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A QUARTERLY ECONOMETRIC MODEL FOR
THE PRICE FORMATION OF COFFEE ON
THE WORLD MARKET.

E. Vogelvang

Researchmemorandum 1981-1

Amsterdam, december 1980



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1. Introduction*)

The main objective of the International Coffee Agreement (ICA) is to achieve a price for coffee which is fair to consumers and producers. Since the fifties, producing and importing countries are trying to realize this objective. But in spite of a number of agreements, it is still rather problematical to control the market. It is plausible to assume that conflicting interests of producers and importers form the root of this troubles. Producers want maximal returns for their coffee, and importers want to buy coffee at low prices.

Producing countries sometimes unite and form companies with the objective to stabilize the price of coffee at a high level by means of interference in the market by buying and selling coffee. This happens even though an I.C.A. forbids such cartels, e.g. the Bogota Group of a number of producing countries. On the other hand high prices result in actions by the consuming countries, see e.g. the appearance of consumer boycotts in the U.S.A. The implication for an econometric model of the world coffee market is that the formation of market prices requires special attention. This attention on the price formation will be given in this study.

My first objective is to specify a model which explains the price formation of coffee on the world market. The second objective is to simulate different policies of producing and consuming countries for analysing the effects on the price formation. Because of this second objective, a more general model than only some price equations will be specified. The model must be appropriate for the simulations.

Also various impacts of the working of the I.C.A. under different market circumstances might be analysed in the same way. Some scepticism, with respect to the impact of commodity agreements on the market behaviour, does also exist in the literature, as will be seen later on in this paper. The consequences of the agreements on the formation of the coffee price has to be investigated. Therefore, hypotheses will be formulated and tested, policies will be simulated. In that way the following kind of questions will be investigated:

- How far has the I.C.A. stabilized the coffee market?
- What is the effect of other policies compared to the results of the I.C.A.?
- What is the influence on the coffee price by common actions of producing countries?
- What is the relationship between spot and futures prices?

* I wish to thank Franz Palm for helpful comments and suggestions on earlier drafts of this paper.

In a previous study daily coffee prices were analysed. Because of this small time interval, I assumed that the daily prices can be described by the random walk model. It is hardly possible to specify an economic structural model on a daily basis. Daily prices react to news items concerning market circumstances which result in random shocks on the price. For testing the adequacy of the random walk model, the autocorrelation structure of the price changes has been investigated. Most of the series of price changes of different types of coffee were white noise, which is in correspondence with the above assumption. In the case that these price changes were autocorrelated, an explanation was available, such as the Brazilian price policy and the limiting conditions for price changes on the New York Coffee and Sugar Exchange (NYCSE). So far, only the 4th order autocorrelation of Robusta in the sample period 1976/77 cannot be explained.

So coffee prices resulting without limiting conditions (in both analysed sample periods 1974 and 1976/77 an I.C.A. did not exist) can be described by the random walk model. For the other prices a time series model can be estimated, representing the above-mentioned price formation, with the exception of Robusta.

As the present study has to be done for a sample longer than one year as follows from the objectives formulated above, a sample, starting in the early sixties, seems appropriate. A short data exploration has indicated that data on prices are available on any desired time interval, but data on other variables that will enter into the model are mostly only available as quarterly averages. In this paper I give a detailed description of a quarterly model for the coffee market.

In paragraph 2 a survey of the literature will be given, with the aim to discuss in more details those distributions which can be used in my quarterly model. This paragraph consists of two sections. One section concerns commodity market modelling in general, while the first section describes various studies of the coffee market. In both parts the price analysis will be emphasized. Mainly the price equations of these coffee models are discussed. From the literature on commodity markets the accent is on relationships among different prices, such as spot prices, futures prices, expected spotprices.

In section 3.2 the specification of a general model will be presented and a detailed description of the equations using theoretical considerations is given in 3.3. In the empirical work the equations have to be

written explicitly for the various groups of countries. This aggregation of the model is described in the beginning of 3.2. In 3.4 the data is discussed. A summary is given in paragraph 4.

2. Theoretical and empirical studies of commodity markets in general and the world coffee market in particular

2.1 Introduction

The way a commodity market, complete or partial, is modelled, depends on the objective of the research. Possible objectives are:

- Specifying, estimating and testing of structural equations to get more insight in the causal structure of the market.
- Partial or entire modelling of the market for testing specific hypotheses with respect to relationships among some variables.
- Modelling for prediction objectives.
- Formulating a model for policy purposes.

These different objectives of commodity market models are not mutually exclusive, e.g. a structural model can be used for several of these objectives. In section 2.2 some studies of the coffee market are discussed, studies that distinguish themselves by various research aims. The same is done for general commodity models in section 2.3. In both paragraphs the price formation and relationships among prices will be emphasized.

2.2 Econometric models for the coffee market

This survey of econometric models for the coffee market is not a complete summary of the entire literature of this subject. I shall concentrate on those aspects of existing models of the coffee market which may be used for the specification of the quarterly model in this paper.

