A Supply Model of Reduced Type for Marketing of Agricultural Crops in Tanzania

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Abstract

This article focuses on marketing of agricultural crops in Tanzania, with a particular emphasis on maize. The study concentrates on Arusha and Rukwa Regions, and data for production, prices, and transport costs are related to the year 1989/90, representing the situation before the deregulation of the marketing system came into effect. A linear programming model has been constructed, describing possible patterns of transport and storage for marketing the crops. Surplus and deficit production areas within and outside the regions have been defined, and quantities to be delivered to different markets have been estimated. The model is basically a supply model for the marketing system, considering purchase and sales prices as exogenous variables.

Two model variants have been introduced: (1) A contribution margin model, which is a relevant reduced supply model under a market-oriented system. This model is maximising the contribution margin of the transporters. (2) A model for maximising marketed quantities, assuming that the *total* contribution margin of the transporters should be non-negative. The latter model is relevant in the case of a single parastatal marketing agent, being supposed to subsidise among areas and crops.

The article discusses the short and long-term effects of a gradual transition to a market-oriented system. The main conclusion is that, in a medium and long-term perspective, dramatic changes in the geographical pattern of production may take place unless regional and sector-oriented policies are introduced to counteract such a development.

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1. Introduction

Over the last years, Tanzania has experienced a period of transition from a governmental-controlled to a market-oriented economy. This change of policy also affects the agricultural sector, regarding production, transport and marketing of crops, and supply of inputs. In a medium and long-term perspective, this policy change may have dramatic effects on the geographical pattern of production. The results of the present study give an illustration of such possible consequences.

Analyses of the kind presented in this article are of major importance, not only as an academic exercise, but as a tool for providing basic background material relevant for policy discussions on vital development issues in Tanzania. Broadly speaking, these issues concern the future pattern of regional growth and development, the geographical pattern of production of different crops, and the competitive strength of different regions and districts if changes are made in the transport infrastructure. Such analyses also constitute a vital element for evaluating the effects on the national economy, as well as food security, arising from the introduction of alternative subsidy regimes.

The data used in the present study refer to the year 1989/90. This period has been deliberately chosen to characterise the situation before the deregulation of the marketing system. In particular, two issues will be investigated and discussed in this article. First, the intention is to illustrate short and long-term effects on agricultural production, and, in particular, on production of maize, when changing from a governmental-controlled to a liberalised market system. Secondly, the scope of the article is to quantify and analyse cross-subsidy effects, under the condition that one parastatal is operating as marketing agent, being solely responsible for collecting, transporting, storing, and marketing agricultural produce.

Since 1988/89, maize production in the country has been declining at an average rate of -10 per cent per annum (URT, 1996). This raises some concerns about food self-sufficiency in the medium term (1996/97-2000/01). The government has realised that the abolition of pan-territorial pricing system and the fertilizer subsidies has weakened the relative competitive position of the far-off from the centre, but potentially productive, regions like Rukwa due to the high transport costs of both fertilizers and maize. As such, other regions which receive less rainfall (Dodoma, Morogoro, Singida, etc.) have taken over part of the supply of maize to Dar es Salaam.

When treating both the above issues, a supply model of reduced type is applied, according to which storage and transport are performed in the most efficient way. In the case of a liberalised market system, a contribution margin model—maximising the contribution margin of the marketing agents—is applied. When assuming that the marketing functions are executed by a parastatal operator, a model—maximising marketed volumes—is introduced; the maximising procedure being subject to the restriction that total contribution margin should be non-negative. A more thorough description of these models is given in the next section, and the mathematical description is presented in Annex 1.

The present analysis does not aim to cover the whole vertical chain in the production and marketing process. Production and consumption are regarded as exogenous to the basic model. On the one hand, the marketing system provides important incentives to the producer as to what to produce, and supply to the marketing system. On the other hand, final demand depends on what the marketing agents bring to the market, at what time, and at what price. These considerations lie outside the present model. The model is a supply model for the marketing system with given available input at the farming end. On the demand side, observed prices, along with restrictions on marketed quantities in different markets and in different periods, are inputs to the model.

In Section 3, the price and cost assumptions are presented and discussed. For practical reasons, the analyses are restricted to deal with Arusha and Rukwa, two important maize producing regions. The choice of Rukwa is based on the fact that it is a typical food surplus producing region. At the same time, the region is beset with serious transportation problems. Arusha region is important for cash as well as food crop production. Compared to Rukwa, its districts are relatively more accessible. For comprehensive analysis, the emphasis is on maize. Maize is a produce which is used as a basic, daily foodstuff in many regions in Tanzania, and the product is essential as a food security commodity. Consequently, the development of total production and regional distribution of this production are of significant national interest.

In Section 4, the results of the calculations are presented and interpreted, and some policy implications are discussed in Section 5.

2. Model Description and Assumptions

The models applied in this study are supply models of a reduced type, focusing on the storage and transportation problem. As mentioned above, the models are basically of two kinds: a contribution margin model, maximising the contribution margin of the transporters; and a model for maximising marketed quantities, assuming that the contribution margin of the transporters should be non-negative.

The models describe the pattern of transport routes and storage facilities from primary societies to the final markets, if necessary, via branch offices and headquarters, as shown in Figure 1. The nodes in this figure represent storage and market points. The year is divided into three periods, July to November (5 months), December to March (4 months), and April to June (3 months), reflecting variations in the conditions of roads and transport over the year. Whereas harvesting takes place in the first period, demand and consumption are more or less evenly distributed throughout the year.

The transport cost varies considerably from area to area, and from season to season, due to road conditions and rainfall patterns. Generally, the roads are best in the first period, and at worst—some not even passable—during the long rain (third) period. As such, for a given route, transport costs are at the lowest during the first period. Consumer prices, however, tend to increase over the periods, among others, as a reflection of increased costs related to storage and—not the least—loss of produce throughout the year. Food supplies also tend to diminish in the last period, just before the next planting season.

