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An Econometric Model with Applications to
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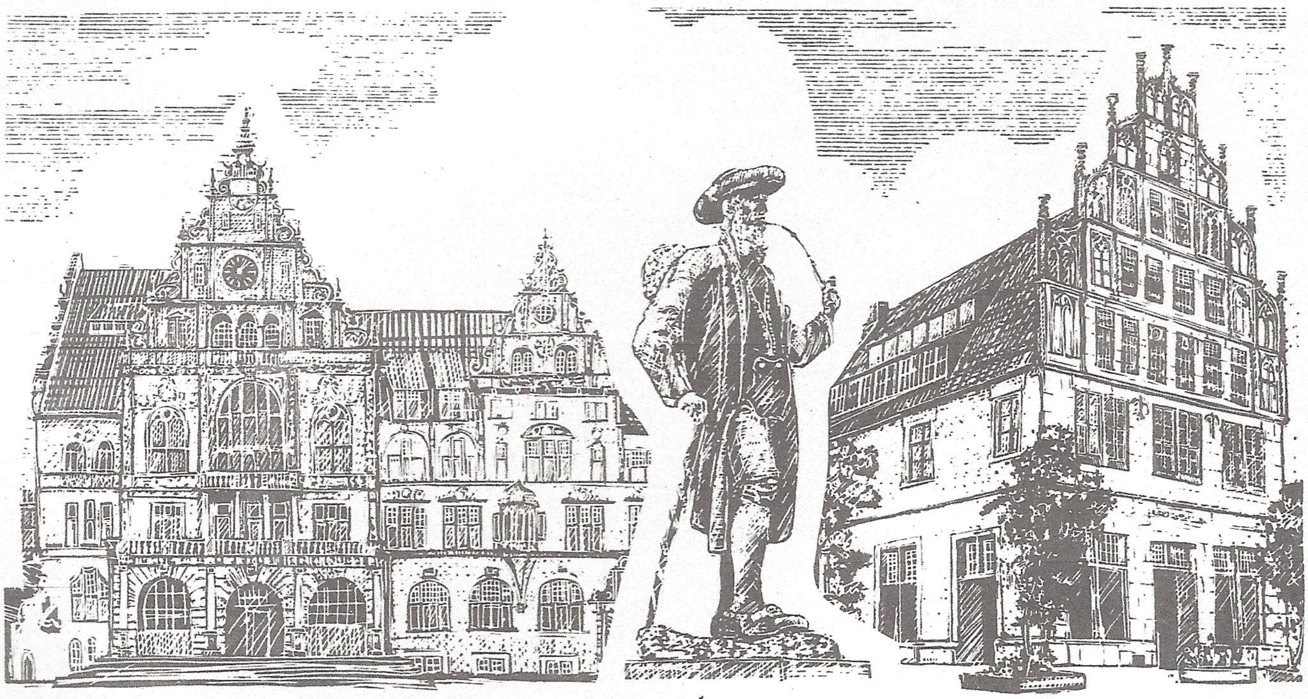

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The World Cotton Market (1953-1965): An Econometric Model with Applications to Economic Policy

I. Introduction:

The development of the world cotton market[1)] after the Second World War is characterized by the following phenomena:

(a) The production surplus:

In the period considered there was a rapid improvement of productivity in agriculture and an increase of acres for cotton production in many small producing countries.

Total world cotton consumption increased during the postwar time, but not so rapid as world production. The result of this development is the expansion of the world cotton stocks.

(b) The influences of the governments of cotton producing countries on cotton production and export, such as support prices for cotton farmers, acreage allotment, soil-bank policy, export subsidies etc., in the U.S.A., various credit conditions for cotton production in distinct areas and export tax in Mexico, support prices, export duties, export quotas etc. in Brazil, support prices, monopolization of the cotton economy by the Egyptian Cotton Commission (E.C.C.) etc. in Egypt.

(c) The severe competition by synthetic fibers:

Since they are industrial products, synthetic fibers are mostly produced in developed countries, i.e. in western europe, the U.S.A., and Japan. With the exception of the U.S.A., these countries are also the important cotton import countries of the World.

(d) The decreasing trend of world cotton prices:

The development is the result of the production surplus, the severe competition from synthetic fibers and the unelastic supply of the export countries.

This paper reports on the econometric results of an investigation of the cotton market.[2)]

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1) Without communist countries.

2) The paper is based in part on the author's doctoral thesis"D Weltbaumwollmarkt - Ein ökonometrisches Modell" which has been presented to the Johann-Wolfgang-Goethe University of Frankfurt am Main, Germany.
I am greatly indebted to Prof. Heinz Sauermann and Prof.

The construction of the model has been prepared by a series of regressions by which various model ideas were examined. On the basic of these "statistical experiments" the model equations were chosen according to the following criteria: (1) correct signs of regression coefficients in the sense of theoretically expected economic relations, (2) high coefficients of determination, (3) statistically significant regression coefficients.

Only the export countries are considered explicitly in the model, for the world cotton market is almost fully determined by the decisions of the export countries. The model consists of seven main sectors, i.e. six export countries which supplied about 75% of the world cotton market in the last twelve years, and the rest of the world as an additional sector. The countries which are aggregated in this sector have very small market shares. There are more than seventy countries in the world which produce cotton, and more than fifty countries which export cotton. The six export countries which are explicitly considered in this model are the U.S.A., Mexico, Brazil, Egypt, Sudan and Peru.

According to its staple length cotton is classified on the world market into three main categories, i.e. short staple (with the staple length of under 3/4 inches), middle staple (with the length between 3/4 inches and 1 1/8 inches), and long or extra-long staple (between 1 1/8 and 1 3/8 inches, respectively over 1 3/8 inches). Because of its small share on the world market the short staple cotton is not considered separately in our model.

Since the U.S.A. is the largest supplier of middle staple cotton, this sort is also called "American cotton" or "American Upland cotton", while the long- and extra-long staple sorts are called Egyptian cotton because of the dominant position of Egypt on the world market for this sort. The U.S.A., Mexico,

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Reinhard Selten without whose guidance this paper would not have been completed, expecially to Prof. Reinhard Selten who made helpful comments. I am also indepted to Professor Lawrence Nitz who read the manuscript.
Any errors are solely my responsibility.

and Brazil supply the first sort, while Egypt, Sudan and Peru supply the second.

The fluctuations of the world market price are the same for the same sort of cotton from different countries because of a high degree of substitutability. American, Mexican and Brazilian cotton prices are highly correlated. The same is true for Egyptian, Peruvian and Sudanes cotton, but there is no correlation between those two groups because there is not much substitution between the two sorts. The correlation coefficients[1)] between the deflated prices of U.S.A., Mexico and Brazil (c.i.f. Liverpool) are all near 0.9. The same is for Egypt, Peru and Sudan. But the correlation coefficients between the deflated prices of American and Egyptian sorts have values near 0.1.

According to this surprising result we must consider the world cotton market as two markets, i.e. the market for American and that for Egyptian cotton.

II. The Structual Equations and the Result of the Estimation

For our statistical estimation we have twelve observations (from 1953/54 to 1964/65). Each observation represents a period of one year. The standard errors of the regression coefficients are given in parenthesis under the respective regression coefficients. MR is the coefficient of determination. DWS is "Durbin-Watson statistic" which is used to test the interdependence of the first-order auto-correlation of residuals of regression equations. In our case the first-order auto-correlation is statistically nonsignificant (5% level of significance), if DWS lies between 0.9 and 3.2.

As world market prices we take the Liverpool c.i.f.-prices which are deflated by Reuter's price index. Domestic market prices of every producing country are deflated by the wholesale price index in the respective country.

In the following we shall present the two-stage least square estimations of the structural equations (see appendix A).

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1) Appendix C

But now we list at first the symbols of variables which are contained in more than one regression equation.

If there are two indices at a variable the first index represents the export country; we use index 1 for the U.S.A., 2 for Mexico, 3 for Brazil, 4 for Egypt, 5 for Sudan, 6 for Peru and 7 for the rest of the world, while the second index refers to the type of the equation. There are 5 types of equations: (1) foreign demand equation, (2) domestic demand equation, (3) total supply equation, (4) world market supply equation and (5) domestic market price equation.

A is the harvested acreages for cotton.
E is the average cotton yield per acreage.
G is the cotton production.
K is the domestic cotton consumption of export country.
L is the beginning stock of export country.
P is the world market price for cotton.
P^{in} is the domestic market price in export country.
P^{u} is the guarentee or support prices for cotton.
R is the dummy variable.
S is the total supply of cotton from a producing country.
T is the linear trend variable.
U is the error term.
X is the cotton export.
Y is the national income in calender year.

(A) U. S. A.

(1) The foreign demand equation (TSLS)[1]:

$$P_1 = 838 - \underset{(0.029)}{0.040}\, X_1 - \underset{(0.008)}{0.025}\, TW_1 + U_{11} \ldots\ldots \qquad (1)$$

$MR = 0.76 \qquad DWS = 2.34$

Where TW_1 is the sum of the total export of American sorts from other countries (XW_1) and the total world production of synthetic fibers not including production in the U.S.A. (KW_1).

1) Two-stage least square estimation.

Equation (1) looks like a demand equation for a quantity variation oligopoly model. Since the government regulations of the export countries influence quantities more directly than prices, this kind of equation seems to be more adequate, than a demand equation with prices as independent and quantity as dependent variable. This alternative approach has been tried as a "statistical experiment" but the coefficient of determination was much lower (0.38).

In equation (1) synthetic fibers produced outside the U.S.A. and American cotton exported from other countries are treated as the same substitute good for cotton from the U.S.A., because the correlation coefficient between P_1 and XW_1 is nearly the same as that between P_1 and KW_1. Besides there is a very high positive correlation between XW_1 and KW_1. By using TW_1 instead of XW_1 and KW_1 separately we did not only get one more degree of freedom which is important because of our small sample size but we also avoided the difficulty of multicollinearity in the regression equation. TW_1 can be regarded as a "representative variable". The more formal method of constructing a representative variable from XW_1 and KW_1 by using the partial correlation coefficients as weights has been tried as a "statistical experiment". The result was nearly the same as that of our equation (1). This method is recommended by some econometricians such as Liu.[1)]

The competitive effects of the Egyptian sort as well as many other model ideas for this equation were also tested by "statistical experiments". There were no significant results.

<u>(2) The domestic demand equation:</u>

$$K_1^P = 51.6 - \underset{(0.007)}{0.064} P_1^{in} + \underset{(0.005)}{0.020} Y_1^P - \underset{(0.39)}{2.65} T + U_{12} \quad \cdots\cdots (2)$$

$$MR = 0.87 \qquad DWS = 1.34$$

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1) Liu, Ta-chung: "An Exploratory Quarterly Econometric Model of affective Demand in the postwar U.S. Economy", Econometrica Vol. 31. 1963. S. 301-348.

where K_1^p is the per capita cotton consumption in the U.S.A. and Y_1^p is the per capita disposable income.

The decreasing trend of K_1^p may be due to the increasing competition from synthetic fibers which are produced in increasing quantities.

The independent variable Y_1^p has a time lag of a half year in comparison to K_1^p, i.e., Y_1^p is the per capita disposable income in the calender-year.

Unfortunately, we could not use a regression equation with Y_1 as independent variable, because regression equations in this forms have either very low coefficients of determination or false signs for the regression coefficients. This may be explained from the compensation between the increasing trend of the population and the decreasing trend of the per capita consumption of cotton in the U.S.A. due to the increasing competition from the synthetic fibers. This compensation can be avoided by taking per capita consumption as dependent and per capita income as independent variables because thereby the influence of the increasing trend of population is eliminated.

We now obtain the domestic demand equation of the U.S.A. as:

$$K_1 = B_1 \cdot K_1^p = B_1 \cdot (51.6 - 0.064P_1^{in} + 0.020Y_1^p - 2.65T + U_{12}) \quad \ldots. (3)$$

where B_1 is the population in the U.S.A.

(3) The total supply equation:

$$A_1 = -848 + \underset{(0.149)}{0.994AA_1} - \underset{(201)}{1113R_{13}} + U_{13} \quad \ldots. \quad (4)$$

$$MR = 0.91 \qquad DWS = 1.67$$

where AA_1 is the acreage allotment of the American government for cotton production.

Equation (4) shows a relation between the acreage allotments, the influence of introducing "soil-bank" policy and the harvested acreages. We may call this equation a decision equation or a behavior equation, because this is not a production equation which describes the relation between the factor-input and the product. The total production in a period according to our definition is the product of the havested acreages which are restricted by the government and the average yield per acre which is treated as an exogenous factor in our model. We are interested in the reaction of the farmers which influences cotton supply. Equation (4) is not influenced by the fluctuations of average cotton yield per acre.

The introduction of the "soil-bank" policy caused the unusual high deviation of the cotton acres harvested from the alloted acreages in 1957/58 and 1958/59. To estimate this effect we make use of a dummy variable and take the value 1 for the years 1957/58 and 1958/59 and 0 for the other years.

We receive the following total supply equation:

$$S_1 = E_1 \cdot (-848+0.994AA_1-1113R_{13}+U_{13}) + L_1 \ldots\ldots (5)$$

where E_1 (average yield per capita) and L_1 are exogenous variables in our model.

(4) The world market supply equation (TSLS):

$$X_1 = \underset{(1.273)}{-2874+5.180}(P_1+Sub_1) - \underset{(129)}{564}R_{41} + U_{14} \ldots\ldots (6)$$

$$MR = 0.81 \qquad DWS = 2.14$$

where Sub_1 is the rate of export subsidy.

From this equation we see that the American export policy, especially the export subsidy, had a decisive influence on the cotton export of the U.S.A. in the period considered. There are two effects of the export subsidy on the export decision: (a) the export encouragement effect and (b) the speculation effect which arises from the suspicion of the cotton exporters about the changes of the export policy of the American government, for example, the change of the subsidy rate or the introduction of new export measures. Since the decision of American export policies are discussed in the Senat for several months, the cotton exporters wait for better export conditions, long before the new measures become effective. This speculation effect occurred in 1955/56, 1958/59 and 1962/62. In order to estimate this effect we use a dummy variable which takes the value 1 for the years.

