikutuksesta, jonka mukaan laskemalla markkinahintoja elintarvikeapu vähentää kotimaista tuotantoa, esitti ensimmäisenä Schultz (1960). Hänen mukaansa elintarvikeapu johtaa pitemmällä tähtäyksellä elintarviketuotannon laskuun kehitysmaissa ja siten elintarvikeavun vaikutus on negatiivinen. Hypoteesin arvioimiseksi kerättiin empiiristä aineistoa Tansaniasta sekä muodostettiin teoreettinen malli, joka kuvasi Tansanian institutionaalisia olosuhteita.

Tutkielman aluksi arvioitiin aiempaa teoreettista ja empiiristä tutkimusta. Taloustieteelliseen teoriaan perustuvia aikaisempia teoreettisia ja empiirisiä tutkimuksia on varsin vähän. Sen vuoksi maataloustuotannosta tehtiin ja analysoitiin parametrinen markkinamalli, jossa oli mukana myöskin elintarvikeapu. Aikaisempaa teoreettista tutkimusta esiteltiin, tulkittiin ja arvioitiin mallin laadullisten tulosten pohjalta.

Seuraavaksi tutkimuksessa kehitettiin maataloustuotannon teoreettinen malli, joka heijastaa Tansanian institutionaalisia piirteitä. Tutkimuksen ajanjakso oli vuodesta 1971 vuoteen 1996. Tansaniassa oli lähes koko tutkimusjakson ajan vallalla maatalouspolitiikka, joka perustui hallituksen markkinointimonopoliin. Asteittainen markkinoiden vapauttaminen alkoi 1986 ja saatiin päätökseen 1991. Mallissa kuvataan viljelijöiden tuotantopäätöstä sekä virallisilla että epävirallisilla markkinoilla. Jälkimmäinen malli tuo myös uuden näkökohdan aikaisempiin tutkimuksiin liittämällä malliin hintariskin.

Viljelijöiden tarjontakäyttäytymistä eri markkinoilla tarkasteltiin mallintamalla erikseen viralliset markkinat, joissa on kiinteät hinnat sekä epäviralliset markkinat, joissa on hintariski. Tämä kuvastaa tansanialaisten viljelijöiden valinnan mahdollisuuksia. Molemmissa malleissa viljelijät käyttävät tuotantopanoksina työtä ja lannoitteita. Maan määrä on oletettu vakioksi. Virallisille markkinoille tuottaminen on luonteeltaan determinististä, koska hallitus julkistaa hinnat ennen viljelykauden alkua. Tuotantopanosten komparatiivinen statiikka oli konventionaalinen. Tuottaessaan epävirallisille markkinoille viljelijät voivat saada korkeamman hinnan, mutta joutuvat ottamaan riskin. Lisäksi viljelijät joutuvat kattamaan kuljetuskustannukset viljan

viennistä markkinoille. Epävirallisilla markkinoilla korkeampi hintaodotus lisää tuotantoa kun taas varianssilla mitattava suurempi hintaepävarmuus samoin kuin korkeammat kuljetuskustannukset vähentävät tuotantoa.

Virallisten markkinoiden tarjontamallin empiiriset estimoinnit osoittavat mallin toimivan varsin hyvin ja kaikkien muuttujien merkit olivat teorian ennakoimat. Myöskin epävirallisten, vapaiden markkinoiden malli toimi hyvin. Positiivinen hintavaikutus vahvistaa viljelijöiden reagoivan hintojen muutoksiin. Kuten teoria ennustaa, korkeampi palkkataso vähentää työvoiman käyttöä tuotannossa. Sekä lannoitteiden hinnat että kuljetuskustannukset olivat tilastollisesti merkittäviä mutta vaikutus oli päinvastainen kuin teorian pohjalta olisi olettanut. Selitys löytyy Tansanian erityisistä tuotanto-olosuhteista. Lannoitteiden kysyntä on ollut suurempaa kuin saatavilla olleiden lannoitteiden määrä. Maanviljelijöiden halutessa kasvattaa tuotantoaan, on lannoitteiden tarjontaa suurempi kysyntä johtanut hintojen nousuun. Kuljetuskaluston puute on myöskin toiminut viljan markkinoinnin pullonkaulana.