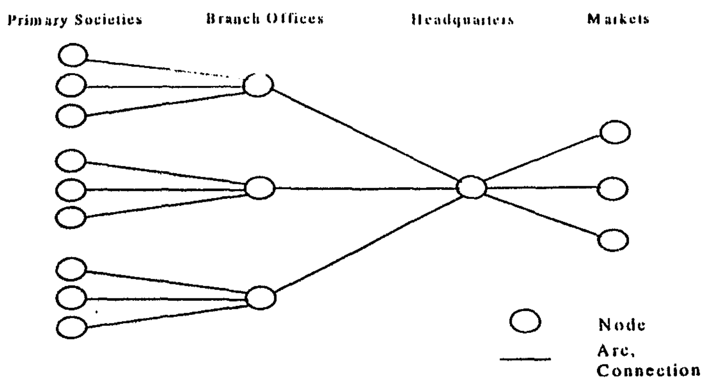

Fig. 1: Transportation and storage network

For each of the two producing regions, internal (as to region) and external markets are defined for areas supposed to have a deficit production of maize. Some areas may have a production sufficient to cover demand for some part of the year (particularly the first period), whereas other areas may need to 'import' maize in all periods.

For the marketing agents, the basic question is thus to identify which quantities of produce to collect from which area given the transport and storage possibilities, and given the demand characteristics of each final market in each period.

In a market-oriented system, a reasonable assumption is that the objective of the marketing agents is to maximise the contribution margin, defined here as the margin obtained when cost of purchase, transport, and storage is deducted from gross income. In the basic computation, sales prices are set equal to the observed prices in each period in the year of analysis. Given these prices, upper limits are assumed for the quantities allowed to be delivered to each specific market in each period. The determination of prices in each market in each period is a result of a complicated interaction between supply and demand, where differences in disposable income characteristics, variations as to availability of substitutes, differences in consumption habits, etc., may influence the price level in each market area (Stevens and Jabara 1988). To obtain data for estimating parameters in such kind of relationships is outside the scope of this analysis. In the context of a linear programming model, which is applied here, we restrict ourselves to specify certain sales prices (observed prices) and upper limits for quantities delivered given these prices. The limits are thus estimated taking into account the size of population and the extent of self-sufficiency of the crop in question.

When calculating maximum contribution margin for the marketing agents at observed sales prices in each market, the consequence is that production areas, contributing to a positive margin, are serviced. As a result, the marginal area to be included has a positive margin close to zero, whereas the other included areas have positive margins of different magnitude. Here, it is assumed that the overall contribution margin covers administrative and other overhead costs not taken into account in the contribution margin concept. Such a behaviour would be typical in a competitive environment where several private agents are allowed to operate.

If there was only one benevolent marketing agent, restricted by regulations to operate at a total profit margin close to zero, and given that this marketing agent faced the same observed prices as discussed above, a cross-subsidy mechanism would be in function. In such a case, more produce would be collected, transported, and marketed, implying that deliveries from areas rendering a positive profit margin are subsidising deliveries from areas achieving a negative profit margin.

The cross-subsidy mechanism will not only affect markets and production areas, but also products: crops yielding a high contribution margin would be subsidising crops rendering a negative contribution margin. For performing these calculations, the model is reformulated into a model maximising marketed produce subject to the restriction that the total profit margin should be non-negative. When calculating areas to be included for deliveries in the case of a non profit operating organisation, all overhead costs should also be accounted for. Since we do not have estimates for these cost components, they have not been taken into account in the calculations.

The models are formulated as linear programming models. It is assumed that the marketing agents are collecting, transporting and marketing the crops throughout the three periods, according to given assumptions concerning purchase prices and the development of demand and sales prices in each market; and under the assumption that the objective of the marketing agents is to maximise the contribution margin in the case of a liberalised market system, and to maximise marketed volume in the case of a single parastatal operator.

If the marketing agents operate under free competition, assuming free and easy entry to this line of business, and if purchase prices are not fixed, it is likely that competition in the most profitable markets would tend to increase the purchase prices in areas delivering products to these markets, thus reducing the contribution margin. In markets being unprofitable, when applying the contribution margin model, the sales prices would probably have been higher than the observed ones, if free competition had been in function; and the purchase prices would have been lower than the prevailing prices in a competitive market context. However, in the present analysis, purchase and sales prices are regarded fixed and equal to the observed ones. Possible effects on purchase and sales prices, and on production patterns in a market-oriented system will be discussed further in Section 4.

Through a reformulation of the model it is also possible to compute a pan-territorial consumer price high enough to market all produce available, given that the transporting agent is a monopoly restricted to operate on a close to zero-profit basis. Such analyses fall outside the scope of this study.

3. Data Assumptions, Prices and Cost Estimates

3.1. Marketable Surpluses

The most comprehensive data available were for the 1988/89 and 1989/90 crop seasons. At this time, the cooperative unions and their societies were heavily engaged in the procurement of crops and delivery of inputs to the farmers. Hence, most of the data is from official statistics recorded by the unions and societies in the respective regions.

Farmers' sales to the primary societies are assumed to be the marketable surpluses. Sales which entered the private channel have not been captured since these data are not avaiable.

3.2. Distances and Travelling Time

For the three time periods, data were collected concerning distances from the primary societies to the branches (districts) and the headquarters of the cooperative unions. Information on the average time (hours) a 7-tonne lorry would need to travel the various distances (connections) in the three time periods were also collected.

3.3. Storage Capacity

The present study takes into account storage capacity at society, branch, and headquarters level. Normally, goods would be transported from society to branch level, and finally to headquarter level, particularly for deliveries outside the region. The storage capacity in Arusha was lower than required, and not optimally distributed among storage points. In Rukwa, storage capacity was in most cases sufficient, although the quality of the storage facilities was not always up to standard.