P_1 and Sub_1 where aggregated as an independent variable in this equation, because the sum of P_1 and Sub_1 means nothing else than the price which the cotton exporters of the U.S.A. received.

(5) Prices at the domestic market:

$$P_1^{in} = 27{,}5 + \underset{(0.440)}{8.929}\ \overline{P}_1^u + U_{15} \quad \ldots\ldots\ldots (7)$$

MR = 0.84 DWS = 1.41

where $\overline{P}_1^u$ is the percentage of the support price in the parity price.

The domestic market prices of the American cotton are determined chiefly by the support prices because the C.C.C. (Commodity Credit Corperation) as an agency of the Agriculture Department guarantees cotton farmers this price for their cotton so that the domestic market prices cannot be lower than the support prices. The C.C.C. sells at prices which consist of the support prices, stock costs and other administrative costs, therefore the domestic market prices cannot be higher than this level.

In the regression equation we take the percentages of the support prices in the parity prices which are calculated by the C.C.C. monthly, instead of taking the support prices. While the support prices as well as the parity prices are changing monthly, the percentages of the support prices are fixed for a year. In order to avoid the calculation of yearly support prices from the percentages and the parity prices and in order to eliminate the influence of statistical observation errors, we take the percentages of support prices in the parity prices as data from the estimation of the regression equation.

The relation between $\overline{P}_1^u$, P_1^u and P_1^p is given as following:

$$\overline{P}_1^u = \frac{P_1^u}{P_1^p} \cdot 100 \quad \ldots\ldots\ (8)$$

(B) Mexico:

(1) The foreign demand equation (TSLS):

$$P_2 = 126 - \underset{(0.139)}{0.312}\ X_2 + \underset{(0.184)}{0.938}\ P_1 + U_{21} \quad \ldots\ldots\ldots (9)$$

MR = 0.78 DWS = 1.74

This demand equation incorporates the idea of American price leadership. Because of high substitution between the cotton from Mexico and from the U.S.A. and because of the dominant position of the U.S.A. at the world market for "upland cotton", the Mexican cotton price depends on the price for cotton from the U.S.A.

A foreign demand equation of the same form as that for the U.S.A. was estimated for Mexico. All regression coefficients and the coefficient of determination are statistically significant. But its coefficient of determination is lower than that of equation (9).

All other forms which we tested for the foreign demand equation of the U.S.A. were also tried for Mexico.

(2) The domestic demand equation (TSLS):

$$K_2 = 118 - \underset{(0.076)}{0.086} P_2^{in} + \underset{(0.038)}{0.297} Y_2 + U_{21} \quad \ldots\ldots\ (10)$$

$$MR = 0.90 \qquad\qquad DWS = 1.74$$

The difference between the domestic demand equation of all other important export countries and that of the U.S.A. rests on the variable Y. While we take the per capita income for the estimation of the U.S. demand equation at the domestic market, the national income is used for the estimation of the domestic demand equations of other important export countries. We have already explained that the compensation of the influences from competition by synthetic fibers and of the rising trend of the population in the U.S.A. induces us to take the average consumption equation instead of a global consumption equation. This compensation does not occur in the other important export countries, because the competition by synthetic fibers does not exist in these countries.

(3) Total supply equation:

$$G_2 = -1196 + \underset{(0.360)}{2.163} P^{in}_{2t-1} + \underset{(4)}{35} T - \underset{(25)}{85} R_{23} + U_{23} \quad \ldots\ldots\ (11)$$

$$MR = 0.87 \qquad\qquad DWS = 2.44$$

where P^{in}_{2t-1} is the domestic price with a time lag of one year.

Due to a better irrigation system, better pest control methods and the use of chemical fertilizer the yield of the Mexican cotton production rose substantially in the last twelve years. This causes an increasing trend of Mexican cotton production. To estimate this trend we use the linear trend variable T.

Unusually poor average cotton yields caused the low cotton production of Mexico in 1959/60 and 1961/62. We take a dummy variable to estimate the influences of **these poor** yields and assign the value 1 for the years 1959/60 and 1961/62 and the value 0 for the other years.

A supply equation of the form used for the U.S.A. was tested for Mexico. But this regression equation has a low coefficient of determination. This may be due to the low price elasticity of acreage input, because the Mexican farmers have no good alternative to the production of cotton, if cotton price decreases, since cotton is the most important agricultural good produced in Mexico.

The form of the supply equation (11) has an advantage in comparison to that of equation (4), because with this equation we could descripe not only the acreage-input of the farmers but also the input of capital and labor (the intensity of the production process), in relation to cotton price. Especially in the developing countries, the farmers can invest more capital only when the revenues are high, because there is capital scarcity in those countries. This is also the reason why the Mexican Government tries to influence the cotton production by credit measures.

(4) The world market supply equation (TSLS)

$$X_2 = \underset{}{-636}+\underset{(0.366)}{0.960}P_2+\underset{(0.181)}{0.803}(G_2-K_2)+\underset{(0.598)}{1.341}L_2+U_{24} \quad \ldots\ldots(12)$$

MR = 0.73 DWS = 2.15

The world market supply equation for Mexico is different from that of the U.S.A., since it is based on another set of variables. An equation similar to that for the U.S.A. has been tried experimentally but it did not give a good fit. The regression equation $X_2 = f(P_2-ES_2, G_2, K_2, L_2)$ has not only a low coefficient of determination but also a false sign for the regression coefficient of the variable (P_2-ES_2). Unlike the export subsidy in the U.S.A., the export tax of Mexico does not seem to have any visible influence on the export decision. This may be due to the following reasons: (i) During the time considered here the tax rate was relatively constant; (ii) The time when tax rates are changed is not in agreement with the period of the cotton year; (iii) The discriminatory tax rates for cotton produced in various areas of Mexico make it difficult to set up a sensible aggregate equation; (iv) The tax rate is relatively low in comparison to the price (about 4-5%)

(5) The domestic market prices:

$$P_2^{in} = P_2 - ES_2 \quad \ldots\ldots\ldots \qquad (13)$$

This is a definition equation.

(C) Brazil:

(1) The foreign demand equation (TSLS):

$$P_3 = \underset{}{-301}-\underset{(0.216)}{1.485}X_3 + \underset{(0.199)}{1.808}P_1 - \underset{(33)}{227}R_{31} \pm U_{31} \quad \ldots\ldots \qquad (14)$$

$$MR = 0.86 \qquad\qquad DWS = 2.34$$

The foreign demand equation of Brazil incorporates the idea of U.S. price leadership. The same was true for the corresponding equation for Mexico. The reason for this is the dominent position of U.S. cotton at the world market for the "upland cotton" as well as the policy of the Brazilian government who buys the cotton at the guarantee prices from the farmers and sells for export at the prices of the New York forward market.

Now we must say some words about the dummy variable contained in this equation. The bad weather from 1956/57 to 1959/60 was not only the cause of lower average yields of cotton production in Brazil but also caused a bad cotton quality in these years. The world market prices for Brazilian cotton in these years were lower, though the exported quantities were also lower in these years. We assign to the dummy variable the value 1 for the years 1956/57, 1957/58, 1958/59 and 1959/60 and the value 0 for the other years.

(2) The domestic demand equation:

$$K_3 = -184 - \underset{(0.038)}{0.240 P_3^{in}} + \underset{(0.333)}{4.412 \overline{Y}_3^p} + U_{32} \quad \ldots\ldots\ldots \qquad (15)$$

$$MR = 0.97 \qquad\qquad DWS = 2.19$$

Where $\overline{Y}_3^p$ is the index of per capita real net national product.

We encounter two difficulties in equation (15): (1) to find a fair basis for comparison between the domestic and the world market prices: we know that the Brazilian government carries on foreign exchange control and multiple exchange rates which were changed from time to time. Therefore there is no unique basis to compare the domestic and the world market prices; (ii) the problem of inflation: the hyperinflation in Brazil in the last years makes it difficult to find a basis for the comparison between prices of different years. It is very difficult to estimate the influences of money illusion and speculation on the cotton consumption.

To avoid the first difficulty we use the domestic market prices in Brazilian monetary units for the estimation of the regression equation. To be free from the second difficulty, we take the deflated domestic prices for the estimation of this equation.

(3) The total supply equation:

$$A_3 = 1222 + \underset{(0.246)}{0.511 P_3^u} - \underset{(0.273)}{0.219 P_3^K} + U_{33} \quad \ldots\ldots\ldots \qquad (16)$$

$$MR = 0.55 \qquad\qquad DWS = 1.71$$

Where P_3^K is the world market price for coffee at New York market.

This is a decision equation of the farmers about the land input for cotton production. We know that the Brazilian cotton is produced chiefly in the State Sao Paulo where coffee is a serious competitive product for cotton. Therefore coffee price was taken as one of the important factors which influence the production decisions of Brazilian cotton farmers.

The total supply equation is given as follows:

$$S_3 = E_3 \cdot A_3 + L_3 = E_3 \cdot (1222 + 0.511 P_3^u - 0.219 P_3^K + U_{33}) + L_3 \quad \ldots\ldots \quad (17)$$

where E_3 and L_3 are both exogeneous in our model.

(4) The world market supply equation:

$$X_3 = -54 + \underset{(0.078)}{0.647}\,(G_3 - K_3) + \underset{(0.062)}{0.663} L_3 + U_{34} \quad \ldots\ldots \quad (18)$$

MR = 0.96 DWS = 2.44

Other than those of the U.S.A. and Mexico the supply equation (18) of Brazilian cotton at the world market contains no independent variable "price". The same form of supply equation as that for Mexico was set up, but it has a false sign for the variable P_3. This may be explained by the fact that exchange rates for cotton export are sometimes changed several times during a year. The prices which the exporters receive are the prices in their home monetary unit. Therefore the exchange rate may have an important influence on their export decision.

It is fair that we take $(G_3 - K_3)$ as an independent variable in our equation (18), because the Brazilian government has to protect the domestic consumption of cotton.

(5) The domestic market prices:

$$P_3^{in} = 15 + \underset{(0.181)}{0.950}\, P_3^u + U_{35} \quad \ldots\ldots\ldots \quad (19)$$

MR = 0.71 DWS = 0.5

The equation (19) has the same form as that of the U.S.A.; i.e. the domestic market price is a function of the guarantee price.

From the DWS of equation (19) we see that there is a high autocorrelation of the residues which violates the assumption about the error term. We shall try to avoid this autocorrelation of the residues by autoregressive transformation.[1] The transformated equation is:

$$(P^{in}_{3t} - 0.76P^{in}_{3t-1}) = 12 + \underset{(0.249)}{0.751}\,(P^{u}_{3t} - 0.76P^{u}_{3t-1}) + U_{36} \quad \ldots(20)$$

$$MR = 0.69 \qquad\qquad DWS = 1.12$$

The high autocorrelation of the equation (19) may be explained by: (i) the decreasing trend of the world coffee prices indues the Brazilian government to promote cotton production in Brazil. Hence the guarantee prices have an increasing trend; (ii) the hyperinflation in Brazil during the last years in responsible for the increasing trend of the domestic cotton prices in Brazil. To protect the real income of farmers the guarantee prices for cotton must increase with the general price level. Probably the high autocorrelation of (19) is due to the fact that we did not consider these factors explicitly.

To avoid this high autocorrelation we could take more independent variables such as P^{u}_{3t-1} and P^{in}_{3t-1} into the regression equation. But this method has some disadvantages: (i) the number of independent variables which we can take into an equation is limited by the small statistic sample; (ii) due to the high correlation between P^{u}_{3t} an the other independent variables which are in the equation now, it may cause high multicollinearity in the equation.

Another way to cope with the high autocorrelation is the autoregressive transformation as we use it here. It is not objectionable to employ the method in our equation (19), since this equation is recursive in our model.

For the autoregressive transformation we take the first autocorrelation coefficient of the residues as the parameter "a" in the following linear stochastic difference equation of first-order:

$$X'_t = aX'_{t-1} + V_t$$

1) Tintner, G.: Econometrics. New York. 1952. Pp. 323.
Tintner, G.: Handbuch der Ökonometrie. Berlin, Göttingen, Heidelberg. 1960. Pp.305.

where V is a random variable with expectation zero, constant deviation and no autocorrelation. This stochastic process is a Markoff-process.[1)]

(D) Egypt:

(1) The foreign demand equation (TSLS)

$$P_4 = 1758 - \underset{(0.359)}{1.501} (X_4+X_5+X_6) + \underset{(56)}{221} R_{41} + U_{41} \quad \ldots\ldots \quad (21)$$

$$MR = 0.88 \qquad DWS = 2.51$$

The Egyptians have a dominant position at the world cotton market for the long- and extra-long-staple sorts. We have seen that the world cotton market can be considered as two partial markets; i.e. a market for middle staple sorts and a market for long- and extra-long-staple sorts.

The assumption of price leadership of the American cotton for Egypt is refused because of the low coefficient of determination (MR = 0.05). The regression equation of the form for equation (1) is also tested for the foreign demand equation for Egyptian cotton. This is refused because of low coefficient of determination (MR = 0.36), since the variable TW_4 has only a low correlation coefficient with P_4.

The Suez-canal crisis has influenced seriously the demand for Egyptian cotton at the world market. To estimate this influence we take a dummy variable in our equation (21) and assign the value 1 for the years 1955/56 and 1956/57 and the value 0 for the other years.