Vastoin teoreettista mallia maissin epävirallisten markkinoiden hinta sekä maissin tuotannon määrä korreloivat negatiivisesti. Tämä selittyy tansanialaisen tuotantojärjestelmän ominaisuuksilla. Suurin osa tuottajista on kotitarveviljelyyn suuntautuneita pienviljelijöitä, joiden kotitalouksien ruokaturva on heikko. Noin 70% perusviljan tuotannosta menee kotitalouksien omaan käyttöön, epäedullisina tuotantovuosina luku on 80%. Aliravitsemus on erittäin yleistä, noin 60% alle viisivuotiaista on aliravittuja. Viljamarkkinat eivät ole tyydyttävästi integroituneita. On tapauksia, jolloin Eteläisellä Ylänköalueella (Southern Highlands) on esiintynyt ylituotantoa, tuottajat eivät ole saaneet tuotteitaan myydyksi ja samaan aikaan maan pohjoisosissa on ollut pulaa viljasta. Käytännössä valtiollinen viljamonopoli, National Milling Corporation, pystyi tarjoamaan viljaa virallisella hinnalla vain tietyille avainryhmille, julkisille laitoksille ja rannikkoseutujen kaupunkilaisille sekä jonkin verran hätäapua. Tämä johti siihen, että sisämaassa, jossa ei ollut varmuutta viljan saatavuudesta ja hinnasta, kotitalouksien kotitarvetuotantoa priorisoitiin ja riskien minimointi oli rationaalisin toimintatapa.

Kun tarjontafunktio oli analysoitu empiirisesti ryhdyttiin analysoimaan epävirallisten markkinoiden markkinatasapainoa, tarkoituksena selvittää mahdollisen negatiivisen kannustinvaikutuksen olemassaolo. Tutkimuksessa kehitettiin kannustinvaikutuksen tutkimiseksi ekonometrinen markkinatasapainomalli perustuen parametriseen markkinamalliin, jossa oli elintarvikeapu mukana.

Markkinatasapainomallissa viljan hinta ja sen tuotannon määrä määrittyy samanaikaisesti kysyntään ja ruoka-avulla lisätyn tarjonnan perusteella. Siten niitä ei voida analysoida ekonometrisesti tavanomaisella pienimmän neliösumman menetelmällä. Sen vuoksi malli estimoitiin täyden informaation suurimman uskottavuuden menetelmällä.

Markkinatasopainomallin empiirinen estimointi osoitti, ettei elintarvikeavulla ollut tilastollisesti merkittävää negatiivista vaikutusta maissin tuotantoon tutkittavana ajankohtana. Korkeampi epävirallinen hinta oli viljelijöille kannuste tuottaa lisää. Tämän arvioitiin johtuvan Tansanian maatalouden tuotantorakenteesta. Kaksien markkinoiden järjestelmässä hintavaikutus on vahvempi kuin kielteinen kannustinvaikutus. Elintarvikeapu sekä kaupallinen tuonti samoin kuin kotimaasta tehdyt julkiset ostot käytettiin sen varmistamiseen, että valtion viljamonopoli pystyi tarjoamaan riittävästi viljaa avainryhmille. Epäedullisina vuosina hinnat kohosivat epävirallisilla markkinoilla ja suurempi osuus tuotannosta myytiin niillä. Epätäydellisesti integroituneet markkinat kärjistivät tilannetta. Tuotannollisesti heikot vuodet ja elintarvikeapu liittyvät Tansanian pohjoisten osien kuivuuteen kuten säätilastot osoittavat. Eteläisten ylänköalueiden luotettavammat sadot yltävät harvoin alituotantoalueille pohjoiseen, ja elintarvikeapu samoin kuin kaupallinen tuonti jää yleensä rannikolle ja Dar es Salaamiin.

Poliittisesti elintarvikeapu oli osa hallituksen strategiaa turvata poliittisesti tärkeille ryhmille, erityisesti pääkaupunkilaisille, halpaa perusruokaa sekä estää nälänhätä tilanteiden syntyminen maan jossakin osassa. Virallinen markkinointijärjestelmä kehittyi valtiontaloudelle suureksi taakaksi. Se ei myöskään koskaan toiminut kuluttajien eikä myöskään tuottajien kannalta tyydyttävästi. Järjestelmää olisi tuskin voitu ylläpitää ilman huomattavaa taloudellista tukea ulkomailta elintarvikeavun muodossa. Markkinoiden vapauttamisen jälkeen tarve suuriin ruoka-apu määriin katosi. Ei ole olemassa merkkejä siitä, että väestön ravitsemuksellinen tila olisi huonontunut, ei tosin myöskään parantunut, markkinoiden vapautumisen ja siihen liittyvän elintarvikeavun vähenemisen myötä. Siten voidaan todeta, että elintarvikeapu mahdollisti osaltaan epäonnistuneen ja taloudellisesti epäterveen maatalouspolitiikan harjoittamisen niinkin kauan kuin Tansaniassa tapahtui. Tällä johtopäätöksellä on merkittäviä seuraamuksia elintarvikeavun antajamaiden kannalta. Elintarvikeapu täytyy nähdä osana kansallista ruokajärjestelmää ja sen vaikutukset täytyy analysoida tästä lähtökohdasta poliittisen päätöksenteon pohjaksi.

