STAGES OF DEVELOPMENT AND INTERNATIONALLY-AGREED TRADE POLICIES.

By Paul Clark and Charles Frank

I. Summary

1. The central question to be considered is whether differences in stage of development, among the many developing countries in Africa, Asia, and Latin America, should be recognized as a basis for differences in internationally-agreed trade and aid policies affecting them.

2. A country's stage of development is a concept with several dimensions, not simply its per capita income. Moreover, any single indicator of development is subject to definitional and statistical inaccuracies. Gross domestic product per capita in particular suffers from unavoidable difficulties in estimating subsistence production, definitional ambiguities in less developed economies, and biases in using official exchange rates to convert national estimates into a common currency. Therefore a country's stage of development is represented in this paper by its composite ranking, among a group of 65 developing countries, with respect to four statistical indicators: (a) gross domestic product (GDP) per capita, (b) share of GDP produced in non-agricultural sectors, (c) energy consumption per capita, (d) adult literacy rate.

3. Substantial differences in stage of development do exist among developing countries. Countries near the top of the list overlap with some of the poorest European countries. Countries in the upper quarter have a median per capita GDP four times that of countries in the lower quarter, as well as twice as high a share of non-agricultural product, energy consumption eighteen times as great, and adult literacy six times as favorable. African countries, including Uganda, Tanzania, and Kenya, tend to be concentrated in the bottom half of the list, and Latin American countries in the top half, with Asian and Middle Eastern countries distributed throughout the list. There is a difference between the distribution of all African countries and 9 for all Latin American countries. There is almost a significant difference between Latin American and Asian. Thus there are objective grounds for special concern for African countries, and to a lesser extent Asian countries, relative to Latin America.

4. Dependence on total exports, as measured by the rate of exports to GDP, is only weakly correlated with stage of development among the developing countries. The direction of the correlation, moreover, is that countries at a lower stage of development tend to be less dependent on total exports. This relationship is maintained even after adjustment for differences in size, as measured either by population or by total GDP. Thus internationally-agreed policies promoting total exports of all kinds from developing countries would have similar effects on countries at a lower stage of development, and if anything, would tend to favor countries at a higher stage.

5. Dependence on primary exports, as measured by the ratio of primary to total exports, is however clearly and significantly correlated with stage of development among developing countries. Countries at a lower stage of development tend to be more dependent on primary exports. Thus...
internationally-agreed policies improving markets for primary exports would be especially favorable to countries at a lower stage of development. Such policies would tend to narrow inequalities among developing countries as well as to promote accelerated development for all primary exporters.

6. Uganda, Tanganyika, and Kenya, as comparatively small countries at a lower stage of development, therefore have particular interest in internationally-agreed policies promoting primary exports. Such policies, even though extended non-preferentially to all countries, would automatically give relatively greater assistance to most African countries. Policies promoting exports of tropical agricultural products would of course be especially desirable. On the other hand, existing preferences for some developing countries in access to markets in developed market economies and centrally planned economies are believed to be on balance unfavorable to East African exports. Thus all things considered, Uganda, Tanganyika, and Kenya seem to have most to gain from internationally-agreed policies promoting primary exports, especially of tropical products, on a non-preferential basis.

7. At the same time, Uganda, Tanganyika, and Kenya, along with other African countries at a stage of development, probably would benefit little in the near future from measures improving access to developed and centrally planned markets for semi-manufactured and manufactured products. The benefits of non-preferential measures would accrue largely to developing countries at a higher stage of development. Preferential measures, varying in the degree of preference according to stage of development, are conceivable, but would be awkward to administer, would open the door to preferences on political grounds, and might still be ineffective in the near future.

8. Industrialization in countries at a lower stage of development, such as Uganda, Tanganyika, and Kenya, seems more likely to be promoted in the near future by means of (a) import substitution in the domestic market, and (b) preferential trade arrangements with other developing countries to provide larger markets for import substitutes. Preferential trade arrangements are already internationally accepted in the form of full customs unions, but preferences for selected products traded among a limited number of developing countries would in some cases be more constructive. Thus Uganda, Tanganyika, and Kenya may have much to gain from international acceptance of a wider variety of preferential trade arrangements among developing countries.