The studies can be distinguished as follows:

I Models of the world coffee market

Bacha (1968), Parikh (1974), Ford (1977)

II Models for the coffee economy of one country

Bucholz (1964) Germany

Verdam (1977) England

Vogelvang (1980) Netherlands

III Special features of the coffee economy

a. Supply of coffee

Arak (1968)
Wickens and Greenfield (1969)
Rourke (1970)
Parikh (1979)

b. Policy

Gelb (1977)
Edwards and Parikh (1979)

c. Prices

Gelb (1974, 1979)
Kofi (1973)

I shall give some characteristics of these studies. As said earlier in this paper I concentrate on the price formation of coffee, so the main characteristics discussed here, refer to prices. The first model for this discussion is the model of Bacha (1968). He has constructed a policy-oriented linear econometric model for the period 1951-1965 using yearly figures. He analyses the supply and demand sectors of the coffee market, with special emphasis on the U.S. coffee market. Policy simulation experiments are carried out with the reduced form of the model. Supply equations are estimated for two states of Brasil (Sao Paulo, Parana), Columbia, other Latin American countries and Africa. Demand equations for the U.S.A. and the rest of the world, using the civilian disappearance (total consumption minus that of the Armed Forces) of regular and instant coffee as dependent variable. Why this distinction has been made, is not made clear.

Bacha (1968) specifies two price equations, one for the Milds and one for the Robusta coffee (for yearly data):

$$P_t^M = f(P_t^B, P_t^R, \forall P_t^M, IMP_t^M, CONSIND_t^{OECD})$$

$$P_t^R = f(P_t^B, P_t^M, \forall P_t^R, IMP_t^R, CONSIND_t^{OECD}),$$

where

P_t^M, P_t^B, P_t^R are the prices of Milds, Brazils and Robusta (deflated),

IMP_t is aggregated import and $CONSIND_t^{OECD}$ is the index of total consumption expenditure for the OECD countries.

The finally estimated equations are restricted for the coefficients of IMP_t and $CONSIND_t^{OECD}$ by taking these coefficients as a fixed ratio because of multicollinearity problems, and the one year lagged dependent variable is specified as explanatory variable because of significant autocorrelation.

The price-determination of regular and instant coffee is derived by combining an equation for the desired level of the retail price as function of the mark up of the import price and an adjustment equation:

$$PCON_t^* = (1 + UP) \left(W + \frac{1}{EXT_t} \cdot P_t \right)$$

$$PCON_t - PCON_{t-1} = \gamma (PCON_t^* - PCON_{t-1})$$

where $PCON$ = consumers price W = unit prime costs
 $PCON^*$ = desired consumers price P = import price
 UP = mark up rate EXT = extraction rate.

His estimation results were not quite satisfactory.

The coffee model of Parikh (1974) is also a yearly model, for the sample period 1950-1968. It is a structural, highly aggregated model: world production, exports from some major producing countries, imports into the U.S.A., Europe, the rest of the world. World prices are among the dependent variables, explained in the model. A variable for expected world market prices appears in the stock equation for importing countries. Parikh assumes that these expected spot prices are determined by the adaptive expectations relation:

$$Pw_t^{**} - Pw_{t-1}^{**} = \gamma (Pw_t^{**} - Pw_{t-1}^{**}) ,$$

with Pw being a world market price and Pw^{**} the expected world market price. But a structural equation for Pw^{**} is also specified:

$$Pw_t^{**} = f(I_t^{**}, FEWP_t) , I_t^{**} = \text{expected import demand}$$

$FEWP$ = first estimate world production.

The variable I_t^{**} , which is not included in other equations is, surprisingly, considered as exogenous.

A value of γ has been determined by a search procedure: it is the value of γ which maximizes the multiple correlation coefficient for the stock equation.

This is a rather curious procedure. Expected prices are computed using the chosen value of γ , and serve as observations on P_w^* in the structural equation. Parikh assumes for I_t^* also an adaptive expectations relation. But it is not clear how he derives the finally estimated equation:

$$P_w^* = 506.30 + .98 P_w^* - 416.00 \frac{FEWP_t}{IMP_{t-1}} \quad \bar{R}^2 = .74$$

t-values: (2.93) (5.39) (2.42) h = 4.32

The purpose and interpretation of this equation is not clear. The equation is not specified for generating price expectations to be used in other (policy-) equations. When the equation is interpreted independently, it is not self-evident that a high estimate of the world production should lower the expectations concerning the future world market price. It is obvious that producing countries will try to obtain (or maintain) a maximum coffee price, and will use inventory manipulation to realize this purpose. A low estimate of world production will more easily rise the price expectations. But in both cases the ICA will come into operation, after some delay, trying to keep the price within its range. Variables, such as producer's/consumer's inventories and quota's, seem useful for this equation. Also the difference between the estimated world production and the mean of the former five years production is perhaps more appropriate than only the estimated production.

In my opinion, it is not of direct interest to specify a relationship in that way. A specification that supplies good forecasts for future spot prices, to be used as expectations in the model, seems more useful. Parikh does not comment on the high value of the h-statistic indicating the presence of significant positive autocorrelation. Possibly, this autocorrelation indicates that the equation is inappropriate to explain price expectations.

The aggregated price equation of the model is:

$$P_t^W = f(INV_{t-1}, P_{t-5}^W, \nabla INV_t, Q_t, D_{ti}, D_{tj}).$$

The inventories INV are inventories in producing and importing countries. The 5 year lagged world market price is inserted because of the slow

reaction of production on prices. Q_t stands for the quota at the beginning of the crop year. D_{ti} is a dummy variable for events in importing countries (e.g. strikes) and D_{tj} for exporting countries (e.g. weather). In estimating this equation some variations arise. Imports are explained in the model by inventories, world prices and a dummy variable as above, and exports depend only on price ratios of different types of coffee.

A third model of the world coffee economy is the model built by Ford (1977). He has developed a complete simultaneous equation model for the world coffee economy, using yearly data over the sample period 1930-1969. He gives a very extensive description of the coffee market in the 731 pages of his dissertation.