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Appendix 1. Technical details with substitution and complement case

A. Production for the controlled grain markets

The effect of **an increase in the price of the final product**, food grain, on the input levels

$\pi_{lp} = f_l$

$\pi_{kp} = f_k$

a) k, the external input use

$$\frac{\partial k}{\partial p} = \Delta^{-1} \begin{vmatrix} \pi_{ll} & -f_l \\ \pi_{kl} & -f_k \end{vmatrix} = \Delta^{-1} \{\pi_{ll}(-f_k) - \pi_{lk}(-f_l)\} > 0$$

Thus, the increase in grain price increases the external input use.

b) l, the use of labour

$$\frac{\partial l}{\partial p} = \Delta^{-1} \begin{vmatrix} -f_l & \pi_{lk} \\ -f_k & \pi_{kk} \end{vmatrix} = \Delta^{-1} \{-f_l \pi_{kk} - (-f_k)\pi_{lk}\} > 0$$

Thus, the increase in grain price increases the labour use.

The effect of **an increase in the price of labour** on the use of external inputs and labour

$\pi_{lw} = -1$

$\pi_{kw} = 0$

a) the impact on k, the use of external inputs in the substitution case

$$\frac{\partial k}{\partial w} = \Delta^{-1} \begin{vmatrix} \pi_{ll} & 1 \\ \pi_{lk} & 0 \end{vmatrix} = \Delta^{-1} \{-\pi_{lk}\} > 0$$

Interpretation: The increase in labour price increases the use of external inputs.

b) the impact on k, the use of external inputs in the complement case

$$\frac{\partial k}{\partial w} = \Delta^{-1}\begin{vmatrix}\pi_{ll} & 1 \\ \pi_{lk} & 0\end{vmatrix} = \Delta^{-1}\{-\pi_{lk}\} < 0$$

Interpretation: The increase in labour price decreases the use of external inputs.

c) the impact on l on the labour use

$$\frac{\partial l}{\partial w} = \Delta^{-1}\begin{vmatrix}1 & \pi_{kl} \\ 0 & \pi_{kk}\end{vmatrix} = \Delta^{-1}\{\pi_{kk}\} < 0$$

Interpretation: The increase in the price of labour decreases the use of labour.

The effect of **increase in the external input costs** on the use of external inputs and labour

$\pi_{lr} = 0$

$\pi_{kr} = -1$

a) the impact on k

$$\frac{\partial k}{\partial r} = \Delta^{-1}\begin{vmatrix}\pi_{ll} & 0 \\ \pi_{lk} & 1\end{vmatrix} = \Delta^{-1}\{\pi_{ll}\} < 0$$

Interpretation: when external input costs increase, the use of external inputs decreases.

b) the impact on l in the substitution case

$$\frac{\partial l}{\partial r} = \Delta^{-1}\begin{vmatrix}0 & \pi_{kl} \\ 1 & \pi_{kk}\end{vmatrix} = \Delta^{-1}\{\pi_{kl}\} > 0$$

Interpretation: when external input costs increase, the use of labour increases.

c) the impact on l in the complement case

$$\frac{\partial l}{\partial r} = \Delta^{-1} \begin{vmatrix} 0 & \pi_{kl} \\ 1 & \pi_{kk} \end{vmatrix} = \Delta^{-1} \{ \pi_{kl} \} < 0$$

Interpretation: when external input costs increase, the use of labour decreases.