9. Presently discussed schemes of financial support for developing countries suffering from export fluctuations would have provided modest benefits in the past to Uganda, Tanganyika, and Kenya. Alternative schemes related to primary exports rather than total exports, and assessing contributions on the basis of stage of development as well as export volume, would be more favorable.

10. Financial aid to developing countries is bound to be based on a variety of criteria, of which stage of development is only one. However, there is a strong case for easier terms on financial aid to countries at a lower stage of development, because of their greater difficulties in expanding exports and the longer time needed to approach a stage of self-sustaining growth. Thus Uganda, Tanganyika, and Kenya, like most other African countries, have particular interest in international agreement to raise the proportion of grants and deferred-payment loans in financial aid to countries at a lower stage of development.
that the individual \( a_i \) are now allowed to vary. Then

\[
(5) \quad C_R = \sum_{j=1}^{n} c_{ij} \cdot b_j
\]

is the minimum total transport cost where

\[
(6) \quad c_{ij} = \min c_{ij}, \text{ for } j = 1, \ldots, n
\]

Furthermore

\[
(7) \quad G_a = C_{BA} - C_R
\]

is the additional savings in transport costs which can be obtained by a reallocation of amounts supplied among the various points of supply (assuming that the total amount supplied is given) so that each point of demand receives its allotted amount from the point of supply where transport costs are the cheapest. The sum

\[
(8) \quad G = G_1 + G_2
\]

is the total savings in transport costs which may be obtained both by allowing free movement of sugar across all borders and by allowing a reallocation of production among the various factories which manufacture sugar.

III. Application.

Our analysis centered on the year 1970. The estimated production of sugar in East Africa for the year 1970 is given in Table I. The maximum estimates differ from the minimum estimates largely because the production levels of four new factories now in the planning stage are extremely uncertain, and there is the possibility that two minor producers in Tanganyika will engage in large scale expansions. In addition

<table>
<thead>
<tr>
<th></th>
<th>Estimate of Consumption</th>
<th>Maximum Estimate of Production</th>
<th>Maximum Surplus</th>
<th>Minimum Estimate of Production</th>
<th>Minimum Surplus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tanganyika</td>
<td>105</td>
<td>165</td>
<td>62</td>
<td>115</td>
<td>12</td>
</tr>
<tr>
<td>Kenya</td>
<td>171</td>
<td>205</td>
<td>34</td>
<td>98</td>
<td>-73</td>
</tr>
<tr>
<td>Uganda</td>
<td>111</td>
<td>180</td>
<td>69</td>
<td>160</td>
<td>49</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>385</strong></td>
<td><strong>550</strong></td>
<td><strong>165</strong></td>
<td><strong>375</strong></td>
<td><strong>-12</strong></td>
</tr>
</tbody>
</table>

Source: East African Common Services Organisation.
to the gross estimates of production in Table I, we obtained maximum and minimum estimates for each of the twelve factories expected to be in operation by 1970 from the East African Common Services Organization and the Tanganyika Ministry of Commerce and Industry.

Estimated consumption for the year 1970 is also shown in Table I. These estimates were based on an assumed rate of growth of consumption of 8% in Kenya, 8% in Tanganyika, and 6% in Uganda. These estimated rates of growth were determined on the basis of the findings of Viton and Pignaio (1).

The East African Common Services Organization, the East African Railways and Harbours, and the Ministry of Commerce and Industry in Kenya supplied estimates of consumption by locality in all three territories for previous years. The quality of these estimates varied, and some estimates were in terms of sugar consumed in and around major population centres while other estimates were in terms of administrative areas (some containing more than one major population centre). Using population data from (2) and (3) and a knowledge of the relative prosperity and economic activity of each population centre, consumption of sugar in an administrative district was allocated to each population centre so that all consumption estimates were in terms of population centers (towns of about 5000 population or more). The estimates of past consumption of each population center and surrounding area were converted into percentages of total consumption within the country in which the center was located. These percentages were applied to the total consumption estimates of each country for 1970 to obtain estimates of tons of sugar consumed for each population center for 1970.