3.4. Prices

In the basic contribution margin model, observed sales prices in different markets are treated as input to the calculations. In the year 1989/90, these were the observed market prices in each market area. Likewise, observed purchase prices in different producer areas are used as model input. The sales and purchase prices were collected by the Marketing Development Bureau (MDB) on a weekly basis, which were then averaged into monthly and periodical prices. These were treated as nominal prices in the model.

Regarding maize, the price assumptions are shown in Table 1.

Table 1:Purchase prices for maize (Tshs per kg). 1989/90.

Purchase price	*Tsh per kg*	
	Arusha	Rukwa
	11.32	11.00

Source: Ministry of Agriculture, Livestock and Cooperatives (MRT). 1991. Marketing Development Bureau (MDB)

3.5. Cost estimates

3.5.1. Transportation costs

The cost structure of the activities of the marketing agent includes a description of the costs of collecting, transporting, storing, and marketing the produce in question, from the producer collection points (primary societies) to the various consumer markets. The essential parameters in this cost structure are estimated as explained below.

The costs of transportation are dependent on several variables taking the following into consideration: average size of lorry, average obtainable speed according to road conditions and season, depreciation rate and capital cost, cost of fuel and other variable inputs, maintenance costs, etc. The calculations are based on the assumption that the transport fleet is composed of seven-tonne lorries, which is a typical vehicle size in Tanzania for rural transport. According to estimates done by the National Transport Corporation, average mileage for a seven-tonne lorry is about 36,000km per year, whereas the Regional Transport Company (RETCO) recorded an average of 34,500 km per year for the company's fleet. Accepting the last figure to be reasonably correct, and estimating the average speed for all the distances covered to be 30 kilometres per hour, 1,150 hours would be the effective driving time per year.

The cost function is of the following structure:

$$\beta_{it} = \eta T_{it} + \kappa D_i$$

where

β_{it} = weighted total transport cost per tonne for connection i in period t
η = cost of transport, time component (Tshs/tonne-hour)
T_{it} = transport time for connection i in period t
κ = cost of transport, distance component (Tshs/tonne-kilometer)
D_i = distance of connection i (km)

When describing the transport costs, we have introduced a time component, and a distance component. It seems reasonable to assume that most of the above mentioned variable inputs, like fuels, lubricants, tyres, etc., are more closely related to distance travelled than to time used. Also maintenance is likely to fall into this category. It may be argued that cost components like fuel consumption, maintenance, etc., are not related to distance only, but also to the conditions of the roads. These costs may thus be under-estimated for the worst roads. Consequently, we estimate two main cost parameters, the results of which are shown in Table 2.

Table 2: Cost per tonne-hour
Average for all roads. Tshs. 1989/90

Cost parameter	*Unit*	*Tshs*
n	per tonne-hour	303
k	per tonne-km	9

Source: Rift Valley Corporation, Arusha.

For calculation purposes, we want to apply cost estimates for a transport fleet which is used efficiently. Our (average) estimates are thus based on a sample of the five most effectively used lorries belonging to Rift Valley Corporation in Arusha Region.

In Table 3, transport costs are calculated for three different road standards of the same length (100 km). Road standard is defined by estimated obtainable average speed. Transport costs per tonne-km are computed for the three cases to allow a comparison with actual freight rates. For each connection throughout the transportation network, transport time (hours and fraction of hours) is estimated for each season.

Table 3: Calculated transport costs according to estimated coefficients

100 km route, D_i = 100	Road condition	TSB per tonne-km, b_{it}/D_i
- 50 km/h average speed, T_{it} =2	Good	15.06
- 30 km/h average speed, T_{it}=3.33	Average	19.10
- 20 km/h average speed, T_{it}=5	Bad	24.15

Source: Rift Valley Corporation, Arusha

3.5.2. Storage costs

Another cost component is related to storage. This component can further be divided into two parts: normal inventory costs related to the use of storage facilities, and cost of invested working capital per tonne; and costs related to losses of produce caused by deterioration of quality, pilferages etc. The normal inventory costs are assumed to be proportional to the tonnage stored, and is estimated to be about TSB 500 per tonne per month; whereas losses are assumed to be of the magnitude of 4% of total stored tonnage from period 1 to period 2, and 10% from period 2 to period 3.

The assumption that normal inventory costs are proportional to the tonnage stored with a fixed cost per tonne for all crops is a simplification implying that:

1. Cost of capital invested in the crops stored is not fully appreciated.
2. The fact that various crops may have different specific weight is not accounted for.
3. Moreover, storage costs related to storage capacity involve some economies of scale, which we have not taken into account.
4. Finally, percentage loss of crops, due to deterioration of quality, may vary from crop to crop.

The calculation results in section 4 should be interpreted in view of the these simplified assumptions.

4. Analysis and Interpretation of Results

4.1. Calculation Results for Arusha Region

4.4.1. A Competitive Market Regime

In Arusha Region, total production of marketable maize amounts to 51,426 tonnes. In terms of tonnes, the next largest crop is peas, accounting for 4,895 tonnes, and the third largest is coffee, totalling 4,705 tonnes. For Mbulu, Babati, Hanang, Arumeru, and Kiteto districts, the markets for food crops are regarded to be rather negligible. For maize, a small market is assumed in Arumeru, Mtowambu, and Monduli. Arusha town, however, represents a substantial deficit area for food crops, and also for maize production. Given the observed prices, the upper limit for delivered quantities is set at 1000 tonnes per month throughout the year for Arusha town. Namanga, located at the Kenyan border, is supposed to represent a possible export market to Kenya. For this market the upper limit is set to 500 tonnes per month.

Table 4 shows the percentage of total produce of maize from different districts which can be marketed, rendering a positive contribution margin at observed prices. Hanang, Babati, Mbulu—and particularly Hanang—are problem areas in terms of obtaining production viable for commercial markets outside the districts. And these are the districts which in 1989/90 had a large surplus production.

Table 4: Percentage of maize available at the buying posts which may be marketed with a positive contribution margin

District (Source)	*Surplus produced (tonne)*	*Percentage marketed*
Mbulu	14 520.7	59.7
Babati	20 937.6	25.6
Hanang	14 330.7	4.0
Kiteto	1 397.1	100.0
Arumeru	239.9	99.9
Total	51 426.0	31.6

Source: Calculations according to the contribution margin model.