Ford divides the world coffee economy in many production and consumption zones and defines price and trade functions between these zones. The price equations between the production (i) and consumption zones (j) are all of the same specification. The prices used, are New York spot market prices (PM) and the one year lagged interzone price:

$P_{ij,t}^j = f(PM_t^k, P_{ij,t-1}^j)$, where k is the coffee type. PM_t^k is determined by the price of Brazils, quota's, exportable production and inventories. He estimates trade equations between production and consumption zones, which have the form:

$$Q_{ij,t}^j = f(\text{deflated prices, trend, war-dummy, } Q_{ij,t-1}^j)$$

Sometimes, deflated prices are replaced by price ratio's and a consumption ratio of regular coffee and soluble coffee is added. I do not think that these tight similarities are justified.

Now I discuss some coffee models of importing countries. The work of Bucholz (1964) belongs to the earliest econometric research that has been done on coffee. He has specified and estimated an econometric model for the coffee market in Germany, consisting of equations for consumption, price determination, imports and inventories.

Verdam (1977) has done some work on an import equation of the United Kingdom. A quarterly econometric model specified as

$$IMP_t^{cof} = f(IMP_t^{tea}, Pw_t \text{ (or lagged), trend, seasonal dummies})$$

did not result in satisfactory estimates for the parameters (sign,

significance level) or a good explanation ($\bar{R}^2 \approx .35$).

If yearly figures are used, the quarterly fluctuations are eliminated and the results improve considerably. Using yearly data he estimated the model

$$\text{IMP} = f(\text{trend, price, imports of tea})$$

The poor results, when using quarterly data, might be caused by fluctuations in inventories, not included in the model by Verdam because data on inventories were not available at that time. Vogelvang (1980) has estimated a consumption function for the Netherlands using monthly figures. His specification can be used in the model presented in this paper. His linear model is given by:

$$C_t = f(C_{t-12}, P_t, (1-B^{12})^+ P_t, (1-B^{12})^- P_t, P_t^W, P_t^S, \text{TCI}_t, D_t),$$

with P_t = retail price, P_t^S = price of soft drinks, TCI_t = total consumption index, and B being the lag operator, where

$$\begin{aligned} (1-B^{12})^+ P_t &= (1-B^{12}) P_t \quad \text{if } P_t > P_{t-12}, \\ &= 0 \quad \text{otherwise.} \end{aligned}$$

For $(1-B^{12})^- P_t$ the opposite is valid.

The last part of this section concerns special features of the coffee market, which will be briefly described, starting with the production side.

Arak (1968) describes the relationship between coffee prices and the number of trees in the Brazilian state of Sao Paulo. After some theoretical derivations, the estimated model is:

$$\frac{A_t}{T_{t-1}} = b_0 + (b_1 + b_2 P_t) \frac{T_{t-1}^M}{T_{t-1}} + (b_3 + b_4 P_t) \frac{T_{t-1}^Y}{T_{t-1}},$$

where T = acreage with coffee plants, P_t = level of price expectations,

T^Y = number of coffeetrees between 3 and 9 years of age,

T^M = number of coffee trees over 10 years of age,

A_t = total abandonment of coffee trees.

The estimation results for the sample period 1933-'50 are:

$$\begin{array}{ll} b_0 = .04 & b_3 = .00012 \\ (.01) & (.00010) \\ \\ b_1 = -.47 & b_4 = .44 \cdot 10^{-6} \\ (.12) & (.11 \cdot 10^{-6}) \\ \\ b_2 = .67 \cdot 10^{-4} & R^2 = .71 \\ (.25 \cdot 10^{-4}) & \end{array}$$

So the conclusion of his study is, that abandonments of younger trees are inversely related to farmers' price expectations, as was assumed by Arak; while farmers abandon a greater number of old coffee trees, the higher the real coffee price expectations are.

Rourke (1970) estimated the biennial cycle in the coffee production of various Brazilian states, Columbia and Ivory Coast, by using the simple equation $\nabla Q_t = f(\nabla Q_{t-1}, t, u)$, with ∇Q_t being the change in production. He does not mention how the parameters of this equation were estimated, but it seems likely that the estimates have been computed by o.l.s., without checking whether this is the most appropriate method for this dynamic model.

Parikh (1979) has estimated a number of supply functions for several coffee producing countries using polynomial distributed lags on spot prices of coffee in New York. Similar work is done by Wickens and Greenfield (1969). The purpose of Parikh's paper is to formulate a theory of the production function for tree crops and to estimate the model on the basis of data available for eight countries (Latin American and African) over the period 1946-'47 to 1975-'76. The form of the supply function used for estimation is

$$y_t = \alpha_0 + \sum_{i=0}^8 \beta_i P_{t-i} + \alpha_1 y_{t-1} + \alpha_2 y_{t-2} + \epsilon_t,$$

where y_t is production and P_t is the spot price in New York.

The estimation results are rather different for the various countries. The function does not explain the supply of Brazil at all. For the other countries substantial differences exist between the estimated coefficients $\hat{\beta}_i$ in terms of sign, magnitude and significance level. Although Parikh states that this model has a theoretical rationale for a crop like coffee, it seems that a less uniform specification of the equations for the different countries might yield more satisfactory results.

In Edwards and Parikh (1979) the structure of the world coffee market is analysed to find policies that stabilize the export earnings of coffee exporting countries, by minimizing its fluctuations. This study is based on the simultaneous model of Parikh (1974), which was described earlier in this paragraph.