Several problems arose in trying to determine the costs of transporting sugar between each of the twelve factories and each population center. Two producers in Uganda and two in Tanganyika have negotiated special rates with the East African Railways and Harbours. All other producers transport their sugar by rail and by the East African Railways and Harbours road services at higher rates. Furthermore the Railways and Harbours Administration is considering a change in the rate structure so that rates correspond more closely with costs. One major change which is being considered is a modification of the taper. (The taper refers to a declining average charge per mile as distance increases.)

5. The Uganda rate of growth was assumed to be lower because a large part of the population has a diet consisting mostly of starched plantains (mutoko) which has a high sugar content.
The present taper is such that the charge for each additional mile declines with distance. The Railways and Harbours administration, however, calculates that the actual cost of each additional mile is the same regardless of distance, although there is an initial cost of loading and handling which means that the average cost per mile declines with distance.

In view of these considerations, we assumed that by 1970 at least all East African sugar producers will have negotiated special rates for the rail and road services and that the taper will be modified to reflect the Railways and Harbours estimates of their actual costs. In order to obtain estimates of rates which would approximate the rates under these assumptions, we calculated two regression lines with total transport charge per ton as the dependent variable and distance in miles as the independent variable, using the special rates quoted in (4) for rail services and road services as separate samples. The regression equations provided estimates of road and rail charges with the following properties:

(1) The charge for each additional mile is constant and the average charge per mile falls with distance.

(2) Assuming a random distribution of traffic over the sample distances, the expected total revenue obtained using the rates estimated from the regression lines is equal to the expected total revenue obtained under the special rates.

\[ R = w, \quad \frac{1}{n} \sum_{i=1}^{n} y_i = n \cdot w, \quad \bar{y} = T \cdot \bar{y} \]

where \( \bar{y} \) is the sample mean of the special rates. If \( y_i \) for \( i = 1, \ldots, n \) are the rates estimated by the regression equation for the specially rated routes, then expected total revenue using the estimated rates is:

\[ R' = w, \sum_{i=1}^{n} y'_i \]

The rate \( y'_i \) is calculated from the regression equation:

\[ y'_i = a + b \cdot x_i \]

where the regression coefficient \( a \) is determined from the normal equations. (Footnote continued on next page)

4. Proof. Let \( T \) be the total annual traffic over the sample distances \( x_i \) for \( i = 1, \ldots, n \) with sample rates \( y_i \) for \( i = 1, \ldots, n \). Let \( w_i \), a random variable, be the number of tons of traffic over the route with distance \( z_i \). If \( E(w) \) is the expected value of \( w_i \), then, since the \( w_i \) are all similarly distributed, \( E(w_i) = w \).

The expected total transport revenue using the special rates is
The first property modifies the taper to correspond more closely with costs, and the second property ensures that the expected total revenue on the basis of the estimated rates equals total costs, assuming that the traffic is randomly distributed over all specially rated routes and that the special rates are expected to cover total cost.

In order to determine the number of points of supply and demand, a certain amount of aggregation was performed. Factories which were within thirty miles of each other were combined into one point of supply. The transport costs from the factories which were combined to form an aggregated point of supply were averaged and the average used as the transport cost from the aggregated point of supply to each point of demand. In order to reduce the number of points of demand, we took advantage of the following theorem:

Theorem 1. If \( x_{ij} \) for \( i = 1, \ldots, n \) and \( j = 1, \ldots, m \) minimize \( C \) in (1) subject to (2) and (3), then these same values of the \( x_{ij} \) minimize

\[
C^0 = \sum_i \sum_j (c_{ij} + \alpha_i + \beta_j) x_{ij}
\]

subject to (2) and (3).

This theorem means that any constant can be added to any row or any column of the transportation cost matrix \( (c_{ij}) \) and the solution remains invariant.

Proof: We may write (9) as follows:

\[
C^0 = \sum_i \sum_j c_{ij} x_{ij} + \sum_i \alpha_i \left( \sum_j x_{ij} \right) + \sum_j \beta_j \left( \sum_i x_{ij} \right)
\]

From (1) and (2), we have

\[
C^0 = C + \sum_i \alpha_i \cdot a_i + \sum_j \beta_j \cdot b_j
\]

Thus \( C^0 \) is equal to \( C \) plus a constant. Q.E.D.