Regional sales are restricted by the upper limits forced on the solution. For example, if sales to Kenya could be increased under unchanged prices, a larger part of the available surplus in Arusha region could be sold at a profit. Domestic markets, large enough to absorb any substantial part of the surplus, are situated outside the region, and can be reached only at costs exceeding the observed sales prices. As for internal regional markets, upper limits are assumed for possible markets outside the region, e.g., the Moshi market and the Tanga market. As mentioned earlier, no upper limits are assumed for the Dar es Salaam market.

Consequently, given that the marketing agents should be able to operate at a positive contribution margin for any amount of maize collected and marketed, the market prices had to be higher than those observed. Figure 2 shows calculated percentage price level increase related to percentage purchased and marketed maize at a positive contribution margin.

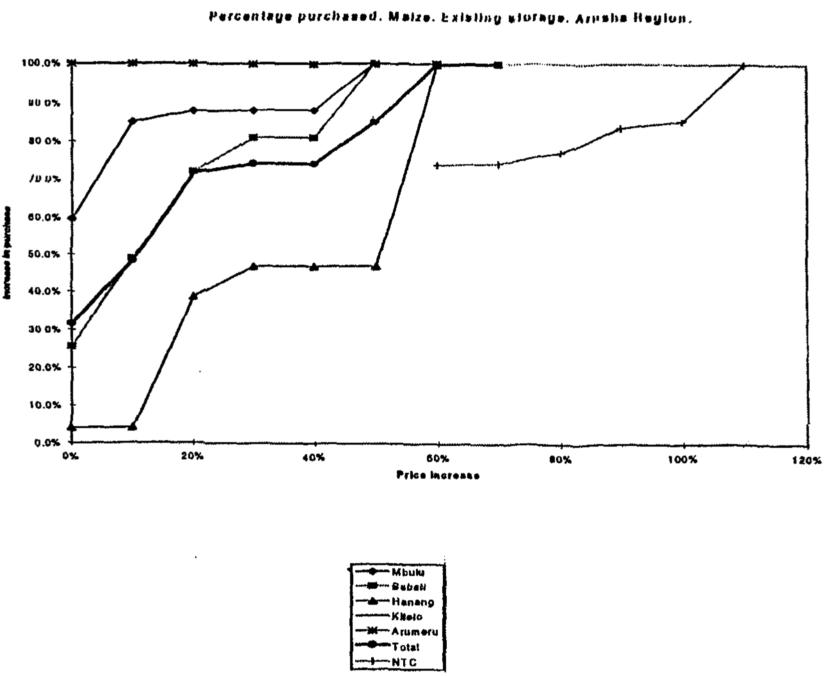

Figure 2:** **Calculated marketed share of total maize production as a function of proportional increases in sales prices. Arusha.

Source: Calculations according to the contribution margin model.

Taking a closer look at the Figure 2, we see that a 10 per cent increase in prices improves the results significantly. Under this assumption, it is profitable to reach the Moshi market in the first period, and even Tanga in the last period, a period in which the sales prices are at the highest. Totally, the marketable share of the available surplus production in the region increases from 31.6 to 48.2%, given this proportional ten percent price increase. For the problem area, Hanang, a ten percent increase in prices is not enough to make this area profitable. A sales price increase of twenty percent is necessary for Hanang to become commercially attractive as a supplier of maize. At this increase some produce may reach the Dar es Salaam market, but only in the third period. For all the maize to be marketed in the year 1989/90, the price increase should be of the magnitude of 60 percent. At these prices, however, it is doubtful that the markets in question would actually absorb the quantities assumed to be delivered. The equilibrium sales prices would depend on the existence of alternatives in the three periods of this particular year, e.g., on the magnitude of maize supply from other regions (not included in the analysis), on import possibilities, and on the supply and prices of relevant substitutes.

4.1.2. A Cross-Subsidy Regime

The above results are calculated under the condition that the marketing agents maximise the contribution margin. Assuming one marketing agent operating under the same cost structure, but restricted to achieve, if necessary, a zero profit performance, the results of the calculations will be dramatically changed. As stated in Section 2, the calculations are based on the assumption that all crops to be marketed are taken into account when assuming a zero profit performance, implying, among others, that a partial loss concerning the transport/storage of maize or other produce may be subsidised by crops achieving a positive contribution margin. In the case of a zero profit operator, all produce from Arusha region is marketed at observed prices.

Figure 3 shows the cross-subsidy impact of the latter example. Total contribution margin for crops achieving a positive margin is of the magnitude TSB 472m. To this positive margin, coffee is contributing 62%, peas 24%, with finger millet having the biggest of the remaining share. About TSB 340m. of this total are used to subsidise maize.

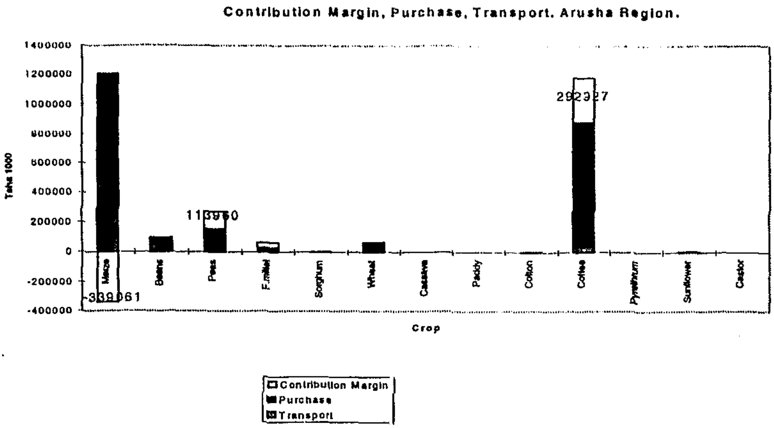

Figure 3: Calculated contribution margins for different crops under a cross-subsidy regime. Arusha.