(2) The domestic demand equation:

$$K_4 = 85 - \underset{(0.078)}{0.152} P_4^{in} + \underset{(0.36)}{6.1} T + U_{42} \quad \ldots\ldots \quad (22)$$

$$MR = 0.98 \qquad DWS = 2.38$$

This equation has the same form as the domestic demand equation of Mexico and Brazil. Because we have no statistic

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1) Tintner, G.: op.cit.(1952). S. 324
   Tintner, G.: op.cit.(1960. S. 295

materials about the national income of Egypt, a linear trend variable is used expressing the assumption that the cotton consumption in Egypt is increasing because of the industrialization and the development of national income.

To estimate the equation (22) we use the domestic market price in Egyptian monetary units.

<u>(3) The total supply equation:</u>

$$G_4 = -195 + \underset{(0.213)}{0.734P_4^u} + \underset{(3)}{13T} - \underset{(26)}{128R_{43}} + U_{43} \ldots\ldots \quad (23)$$

$$MR = 0.84 \qquad DWS = 2.36$$

The equation differs only by one variable from the supply equation of Mexico. We have a time lagged variable P_{2t-1}^{in} for the case of Mexico and the guarantee price for the case of Egypt, because the guarantee price is the price which the farmers receive for their cotton, especially after the monopolization of the cotton economy by the ECC (Egypt Cotton Committee).

The linear trend variable could be interpreted as improvement of average yield in the agriculture.

The dummy variable is used to estimate the influences of qualitative factors such as weather on the cotton production in Egypt. We assign the value 1 to the years 1955/56, 1956/57 and 1961/62 and the value 0 to the other years. The low yield in 1955/56 and 1956/57 were caused by the Suez-canal crisis; in 1961/62 yields were low because of bad weather.

<u>(4) The world market supply equation (TSLS):</u>

$$X_4 = -1507 + \underset{(0.064)}{0.794P_4} + \underset{(0.199)}{2.894(G_4-K_4)} + \underset{(0.127)}{1.331L_4} + U_{44} \ldots (24)$$

$$MR = 0.95 \qquad DWS = 1.47$$

In this equation we use the difference between the production and the domestic consumption as an independent variable as in equation (18), because the Egyptian government has to protect the domestic demand.

<u>(5) The domestic market prices:</u>

$$P_4^{in} = (P_4 - ES_4) \cdot W_4 \ldots\ldots \quad (25)$$

where W_4 is the exchange rate and P_4^{in} in measured in Egyptian monetary units.

Though the Egyptian government (by ECC) gives their farmers a guarantee price for cotton, it tries to uphold an uniform price system for the domestic and the world market. The domestic market price differs from the world market price only by the export tax.

The relation between the domestic market price and the guarantee price has been investigated. There is only a low correlation between these variables. This can be explained by the policy of the Egyptian government, because the E.C.C. fixes its selling price of cotton independent of the guarantee price.

(E) Sudan:

(1) The foreign demand equation (TSLS):

$$P_5 = 418 - \underset{(1.046)}{1.587X_5} + \underset{(0.192)}{0.660P_4} + U_{51} \quad \ldots\ldots\ldots \quad (26)$$

$$MR = 0.75 \qquad DWS = 2.42$$

Because Egypt has a dominant position for long- and extra-long-staple cotton at the world market, the foreign demand equation for Sudanese cotton has the cotton price of Egypt as independent variable, which means that Egyptian price leadership is assumed for long- and extra-long-staple cotton. The market share of Sudan is relatively small.

(3) The total supply equation:

$$G_5 = -112 + \underset{(0.069)}{0.195P_{5t-1}} + \underset{(2.6)}{12T} - \underset{(19)}{80R_{52}} + U_{53} \quad \ldots\ldots \quad (27)$$

$$MR = 0.74 \qquad DWS = 1.66$$

Equation (27) has the same form as equation (11) for Mexico. The Sudanese government does not give a guarantee price for cotton.

The linear trend variable is used to estimate the increasing acreage yield in the last twelve years.

The dummy variable is used to express the influences of the bad weather condition on cotton production. We assign the value 1 to the years 1957/58, 1959/60 and 1963/64 in which the bad weather happened, and the value 0 to the other years.

(4) The world market supply equation (TSLS)

$$X_5 = 9 + \underset{(0.199)}{0.467G_5} + \underset{(0.211)}{0.609L_5} + U_{54} \quad \ldots\ldots \qquad (28)$$

MR = 0.63 DWS = 2.35

A regression equation of the form of the Egyptian supply equation at the world market has a lower coefficient of determination and a statistically non-significant regression coefficient for P_5. The cotton supply from Sudan at the world market seems to depend mainly upon production and beginning stocks. This may be due to the limited capacity of the stock houses and high inventory costs.

The domestic consumption of the Sudan is very small; consequently we shall not consider it explicitly. The same can be said about Peru.

(F) Peru:

(1) The foreign demand equation (TSLS):

$$P_6 = 924 - \underset{(1.531)}{2.738X_6} + \underset{(0.158)}{0.193P_4} + U_{61} \quad \ldots\ldots\ldots\ldots \qquad (29)$$

MR = 0.55 DWS = 2.22

This is the same form of foreign demand equation as that of equation (26) for the Sudan. The average prices for Peruvian cotton at the world market are somewhat lower than those for Egyptian and for Sudanese cotton. This is due to the lower quality of Peruvian cotton, especially to the shorter staple length.

(3) The total supply equation:

$$G_6 = 42 + \underset{(0.060)}{0.073P_{6t-1}} + \underset{(1)}{3T} - \underset{(12)}{14R_{62}} + U_{63} \quad \ldots\ldots \qquad (30)$$

MR = 0.58 DWS = 2.51

In this equation only the dummy variable requires some explanations. We assign to it the value 1 for the years 1954/55, 1956/57 and 1957/58 in which bad weather condition caused lower average yields of cotton production.

(4) The world market supply equation (TSLS):

$$X_6 = -38 + \underset{(0.66)}{0.996G_6} + \underset{(0.329)}{0.562L_6} + U_{63} \quad \ldots\ldots\ldots\ldots \qquad (31)$$

$$MR = 0.66 \qquad DWS = 2.04$$

This is the same form as that of equation (28) for the Sudan.

(G) The rest of the world:

To complete our model of the world cotton market, we aggregate all other countries which were not considered explicitly in our model. They have a joint market share of about 20%.

In our model the export of the rest of the world was taken as part of the independent variable TW_1 for the equation (1). The regression equation for X_7 is estimated as follows:

$$X_7 = -800 + \underset{(0.221)}{0.770G_7} - \underset{(26)}{40T} + U_{71} \quad \ldots\ldots\ldots \qquad (32)$$

$$MR = 0.78 \qquad DWS = 2.15$$

The negative coefficient for the linear trend variable of our equation (32) could be explained by the increasing consumption in these countries since the end of the Second World War, because the most countries of the rest of the world belong to the developing countries which try to develop their industry.

Due to equation (32) in which we have introduced one more endogeneous variable G_7, we must have one more structual equation to close our model. This is the supply equation of the rest of the world.

$$G_7 = 1781 + \underset{(22)}{108\ T} + U_{73} \quad \ldots\ldots\ldots \qquad (33)$$

$$MR = 0.85 \qquad DWS = 1.10$$

Owing to technical progress many countries in which no cotton could be produced become cotton producing and even export countries. The linear trend variable T is used to estimate this tendency.

III. Two recursive models

Whether an econometric model should be recursive or interdependent is a much discussed problem. It is not only important for the economic interpretation but also for the method of estimation. As a "statistic experiment" two recursive models were tried beside the interdependent models above. These models are based on the following submodels for the demand relationship.

(A) The cobweb-model with

(1) The demand function: $P_i = f(x_i, TW_i)$ and

(2) the supply function: $x_i = g(P_{it-1}, G_i - K_i, L_i)$

This results in a bad fit, probably because the reaction period of the cotton exporters is much shorter than one year.

A time-lag of three or four months would be more realistic, but we do not have the statistical material necessary for the exploration of this idea.

(B) The Samuelson-Wold model with

(1) the demand function: $D_t = f(P_t, Z_t)$;

(2) the supply function: $S_t = g(P_{t-1}, X_t)$ and

(3) the price mechanism function: $P_t = h(S_t - D_{t-1}, Y_t)$

where D_t is demand at period t; S_t is supply at period t, P_t is the price at period t; Z_t, X_t and Y_t are exogeneous variables; P_{t-1} indicates the lagged price.

This model was rejected for the following reasons:

(a) The demand functions have low coefficients of determination (under 0,50) and statistically nonsignificant regression coefficients. This may be due to the export policies of the export countries as we have explained during the discussion of the U.S. foreign demand equation.

(b) The reaction period of one year is apparently too long.

IV Application of the Economcetric Model for the World Cotton Market:

1. The Reduced Forms:

The application of economic models to real economic decisions requires first, that the assumptions of the model be acceptable and second, that the parameters in the economic model be known. Both conditions are fulfilled by our econometric model for the world cotton market. We want to analyse the influence of cotton producing countries' governments on cotton production, consumption, export and price as well as on the revenue of foreign exchanges. For this purpose we shall first solve the interdependent part of our econometric model.

The interdependent part of the submodel for the middle staple cotton can be written in matrixform as follows:

$$\Phi_{12} \cdot X'_{12} = \beta'_{12} \qquad \ldots (34)$$

$$\Phi_{12} = \begin{array}{c} \begin{array}{cccccc} P_1 & X_1 & P_2 & K_2 & X_2 & P_3 \end{array} \\ \begin{bmatrix} 1{,}0 & 0{,}04 & & & 0{,}025 & \\ -5{,}18 & 1{,}0 & & & & \\ -0{,}938 & & 1{,}0 & & 0{,}312 & \\ & & 0{,}086 & 1{,}0 & & \\ & & -0{,}96 & 0{,}803 & 1{,}0 & \\ -1{,}808 & & & & & 1.0 \end{bmatrix} \end{array}$$

$X_{12} = (P_1, X_1, P_2, K_2, X_2, P_3)$

and

$$\beta'_{12} = \begin{bmatrix} 836{,}4 - 0{,}025\ \hat{TW}_1 - (19{,}8 + 0{,}0083\ P_3^u - 0{,}0036\ P_3^k)\cdot \\ \qquad E_3 - 0{,}0037\ P_3^u + 0{,}0714\ Y_3^P - 0{,}0166\ L_3 \\ -2874 + 5{,}18\ Sub_1 - 564\ R_{14} \\ 126 \\ 1{,}8 + 0{,}086\ ES_2 + 0{,}297\ Y_2 \\ -1596{,}4 + 1{,}7369\cdot(P_{2t-1} - ES_2) + 28{,}4\ T - 683\ R_{23} \\ \qquad + 1{,}341\ L_2 \\ -397{,}4 - (1172{,}5 + 0{,}491\ P_3^u - 0{,}2106\ P_3^k)\cdot E_3 + 4{,}234\ \bar{Y}_3^P \\ \qquad - 0{,}2195\ P_3^u - 0{,}9832\ L_3 - 227\ R_{31} \end{bmatrix}$$

The interdependent part of the submodel for the long- and extra-long staple cotton can be written in matrixform as follows:

$$\Phi_{22} \cdot X'_{22} = \beta'_{22} \qquad \ldots (35)$$

with

$$\Phi = \begin{array}{ccc} P_4 & K_4 & X_4 \\ \end{array}$$

$$\Phi = \begin{bmatrix} 1 & & 1.501 \\ 0{,}152 & 1 & \\ -0{,}794 & 2{,}894 & 1 \end{bmatrix}$$

$X_{22} = (P_4, K_4, X_4)$

and

$$\beta'_{22} = \begin{bmatrix} 1817 - 0{,}9141\ L_{5t} - 0{,}8436\ L_{6t} - 0{,}1367\ P_{5t-1} \\ - 0{,}1091\ P_{6t-1} - 12{,}9t + 221\ R_{41} + 56{,}1\ R_{52} \\ + 20{,}93\ R_{62} \\ 85 + 0{,}152\ ES_{4t} + 6{,}1t \\ -2071 + 2{,}1242\ P^{u}_{4t} + 37{,}6t - 370\ R_{43} + 1{,}331\ L_{4t} \end{bmatrix}$$

The inverse-matrices for Φ_{12} and Φ_{22} are

$$\Phi^{-1}_{12} = \begin{bmatrix} 0{,}816 & -0{,}0326 & -0{,}0159 & 0{,}0124 & -0{,}0154 & 0 \\ 4{,}227 & 0{,}8309 & -0{,}0823 & 0{,}0624 & -0{,}0800 & 0 \\ 0{,}5794 & -0{,}0232 & 0{,}7457 & 0{,}1985 & -0{,}2471 & 0 \\ -0{,}4983 & 0{,}002 & -0{,}0641 & 0{,}9829 & 0{,}0213 & 0 \\ 0{,}5962 & -0{,}0238 & 0{,}7673 & -0{,}5988 & 0{,}7457 & 0 \\ 1{,}4754 & -0{,}059 & -0{,}0287 & 0{,}0024 & -0{,}0279 & 1 \end{bmatrix} \quad \ldots (36)$$

and

$$\Phi_{22}^{-1} = \begin{bmatrix} 0,3506 & 1,5231 & -0,5263 \\ -0,0533 & 0,7685 & 0,080 \\ 0,4326 & -1,0147 & 0,3506 \end{bmatrix} \quad \ldots (37)$$