It becomes apparent in calculating transport costs from each factory to each population center that there often the difference in transport costs to one population center, say center \( A \), and to another population center, say center \( B \), from each point of supply was the same. That is, \( c_{iA} = c_{iB} + \beta \) for \( i = 1, \ldots, n \).
This occurred whenever in order to transport sugar from any factory to point A, it was always necessary to first travel through point B. The transport cost matrix could then be transformed by adding the constant $\beta$ to the B column while leaving the optimal solution to the transportation problem invariant. The result was two identical columns in the transportation cost matrix. In other words, the cost from each point of supply to both points of demand A and B was the same. It is relatively easy to show that under these circumstances the two points of demand may be combined into one. In this way we were able to reduce the number of points of demand from about 60 to 48.

If an area is a net importer, then it is necessary to add a fictitious source of supply so that the total amount demanded equals the total amount supplied. The amount supplied by the fictitious source of supply is equal to the difference between estimated internal consumption and estimated internal production. In order to determine the transport cost from the fictitious source of supply, we estimated the cost of transport between the nearest port of entry and each point of demand. If an area is a net exporter, one must add a fictitious source of demand. In order to determine the transport cost to the fictitious source of demand, we estimated the transport cost from each point of supply to the nearest port of exit.

Having accumulated all the necessary data, we calculated $G_1$, the savings possible from a policy of complete integration as opposed to a policy of national autarky, assuming that the minimum production estimates for each factory for the year 1970 are satisfied. We also determined $G_2$, the additional savings which are possible if the minimum total production estimate for East Africa for the year 1970 is reallocated among firms. Then we calculated $G_1$ and $G_2$ assuming that the maximum production estimates for the year 1970 are satisfied.

The above analysis contains several implicit assumptions. One is that there is an even flow throughout the year between all points of supply and all points of demand. Although production schedules in the past have been uneven, a steady flow can be achieved by holding sufficient stocks at each factory. In order to compensate for fluctuations in demand, stocks may be held by dealers at each point of demand. Another assumption is that the product is homogeneous. Although differences in quality are probably insignificant as far as the East African consumer is concerned, for the
export market, quality can be a crucial factor. In working out the solutions to the transportation problems, however, it turned out that in most instances the factory at Wami River in Tanganyika, which is geared to producing raw sugar, was an exporter in sufficient quantity to satisfy the present East African obligations under the Commonwealth Sugar Agreement. It is not unreasonable to assume that some market can be found for all other sugar exported regardless of the quality. A third implicit assumption is that under national autonomy (no movement of sugar across territorial boundaries) the transport costs will be minimised within each territory, and with complete integration total transport costs will be minimised on an East African basis. If the divergencies from an optimal pattern of distribution are about the same in either case, however, the estimate of savings will not be substantially affected.

IV. Method of Solution.

In order to determine $G_1$ and $G_2$ for maximum and minimum production estimates, it was necessary to solve eight different transportation problems, the largest having 40 points of demand and 9 points of supply. Since an electronic computer was not readily available, we decided to solve them by hand. We devised a simple and fast method of computation, making use of the following theorem:

Theorem 2. Let $(x_{ij}^*)$ represent a set of values for the variables $x_{ij}$ for $i = 1, \ldots, n$ and $j = 1, \ldots, m$. The theorem falls into two parts:

(a) If $(x_{ij}^*)$ satisfies

\[ \sum_j x_{ij}^* = b_j \quad \text{for} \quad j = 1, \ldots, m \]

then $(x_{ij}^*)$ is an optimal solution to the transportation problem (minimises (i) subject to the restrictions in (2) and (5)) if and only if there exists a set of number $\alpha_i$ for $i = 1, \ldots, n$ such that

\[ \alpha_i + \alpha_j > \min(c_{ij} + \alpha_i) \quad \text{if} \quad \alpha_i + \alpha_j > \min(c_{ij} + \alpha_j) \quad \text{then} \quad x_{ij}^* = 0 \]

\[ \alpha_i + \alpha_j = \min(c_{ij} + 0_i) \quad \text{then} \quad x_{ij}^* \geq 0, \quad \text{and} \]

\[ \sum_j x_{ij}^* = a_i \quad \text{for} \quad i = 1, \ldots, n \]

are satisfied.