The conclusions of Edwards' and Parikh's study are that, in the long run, the most successful policies include the development of rapidly maturing trees and the imposition of a quota on exports, and in the short run, a buffer stock policy is effective, given sufficient resources. I agree with the authors' own criticism concerning the level of aggregation and think it might be worthwhile to do such an analysis on a more disaggregated level.

Lastly, I should like to mention the work of Gelb. In Gelb (1974) the relationship between coffee prices and the Brazilian exchange rate has been analysed by using spectral techniques. In his 1977 paper, he uses the techniques of stochastic control theory for analysing policies, which can stabilize the coffee economy. Spectral techniques are used again in Gelb (1979) to analyse the behaviour of coffee prices for the years 1822-1969. He finds one cycle with a period of 18 years. I shall not go into a further detail of Gelb's work at the moment, as it is not of direct interest for the coffee model at this stage of the project.

2.3 Econometric analyses of commodity markets in general

In this paragraph some features of modelling commodity markets in general are described. As the main objectives of my study are to analyse the price formation of coffee on the world market and to simulate some policies, I shall treat here those aspects of modelling commodity markets that are related to these two objectives.

The subjects to be discussed in this paragraph are:

- the supply of storage theory,
- relationships among prices from the spot and futures market,
- market efficiency,
- policy models.

First, I will give a brief presentation of the supply of storage theory. The supply of storage theory has been developed in order to explain the dynamic nature of world commodity prices. This is a long used theory for investigating price relationships in commodity markets. See e.g. articles

from Holbrook Working (1949), Brennan (1958) and Telser (1958). In this paper, I will not go into these articles in detail, but I shall limit myself to the study of Weymar (1968), which is based on the work of the authors mentioned here. Weymar gives an extensive treatment of the supply of storage theory with an application to the world cocoa market. There exist many similarities between the cocoa and coffee economy. It therefore seems worthwhile to investigate whether this theory yields a satisfactory explanation of the spot price determination in a model for the coffee market. Weymar starts with the following model for a commodity.

$$(i) \quad C_t = f_c (P_t, P_{t-1}) + \epsilon_c$$

$$(ii) \quad H_t = f_h (P_t, P_{t-1}) + \epsilon_h$$

$$(iii) \quad (P_t^* - P_t) = f_p (I_t) + \epsilon_p$$

$$(iv) \quad I_t = I_{t-1} + H_t - C_t$$

where: C_t = consumption,

P_t, P_{t-1} = price, lagged price,

P_t^* = expected price at some point in the future,

H_t = production (harvest),

I_t = inventory.

The third equation of the model represents the supply of storage curve. One assumes that the amount of a commodity that people are willing to store depends on their expectations of the price in the future. The derivation of a specification that can be estimated, is tedious (for the details, see Weymar (1968)). I will give a summary in this paragraph. The theoretical derivation results in the equation:

$$\ln P_t - \ln P_t^{*\infty} = F^{*h1} (Y_t, Y_t^{*h1}) - F^{*\infty} (Y_t^{*h1}, Y_t^{*\infty}),$$

which explains the difference between the spot price (P_t) and the long run equilibrium price ($P_t^{*\infty}$) by two components: one for the crop year $F^{*h1}(\cdot)$ and one for the period after the crop year $F^{*\infty}(\cdot)$. These

components depend on the current inventory ratio, $Y_t = \frac{I_t}{C_t}$, the market's forecasted inventory ratio for the end of the crop year h_1 , $Y_t^{*h_1}$, and the expected long run equilibrium inventory ratio, $Y_t^{*\infty}$. Both the components have to be made operational.

Therefore, Weymar assumes that both the price and inventory ratios approach their expected equilibrium values as t goes to infinity. Weymar assumes initially that the equilibrium price equals the mean of the deflated postwar prices. The monthly inventory ratio is known at the beginning of the period, also known are the predictions concerning the inventories at the end of the crop year and consumption during the period, till the end of the crop year.

Weymar assumes that price expectations are a function of the expected storage ratio and calls this the short run supply of storage function. This function is assumed to be of the following form

$$\ln\left(\frac{P_t^{*h+1}}{P_t^{*h}}\right) = b_1 + b_2 \ln Y_t^{*h}, \text{ where } P_t^{*h} = \text{expected price at horizon interval } h;$$

$$Y_t^{*h} = \text{inventory ratio expected at horizon interval } h.$$

In Weymar's study the time unit h is one month. The expected price change from the present to the end of the crop year (h_t) can be written as

$$\ln\left(\frac{P_t^{*h_t}}{P_t^{*h}}\right) = \sum_{h=0}^{h_t-1} (b_1 + b_2 \ln Y_t^{*h})$$

or

$$\ln\left(\frac{P_t^{*h_t}}{P_t^{*h}}\right) = b_1 h_t + \sum_{h=0}^{h_t-1} \ln Y_t^{*h},$$

where h_t is defined as

$$h_t = 12 \text{ in the final crop month}$$

$$= 11 \text{ in one month before the final crop month, etc.}$$

I follow Weymar's study in which monthly data are used, but that is not a loss of the generality, this theory can also be used for quarterly data.