Source: Calculations according to the model maximising marketed volume.

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4.2 Calculation results for Rukwa Region

4.2.1. A competitive market regime

In Rukwa, total production of marketable maize is 28,989 tonnes, followed by beans, 8,133 tonnes; and finger millet, 3,026 tonnes. The regional market for Rukwa—which has a rich potential for agricultural production, including maize—is very limited. Since Rukwa was a major supply region of maize in 1989/90, substantial number of tonnes had to be marketed outside the region. As to external markets for maize, the Dar es Salaam market is the only one of considerable size. If allowed—formally and practically—there should be a potential market in Zambia. Such possibilities have not been thoroughly examined in this analysis. However, a limit for deliveries has been set for the Kasesya market, representing potential exports.

At observed prices, only 0.6% of the marketable surplus of maize is delivered in order to obtain a positive contribution margin. Small quantities are delivered to Sumbawanga town from the nearby primary society, Kasangula, and even smaller quantities are delivered from Mkole to Nkansi. At observed prices, nothing is marketed outside the region.

As for Arusha region, the following question has been focused upon: how much must the market prices of maize increase to allow for a positive contribution margin when marketing larger amounts of maize produced in Rukwa? The results of the calculations answering this question is visualised in Figure 4.

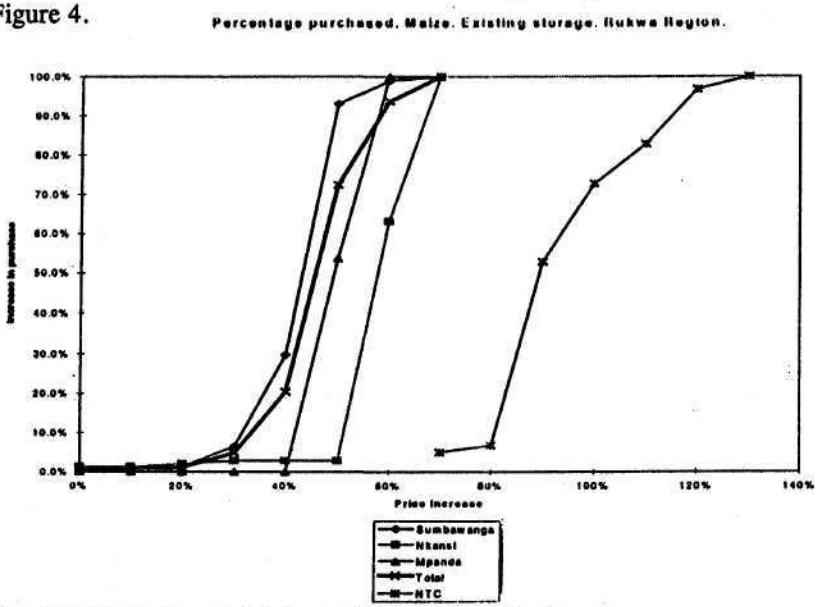

Fig. 4: Calculated marketed share of total maize production as a function of proportional increases in market prices. Rukwa.

Source: Calculations according to the contribution margin model.

As stated earlier, the Dar es Salaam market is the only external market of any considerable size. Tunduma (in Mbeya), Kigoma, Kasesya (in Sumbawanga Rural Rural District, on the border with Zambia—potential export) represent smaller markets. Assuming a gradual increase in the market price level, Tunduma is the first market to render a positive contribution margin. At a 20% increase, Kigoma is also included for deliveries of maize. At 30% increase of prices, the Kasesya market is supplied up to the assumed limit. For deliveries from Sumbawanga District to reach the Dar es Salaam market, the price increase must be 40%. The supply from this district is nearby emptied by an increase of 50%, as well as a major part of the supply from Mpanda. A 60% price increase is necessary to make deliveries from Nkasi profitable. An overall increase in market prices of 70% is necessary to include profitably to all supplies from Rukwa.

4.2.2. A Cross-Subsidy Regime

As shown in Figure 4, very small quantities of maize originating from surplus producing areas in Rukwa are profitably marketed at observed sales prices. For other crops like beans, however, the contribution margin is high. Consequently, when applying the model maximising marketed volume subject to a restriction implying that the total contribution margin should be non-negative, and allowing for cross-subsidies among areas and crops, the basic solution for maize is very much changed also for Rukwa: at observed sales prices all marketable supplies are being transported and marketed. For Rukwa, however, this result is achieved at a total contribution margin very close to zero. As shown in Figure 5, the total positive contribution margin achieved for beans and cassava, respectively 84% and 13%, is used almost entirely to subsidise maize.

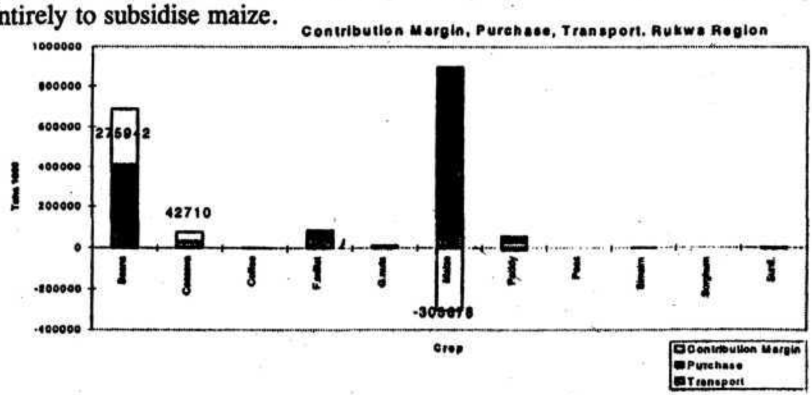

Figure 5: ***Calculated contribution margins for different crops under a cross subsidy regime. Rukwa.***

Source: Calculations according to the model maximising marketed volume.