(b) If $(x_{ij}^*)$ satisfies (14), then $(x_{ij}^*)$ is an optimal solution to the transportation problem if and only if there exists a set of numbers $\beta_j$ for $j = 1, \ldots, m$ such that
If \(-c_{ij} + \beta_j < \max_j(-c_{ij} - \beta_j)\), then \(x_{ij}^t = 0\)

\(15\) If \(-c_{ij} + \beta_j = \max_j(-c_{ij} + \beta_j)\), then \(x_{ij}^t = 0\)
and (13) are satisfied.

The above theorem states that if it is possible to find a set of numbers \(\alpha_i\) and a solution \((x_{ij}^t)\) which satisfy (12), (13), and (14), then \((x_{ij}^t)\) is an optimal solution to the transportation problem. Furthermore, if \((x_{ij}^0)\) is an optimal solution to the transportation problem, then there exists a set of numbers \(\alpha_i\) such that (12), (13), and (14) are satisfied. Our algorithm consists of finding successive approximations to the numbers \(\alpha_i\) and solutions \((x_{ij}^t)\) which satisfy (12) and (13) but not necessarily (14). When a solution is reached (14) is satisfied as well.

The algorithm may be described as follows:

(a) Let \((x_{ij}^t)\) be the solution at stage \(t\) in the algorithm, and let \(\alpha_i^t\) be the values of the \(\alpha_i\) for \(i = 1, \ldots, n\) at stage \(t\). Initially let the \(\alpha_i^0\) be arbitrary for \(i = 1, \ldots, n\).

Let \(\min_j(c_{ij} + \alpha_i^0) = c_{ij}^0 + \alpha_i^0 = \beta_j^0\)

Then set

\[ \begin{align*}
\alpha_i^t &= \begin{cases} 
\beta_j^t, & \text{if } i = I_t \\
0, & \text{otherwise}
\end{cases} \\
\end{align*} \]

(b) Define the following quantities:

\[ \beta_j^t = \min_j (c_{ij} + \alpha_i^t) \text{ for } j = 1, \ldots, m \]

\[ E_i^t = \sum_{j=1}^m x_{ij}^t - a_i \text{ for } i = 1, \ldots, n \]

\[ E_{I_t}^t = \max_i |E_i^t| \]

Then follow either of the two steps below, whichever is appropriate.

(b.1) If \(E_{I_t}^t < 0\), define the set \(A(I_t)\) as follows:

\[ A(I_t) = \left\{ j \left| x_{ij}^t > 0 \right. \right\} \text{ for at least one } i \neq I_t \]

Set \[ \Delta = \min_{j \in A(I_t)} \left( c_{I_tj} + \alpha_i^t - \beta_j^t \right) \]

\[ = c_{I_tj} + \alpha_i^t - \min_j (c_{ij} + \alpha_i^t) \]

\[ = c_{I_tj} + \alpha_i^t - c_{I_tj} - \alpha_i^t \]
(b.2) If $E_{I^t} > 0$, define the set $V(I')$ as follows:

$$V(I') = \{ j \mid x_{I^t}^t > c_j \}$$

Set

$$\Delta = \min_{i \notin I'} \min_{j \in V(I')} (c_{ij} + \alpha_i^t - \beta_j^t)$$

$$= \min_{i \notin I'} \min_{j \in V(I')} (c_{ij} + \alpha_i^t - c_{I^t}^t - \alpha_{I^t}^t)$$

$$= c_{I^t}^t + \alpha_{I^t}^t - c_{I^t}^t - \alpha_{I^t}^t$$

(c) In order to determine the $\alpha_i$ and the $x_{ij}^t$ at stage $t + 1$ set

$$\alpha_{i}^{t+1} = \begin{cases} t_i^t + \Delta, & \text{if } E_{I^t} > 0 \\ t_i^t - \Delta, & \text{if } E_{I^t} < 0 \end{cases}$$