Thus the qualitative effects can be expressed as $Q = Q(\underset{+}{p}, \underset{-}{r}, \underset{-}{w})$

B. Production for the unofficial grain markets

The effect of **an increase in the price of the final product**, food grain, on the input levels

$$R_{lp} = f_l$$
$$R_{kp} = f_k$$

a) the impact on k, external input use

$$\frac{\partial k}{\partial p} = \Delta^{-1} \begin{vmatrix} R_{ll} & -f_l \\ R_{lk} & -f_k \end{vmatrix} = \Delta^{-1} \{ R_{ll}(-f_k) - R_{lk}(-f_l) \} > 0$$

Interpretation: the increase in the expected grain price increases the external input use.

b) the impact on l, labour use

$$\frac{\partial l}{\partial p} = \Delta^{-1} \begin{vmatrix} -f_l & R_{lk} \\ -f_k & R_{kk} \end{vmatrix} = \Delta^{-1} \{ -f_l R_{kk} - (-f_k) R_{lk} \} > 0$$

Interpretation: the increase in the expected grain price increases the labour use.

The effect of **an increasing price variance** σ_p^2, and thus an increasing risk on the use of inputs

$$R_{l\sigma_p^2} = -AQ^2 f_l$$
$$R_{k\sigma_p^2} = -AQ^2 f_k$$

a) the impact on k

$$\frac{\partial k}{\partial \sigma_p^2} = \Delta^{-1} \begin{vmatrix} R_{ll} & AQ^2 f_l \\ R_{lk} & AQ^2 f_k \end{vmatrix} = \Delta^{-1} AQ^2 (f_k R_{ll} - f_l R_{lk}) < 0$$

Interpretation: increases in risk decrease the external input use.

b) the impact on l

$$\frac{\partial l}{\partial \sigma_p^2} = \Delta^{-1} \begin{vmatrix} AQ^2 f_l & R_{lk} \\ AQ^2 f_k & R_{kk} \end{vmatrix} = \Delta^{-1} AQ^2 (f_l R_{kk} - f_k R_{lk} \} < 0$$

Interpretation: increases in price variability decrease the labour use.

The effect of an **increasing labour price** on the use of inputs:

$$R_{lw} = -1$$
$$R_{kw} = 0$$

a) the impact on k, the external input use in the substitution case

$$\frac{\partial k}{\partial w} = \Delta^{-1} \begin{vmatrix} R_{ll} & 1 \\ R_{lk} & 0 \end{vmatrix} = \Delta^{-1} \{-R_{lk}\} > 0$$

Interpretation: When the price of labour increases the use of external inputs increases.

b) the impact on k, the external input use in the complement case

$$\frac{\partial k}{\partial w} = \Delta^{-1} \begin{vmatrix} R_{ll} & 1 \\ R_{lk} & 0 \end{vmatrix} = \Delta^{-1} \{-R_{lk}\} < 0$$

Interpretation: When the price of labour increases the use of external inputs decreases.

c) the impact on l, the labour use

$$\frac{\partial l}{\partial w} = \Delta^{-1}\begin{vmatrix} 1 & R_{lk} \\ 0 & R_{kk} \end{vmatrix} = \Delta^{-1}\{R_{kk}\} < 0$$

Interpretation: increase in labour price decreases the use of labour.

The effect of **increasing external input costs** on the use of labour and external inputs:

$$R_{lr} = 0$$
$$R_{kr} = -1$$

a) the impact on k

$$\frac{\partial k}{\partial r} = \Delta^{-1}\begin{vmatrix} R_{ll} & 0 \\ R_{lk} & 1 \end{vmatrix} = \Delta^{-1}\{R_{ll}\} < 0$$

Interpretation: the increase in external input costs decreases their use.

b) the impact on l in the substitution case

$$\frac{\partial l}{\partial r} = \Delta^{-1}\begin{vmatrix} 0 & R_{lk} \\ 1 & R_{kk} \end{vmatrix} = \Delta^{-1}\{-R_{lk}\} > 0$$

Interpretation: increases in the external input costs increases the use of labour.

c) the impact on l in the complement case

$$\frac{\partial l}{\partial r} = \Delta^{-1}\begin{vmatrix} 0 & R_{lk} \\ 1 & R_{kk} \end{vmatrix} = \Delta^{-1}\{-R_{lk}\} < 0$$

Interpretation: increases in the external input costs decreases the use of labour.

The effect of **increasing transport costs** on the use of labour and external inputs:

$$R_{lc} = -f_l$$
$$R_{kc} = -f_k$$

a) the impact on k

$$\frac{\partial k}{\partial c} = \Delta^{-1} \begin{vmatrix} R_{ll} & f_l \\ R_{lk} & f_k \end{vmatrix} = \Delta^{-1} \{ R_{ll} f_k - R_{lk} f_l \} < 0$$

Interpretation: increasing transport costs decrease the use of external inputs.

b) the impact on l

$$\frac{\partial k}{\partial c} = \Delta^{-1} \begin{vmatrix} -f_l & R_{lk} \\ -f_k & R_{kk} \end{vmatrix} = \Delta^{-1} \{ -f_l R_{kk} + f_k R_{lk} \} < 0$$

Interpretation: increasing transport costs decrease the use of labour.