The reduced forms solved from the econometric model for the world cotton market are given by the following equations:

$$P_{1t}^{in} = 27,5 + 8,929\ \bar{P}_{1t}^{u} \quad \ldots (38)$$

$$K_{1t} = B_{1t} \cdot (49,8 + 0,02Y_t^P - 2,65t - 0,571\ \bar{P}_{1t}^{u}) \quad \ldots (39)$$

$$A_{1t} = -848 + 0,994AA_{1t} - 1113R_{13} \quad \ldots (40)$$

$$G_{1t} = E_{1t} \cdot A_{1t} \quad \ldots (41)$$

$$G_{2t} = -1196 + 2,163(P_{2t-1} - ES_{2t-1}) + 35t - 85R_{23} \ldots (42)$$

$$P_{3t}^{in} = 15 + 0,95P_{3t}^{u} \quad \ldots (43)$$

$$K_{3t} = -184,4 + 4,412\ \bar{Y}_{3t}^{P} - 0,228P_{3t}^{u} \quad \ldots (44)$$

$$A_{3t} = 1222 + 0,511\ P_{3t}^{u} - 0,219\ P_{3t}^{k} \quad \ldots (45)$$

$$G_{3t} = E_{3t} \cdot A_{3t} \quad \ldots (46)$$

$$X_{3t} = -54 + 0,647\ (G_{3t} - K_{3t}) + 0,663 \cdot L_{3t} \quad \ldots (47)$$

$$\begin{aligned} P_{1t} = 800,3 &- 0,0204\ \hat{TW}_{1t} - 0,0013\ (G_{3t} - K_{3t}) \\ &- 0,0135L_{3t} - 0,1689SUB_{1t} \\ &+ 18,4R_{14} + 0,0278ES_{2t} + 0,0037\ Y_{2t} \\ &- 0,0267\ P_{2t-1} - 0,4t + 1,1R_{23} \quad \ldots (48) \\ &- 0,0207\ L_{2t} \end{aligned}$$

$$X_1 = 1262 - 0{,}1057\hat{T}W_{1t} - 0{,}0686\ (G_{3t}-K_{3t}) - 0{,}0702L_{3t} + 4{,}3041\ Sub_{1t} - 467{,}6R_{14} + 0{,}1445ES_{2t} + 0{,}0191\ Y_{2t} - 0{,}139\ P_{2t-1} - 23t + 5{,}5\ R_{23} - 0{,}1073\ L_{2t} \qquad \ldots(49)$$

$$P_{2t} = 1061{,}5 - 0{,}0145\hat{T}W_{1t} - (0{,}0094\ (G_{3t}-K_{3t}) - 0{,}0096L_{3t} - 0{,}1202Sub_{1t} + 13{,}1R_{14} + 0{,}4463ES_{2t} + 0{,}059Y_{2t} - 0{,}4292P_{2t-1} - 7{,}0t + 16{,}9R_{23} - 0{,}3314L_{2t} \qquad \ldots(50)$$

$$K_{2t} = 448{,}6 + 0{,}0125\hat{T}W_{1t} + 0{,}0081\ (G_{3t}-K_{3t}) + 0{,}0083L_{3t} + 0{,}0104Sub_{1t} - 1{,}1R_{14} + 0{,}0475ES_{2t} + 0{,}2919Y_{2t} + 0{,}037P_{2t-1} + 0{,}6t - 1{,}5R_{23} + 0{,}0286L_{2t} \qquad \ldots(51)$$

$$X_{2t} = -540 - 0{,}0149\hat{T}W_{1t} - 0{,}008\ (G_{3t}-K_{3t}) - 0{,}0099L_{3t} - 0{,}1233Sub_{1t} + 1{,}3R_{14} - 1{,}3659ES_{2t} - 0{,}1778Y_{2t} + 1{,}2952P_{2t-1} + 21{,}2t - 51{,}3R_{23} + 1{,}0 \cdot L_{2t} \qquad \ldots(52)$$

$$P_{3t} = 528{,}6 - 0{,}0369\hat{T}W_{1t} - 0{,}985\ (G_{3t}-K_{3t}) - 1{,}0077 \cdot L_{3t} - 227 \cdot R_{31} - 0{,}3056Sub_{1t} + 3{,}3 \cdot R_{14} + 0{,}0504 \cdot ES_{2t} + 0{,}0067Y_{2t} - 0{,}0485P_{2t-1} - 0{,}8t + 1{,}9 \cdot R_{23} - 0{,}0374L_{2t} \qquad \ldots(53)$$

$$G_{4t} = -195 + 0{,}734P^{u}_{4t} + 13t - 128R_{43} \qquad \ldots(54)$$

$$G_{5t} = -112 + 0{,}195P_{5t-1} + 12t - 80R_{52} \qquad \ldots(55)$$

$$G_{6t} = 42 + 0{,}073\ P_{6t-1} + 3t - 14R_{62} \qquad \ldots(56)$$

$$X_{5t} = -43 + 0{,}0911P_{5t-1} + 5{\cdot}6T - 37{,}4R_{52} + 0{,}609L_{5t} \qquad \ldots(57)$$

$$X_{6t} = 4 + 0{,}0727P_{6t-1} + 3t + 14\,R_{62} + 0{,}562L_{6t} \qquad \ldots(58)$$

$$\begin{aligned} X_{4t} = {} & -26 + 0{,}4667\,L_{4t} - 0{,}3954\,L_{5t} - 0{,}3649\,L_{6t} \\ & + 0{,}7447P^{u}_{4t} - 0{,}0591P_{5t-1} - 0{,}0472P_{6t-1} \\ & - 0{,}1542ES_{4t} + 1{,}4t + 95{,}6R_{41} + 24{,}3R_{52} + 9{,}1R_{62} \\ & - 129{,}7R_{43} \end{aligned} \qquad \ldots(59)$$

$$\begin{aligned} P_{4t} = {} & 1856 - 0{,}7005\,L_{4t} - 0{,}3205\,L_{5t} - 0{,}2958L_{6t} \\ & + 0{,}2315\,ES_{4t} - 1{,}118\,P^{u}_{4t} - 0{,}0479\,P_{5t-1} \\ & - 0{,}0383\,P_{6t-1} - 15t + 77\,R_{41} + 195\,R_{43} + 20\,R_{52} \\ & + 7\,R_{62} \end{aligned} \qquad \ldots(60)$$

$$\begin{aligned} K_{4t} = {} & -197 + 0{,}1065\,L_{4t} + 0{,}0487L_{5t} + 0{,}045\,L_{6t} \\ & + 0{,}0073\,P_{5t-1} + 0{,}0058\,P_{6t-1} + 0{,}1699\,P^{u}_{4t} \\ & + 0{,}1168\,ES_{4t} + 8{,}4t - 12\,R_{41} - 3\,R_{52} - R_{62} \\ & - 30\,R_{43} \end{aligned} \qquad \ldots(61)$$

$$\begin{aligned} P_{5t} = {} & 1312 - 0{,}7379\,P^{u}_{4t} - 0{,}1761\,P_{5t-1} - 0{,}4623\,L_{4t} \\ & - 1{,}178\,L_{5t} - 0{,}1952\,L_{6t} + 0{,}1528\,ES_{4t} \\ & - 0{,}0253\,P_{6t-1} - 25{,}1t + 72\,R_{52} + 5\,R_{62} + 51\,R_{41} \\ & + 129\,R_{43} \end{aligned} \qquad \ldots(62)$$

$$P_{6t} = 1272 - 0{,}2158\ P^{u}_{4t} - 0{,}1352\ L_{4t} - 0{,}0092\ P_{5t-1}$$
$$- 0{,}2065\ P_{6t-1} - 0{,}0619\ L_{5t} - 1{,}5959\ L_{6t} + 0{,}0447\ ES_{4t}$$
$$- 13{,}5t + 39\ R_{62} + 15\ R_{41} + 38\ R_{43} + 4R_{52} \qquad ...(63)$$

For simplification we set in our following discussion:

$$R_{13} = R_{14} = R_{23} = R_{31} = R_{41} = R_{43} = R_{52} + R_{62} = 0$$

2. The Solution of the Systems of Difference Equations

The reduced forms obtained from our model given above consist of two difference equation systems for the middle staple cotton and the long and extra-long staple cotton respectively. The time-lags occur in these variables as P_2, L_2, L_3, L_4, P_5, P_6, L_4, L_5 and L_6 due to the reactions of cotton producers in Mexico, Sudan and Peru to the cotton prices and the effects of stocks to the export supply in Mexico, Brasil, Egypt, Sudan and Peru.

Solving the systems of the difference equations we can see easily that our econometric model for the world cotton market is stable. Therefore we can use a comparative-static and -dynamic analysis of the particular solutions to the difference equation system to find the effects of exogeneous variables, particularly those of economic policy variables.

Using the definition for the stock L_i

$$L_{it} = L_{it-1} + G_{it-1} - K_{it-1} - X_{it-1} \qquad \ldots (64)$$

for $i = 1,2,\ldots,6$

assuming the exogeneous variables are stationary and specifying:

$$K_{it} = \tilde{K}_{it} + \bar{K}^o_{it} \;; \qquad \bar{K}^o_{it} = \bar{K}_i + K^o_i\, t$$

$$G_{it} = \tilde{G}_{it} + \bar{G}^o_{it} \;; \qquad \bar{G}^o_{it} = \bar{G}_i + G^o_i\, t$$

$$X_{it} = \tilde{X}_{it} + \bar{X}^o_{it} \;; \qquad \bar{X}^o_{it} = \bar{X}_i + X^o_i\, t$$

$$P_{it} = \tilde{P}_{it} + \bar{P}^o_{it} \;; \qquad \bar{P}^o_{it} = \bar{P}_i + P^o_t\, t$$

$$L_{it} = \tilde{L}_{it} + \bar{L}_{it} \;; \qquad \bar{L}_{it} = \bar{L}_i + L^o_{it}$$

for $i = 1, 2, \ldots, 6.$

We solve the difference equations for the middle staple cotton.

For Brazil we have:

$$\left.\begin{aligned} \tilde{L}_{3t} &= (L_{30} - \bar{L}^{o}_{30})\ 0{,}337\ t \\ \bar{L}^{o}_{3t} &= 81 + 0{,}532\ (\bar{G}_3 - \bar{K}_3) + \frac{(G^{o}_3 - K^{o}_3)}{0{,}663 + \frac{1}{(t-1)}} \end{aligned}\right\} \quad \ldots (65)$$

$$\bar{X}^{o}_{3t} = -54 + 0{,}647 \left[(\bar{G}_3 - \bar{K}_3) + (G^{o}_3 - K^{o}_3)\ t\right] + 0{,}663\ \bar{L}^{o}_{3t} \quad \ldots (66)$$

For U.S.A. and Mexico we have to solve:

$$\left.\begin{aligned} P_{2t} + 0{,}4292\ P_{2t-1} + 0{,}3314\ L_{2t} &= M_{21} \\ -\ 0{,}8308\ P_{2t-2} + L_{2t} + 0{,}0286\ L_{2t-1} &= M_{22} \end{aligned}\right\} \quad \ldots (67)$$

with
$$\begin{aligned} M_{21} = {} & 1061{,}5 - 0{,}0145\ \hat{TW}_{1t} - 0{,}0094\ (G_{3t} - K_{3t}) \\ & -0{,}1202\ SUB_{1t} + 0{,}4463\ ES_{2t} + 0{,}059\ Y_{2t} - 7t \\ & -0{,}0096\ L_{3t} \end{aligned}$$

$$\begin{aligned} M_{22} = {} & -1106 + 0{,}0024\ \hat{TW}_{1t} + 0{,}0015\ (G_{3t} - K_{3t}) + 0{,}1129\ SUB_{1t} \\ & +1{,}3184\ ES_{2t} - 0{,}1141\ Y_{2t} + 13{,}2t - 2{,}163\ ES_{2t-1} \end{aligned}$$

The roots of the characteristic equation of the difference equation system (67) are:

$$0,\ -0{,}2289 \pm \sqrt{0{,}2352} \cdot \sqrt{-1}$$

Consequently the difference equation system (67) is stable. The particular solutions for (67) are:

$$\bar{L}^{o}_{2t} = (0{,}476\ \bar{M}_{21} + 0{,}8188\ \bar{M}_{22}) + \frac{(0{,}8308t^{2} - 1{,}6616t)\ M^{o}_{21} + (1{,}4292t^{2} - 0{,}4292t)\ M^{o}_{22}}{1{,}7453t^{2} - 1{,}033^{t} + 0{,}0123} \qquad \dots (68)$$

$$\bar{P}^{o}_{2t} = (0{,}5893\ \bar{M}_{21} - 0{,}1899\ \bar{M}_{22}) + \frac{(1{,}0286t^{2} - 0{,}0286t)\ M^{o}_{21} - 0{,}3314t^{2}\ M^{o}_{22}}{1{,}7453t^{2} - 1{,}033t + 0{,}0123} \qquad \dots (69)$$

assuming: $M_{21} = \bar{M}_{21} + M^{o}_{21} \cdot t$

$M_{22} = \bar{M}_{22} + M^{o}_{22} \cdot t$

$\bar{M}_{21}$, M^{o}_{21}, $\bar{M}_{22}$ and M^{o}_{22} are constant

$1{,}7453t^{2} - 1{,}033t + 0{,}0123 > 0$ for $t \geq 0$

For the sub-model for the long- and extra-long staple cotton we have to solve the following difference euqation system:

$$L_{4t} - 0{,}4488\ L_{4t-1} - 0{,}2945\ L_{5t} - 0{,}1675\ L_{5t-1} - 2{,}7204\ L_{6t} - 0{,}2553\ L_{6t-1} = M_4 \qquad \ldots (70)$$

$$0{,}0567\ L_{4t-2} + L_{5t} - 0{,}1605\ L_{5t-1} + 0{,}1072\ L_{5t-2} + 0{,}4246\ L_{6t} + 0{,}0412\ L_{6t-1} = M_5 \qquad \ldots (71)$$

$$0{,}0013\ L_{4t-2} + 0{,}0011\ L_{5t-1} + 0{,}0006\ L_{5t} + L_{6t} + 0{,}1284\ L_{6t-1} + 0{,}0179\ L_{6t-2} = M_6 \qquad \ldots (72)$$

where $M_4 = -1751 - 0{,}5\ P^u_{4t} + 9{,}1\ t + 1{,}1261\ ES_{4t}$

$M_5 = 85 + 0{,}014\ ES_t - 0{,}1315\ P^u_{4t} - 5t$

$M_6 = -51{,}5 - 0{,}0031\ P^u_{4t} + 0{,}0003\ ES_{4t} - 0{,}6t$

The roots of the characteristic equation of the difference equation system (70), (71) and (72) are:

$$0{,}39 - 0{,}045 \pm\sqrt{0{,}0893}\ \sqrt{-1} \quad \text{and}$$

$$0{,}0905 \pm\sqrt{0{,}3766}\ \sqrt{-1}$$

We see that this difference equation system is stable. The particular solutions are:

$$\bar{L}^{o}_{4t} = 1{,}7188\ \bar{M}_4 + 0{,}8314\ \bar{M}_5 + 4{,}1241\ \bar{M}_6$$
$$+ \frac{1}{D(t)}(D_{11}(t)M^{o}_{4}t + D_{21}(t)M^{o}_{5t} - D_{31}(t)M^{o}_{6t}) \quad \ldots (73)$$

$$\bar{L}^{o}_{5t} = 0{,}1021\ \bar{M}_4 + 1{,}0076\ \bar{M}_5 - 0{,}6744\ \bar{M}_6$$
$$+ \frac{1}{D(t)}(D_{12}(t)M^{o}_{4}t + D_{22}(t)M^{o}_{5}t - D_{23}(t)M^{o}_{6}t\ ) \quad \ldots (74)$$

$$\bar{L}^{o}_{6t} = -0{,}0017\ \bar{M}_4 - 0{,}0024\ \bar{M}_5 + 0{,}8686\ \bar{M}_6$$
$$+ \frac{1}{D(t)}(D_{13}(t)M^{o}_{4}t - D_{23}(t)M^{o}_{5t} + D_{33}(t)M^{o}_{6t}) \quad \ldots (75)$$

where[1)]

$$D(t) = \begin{vmatrix} (0{,}5512t+0{,}4488) & -(0{,}462t-0{,}1675) & -(2{,}975t-0{,}2553) \\ (0{,}0567t-0{,}1134) & (0{,}9467t-0{,}1539) & (0{,}4658t-0{,}0412) \\ (0{,}0013t-0{,}0026) & (0{,}0017t-0{,}0011) & (1{,}1463t-0{,}1642) \end{vmatrix}$$