$$\alpha_i^{t+1} = \alpha_i^t \quad \text{for } i \notin I' ,$$

and set

$$x_{i,j}^{t+1} = x_{i,j}^t \quad \text{for } j \notin J$$

For $j = J$, use one of the following four rules, whichever is applicable:
In order that the system approach equilibrium, the asking prices must be altered. We assume that the supplier at point \( I \) who has one of the largest excess demand or excess supply is the first to modify his asking price. If the supplier at point \( I \) has an excess demand \( \Delta^I > 0 \), he raises his asking price by an amount \( \Delta \) sufficient to cause buyers from at least one point of demand to ask for sugar from a supplier at some point other than \( I \). In order to determine \( \Delta \), one looks at all points of demand from which buyers ask for sugar from the point \( I \); this is the set \( J(I') \). For each of these points of demand, we determine the minimum rise in price which will cause buyers from that point to go elsewhere because the asking price plus transport cost is lower. Then we set \( \Delta \) equal to the least of these minimum rises in price. When the asking price at point \( I \) is raised by \( \Delta \), buyers from the point of demand \( J \) begin to ask for sugar from point \( I'' \) instead of \( I' \), thus reducing the excess demand at \( I \). Now if the supplier at point \( I \) has an excess supply, he lowers his asking price by an amount \( \Delta \). In this case one determines \( \Delta \) by first looking at all points of demand from which buyers are asking for sugar from points other than \( I \); this is the set \( J(I') \) for the case where \( \Delta^I < 0 \). Then for each of these points of demand, we determine the reduction in asking price necessary to cause buyers to switch to the point of supply \( I' \). The asking price is lowered by which is the minimum of these reductions in asking price. Then buyers from the point of demand \( J \) switch from the point of supply \( I'' \) to the point of supply \( I' \), thus reducing the excess supply at \( I' \). At all times during the process, buyers at each point of demand ask for sugar from the point of supply for which the asking price plus transport cost \( c_{1j} \) is the lowest. That is, the conditions set by (13) are always satisfied. When \( \Delta^I = 0 \) for all points of supply, an equilibrium has been reached since there are no excess demands and no excess supplies. At this point total transport cost (1) is minimized and the conditions (2) and (I) are satisfied. The four rules (a.1) through (a.4) insure that no point of supply switches from an excess demand to an excess supply or from an excess supply to an excess demand at any one stage in the process. This helps prevent cycling although cycling is not eliminated and may occur whenever \( \Delta = 0 \), i.e., whenever a supplier may get rid of a surplus or make up a deficit through no reduction in the asking price. In performing the algorithm
by hand, however, it is relatively easy to choose the proper point of supply in order to break the cycle.

In performing the algorithm above it is simplest to work at all times with the matrix whose entries are $c_{ij} + \alpha_i^t - \beta_j^t$ for $i = 1, \ldots, n$ and $j = 1, \ldots, m$. Since the conditions in (15) are always satisfied, according to the definition of $\beta_j^t$, we have

$$
\alpha_i^t + \beta_j^t \geq 0 \quad \text{for all } i \text{ and } j,
$$

and

$$
\text{if } \alpha_i^t + \beta_j^t > 0, \text{ then } x_{ij}^t = 0.
$$

One may infer from (15) that the final $\alpha_i^t$ and $\beta_j^t$ are nothing more than the shadow prices or the optimal solution to the dual of the transportation problem. Only if the asking price $\alpha_i^t$ or the price at the source of supply plus transport cost is equal to the demand price $\beta_j^t$ or price at the source of demand is sugar transported from point $i$ to point $j$.

If the price at the source of supply $i$ plus transport cost is greater than the price at the source of demand $j$, then no sugar is transported from point $i$ to point $j$, i.e., $x_{ij} = 0$.

The condition (15) also implies that the final $x_{ij}$ do indeed minimize transport cost. Thus the algorithm provides a solution to the primal problem and the dual problem simultaneously.

The computations were further simplified by setting any of the entries in the matrix which were larger than their row minimums by some specified amount equal to an arbitrarily large number $M$ and neglecting these entries in the matrix during the computational procedure. At the end of the procedure, the final $\alpha_i^t$ were added to the original entries in the transportation cost matrix and a new solution $x_{ij}$ determined. If this solution satisfied (12), (13), and (14), it was an optimal solution. Otherwise the final $\alpha_i^t$ were used as the initial $\alpha_i^t$ for a new round of computations.