4.3. General Results

The above calculations show that the parastatals/co-operatives transporting maize in 1989/90 were bound to operate at a loss for transport of maize from remote areas in the regions considered, if they were to collect, transport, store and distribute all produce available. Furthermore, the calculation results of the contribution margin model show that under a market system, involving private competitors, large quantities of maize—about 68% in Arusha, and almost the entire surplus production in Rukwa—would not be transported, given the observed market prices. A resent study by the Marketing Development Bureau (MDB) shows that private traders incurred a contribution margin of -7% for maize delivery to Dar es Salaam from Kondoa via Dodoma, due to high transportation costs caused by the bad road connection from Kondoa to Dodoma (URT, 1992)

Figures 2 and 4 indicate that under a competitive market regime, the supply curves for Arusha and Rukwa have different shapes. For Arusha, a 20% increase in prices imply that more than 75% of available maize is marketed. At the same price increase, only 2% is marketed from Rukwa. For price increases higher than 20%, however—and particularly in the range 30 to 50%—rather large volumes of maize may be profitably marketed from Rukwa. For Arusha, the situation is almost the opposite: price increases in the range 20 to 40% do not increase very much profitable deliveries. On the average, the production areas are far more accessible in Arusha than in Rukwa, implying higher transport costs in the latter region. However, the least accessible areas in Arusha imply very high transport costs also.

The above calculations have been performed under certain assumptions, some of which are disputable in the context of a competitive market system. Under such a system, both purchase prices and sales prices will depend on several supply and demand characteristics, which have not been accounted for. Information about actual quantities of maize delivered to various markets from all available production sources have not been collected for the present analysis, and neither is the information about supply characteristics concerning maize-producing regions other than Arusha and Rukwa. The limits set for quantities to be delivered to each market at observed prices are thus very crude estimates.

Under free market conditions, and in a short-term context, competition will tend to reduce the margin through increased purchase prices for production areas rendering a positive contribution margin. Since the contribution margin model computes that no quantities of maize will be supplied from Arusha and Rukwa to the Dar es Salaam market at observed prices, it is reasonable to assume that total supplies of this crop to Dar es Salaam would be substantially smaller than actual supply under the given prices. In a free market context, the short-term effect is likely to be that the price level in Dar es Salaam would increase considerably, implying that the transporters would profitably market more produce from these regions. Under this assumption, the equilibrium sales price would lie somewhere in between the observed price and the price computed in order to exhaust all supplies from Rukwa. In such a case, purchase prices would be reduced in order that all produce should be collected and transported. At harvesting time, the producers' earlier incurred costs would be 'sunk costs', and prices at the buying posts would be the lower, the more remote the production areas. For the least accessible areas, however, even a zero purchase price would probably not make transport, storage, and marketing profitable.

The short-term effect would thus be increases in purchase price for products, rendering a positive contribution margin, and decreases in purchase price for products rendering a negative contribution margin combined with higher consumer prices than the observed ones for the latter products. The price level will also be influenced by the existence of possible substitutes, and by import possibilities. According to world market statistics, the price of Argentinian white maize CIF Europe was 140 USD per tonne in 1989 (UNCTAD Commodity Yearbook, 1993). At the parallel market exchange rate, the price for imported maize CIF Dar es Salaam would thus be far below the calculated price necessary for delivering all maize from Rukwa.

In a medium and long-term perspective, areas closer to Dar es Salaam having a potential for maize production, will be encouraged to introduce maize as a cash crop and thus affect the geographical pattern of production. Although the yield per unit area is likely to be lower than in Arusha, and particularly in Rukwa, this disadvantage is probably more than outweighed by the latter regions higher transport and storage costs. Consequently, under a market-oriented system, the example from Arusha, and, above all, from Rukwa, indicates the possibility of a future reallocation of maize production, unless regional and sector-oriented policies are introduced to counteract such a development.

Assuming only one transporter, operating at zero profit terms in each of the regions; and assuming that this transporter should bring to the market all kinds of crops, allowing for cross-subsidies among crops and among areas within each region, all maize would be delivered both from Arusha and Rukwa regions under thc observed sales prices. In the case of Arusha, the optimal solution imply a total net contribution margin of the magnitude of TSB 133m; in the case of Rukwa net contribution margin turns out to be close to zero. The example illustrates the effect of one of several possible subsidy regimes. Whereas coffee and peas are the most vital products for subsidising the transport of maize in Arusha, beans is a main subsidy contributor in Rukwa. If a zero profit single operator was restricted to market maize only, the result would be very different, particularly for Rukwa. In such a case very little would be marketed from this region to Dar es Salaam, given the observed prices.

Figures 2 and 4 show, by dotted curves, the effect on maize deliveries from Arusha and Rukwa respectively of successive proportional increases in prices, when applying transport cost estimates calculated by the National Transport Corporation. As can be seen from the figures, proportional price increases of 110% are needed to market all produce from Arusha, and 130% to deliver all produce from Rukwa.

For Arusha—which under the cross-subsidy regime had a net total contribution margin at observed prices of about TSB 133m. When applying our cost estimates of transport—all produce will still be marketed, when using the cost estimates of the National Transport Corporation. Total contribution margin is reduced to only TSB 25m. As could be expected, similar calculations for Rukwa imply that 50% of total produce is not brought to the market. As to maize, only 28% of the produce would be marketed under the new cost conditions. Reduced contribution margin for beans and cassava imply that less produce can be transported of crops achieving a negative margin. In the optimal solution, the contribution margin is negative also for finger millet, which was not the case when applying our cost estimates. At the new cost assumptions, a zero profit operator is thus bound to run at a loss, even though this monopoly operator is transporting and storing the products in the most efficient way. Consequently, cross-subsidies are not sufficient for all produce to be marketed at prevailing sales prices, implying that such an operator has to be subsidised by the government. This fact does not mean that the transporting companies could not have been more efficient in their planning and operations. The parastatal companies were operating at a rather huge loss, widely accepted to be caused by poor and inefficient management (Bryceson, 1985); and quite a number of hundred tonnes of maize, produced in remote areas, have not been collected and brought to the markets, creating considerable discouragement on the part of the producers.