1) D(o) = 0,0082; D(1) = 0,7594; D(2) = 5,9828; D(3) = 18,21

D(4) = 43,529 ....

$D(t) > 0 \quad \text{for } t \geq 0$

$D_{ij}(t) > 0 \quad \text{for } t \geq 0 \qquad i, j = 1,2,3$

and $D_{ij(t)}$ are cofactors of the determinant $D(t)$

We assume:

$$M_{4t} = \bar{M}_4 + M^o_{4t}$$

$$M_{5t} = \bar{M}_5 + M^o_{5t}$$

$$M_{6t} = \bar{M}_6 + M^o_6 t$$

where $\bar{M}_4$, $\bar{M}_5$, $\bar{M}_6$, M^o_4, M^o_5 and M^o_6 are all constant.

$$\bar{P}^o_{5t} = 0{,}8504\ \bar{A}_5 - 0{,}0178\ \bar{A}_6 + \frac{1}{N(t)}(N_{11}A^o_5 \cdot t - N_{21}A^o_6 t) \quad \ldots(76)$$

$$\bar{P}^o_{6t} = -0{,}0065\ \bar{A}_5 + 0{,}829\ \bar{A}_6 + \frac{1}{N(t)}(N_{12}A^o_5 . t - N_{22}A^o_{6t}) \quad \ldots(77)$$

where
$$N(t) = \begin{vmatrix} 1{,}1761t - 0{,}1761 & 0{,}0253(t-1) \\ 0{,}0092(t-1) & 1{,}2065t - 0{,}2065 \end{vmatrix}$$

$N(t) > 0 \quad \text{for } \ t \geq 0$

$N_{ij}(t) > 0 \quad \text{for } \ t \geq 0, \qquad i,j = 1,2$

N_{ij} are cofactors of the determinant $N(t)$

$$A_{5t} = \bar{A}_5 + A^o_{5t} = 1712 - 0{,}7379\ P^u_{4t} - 0{,}4623\ L_{4t}$$

$$- 1{,}178\ L_{5t} - 0{,}1952\ L_{6t} + 0{,}1528\ ES_{4t} - 25{,}1t$$

$$A_{6t} = \bar{A}_6 + A^o_{6t} = 1272 - 0{,}2158\ P^u_{4t} - 0{,}1352\ L_{4t}$$

$$- 0{,}0619\ L_{5t} - 1{,}5959\ L_{6t} + 0{,}0447\ ES_{4t} - 13{,}5t$$

$\bar{A}_5$, A^o_5, $\bar{A}_6$ and A^o_6 are constant.

3. The short-run effects of economic policies:

Using the reduced forms above we can show the short run effects of economic politices of exporting countries on the endogeneous variables. The important economic political variables are as following: P_1^u, AA_1, SUB_1, ES_2, P_3^u, ES_4, P_4^u and P_3^k.

The short run effects of economic policies on the middle staple cotton are shown by table 1 and the short run effects on the long-and extra-long staple cotton are shown by table 2.

The short run effects in table 1 and table 2 agree with the usual theoretical expectations. Thus e.g. the U.S. export subsidies have typical dumping effects."

Tab.1: Short run effects of economic policies (1)

endogeneous Variables \ Political Variables	$\bar{P}_1^u$	AA_1	SUB_1	ES_2	P_3^u	P_3^k
P_1			$-0,1689<0$	$0,0278>0$	$-0,003$ $-0,0068E_{3t} \leq 0$	$0,0029E_{3t}$ >0
X_1			$4,3041>0$	$0,1445>0$	$-0,0351E_{3t}$ $-0,0156 <0$	$0,0152E_{3t}$ >0
P_1^{in}	$8,929>0$					
K_1	$-0,571B_{1t}>0$					
G_1		$0,994E_{1t}>0$				
P_2			$-0.1202<0$	$0,4463>0$	$-0,0048E_{3t}$ $-0,0021 <0$	$+0,0021E_{3}$ >0
X_2			$-0,1233<0$	$-1,3659<0$	$-0,0049E_{3t}$ $-0,0022<0$	$0,0021E_{3}$ >0
K_2			$0,0104>0$	$0,0475>0$	$0,0041E_{3t}$ $+0,0018>0$	$-0,0018E_{3}$ <0
G_2				$-2.163<0$ *)		
P_3			$-0,3056<0$	$0,0504>0$	$-0,5032E_{3t}$ $-0,225<0$	
X_3					$0,331E_{3t}$ $+0,148>0$	$-0,142E_{3t}$ <0
P_3^{in}					$0,95 > 0$	
K_3					$-0,228 < 0$	
G_3					$0,511E_{3t}>0$	$-0,219E_{3t}$ <0

*) with a time-lag of one year

4. The long-run influence of economic policies:

Using the particular solution of the difference equation systems above we can show the long-run influences of economic policies on the endogeneous variables.

In comparison of the short run effects and the long-run influences of economic cotton policies we find that for the USA the short run effects and the long-run influences have the same influence direction on all endogeneous variables. But this is not so for Egypt where the short-run effects and long-run influences of the export taxes on the Egyptian cotton prices and exports are characterized by different directions due to feed-back influences of the Egyptian export taxes via the cotton storage on the price and export of Egyptian cotton.

There are no feed-back effects of the US cotton policies on the endogeneous Variables via the storage of the U.S.cotton because the export of U.S. cotton is independent of the U.S. cotton storage.

Diag. 1 & 2 show these different results of the long-run influences of the U.S. and the Egyptian cotton policies.

Diag. 1 & 2 are drawn from the reduced forms in IV 1 for the period t to show the pattern of influence of cotton policies on the U.S. and Egyptian cotton economies respectively. For the period t+1 the interdependent relations of the cotton economy are drawn from our econometric model to show the further effects. The total effects in the period t+1 can be calculated from the solutions of the difference equations in the last section. The feed-back effects from these effects on the other export countries are not shown in our diagrams.

The sign on the arrows in Diag. 1 & 2 indicates the direction of influence; question marks indicate that the effects are not clear cut.

Tab.3: Long-run influence of economic policies (1)

Political Variables / endogeneous Variables	$\bar{P}_1^u$	AA_1	SUB_1	ES_2	P_3^u	P_3^k
P_1			-	+	-	+
X_1			+	+	-	+
P_1^{in}	+					
K_1	-					
G_1	+	+				
P_2			-	+	-	+
X_2			-	-	-	+
K_2			+	+	+	-
G_2			-	-	-	+
P_3			-	-	-	+
X_3					+	-
P_3^{in}					+	
K_3					-	
G_3					+	-
L_2			-	+		
L_3					+	-

Notes: + for positive influences
- for negative influences

Tab.4: Long-run influence of economic policies (2)

Political Variables / endogeneous Variables	p_4^u	ES_4
P_4	-	-
X_4	+	+
K_4	-	+
G_4	+	
P_5	-	+
X_5	-	+
G_5	-	+
P_6	-	+
X_6	-	+
G_6	-	+
L_4	-	+
L_5	-	+
L_6	-	-

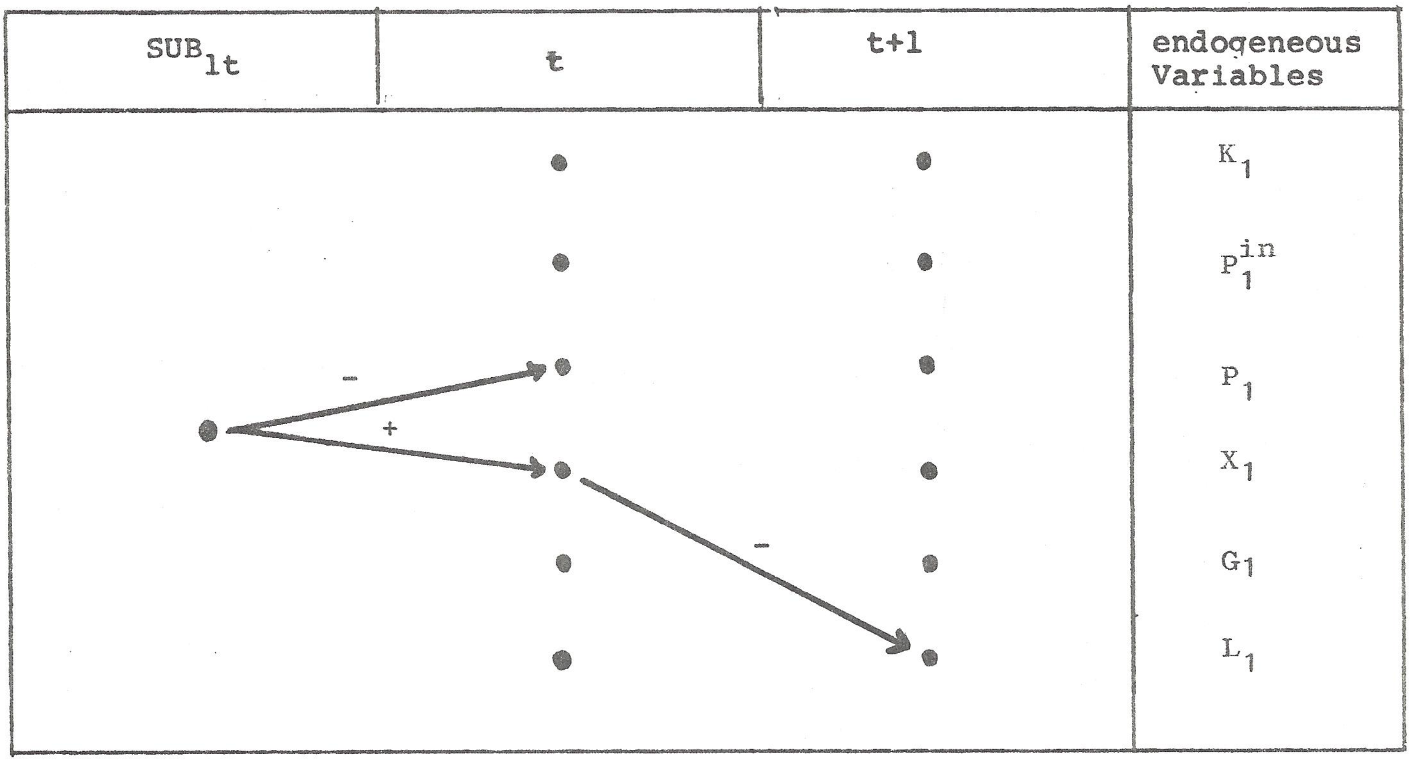
Notes:

+ for positive influences

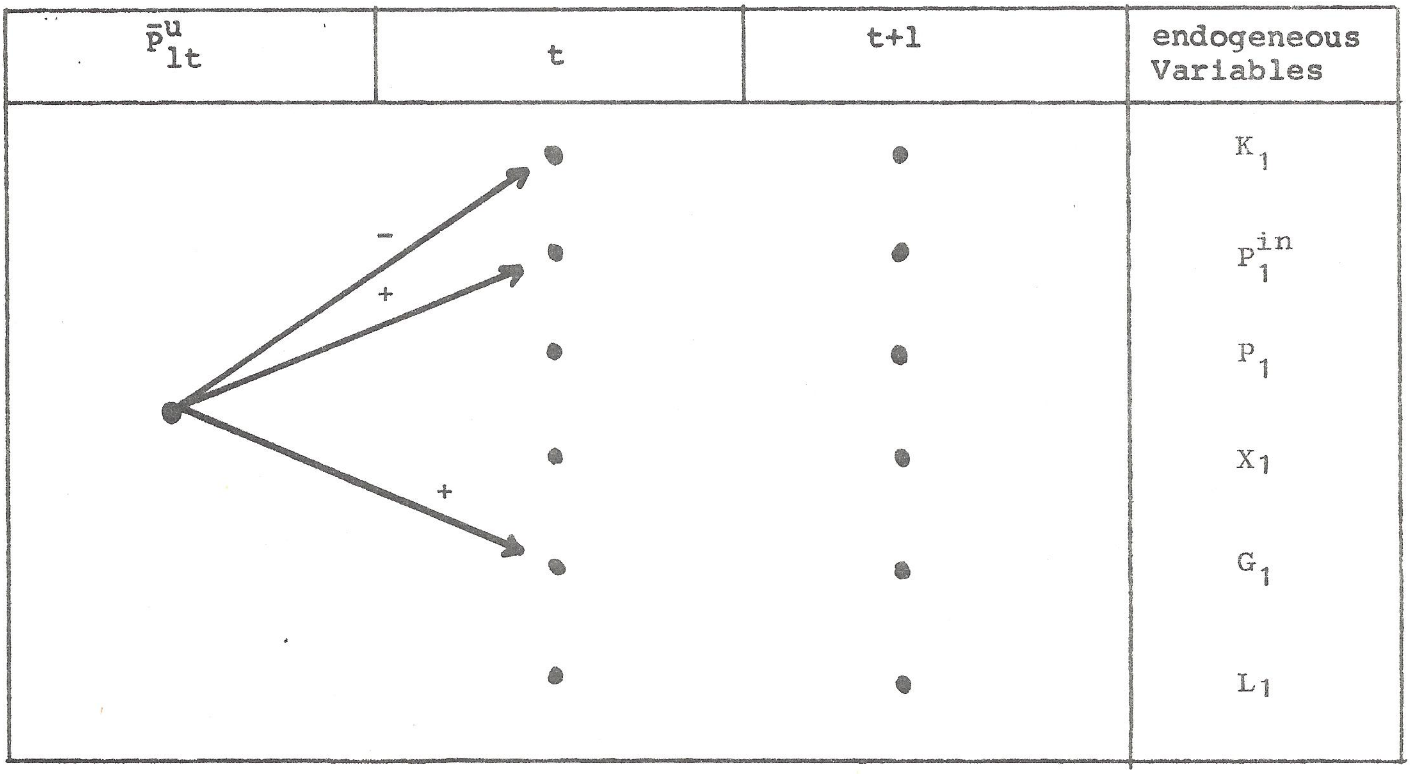
- for negative influences

Diag.1: The pattern of influence of U.S.cotton policies

a. The influence of an increase of U.S.export subsidies on the U.S. cotton economy

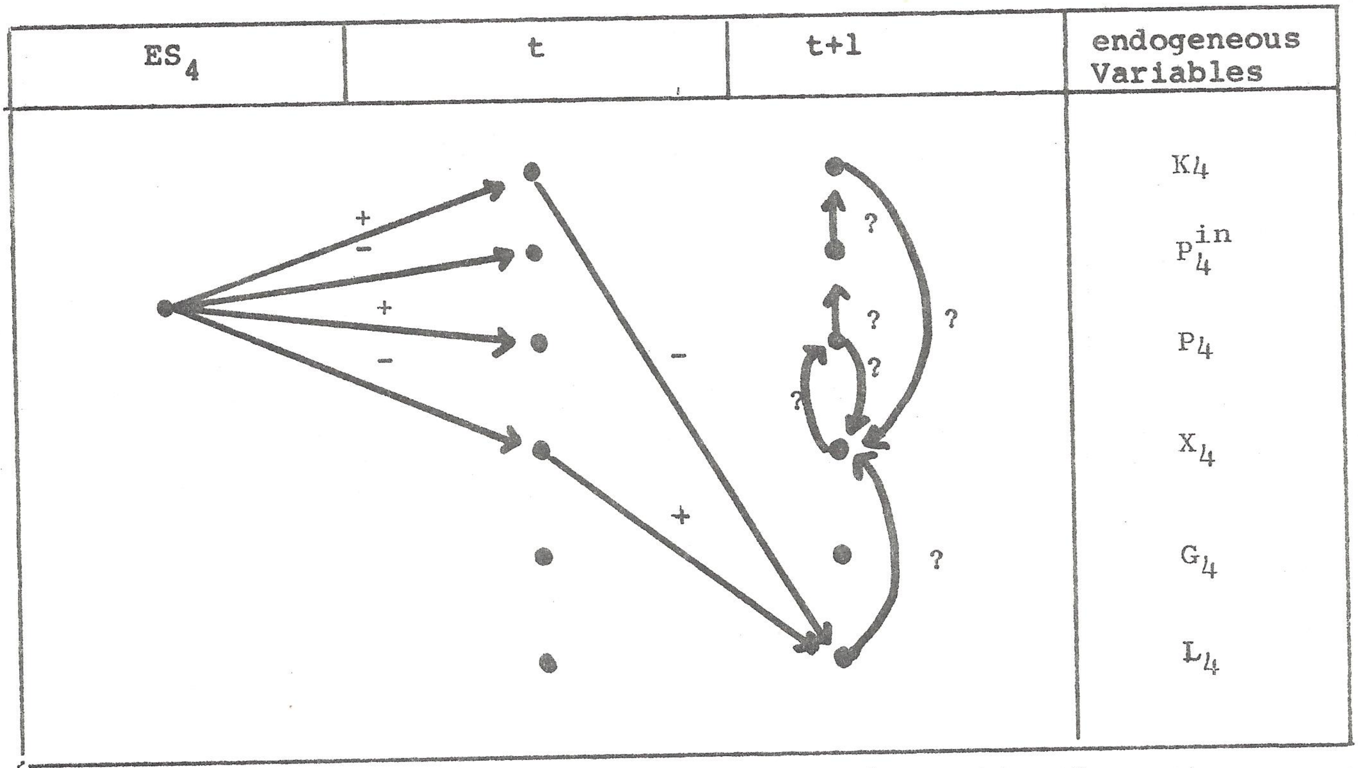


b. the influence of an increase of U.S. support prices on the U.S. cotton economy

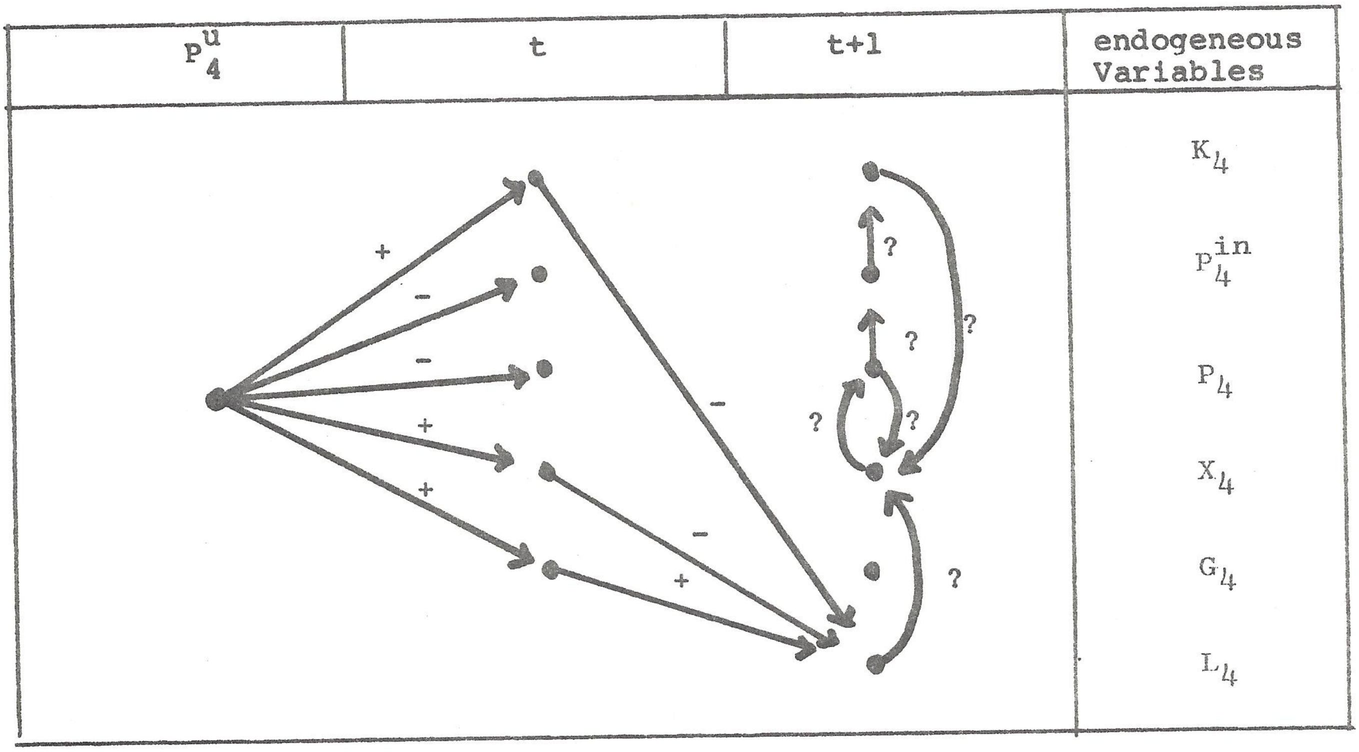


Diag.2: The pattern of influence of Egyptian cotton policies

A. the influence of an increase of Egyptian export taxes on the Egyptian cotton economy



B. the influence of an increase of Egyptian Support price on the Egyptian cotton economy



5. Formulation of cotton policies: Some examples

The effects of the cotton policies are shown in the last section. Economic policies usually try to achieve some political goals.

In this section we give an example of an economic policy application of our cotton model.

The shortage of foreign exchange is one of the difficulties in the developing countries. The foreign trade policies of these countries are often used to earn foreign exchange.

Let us assume that the government of Mexico tries to use the cotton export tax to achieve a maximal foreign exchange revenue from cotton export. This goal may be a short run or a long run goal. In both cases we can compute optimal cotton export tax rates.

A. Short-run:

The foreign exchange revenue of Mexico from cotton export is defined as:

$$U_{2t} = P_{2t} \cdot X_{2t} \qquad \ldots (78)$$

The short-run policy tries to maximize U_{2t} under following condition:

$$X_{2t} \leq G_{2t} + L_{2t} - K_{2t} \qquad \ldots (79)$$

The short-run optimal cotton export will be realized if:

$$\frac{dU_{2t}}{dX_{2t}} = \frac{d}{dX_{2t}} \left[(126-0{,}312X_{2t} + 0{,}938\ P_{1t})\quad X_{2t} \right]$$

$$= 126 - 0{,}624 \cdot X_{2t} + 0{,}938 \cdot P_{1t} = 0$$

or $$X^{*}_{2t} = 202 + 1{,}5032\ P_{1t} \qquad \ldots (80)$$

From the reduced forms above we know X_{2t}, P_{1t} and K_{2t} are functions of ES_{2t}. We derive from (48), (51) and (52) an export tax for the optimal export:

$$\begin{aligned} ES^{*}_{2t} = & - 1382 + 0{,}0112\ \widehat{TW}_{1t} - 0{,}0043\ (G_{3t}-K_{3t}) \\ & + 0{,}0074\ L_{3t} + 0{,}0928\ SUB_{1t} - 0{,}1303\ Y_{2t} \\ & + 0{,}9415\ P_{2t-1} + 15{,}5t + 0{,}7325\ L_{2t} \qquad \ldots (81) \end{aligned}$$

But from the restriction (79)

$$\begin{aligned} ES^{*}_{2t} \geq & - 64{,}4 - 0{,}7075\ G_{2t} - 0{,}0202\ L_{2t} - 0{,}0017\ \widehat{TW}_{1t} \\ & + 0{,}0113\ (G_{3t}-K_{3t}) - 0{,}0129\ L_{3t} \\ & - 0{,}0946\ SUB_{1t} - 0{,}3323\ Y_{2t} + 0{,}8902\ P_{2t-1} \\ & + 14{,}6t \qquad \ldots (82) \end{aligned}$$

If we had a negative ES^{*}_{2t} from (81) which fulfils the condition (82) then only an export subsidy could achieve the maximal exchange revenue for the cotton export of Mexico.

If we compute an ES^{*}_{2t} from (81) which does not fulfil the condition (82), then the optimal value for ES_{2t} will be given by (82) because the optimal cotton export is greater than the cotton export possibility.

B. Long-run:

To derive the long-run optimal export tax rate for Mexico we make use of (42), (50), (51), (52), (68), (69), (78) and (79). We may now maximize:

$$\bar{U}^{o}_{2t} = \bar{P}^{o}_{2t} \cdot \bar{X}^{o}_{2t} \qquad \ldots (83)$$

under the following condition:

$$\bar{X}^{o}_{2t} \leq \bar{G}^{o}_{2t} + \bar{L}^{o}_{2t} - \bar{K}^{o}_{2t} \qquad \ldots (84)$$

For the sake of simplicity we assume a constant export tax:

$$\bar{ES}^{o}_{2} = ES_{2t} = ES_{2t+1} \quad \ldots$$

and

$$\bar{Y}^{o}_{2t} = Y_{2t} = Y_{2t+1} = \quad \ldots$$

$$S\bar{U}B^{o}_{1} = SUB_{1t} = SUB_{1t+1} = \ldots$$

$$\hat{TW}^{o}_{1} = \hat{TW}_{1t} = \hat{TW}_{1t+1} = \ldots$$

The optimal cotton export tax is derived as

$$ES^{o*}_{2} = 0{,}4348\ (M^{o}_{22} + 0{,}844\ ES^{o}_{2})$$

$$- 1{,}4184\ (M^{o}_{21} - 0{,}4463 ES^{o}_{2}) \qquad \ldots (85)$$

if $ES^{o*}_{2} \geq 677 + 0{,}5661\ M^{o}_{23}$

$$+ 0{,}1026\ (M^{o}_{22} - 1{,}3184\ ES^{o}_{2})$$

$$- 0{,}2695\ (M^{o}_{21} - 0{,}4463\ ES^{o}_{2}) \qquad \ldots (86)$$

Summary

The world cotton market after the Second World War is characterized by (1) production surplus because of rapid increase in production, (2) government regulations of export countries especially on production and export, (3) severe competition by synthetic fibers and (4) decreasing trend of world cotton prices.