There was one final shortcut. In order to facilitate solving the East African transportation problem (with a 48 by 9 transport cost matrix), we used the final asking prices $\alpha_i^t$ of the smaller transportation problems involving Kenya, Uganda, and Tanganyika as initial asking prices for the larger problem.
Using the above algorithm and its modifications, we were able to solve the large 46 by 9 transportation problem in a few hours each. The algorithm is very efficient for computation by hand as it is readily amenable to ad hoc changes in the rules which on heuristic grounds would seem to lead to a faster solution.

One may derive an algorithm similar to the one above by operating on bid prices. That is, buyers at each point of demand set an initial bid price of $\beta_4^j$, and each supplier offers the whole amount supplied $a_1$ to the point of demand where the bid price less transport cost is the highest. Those points of demand which are oversupplied lower their bid prices and those points which are undersupplied raise their bid price. A solution results whenever bid prices are such that no point of demand has an excess supply or an excess demand. This algorithm takes advantage of part (b) of Theorem 2. During the whole computational procedure conditions (14) and (15) are satisfied and when the optimal solution is reached, equation (12) is satisfied.

Either of the algorithms which we may devise, the one operating on asking prices and the other operating on bid prices, may be viewed as a market mechanism in which, if equilibrium is reached, transport costs are automatically minimized. In the one case, the amounts demanded from each point of supply adjust through variations in the asking price. In the other case, the amounts supplied to each point of demand adjust with variations in the bid price.

V. Results and Conclusions.

Table IV summarizes the results of the calculations.

<table>
<thead>
<tr>
<th></th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Production</td>
<td>Production</td>
</tr>
<tr>
<td>Savings in transport costs if production of each factory allowed to vary ($G_2$)</td>
<td>$2349,501</td>
<td>$9,107</td>
</tr>
<tr>
<td>Savings in transport costs if production of each factory allowed to vary ($G_2$)</td>
<td>$58,990</td>
<td>$342,729</td>
</tr>
<tr>
<td>Total possible savings in transport costs ($G_1 + G_2$)</td>
<td>$256,081</td>
<td>$351,855</td>
</tr>
<tr>
<td>Estimated total transport costs under autarky ($G_1 + G_2 + G_3$)</td>
<td>$21,262,360</td>
<td>$1,758,080</td>
</tr>
<tr>
<td>Total possible savings as percentage of estimated total transport costs under autarky</td>
<td>24</td>
<td>10</td>
</tr>
<tr>
<td>Total value of production (at the East African producer price of 56e per ton)</td>
<td>$21,296,000</td>
<td>$25,436,000</td>
</tr>
<tr>
<td>Total possible savings as a percentage of the total value of production</td>
<td>8</td>
<td>1</td>
</tr>
</tbody>
</table>

Footnote: see next page.
Footnote: Actually \( (C_T + C_U + C_K) \) as we calculated it differs from the actual transport costs by a constant which depends on the way in which points of demand are consolidated. This constant is included in the estimate in the table. In addition, the costs of loading and offloading are not included in the transport cost matrix but have been added to produce the estimate in the table above.

The total possible savings in transport costs are about the same whether minimum or maximum production estimates hold. The source of savings is vastly different, however. If the minimum estimates hold most of the savings occur with a reorganization of the distribution channels. If the maximum estimates hold, most of the savings occur because of a reallocation of production among the firms. Since the maximum estimates are based on the assumption that the newer ventures will go ahead as planned, this leads one to suspect that the relative rates of expansion should be quite different if the maximum savings in transport costs is to be achieved.

The estimates of total possible savings in Table I do not take into account differences in production costs. If there is a difference in production costs among various factories, then the possible savings will be much greater. The total possible savings ignoring differences in production costs, however, represents about 17 per cent of the 1962/63 estimated Uganda government recurrent and capital expenditures on roads. (See (2).)

One must keep in mind that the savings in Table I are based on the assumption that all of the producers will negotiate special rates with East African Railways and Harbours by 1970. If the present official rates were used, the possible savings would perhaps be about 20 per cent greater.

Finally, there is the question of who will benefit from the possible savings in transport costs. Since the total possible savings is only a small proportion of the total value of production, the possible difference in price to the consumer is almost negligible. If the savings resulted in a higher effective price to the producer, they would most likely mean a significant increase in profits. Alternatively, the governments could raise the sugar excise duty and take off the savings as increased government revenue.
BIBLIOGRAPHY.


(6) M. Gerstenhaber.