In the above discussion, two distinct alternatives have been in focus: a free market alternative, implying many independent transport competitors; and a system where the marketing agent is a *de facto* monopoly restricted to operate on zero profit terms. In a gradually liberalised economy, a combination of these alternatives may exist. In such a case, private marketing agents will exploit the most profitable segments of the market. In the case of Arusha, we found that coffee, peas, and beans were crops which in 1989/90 rendered a positive contribution margin of substantial magnitude. If the marketing of these crops is taken over by private operators, parastatal/co-operative organisations are left with the transport, storage, and marketing of the least-favourable agricultural products. At observed prices in final markets, competition will, as mentioned above, tend to increase purchase prices for coffee, peas, and beans. If the parastatal/co-operative transport organisations are supposed to market maize and other crops, which at the observed prices are unprofitable, these organisations have either to be substantially subsidised, or prices in final markets have to be increased to an extent which probably is unrealistic, and/or purchase prices are bound to be reduced. In a short-term context, the latter is likely to happen. If prices cannot be increased to cover the costs of the marketing agent in a longer time perspective, production—particularly in Hanang—is going to be very much reduced, and producers will turn to more profitable cash crops, if any, or to a subsistence economy.

In a liberalised market, transport of beans is likely to be taken over by private operators in Rukwa. As for Arusha, either huge subsidies have to be introduced if all other crops are to find a market under the observed consumer prices, or the prices in final markets have to be considerably increased, most likely combined with a substantial reduction in purchase prices. As mentioned earlier, in a medium and long time perspective, surplus production of most crops other than beans, and, in particular, of maize, will be reduced, or even phased out, under a competitive market regime; possibly implying a relocation of production into areas closer to the larger markets, perhaps combined with imports.

In the case of a cross-subsidy regime, the above calculations have been undertaken under the assumption that one parastatal is responsible for marketing all crops in each of the regions, and that this parastatal is supposed to cross-subsidise among crops and among districts within the same region.

We could have involved both regions in the same analysis in order to allow for cross-subsides between the regions. Since our calculation example shows that a separate cross-subsidy regime in each of the regions would secure all produce to be marketed at prevailing prices, we have not treated the two regions simultaneously.

In reality, parastatals have in some cases been responsible for nation-wide collection, transporting and marketing of single, major crops. The Coffe Marketing Board and the Cotton Marketing Board are examples of organisations which have been responsible for marketing of single crops. In such a case, cross-subsidies among crops were not possible. However, cross-subsidies among regions was a possible strategy. It was shown earlier that for some products—like coffee (Arusha), and beans (Rukwa)—a single crop operator would be able to operate at a considerable profit. For a crop like maize, a single crop operator was bound to operate at a loss in both regions if all produce were to be marketed at the given prices. In this case, a cross-subsidy among regions would thus not imply profitable operations for the organisation as a whole. It was pointed out above that the supply curves for maize, under a competitive market regime, had different shapes in the two regions. This fact implies that a single crop operator, supposed to cross-subsidise among production areas, would market substantially more maize from Arusha than from Rukwa. Calculations could have been performed, showing the quantities of maize being marketed in the case of a single crop operator. The conclusion is rather clear, however: there is a structural difference between the two regions in favour of Arusha.

In 1989/90, co-operatives/parastatals were involved in the marketing of most crops from both regions. However, coffee was exclusively marketed by the Tanzania Coffee Marketing Board. Since coffee was a main contributor for subsidising 'non profitable' crops in Arusha in the cross-subsidy regime case, the calculation results would have been very different if coffee was not taken into account. In such a case, total contribution margin would have been substantially reduced.

5. Conclusion and Policy Implication

This article has illustrated the consequences of a transport subsidy regime where a single operator is responsible for transportation. Most countries in the world have implemented some sort of subsidy system to influence the pattern of agricultural production, to affect income for primary producers, and to influence consumer prices on these kind of products. Design of alternative subsidy mechanisms should certainly be considered also in Tanzania. Target groups for subsidies could be producers, transporters, or consumers.

In many cases, however, subsidies tend to have an adverse effect on efficiency. A more efficient and non-distorting way of using government resources may be to upgrade the transport infrastructure system in areas with a high agricultural potential, making these regions and districts generally more competitive. A supply model of the kind discussed here, could, among other things, be used to investigate into the effects on transport costs, and thus on competitiveness, arising from such infrastructure investments. Improved transport structures imply the use of increased average truck size, higher average obtainable speed on different roads in different seasons, reduced costs of maintenance, fuel, etc. Improved road systems goes far beyond the effects on transporting, storing and marketing produce *from* the regions in question. Improved transport structures will have effects on all aspects of economic activities. For example, in their global estimates, using a linear programming model for Thailand of the impact of reductions in transportation costs on income. Conley and Heady (1981) estimated that a 30 percent reduction in transportation costs would increase net income in all four regions of the country by 6.4 percent on the average, and by 12 percent in the poorest and most remote areas

Improvement of the road systems reduces effective transport time and thus transport costs. We shall illustrate the importance of improved road standard by a simple example. As stated in Section 3, all connections (distances between nodes) are characterised by expected hours travelled, taking into account road standards for each specific road in each season. Suppose that substantial infrastructure investments have been put into effect, reducing, on the average, travelling time to 40% of the initial estimate for all distances in both regions. How much would be brought to the market under this assumption, given the prevailing sales prices, and according to the contribution margin model?