An econometric model has been constructed for the period from 1953/54 to 1964/56. This model is based on a number of "statistical experiments". By these experiments various model-ideas were tested. The equations in the final model are chosen according to the following criteria: (1) correct signs of regression coefficients in the sense of theoretically expected economic relations. (2) high coefficients of determination, and (3) statistically significant regression coefficients.

Cotton is classified according to its staple length into three main categories, i.e. short staple cotton, middle staple cotton which is exported mainly by the U.S.A., Mexico and Brazil, and long or extra-long staple cotton which is supplied by Egypt, Sudan and Peru at the world market. Because of its small share on the world market the short staple cotton was not considered separately in our model.

The fluctuations of the world market price are the same for the same kind of cotton from different countries because of a high degree of substitutability, but there is no correlation between those two groups because there is not much substitution between them. According to this surprising result we must consider the world cotton market as two markets, i.e. the market for middle staple cotton and the market for long or extra-long staple cotton.

The econometric model is an interdependent model with the following characteristics:

(a) The foreign demand equations look like demand equations for a quantity variation oligopoly model. This is due to the

fact that government regulations of the export countries influence quantities more directly than prices;

(b) the foreign demand equations of Mexico and Brazil incorporate the iedea of American price leadership, while those of Sudan and Peru incorporate Egyptian price leadership;

(c) many exogeneous factors which have important influences the world cotton market are considered by the introduction of dummy variables into the model; e.g. the speculation effect of the American export policies, Suez-canal crisis, etc.;

(d) different supply equations for different countries reflect differences of production and export policies.

Econometric models with estimated parameters can be applied in many ways, such as to see the short-run and long-run effects of economic policies and to formulate programs of economic policies to achieve certain goals. For these applications we must derive the reduced forms of our model and we must solve the diference equation-systems of the reduced form, since our model is interdependent.

While the short-run effects of cotton policies can be easily derived from the reduced forms the long-run effects must be shown by the solutions of the difference equation systems. Solving the difference equation systems we have shown that our model is stable.

One of the interesting results from the comparison of the short-run and long-run effects of cotton policies is the reverse influence of Egyptian export tax on the Egyptian cotton export and price. This is due to the dependence of Egyptian export supply on the cotton storage.

As an example of possible applications we have derived short run and long run optimal Mexican export tax sales for the maximization of foreign exchange revenue.

Appendix A:

The method of two-stage least squares is used to estimate our model. The calculation is carried out by the following steps:

(1) The first-step (the model is estimated by the method of least squares). In this step a "statistical experiment" is carried out to test various model ideas.

(2) The second-step (test of interdependence of the residues in the regression equations calculated in the first-step). Two correlation matrices of the residues of the regression equations "Ui and Uj" are given in Appendix B.

(3) The third-step (estimation of reduced equations with the method of instrumental variables). There are 31 exogeneous variables in our model but we have only 12 observations. The direct application of the two stage least square method is therefore not possible. One way to avoid this difficulty is to estimate the reduced equations separately by the method of instrumental variables. The criteria for the choice of instrumental variables in a reduced equation are as follows:

   (a) The instrumental variables should have the highest correlation coefficients with the corresponding endogeneous variable;
   (b) the instrumental variables should have low correlations between themselves;
   (c) the number of variables in a reduced equation should not be greater than one third of the observations;
   (d) the problem of identification should be considered in the choice of instrumental variables.

   The reduced equations chosen according to these criteria are given in table 1 and 2.

(4) The fourth-step (estimation of the two-stage least square equations).

Table 1: Reduced Equations

AV	Konst.	SUB_1	KW	R_{14}	ES_2	Y_2	L_2	T	L_3	R_{31}	MR	DWS
P_1	778	-5,344 (3,13)	-0,025 (0,01)								0,72	2,02
P_1'	888	-0,825 (0,131)	-0,o18 (0.01)								0,92	1,88
X_1	896	2,569 (0.945)		-551 (162)							0.70	1,32
P_2	782		-0,039 (0,015)		-0,056 (0,466)						0,69	2,44
P_2'	647		-0,014 (0,024)		1,608 (0,747)						0,72	1,64
K_2	45	0,405 (0,071)				0,140 (0,096)					0,91	2,19
X_2	263			106 (27)			0,664 (0,526)				0.70	1,57
P_3	747	-0,679 (0,147)	-0,076 (0,012)								0,82	2,02
P_3'	803	-0,747 (0,223)	-0,022 (0,016)								0,78	2,18
K_3	226							5,351 (1,231)	-0,091 (0,049)		0,79	1,10
X_3	103								0,481 (0,128)	-94 (24)	0,87	1,80

Table 2: Reduced Equations

AV	Konst.	T	R_{41}	KW	L_4	R_{43}	P_4^u	R_{51}	R_{52}	L_5	R_{61}	R_{62}	MR	DWS
P_4	1038	-10 (9)	299 (86)										0,68	2,54
P_4'	1054		262 (96)	-0,025 (0,036)									0,53	1,69
K_4	63	7 (0,4)			0,026 (0,039)								0,98	2,40
G_{14}	344	12 (3)				-78 (22)							0,82	1,76
X_4	593					-33 (39)	-0,384 (0,320)						0,36	2,28
P_5	968	-14 (7)						208 (67)					0,71	2,39
P_5'	1107	-24 (10)	281 (93)										0,73	1,86
G_5	85	8 (o,27)							-62 (18)				0,69	1,57
X_5	54	4 (2,5)								0,455 (0,275)			0,52	2,39
P_6	854	-6 (4)									140 (38)		0,69	2,04
P_6'	976	-14 (7)	159 (63)										0,69	2,54
X_6	93	2,407 (1,198)										-17 (9,5)	0,60	1,78
G_6	101	3,5 (1,10)										- 8,0 (8,0)	0,66	2,43

Appendix B

MATRIX DER KORRELATIONSKOEFFIZIENTEN ZWISCHEN UI UND UJ

U11	U12	U13	U14	U15	U21	U22	U23	U24	U31	U32	U33	U34	U35	U71	U72
1.0000	-0.3213	0.0977	-0.5647	-0.0511	0.0271	-0.1297	0.1238	-0.7292	-0.1489	0.3571	0.0849	-0.1279	0.1172	-0.0327	-0.1703
0.	1.0000	0.1711	0.0001	0.0036	0.2310	0.0600	-0.3969	0.5312	0.0747	-0.1161	0.3155	0.2623	-0.7596	0.3412	0.4754
0.	0.	1.0000	0.3545	-0.3047	0.1854	0.2337	0.0976	0.4294	0.5100	0.6807	0.6385	0.4947	-0.3259	0.2922	0.1713
0.	0.	0.	1.0000	0.0209	0.4541	0.1936	0.2905	0.5964	0.2819	0.0988	0.1285	0.3162	0.3055	-0.2467	-0.1918
0.	0.	0.	0.	1.0000	0.4586	0.6939	0.5397	-0.1764	-0.1224	-0.5477	-0.2579	0.0002	-0.1149	-0.6500	0.4336
0.	0.	0.	0.	0.	1.0000	0.2661	0.3309	0.1312	0.3956	0.1926	0.0968	0.2585	-0.0755	-0.6465	0.1282
0.	0.	0.	0.	0.	0.	1.0000	0.7407	0.0983	0.0127	-0.2350	0.2929	0.2503	-0.2022	-0.3717	0.4175
0.	0.	0.	0.	0.	0.	0.	1.0000	-0.2138	-0.0749	-0.0404	0.1114	0.1672	0.3399	-0.5631	-0.1135
0.	0.	0.	0.	0.	0.	0.	0.	1.0000	0.2787	-0.0469	0.1806	0.1549	-0.3623	0.2609	0.1848
0.	0.	0.	0.	0.	0.	0.	0.	0.	1.0000	0.6772	0.0705	0.1662	-0.3532	-0.0253	0.1351
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.0000	0.4555	0.3665	-0.0576	0.1438	-0.1440
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.0000	0.7416	-0.2089	0.1034	0.2644
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.0000	-0.1961	-0.0497	0.3932
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.0000	-0.3820	-0.7236
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.0000	-0.0837
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.0000

MATRIX DER KORRELATIONSKOEFFIZIENTEN ZWISCHEN UI UND UJ

U41	U42	U43	U44	U51	U52	U53	U61	U62	U63
1.000000	-0.653698	0.296709	-0.091767	-0.339673	0.154055	-0.027060	-0.585321	0.362709	-0.669840
0.	1.000000	0.122432	0.136948	0.032078	-0.137371	-0.078877	0.203507	-0.276748	0.553563
0.	0.	1.000000	-0.031532	0.024797	0.006539	0.260030	-0.070477	0.223451	0.021419
0.	0.	0.	1.000000	-0.164731	0.526083	0.421174	-0.037211	0.185030	0.349256
0.	0.	0.	0.	1.000000	-0.004287	0.254500	0.563478	-0.246776	0.448195
0.	0.	0.	0.	0.	1.000000	0.485739	-0.248833	0.453206	0.026702
0.	0.	0.	0.	0.	0.	1.000000	-0.272854	0.027556	0.275308
0.	0.	0.	0.	0.	0.	0.	1.000000	-0.000311	0.480138
0.	0.	0.	0.	0.	0.	0.	0.	1.000000	-0.380836
0.	0.	0.	0.	0.	0.	0.	0.	0.	1.000000

Appendix C

Deflated Cotton Prices

Year	P_1	P_2	P_3	P_4	P_5	P_6
1953/54	718	704	635	941	993	818
1954/55	738	724	692	966	941	855
1955/56	703	654	608	1023	1047	835
1956/57	623	649	582	1138	1204	1025
1957/58	703	703	595	908	944	907
1958/59	683	633	556	746	738	739
1959/60	648	633	556	923	878	874
1960/61	669	662	607	946	935	837
1961/62	683	663	607	954	826	818
1962/63	627	606	548	803	749	755
1963/64	581	576	504	825	800	773
1964/65	609	575	515	945	857	780

Notes:
The deflated prices are calculated with Reuter's price index. The price indices for the years from 1953/54 to 1964/65 are: 119, 119, 118, 114, 106, 101, 102, 101, 100, 106, 113, 112.

Appendic C
Non-deflated Cotton Prices

Year	P_1	P_2	P_3	P_4	P_5	P_6
1953/54	855	838	756	1120	1182	973
1954/55	878	862	823	1149	1120	1017
1955/56	830	772	717	1207	1235	1007
1956/57	710	719	664	1297	1373	1169
1957/58	745	745	632	962	1001	961
1958/59	690	639	562	753	743	746
1959/60	661	646	567	941	896	891
1960/61	676	669	613	955	944	845
1961/62	683	663	607	954	826	818
1962/63	665	642	581	851	794	800
1963/64	657	651	579	932	904	873
1964/65	682	644	577	1058	960	874

Notes:

1) All prices are the yearly average prices c.i.f. Liverpool/ England in U.S. Dollar/1000 m.t.

2) P_1 is the average price of "Texas M. 15/16"", "Memphis Territ SM. 1-1/16"" and "California S.M. 1-3/32"" for the period from 1953/54 to 1958/59; and the average price of "Orleans Texas M 1"", "Memphis SM 1-1/16"" and "California S.M. 1-3/32"" from 1959/60.

3) P_2 is the yearly average price for S.M. 1-1/16".

4) P_3 is the yearly average price for Sao Paulo Type 5 -- 1-1/32"

5) P_4 is the yearly average price of Ashmouni F.G. Giza 30 F.G. and Karnak F.G. for the period from 1953/54 to 1961/62; from 1962/63 is the average price of Dendera F.G. and Menoufi F.G.

6) P_5 is the average price of G.5L and G.5S.

7) P_6 is the average price of Tanquis Type 5 and Pima No.1-- 1-9/16.

8) Sources: International Cotton Advisory Committee: Cotton - World Statistics; Quarterly Bulletin, Washington D.C. U.S.A.