Weymar assumes that the expected inventory ratio in each month h during the crop year can be defined in terms of the current inventory ratio and the ratio expected at the horizon time h_t :

$$\ln Y_t^{*h} = c_h + d_h \ln Y_t + e_h \ln Y_t^{*h_t} .$$

The coefficients of this equation can be estimated using historical time series. This is done for every month of the crop year. Combining the last two equations gives

$$\ln \left(\frac{P_t^{*h_t}}{P_t} \right) = b_1 h_t + b_2 \left[\sum_{h=0}^{h_t-1} c_h + \left(\sum_{h=0}^{h_t-1} d_h \right) \ln Y_t + \left(\sum_{h=0}^{h_t-1} e_h \right) \ln Y_t^{*h_t} \right] ,$$

where the expressions between the brackets can be computed from the estimates for c_h , d_h and e_h .

Denoting the term between brackets by Z_t , the last equation can be written as

$$\ln \left(\frac{P_t^{*h_t}}{P_t} \right) = b_1 h_t + b_2 Z_t .$$

The expected price change before the end of the crop year is expressed as a linear combination of the unknown coefficients b_1 and b_2 of the short-term supply of storage function, weighted with known data.

An analogous procedure can, of course, be applied in yearly changes (from final crop month to final crop month) in price and inventory expectations by using historical data.

Assume that the path of the expected long run inventory ratio $Y_t^{*s_n}$ moving to its long run equilibrium value \bar{Y}^{*s} in the post horizon period, is described by

$$Y_t^{*s_n} = \left(\frac{Y_t^{*s_0}}{\bar{Y}^{*s}} \right) g^n \cdot \bar{Y}^{*s} ,$$

with $0 < g < 1$ and $n \in \mathbb{N}$,

where

$Y_t^{*s_n}$ = expected inventory ratio n final crop months after the horizon,

- Y^{*s}_0 = expected inventory ratio at the horizon,
 \bar{Y}^{*s} = expected equilibrium final crop month inventory ratio,
 g = parameter indicating the rapidity of Y^* 's approach towards equilibrium.

After some substitutions of relationships given above, the equation to be estimated can be written as

$$\ln\left(\frac{\bar{P}}{P_t}\right) = a + b_1 h_t + b_2 Z_t + b_3 \ln Y_t^{*h} + e_t,$$

with restrictions $a = -b_3 \ln \bar{Y}^{*s}$,

b_3 is a function of b_2 and g .

\bar{P} is the postwar average real spot price.

Weymar obtained good estimation results for this equation, when applied to the cocoa market. Because of the similarities existing between the cocoa and coffee market, the supply of storage theory is a candidate for explaining the spot price of coffee also.

The second subject of this paragraph concerns price relationships among spot, futures and expected spot prices. Much research has been done on this subject. Some articles are briefly discussed in this paper. The choice has been made with regard to the relevance of the hypotheses for my model of the coffee market.

I will give some of the contributions in these articles with respect to commodity prices in the spot and futures market, which illustrate different aspects of commodity market analyses. I make the following distinction.

- The forecasting properties of the futures prices for the spot market prices.
- Hedging.

Let me start with the forecasting properties of the futures prices.

In the study of the futures market, Tomek and Gray (1970) concentrate on the following relationship

$$P_c = a + b P_f,$$

with P_c = cash price at harvest time,

P_f = spring time futures price for end of the crop year.

The futures price is defined as a self-fulfilling forecast of the cash price if for each year $P_c = P_f$. This hypothesis can be tested for a commodity, by estimating the regression relationship between the cash price and the prior futures price and testing whether the intercept is zero and the slope is unity. Tomek and Gray have carried out this test for commodities that are storable and those that are not. They found substantial differences between these two kinds of commodities. The hypothesis, $a = 0$ and $b = 1$, was not rejected for storable commodities (corn, soybeans), for non-storable commodities (potatoes), it was rejected. The distance between the futures and spot quotations was 8 or 9 months.

This hypothesis is further elaborated by Kofi (1973) who uses the same framework for analysing the reliability of futures quotations as predictors of spot prices. Just as Tomek and Gray, he carries out some tests, using monthly data in the form of closing prices on the last trading day of each month. He has computed regressions for the equation $P_h = \alpha + \beta P_{fh} + \epsilon_h$,

with P_h = cash price at harvest time,

P_{fh} = previous futures quotations for harvest time contract. For coffee the September contract is used.

ϵ_h = a random disturbance term.

A difference from the study of Tomek and Gray is the variable distance between futures and spot quotations. The results for coffee over the sample period 1953-1969 are summarized in table 1 and figure 1, for different distances between futures and spot quotations.

Kofi explains the decrease in r^2 after eight months (deviation of the expected pattern) by the impact of the coffee agreement on the coffee prices.

distance	$\hat{\alpha}$	$\hat{\beta}$	r^2
10 months	-5.99 (11.06)	1.27 (.24)	.79
8 months	1.44 (7.05)	1.03 (.15)	.88
6 months	17.73 (7.40)	.66 (.14)	.75
2 months	13.03 (4.46)	.74 (.08)	.92
1 month	-5.73 (3.78)	1.14 (.07)	.97

Table 1: Estimation results of relationships between spot and futures prices, with standard errors in parentheses