The effect of **increasing risk aversion** on the use of labour and external inputs:

$$R_{lA} = -\sigma_p^2 f(k,l) f_l$$

$$R_{kA} = -\sigma_p^2 f(k,l) f_k$$

a) the impact on k

$$\frac{\partial k}{\partial A} = \Delta^{-1} \begin{vmatrix} R_{ll} & \sigma_p^2 f(k,l) f_l \\ R_{lk} & \sigma_p^2 f(k,l) f_k \end{vmatrix} = \Delta^{-1} \sigma_p^2 f(k,l) \{ R_{ll} f_k - R_{lk} f_l \} < 0$$

b) the impact on l

$$\frac{\partial l}{\partial A} = \Delta^{-1} \begin{vmatrix} -\sigma_p^2 f(k,l) f_l & R_{lk} \\ -\sigma_p^2 f(k,l) f_k & R_{kk} \end{vmatrix} = \Delta^{-1} \sigma_p^2 f(k,l \{ -f_l R_{kk} + f_k R_{lk} \} < 0$$

Interpretation: higher risk aversion decreases both input use and production.

The qualitative effects can be summarised as follows

$$Q = (\underset{+}{p}, \underset{-}{c}, \underset{-}{w}, \underset{-}{r}, \underset{-}{\sigma_p^2}, \underset{-}{A})$$

Appendix 2. Tanzania: National consumer price index 1970-1996

(1977 Dec.=100)

Year	NCPI
1970	42,2
1971	44,1
1972	47,9
1973	52,8
1974	63,2
1975	79,6
1976	85,1
1977	95,1
1978	106,6
1979	120,4
1980	156,7
1981	196,9
1982	253,9
1983	322,6
1984	493,2
1985	585,3
1986	775,2
1987	1007
1988	1322
1989	1663
1990	1991
1991	2435
1992	2972,2
1993	3669,7
1994	4777,9
1995	6401,7
1996	*7387.6

Sources: World Bank.1994. Tanzania. Agricultural Sector Memorandum. Volume III: Statistical Annex. Report No.12294-TA.

*estimated from Dar es Salaam Consumer Price Index Business Times, December 13-19,1996.

Appendix 3. Rainfall statistics and weather dummies experimented with in the empirical model.

Year	Annual mean rainfall in Tanzania (mm)	Weather dummy 1 -10% of the average=0	Weather dummy 2 -15% of the average=0	Annual mean rainfall in Mwanza	Weather dummy 3 -10% of the average=0	Weather dummy 4 -15% of the average=0
1970/71	1070.9	1	1	773.8	0	0
1971/72	1106.9	1	1	828.3	0	0
1972/73	1217.9	1	1	1036.3	1	1
1973/74	1053.1	1	1	1227.0	1	1
1974/75	956.3	0	0	1028.5	1	1
1975/76	1077.9	1	1	1068.0	1	1
1976/77	997.6	1	0	1274.8	1	1
1977/78	1362.1	1	1	1117.8	1	1
1978/79	1513.3	1	1	1029.8	1	1
1979/80	995.3	1	0	890.3	0	0
1980/81	1059.8	1	1	1156.0	1	1
1981/82	1046.9	1	1	867.0	0	0
1982/83	1191.4	1	1	951.4	0	1
1983/84	1018.3	1	0	782.2	0	0
1984/85	1197.9	1	1	1008.3	1	1
1985/86	1177.4	1	1	777.7	0	0
1986/87	1171.4	1	1	1241.2	1	1
1987/88	950.7	0	0	1449.4	1	1
1988/89	1082.9	1	1	1077.5	1	1
1989/90	1181.1	1	1	1527.6	1	1
1990/91	1086.9	1	1	1146.5	1	1
1991/92	1045.9	1	1	898.9	0	0
1992/93	1044.4	1	0	1055.7	1	1
Average	1100.4			1076.7*		

* An average of yearly rainfall in Mwanza between 1951/52 and 1992/93.

Source: Bureau of Statistics. 1995. Selected Statistical Series:1951-1993. President's Office - Planning Commission. Dar es Salaam.