For Arusha, the reduction in transport costs implies that 73% of all produce is marketed, and 66% of all maize; compared to 32% when the computations were based on the initial cost estimates. For this region, the effect of improved roads is thus significant. For Rukwa, however, the above assumed reduction in transport costs is not enough to have any pronounced effect on quantities brought to the market. As can be seen in Figure 2, where proportional increases in sales prices were assumed, a price increase of a magnitude up to 30% was not sufficient for marketing larger quantities of maize from Rukwa, indicating the high costs involved for bringing more produce to the market. As to transport costs, the above simple example shows that very huge investments have to be made in this region in order to have a major impact on the marketing agents' profitability under the observed sales prices. The above example is not very realistic for the major roads, for which speed hardly can be, as assumed, more than doubled. For secondary and tertiary road systems, however, improved standards may increase speed considerably by more than double if major infrastructure investments are made. Improved road systems will also allow for a bigger average truck size, implying increased quantities transported per unit of time. If average truck size is increased from seven- to, for example, fifteen-tonne, transport costs would be very much reduced. The extent of reductionwill depend on several cost parameters, which have to be revised when introducing a bigger average lorry size. A more in-depth analysis of the effects on transport costs, and thus on competitiveness caused by infrastructure investments of alternative magnitude, is a major project which has not been a part of this study. However, the present study provides vital information for performing the above suggested kind of consequence analysis.

In order to make a more complete analysis of the above problems, the supply model could be extended to include production functions for producers in different regions, dealing, among others, with the question of yield of production per unit area, and the cost of inputs of essential production factors (e.g., fertilizers). The model could also be extended by undertaking analyses concerning the demand functions related to the major crops, and, in particular, to maize.

Analyses of the above kind are of major importance, not only as an academic exercise, but as a tool for providing basic background material, relevant for policy discussions on vital development issues in Tanzania. Broadly speaking, these issues concern the future pattern of regional growth and development, the geographical pattern of production of different crops, and the competitive strength of different regions and districts if the transport infrastructure is improved. Such analyses also constitute a vital element for evaluating the effects on the national economy, and on food security, arising from the introduction of alternative subsidy regimes.

Currently the government is in the process of devising a new policy framework for promoting agricultural development. Among the most important instruments within this new policy is to look into the taxation and subsidy issues.

The main strategy of the government regarding the foodcrop sector appears to be the extension of the rural infrastructure, particularly roads, in the potentially productive areas. What is needed however, is concrete action and implementation of the above policies and strategies to ensure the realisation of a meaningful agricultural development in the short and long-term.

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ANNEX 1: The Contribution Margin Model

1.1 Subscripts

The model uses the following subscripts

- i arcs in the transportation network, $i \in \{1,\ldots,I\}$
- j nodes in the transportation network, $j \in \{1,\ldots,J\}$
- t time periods, $t \in \{1,\ldots,T\}$
- k crops, $k \in \{1,\ldots,K\}$

1.2 Sets

The following sets are used

- I_j^E arcs with endnode j
- I_J^S arcs with startnode j
- J^{NM} nodes defined as 'non-market nodes', J^{NM} $\{1,\ldots,J\}$

1.3 Constants

All constants are named with greek-letter symbols in order to easily separate them from the variables (latin characters).

- $\varnothing_{jkt}$ sales price of crop k in node j in time period t
- β_{it} total cost of transportation along arc i in time period t
- Θ unit cost of storage capacity
- π_{jkt} purchase price of crop k in node j in time period t
- γ_{jkt} collection of crop k in node j in time period t
- δ_{jkt} maximal allowed sales of crop k in node j in time period t
- α_t loss factor in time period t

1.4 Variables

X_{ikt} allocated transport capacity for arc i and crop k in time period t

Y_{jkt} sales of crop k in node j in time period t

Z_j storge capacity in node j

W_{jkt} purchase of crop k in node j in time period t

V_{jkt} stored amount of crop k in node j in time period t

1.5 LP formulation

The main body of the LP-model is an objective maximising the 'contribution margin' and a set of flow conservation constraints. Finally, two sets of upper bounds on individual variables are included as well as standard non-negativity constraints and a set of constraints limiting total stored amounts within the storage capacity.

$$\text{Max } Z = \sum_{j-t}^{J} \sum_{k-1}^{K} \sum_{t-1}^{T} \alpha_{jkt} y_{jkt} - \sum_{i-t}^{I} \sum_{k-1}^{K} \sum_{t-1}^{T} \beta_{it} x_{ikt} - \sum_{j-1}^{J} \theta_{zj} - \sum_{j-t}^{J} \sum_{k-1}^{K} \sum_{t-1}^{T} \pi_{jkt} w_{jkt} \quad (1)$$

s.t.

$$\sum_{i \in I_j^E} x_{ikt} + \alpha_{t-1} v_{jkt} + w_{jkt} = \sum_{i \in I_j^S} x_{ikt} + y_{jkt} + v_{jkt} \forall_{j,k,t} \quad (2)$$

$$\sum_{k-1}^{K} v_{jkt} \leq z_j \forall_{j,t} \quad (3)$$

$$w_{jkt} \leq \gamma_{jkt} \forall_{j,k,t} \quad (4)$$

$$y_{jkt} \leq \delta_{jkt} \forall_{j,k,t} \quad (5)$$

$$x_{ikt}, y_{jkt}, v_{jkt}, w_{jkt}, z_j \geq O \forall_{j,k,t} \quad (6)$$

The model is executed with some special constraints which can be obtained by fixing some of the variables and constants in equations (1) - (6) as follows:

$$\alpha_o = \mathrm{O} \text{ and } v_{jk-1} = \mathrm{O}\forall_{j,k} \tag{7}$$

Equation (7) indicates that no loss is possible between periods 0 and 1. That is, initial storage is assumed nonexistent.

$$w_{jkt} = \mathrm{O}\ \forall_{j,k} \text{ and } t \in 2,3\ldots,T \tag{8}$$

Equation (8) indicates that purchase of goods is limited to the first time period only.

$$y_{jkt} = \mathrm{O}\forall k, t\Lambda j \in J^{NM} \tag{9}$$

Equation (9) indicates that sales of goods is only allowed in 'market nodes'. These constraints could surely have been explicitly included in the model (1) consistent and compact.

An alternative version of the model includes the maximisation of total marketed goods with the added constraint of positive total contribution margin.