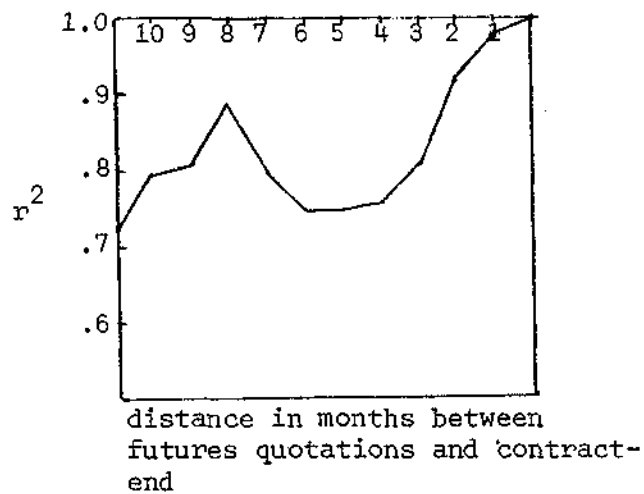


Fig.1: Predictive reliability of a coffee futures contract

The relationship between spot and futures price is also studied by Danthine (1978). He emphasizes the informative role of futures prices. For that reason he investigates the relationship between spot and futures prices. Danthine (1978) analyses futures markets as: "A place where hedgers compensate speculators for sharing the risks inherent to their productive activity and shows that this asymmetry between economic agents reveals to futures price as a biased estimate of the spot price and, in its own right, can generate speculative tradings".

I will now mention some studies with respect to hedging. A commodity trader will hedge his inventory or demand if he wants to eliminate the risk of sustaining a loss, caused by price changes. The explanation of the shifting of risk is an important subject in the futures trading literature. E.g. the analysis of the risk premium required on a futures contract, as is done by Dusak (1973). Black (1976) demonstrates that the futures market is not unique in its ability to shift risk, but it is unique in the guidance of producers and distributors concerning the values of forward contracts and options in terms of the futures price and other variables. Another aspect of futures trading is analysed by Rolfo (1980). In his model he determines the optimal hedging percentage for cocoa producers. Traditionally, speculation has not been taken into account and a complete hedge is therefore recommended. But uncertainty about the agricultural production cannot be hedged in a futures market.

Rolfo shows that: "Limited usage of the futures market may be superior to a full short hedge of expected output, for producing countries when there is production variability". This conclusion is not of direct interest for the specification of the model in this paper, because futures prices are not included in the model at this stage of the project. It might be an interesting hypothesis which can be separately tested later on.

The third mentioned subject for a discussion in this paragraph is the efficiency of the spot and futures market. The efficient market hypothesis is a well-known research topic in the financial literature, and to a smaller extent in the literature with regard to commodity

prices. The literature on market efficiency is voluminous. I will not try to give a complete survey here of the literature, but I will discuss a few articles illustrating some important aspects.

A market is called an efficient market if prices fully reflect the available information about the market. Fama (1970) gives a detailed review of the theoretical and empirical research that has been done on the efficient market model for capital markets. He distinguishes three forms of market efficiency: weak form, semi-strong form and strong form. In the weak form, the information used to determine market prices consists of historical prices only. The semi-strong form concerns whether prices efficiently adjust to public available information. The strong form concerns whether groups of market participants exist which have monopolistic access to information relevant for price formation. Most of the hypotheses that have been tested concern the weak form market efficiency. In that case the tests are concerned with the question whether the prices follow a martingale. This is done by testing whether price changes have been generated by a white noise process or not.

Applications to commodity markets are given in Smidt (1965): soybean futures prices, Stevenson and Bear (1970): corn and soybean futures prices, and Praetz (1975): wool futures prices. Leuthold (1972) has done a study with regard to the live cattle futures market. In all these studies the investigators test whether price changes are serially uncorrelated. With respect to the hypothesis of serially uncorrelated price changes, it is important to mention the study of Danthine (1977) who shows that in an efficient commodity market, changes in spot prices need not necessarily behave like a white noise process. This is caused by specific features inherent in commodity markets and so clearly distinct from capital markets. In Danthine's model the market uncertainty is the demand for the commodity, while in the coffee economy the uncertainty is the production (the yearly crop). This aspect has to be taken into account when Danthine's theory is applied to the coffee market.

It is certainly useful to mention that some of the articles discussed in this paragraph are reprinted in Goss and Yamey (1976). Lastly I will discuss the use of commodity models for policy purposes.

One of the most important policy purposes for a commodity market is to stabilize prices at a level acceptable to producing and importing countries. Examples are the various commodity agreements between producing and importing countries, as e.g. for wheat, coffee, cocoa, sugar, tin. Also the efforts of UNCTAD to start a common fund for raw materials have the same objective; see e.g. Barents (1980). A review and appraisal of commodity price stabilization models is given by Labys (1980). Most of these models use commodity buffer stock policies. Here I will give a brief summary of Labys' article, because many aspects of these types of models have been treated by him.

Labys distinguishes the following three types of models.

1. Simple supply and demand relationships, which make it possible to derive the expected gain to producers and consumers.
2. Empirical models with the same framework as under 1, but with some variations dependent on the objective, showing differences between stabilized and non-stabilized markets concerning income effects and welfare gains.
3. Econometric models with four basic equations: a demand supply and price equation together with a stock identity where the buffer stock variable is crucial to the price stabilization analysis.