Appendix C: Correlation Matrix for Nondeflated Prices

	P1	P2	P3	P4	P5	P6
P1	1.000000000	0.968991958	0.953803346	0.596202195	0.631675065	0.546785839
P2	0.	1.000000000	0.974650949	0.647542804	0.695094459	0.650774851
P3	0.	0.	1.000000000	0.696840659	0.706331015	0.651204757
P4	0.	0.	0.	1.000000000	0.959035054	0.922418311
P5	0.	0.	0.	0.	1.000000000	0.957424492
P6	0.	0.	0.	0.	0.	1.000000000

Correlation Matrix for Deflated Prices

	P1	P2	P3	P4	P5	P6
P1	1.000000000	0.904342331	0.884778261	0.134663932	0.215800494	0.096458301
P2	0.	1.000000000	0.932851307	0.337053336	0.440137818	0.421248369
P3	0.	0.	1.000000000	0.410579555	0.436348632	0.326952778
P4	0.	0.	0.	1.000000000	0.913841851	0.814137593
P5	0.	0.	0.	0.	1.000000000	0.856003210
P6	0.	0.	0.	0.	0.	1.000000000

KORRELATIONSMATRIX

P1	X1	K1P	P1IN	A1	P2	X2	K2	Y2	P2I-1	R23	L2	R31	Y3	P3U	P3K	L3
1.0000	-0.3905	0.3518	0.6398	0.4990	0.9043	-0.1777	-0.7965	-0.7828	0.7676	0.0008	-0.3169	-0.0179	-0.6828	-0.0390	0.6445	0.2882
0.	1.0000	0.0305	-0.3982	-0.2080	-0.0380	-0.4583	0.2351	0.1493	-0.5532	0.3264	-0.1930	0.4421	0.0958	-0.2391	-0.2785	-0.3958
0.	0.	1.0000	0.5627	0.7788	0.4481	-0.3683	-0.7016	-0.6928	0.3934	-0.1341	-0.3576	-0.0800	-0.7119	-0.4304	0.4698	0.5495
0.	0.	0.	1.0000	0.5574	0.6449	-0.1597	-0.8000	-0.8749	0.8415	-0.2766	-0.6358	0.0106	-0.8174	-0.1424	0.7378	0.3678
0.	0.	0.	0.	1.0000	0.5548	-0.5682	-0.7983	-0.6247	0.4122	-0.0842	-0.3692	-0.4424	-0.5682	-0.3662	0.4532	0.8828
0.	0.	0.	0.	0.	1.0000	-0.4480	-0.8287	-0.8396	0.6288	-0.0049	-0.6172	0.0927	-0.7472	-0.1813	0.6761	0.2653
0.	0.	0.	0.	0.	0.	1.0000	0.4572	0.3701	0.1259	-0.1716	0.4330	-0.1233	0.4200	0.6731	-0.3180	-0.4814
0.	0.	0.	0.	0.	0.	0.	1.0000	0.9407	-0.7810	0.1142	0.5130	-0.0000	0.8586	0.3261	-0.6575	-0.5901
0.	0.	0.	0.	0.	0.	0.	0.	1.0000	-0.8054	0.1729	0.6035	-0.1970	0.9574	0.3368	-0.7573	-0.3611
0.	0.	0.	0.	0.	0.	0.	0.	0.	1.0000	-0.1171	-0.3290	0.0242	-0.6735	0.1696	0.5326	0.2256
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.0000	0.3741	0.1581	0.2628	0.3467	-0.4080	-0.2769
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.0000	-0.1152	0.5712	0.2153	-0.6023	-0.1793
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.0000	-0.3022	-0.2449	0.0851	-0.5147
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.0000	0.5232	-0.8064	-0.3633
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.0000	-0.4442	-0.4449
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.0000	0.3403
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.0000

KORRELATIONSMATRIX

P1	X1	K1P	P1IN	A1	P2	X2	K2	KW	LWM	Y1	T	P1L	AA1	SU1	R14
1.000	-0.391	0.352	0.640	0.499	0.904	-0.178	-0.797	-0.797	0.094	-0.816	-0.782	0.626	0.682	-0.743	0.070
0.	1.000	0.031	-0.398	-0.208	-0.038	-0.458	0.235	0.128	-0.322	0.149	0.161	-0.428	-0.329	0.564	-0.677
0.	0.	1.000	0.563	0.779	0.448	-0.368	-0.702	-0.628	-0.568	-0.642	-0.715	0.620	0.605	-0.621	-0.088
0.	0.	0.	1.000	0.557	0.645	-0.160	-0.800	-0.817	-0.331	-0.846	-0.860	0.917	0.617	-0.685	0.241
0.	0.	0.	0.	1.000	0.555	-0.568	-0.798	-0.547	-0.313	-0.557	-0.627	0.698	0.924	-0.716	-0.220
0.	0.	0.	0.	0.	1.000	-0.448	-0.829	-0.831	-0.104	-0.861	-0.828	0.590	0.694	-0.604	-0.221
0.	0.	0.	0.	0.	0.	1.000	0.457	0.327	0.279	0.323	0.374	-0.187	-0.564	0.149	0.801
0.	0.	0.	0.	0.	0.	0.	1.000	0.927	0.439	0.923	0.930	-0.852	-0.891	0.754	-0.016
0.	0.	0.	0.	0.	0.	0.	0.	1.000	0.441	0.990	0.974	-0.790	-0.670	0.647	-0.098
0.	0.	0.	0.	0.	0.	0.	0.	0.	1.000	0.400	0.404	-0.436	-0.223	0.032	-0.075
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.000	0.989	-0.785	-0.671	0.691	-0.074
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.000	-0.800	-0.706	0.744	-0.028
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.000	0.724	-0.702	0.261
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.000	-0.719	-0.120
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.000	-0.107
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.000

KORRELATIONSMATRIX

G2	P3	X3	P3IN	K3	X7	G7	A3	KW	LWM	Y1	T	P1U	AA1	SL1	R14
1.000	-0.513	-0.240	0.498	0.602	0.402	0.654	0.446	0.589	0.443	0.556	0.605	-0.497	-0.748	0.390	0.550
0.	1.000	0.127	-0.120	-0.496	-0.558	-0.728	-0.476	-0.774	-0.093	-0.806	-0.789	0.681	0.722	-0.710	-0.151
0.	0.	1.000	-0.381	-0.127	0.672	0.275	0.502	0.176	0.037	0.155	0.075	0.292	0.526	-0.397	-0.063
0.	0.	0.	1.000	0.820	-0.087	0.158	0.268	0.235	0.309	0.296	0.404	-0.295	-0.471	0.445	0.356
0.	0.	0.	0.	1.000	0.368	0.645	0.658	0.729	0.384	0.771	0.839	-0.647	-0.668	0.702	0.124
0.	0.	0.	0.	0.	1.000	0.849	0.863	0.772	0.280	0.751	0.691	-0.259	-0.224	0.154	0.131
0.	0.	0.	0.	0.	0.	1.000	0.823	0.957	0.383	0.936	0.922	-0.662	-0.601	0.568	0.028
0.	0.	0.	0.	0.	0.	0.	1.000	0.811	0.311	0.809	0.777	-0.354	-0.426	0.328	0.028
0.	0.	0.	0.	0.	0.	0.	0.	1.000	0.441	0.990	0.974	-0.790	-0.670	0.647	-0.058
0.	0.	0.	0.	0.	0.	0.	0.	0.	1.000	0.400	0.404	-0.436	-0.223	0.032	-0.075
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.000	0.989	-0.785	-0.671	0.691	-0.074
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.000	-0.800	-0.706	0.744	-0.028
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.000	0.724	-0.702	0.261
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.000	-0.715	-0.120
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.000	-0.107
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.000

KORRELATIONSMATRIX

G2	P3	X3	P3IN	K3	X7	G7	A3	Y2	P2I-1	R23	L2	R31	Y3	P3U	P3K	L3
1.0000	-0.5130	-0.2400	0.4981	0.6022	0.4022	0.6535	0.4465	0.6983	-0.2069	-0.2661	0.3415	-0.0443	0.5985	0.5569	-0.3198	-0.5865
0.	1.0000	0.1268	-0.1197	-0.4958	-0.5579	-0.7283	-0.4761	-0.8000	0.6780	-0.0201	-0.5579	-0.1625	-0.6713	-0.0511	0.6997	0.3434
0.	0.	1.0000	-0.3810	-0.1268	0.6721	0.2754	0.5021	0.0746	-0.0181	-0.1541	0.0368	-0.8767	0.1407	-0.0415	0.0047	0.8048
0.	0.	0.	1.0000	0.8200	-0.0869	0.1578	0.2681	0.3664	0.0460	0.4942	0.4376	0.0657	0.5131	0.8441	-0.5620	-0.6606
0.	0.	0.	0.	1.0000	0.3682	0.6447	0.6575	0.8140	-0.4708	0.4483	0.5866	-0.1266	0.9014	0.7199	-0.7968	-0.5840
0.	0.	0.	0.	0.	1.0000	0.8486	0.8598	0.6938	-0.4558	-0.1276	0.3851	-0.6657	0.6862	0.2170	-0.4255	0.2356
0.	0.	0.	0.	0.	0.	1.0000	0.8197	0.9205	-0.7101	-0.1177	0.3844	-0.3847	0.8902	0.2963	-0.5875	-0.1937
0.	0.	0.	0.	0.	0.	0.	1.0000	0.7686	-0.5062	0.1622	0.4699	-0.6647	0.8174	0.4756	-0.5741	-0.0789
0.	0.	0.	0.	0.	0.	0.	0.	1.0000	-0.8054	0.1729	0.6035	-0.1970	0.9574	0.3368	-0.7573	-0.3611
0.	0.	0.	0.	0.	0.	0.	0.	0.	1.0000	-0.1171	-0.3290	0.0242	-0.6735	0.1696	0.5326	0.2256
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.0000	0.3741	0.1581	0.2628	0.3467	-0.4080	-0.2769
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.0000	-0.1152	0.5712	0.2153	-0.6023	-0.1793
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.0000	-0.3022	-0.2449	0.0851	-0.5147
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.0000	0.5232	-0.8064	-0.3633
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.0000	-0.4442	-0.4449
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.0000	0.3403
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.0000

KORRELATIONSMATRIX

P4	X4	K4	G4	P5	X5	G5	P6	X6	G6	R41	T	P4L	R43	L4	L5	P5-1	R52	Re2	P6-1	L6
1.000	-0.353	-0.473	-0.571	0.914	-0.693	-0.000	0.814	-0.530	-0.398	0.701	-0.417	0.256	0.657	0.048	-0.576	0.313	-0.197	0.456	-0.026	0.019
0.	1.000	0.283	0.614	-0.348	0.299	-0.075	-0.420	0.080	0.336	-0.356	0.271	-0.553	-0.506	0.469	-0.084	-0.658	0.092	-0.678	-0.370	-0.171
0.	0.	1.000	0.750	-0.688	0.670	0.596	-0.510	0.755	0.800	-0.405	0.988	-0.147	-0.183	0.187	0.492	-0.459	0.170	-0.527	-0.183	-0.178
0.	0.	0.	1.000	-0.617	0.392	0.073	-0.472	0.336	0.510	-0.514	0.751	-0.360	-0.645	0.315	0.327	-0.425	0.333	-0.399	-0.071	-0.165
0.	0.	0.	0.	1.000	-0.748	-0.314	0.856	-0.641	-0.613	0.761	-0.629	0.261	0.529	-0.081	-0.496	0.422	-0.073	0.547	0.116	-0.009
0.	0.	0.	0.	0.	1.000	0.485	-0.688	0.863	0.602	-0.236	0.698	-0.184	-0.060	-0.157	0.633	-0.517	-0.036	-0.707	-0.225	-0.098
0.	0.	0.	0.	0.	0.	1.000	-0.248	0.086	0.579	-0.010	0.526	0.042	0.435	0.098	-0.027	-0.353	-0.489	-0.470	-0.330	-0.051
0.	0.	0.	0.	0.	0.	0.	1.000	-0.620	-0.429	0.574	-0.459	0.224	0.451	-0.258	-0.335	0.544	0.034	0.733	0.253	-0.242
0.	0.	0.	0.	0.	0.	0.	0.	1.000	0.545	-0.147	0.683	0.159	0.167	-0.140	0.548	-0.298	-0.	-0.647	-0.003	0.178
0.	0.	0.	0.	0.	0.	0.	0.	0.	1.000	-0.566	0.795	-0.474	-0.253	0.128	0.379	-0.648	0.047	-0.531	-0.565	-0.526
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.000	-0.389	0.369	0.775	-0.169	-0.200	0.306	-0.258	0.258	0.117	0.148
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.000	-0.148	-0.195	0.206	0.492	-0.460	0.251	-0.474	-0.210	-0.223
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.000	0.577	-0.303	-0.086	0.648	0.276	0.243	0.661	0.562
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.000	-0.209	-0.212	0.307	-0.333	0.111	0.108	0.269
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.000	-0.386	-0.337	-0.305	-0.316	-0.336	-0.083
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.000	0.020	0.396	-0.268	0.228	-0.113
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.000	0.170	0.786	0.880	0.369
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.000	0.111	0.382	0.042
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.000	0.488	0.005
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.000	0.445
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.000

KORRELATIONSMATRIX

KW	LWP	Y1	T	P1U	AA1	SU1	R14	Y2	P2I-1	R23	L2	R31	Y3	P3L	P3K	L3
1.0000	0.4405	0.9903	0.9739	-0.7995	-0.6721	0.0472	-0.0976	0.9834	-0.8314	0.3818	0.5189	-0.2890	0.9272	0.2750	-0.6770	-0.2765
0.	1.0000	0.4305	0.4044	-0.4356	-0.2229	0.0315	-0.0745	0.4321	-0.2399	0.0577	0.3337	-0.3049	0.3917	0.3212	-0.1003	-0.1527
0.	0.	1.0000	0.9890	-0.7849	-0.6776	0.6913	-0.0737	0.9932	-0.8173	0.1623	0.5827	-0.2548	0.9469	0.3014	-0.7527	-0.2900
0.	0.	0.	1.0000	-0.8001	-0.7059	0.7438	-0.0279	0.9953	-0.7802	0.1943	0.5769	-0.2048	0.9750	0.3847	-0.7915	-0.3774
0.	0.	0.	0.	1.0000	0.7237	-0.7318	0.2609	-0.8255	0.8622	-0.0587	-0.4471	-0.1546	-0.7048	-0.0464	0.5823	0.4892
0.	0.	0.	0.	0.	1.0000	-0.7192	-0.1203	-0.7108	0.5679	-0.0981	-0.4014	-0.2897	-0.6362	-0.3316	0.5252	0.8508
0.	0.	0.	0.	0.	0.	1.0000	-0.1072	0.7157	-0.6407	0.3486	0.2130	0.3675	0.6961	0.3317	-0.7294	-0.6236
0.	0.	0.	0.	0.	0.	0.	1.0000	-0.0416	0.5350	-0.2582	0.2607	0.	0.0308	0.4730	-0.0803	-0.1162
0.	0.	0.	0.	0.	0.	0.	0.	1.0000	-0.8054	0.1729	0.6035	-0.1970	0.9574	0.3368	-0.7573	-0.3611
0.	0.	0.	0.	0.	0.	0.	0.	0.	1.0000	-0.1171	-0.3290	0.0242	-0.6735	0.1696	0.5326	0.2256
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.0000	0.3741	0.1581	0.2628	0.3467	-0.4080	-0.2769
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.0000	-0.1152	0.5712	0.2153	-0.6023	-0.1792
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.0000	-0.3022	-0.2449	0.0851	-0.5147
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.0000	0.5232	-0.8064	-0.3633
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.0000	-0.4442	-0.4449
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.0000	0.3403
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.0000