His conclusion is: "None of the studies examined has overcome the myriad of problems that analysts have pointed out as essential for assessing the welfare outcomes of price stabilization schemes. As a consequence, stabilization analyses for similar commodities have produced conflicting results regarding predicted welfare outcome". Because several studies have diverse results, Labys gives a number of recommendations which could help to improve price stabilization models. In short his recommendations are:

- Firstly, Labys mentions some studies with a greater number of commodities involved. By interrelating the corresponding commodity models, multi commodity models are constructed. As to how far this approach yields better results may be concluded after the recent

- literature on this topic has been studied. Possibilities for applying this idea to the coffee market seem to exist. E.g. in my former analysis of daily prices it has been noticed that prices of coffee, cocoa and tea are clearly correlated. At present, it is not my intention to construct a multicommodity model.
- More attention has to be given to the functional specification of the econometric relationships.
 - The necessity of specifying the nature of private as well as public stockholding in a commodity market, including interactions between the two, is important.
 - Attention for the dynamics of commodity market adjustments by using e.g. spectral techniques to determine the underlying generating processes of price and inventory variables. Such an analysis might improve the formulation of a dynamic buffer stock mechanism in which price variance and trends are interrelated. It is our experience too, that the use of spectral techniques can help to improve the specification of a model by better understanding of the dynamics of the variables; see Vogelvang (1980).
 - He recommends also stochastic simulation methods because the "historical record is usually so short that it tells us little of the future". Partial stabilization schemes can also be investigated in this manner. Stochastic methods can help in learning how the form of disturbances affects the outcome of stabilization analysis. This might be done for example by including shocks reflecting uncertainty regarding climate, or by including probability distributions associated with different variables.

In Labys' opinion, more realistic results with stabilization models could be obtained, when analysts take account of these recommendations. In this paragraph many studies of commodity markets, theoretical and empirical, have been discussed. In summary, some of the links between these studies and a model for the coffee market are mentioned.

We reviewed existing econometric research into the coffeemarket, with the intention to show their features of price relationships, and to place this project within the context of the literature. Elements useful for our model have been found.

The supply of storage theory can be applied to the coffee market to provide an equation for the price determination. The studies concerning

price relationships among spot and futures prices, and the efficient market theory might be of use for an equation explaining price expectations.

A second question to be analysed for the coffee market is to what extent the ICA's have stabilized the market, as price stabilization is one of the objectives of the I.C.A. Article 1 sub 1 and 2 of the ICA-'76 reads as:

"The objectives of this Agreement are:

- (1) to achieve a reasonable balance between world supply and demand on a basis which will assure adequate supplies of coffee at fair prices to consumers and markets for coffee at remunerative prices to producers and which will be conducive to long-term equilibrium between production and consumption;
- (2) to avoid excessive fluctuations in the levels of world supplies, stocks and prices which are harmful to both producers and consumers;"

In Barents (1980) opinion, the ability of agreements to control the international trade is very limited for raw materials as well as for coffee; this we will investigate.

3. A model for the world coffee market

3.1 Introduction

In this paragraph a quarterly model for the coffee market will be specified and its equations will be discussed. As the shortest time interval, for which most of the variables of the model are available, is per quarter, we shall use quarterly data. Quarterly data are expected to be more informative on the mechanism of price formation in the coffee market than e.g. annual data.

In this section a flow diagram of the world coffee market is given with a short explanation. The flow diagram forms the basis for the specification of the model equations in section 3.2.

The model, as presented in 3.2, has to be seen as a general basic specification. For the equations of individual countries or regions, the functional form of the equations and the explanatory variables may be different. Data constraints will also influence the specification.

For instance, for the U.S.A., detailed information on imports and consumption is available, while for East Europe and the U.S.S.R. the data are scarce. The degree of aggregation of the model is discussed at the beginning of section 3.2.

The equations of the model are discussed in detail in section 3.3. A brief description of available data (available at this moment) is given in section 3.4.

First we shall start with a flow diagram. Assumptions concerning the causal relationships among variables of a model for the world coffee market are represented by the arrows in figure 2, which gives a general scheme.

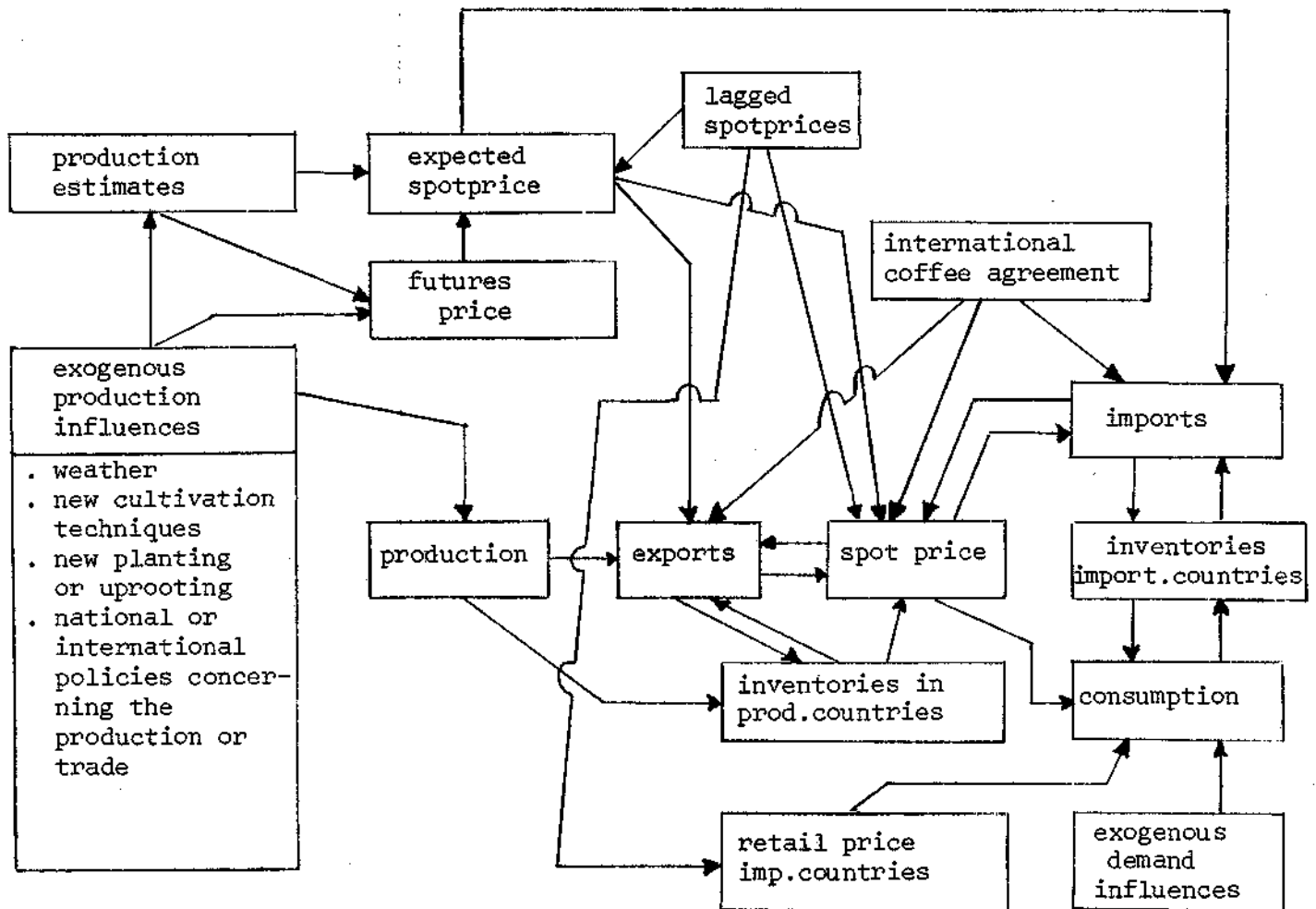


Fig. 2: A flow chart for the world coffee market

Some of the arrows deserve a short explanation. The influence of the ICA on the spot price comes into operation when the spot price is outside a price range during a number of days. The quota-system then acts until the price is in the price range again (see I.C.O. (1976) art.38). Production estimates are made quarterly by the United States Department of Agriculture (USDA) and published in their coffee information sheet. Also the Instituto Brasileiro do Cafe (IBC) furnishes production estimates. Concerning the exogenous production influences, we can mention that, at present, new cultivation techniques are applied particularly in Columbia and result in a higher yield. All the Latin American coffee producing countries have national coffee bureaus, and these bureaus also try to control the coffee price by means of export tax manipulation or by minimum registration prices. Most of these bureaus are governed by the countries' ministry of finance. New planting or uprooting plans are also developed by those bureaus. Another channel through which producing countries today try to affect the coffee price, is by operations on the New York Coffee & Sugar Exchange. The producing countries, united in "the Bogota Group", try to stabilize the coffee price at a high level by trading on this Exchange. The Bogota Group consists of the following countries: Brazil, Columbia, Costa Rica, El Salvador, Guatemala, Honduras, Mexico and Venezuela. Sometimes Ivory Coast attends meetings of the Bogota Group as an observer. As a reaction to the existence of the Bogota Group, no further U.S. congressional action regarding I.C.A. implementing legislation is expected. This is not the first time in the coffee history, that producing countries act together in the market. Exogenous demand influences are e.g. changes in consumption habits, trends and prices of substitutes for coffee, like soft drinks and tea. Obviously some of the relationships represented by the arrows, are explained in the studies described in the former paragraph. For instance, the relationship between production and spot price, between spot and futures price, and aspects of the demand for coffee.

3.2 The specification of the model

In this paragraph I will give a general specification of the model. A classification of importing and exporting countries is first discussed.

In appendix A, a survey is given of the exports and imports of the member countries of the I.C.O. The figures indicate the importance of different countries with respect to their participation in the coffee market. Important countries will be included separately, smaller countries will be grouped.

The producing countries will be distinguished according to the four main types of coffee:

Columbian Milds

- A. Columbia
- B. Kenya and Tanzania

Other Milds

- C. One group of all countries

Unwashed Arabicas

- D. Brazil
- E. The other countries

Robustas

- F. One group of all countries.

The importing countries can be grouped according to their similarities in consumption habits, except for VI. At present, I propose the following grouping:

- I U.S.A.
- II British Commonwealth and Ireland
United Kingdom, Ireland, Canada, Australia, New Zealand
- III Scandinavia
Sweden, Denmark, Norway, Finland.
- IV A number of Western European countries
West Germany, France, Netherlands, Italy, Belgium and
Luxembourg, Switzerland, Austria, Spain
- V Japan
- VI Non-member countries of the I.C.O.

Producing countries

$$(5a - 5f) \text{EXP}^p = f(P^k, EP^k, Q^{p*}) \quad p \in \{1, \dots, 6\}$$

$$(6a - 6f) \text{INV}^p = \text{INV}_{-1}^p + \text{PROD}^{p*} - \text{EXP}^p \quad p \in \{1, \dots, 6\}$$

Importing countries

$$(7a - 7f) \text{IMP}^i = f(\text{INV}^i, \text{CDP}, Q^{i*}, \text{ECDP}) \quad i \in \{1, \dots, 5\}$$

$$(8a - 8f) \text{CONS}^i = f(\text{CDP}, \text{PR}^i, \text{TCI}^{i*}, \text{exogenous demand influences}) \\ i \in \{1, \dots, 5\}$$

$$(9a - 9f) \text{PR}^i = f(\text{CDP}_{-1}, \text{TAX}^*, \text{MARK-UP}^*) \quad i \in \{1, \dots, 5\}$$

$$(10a - 10f) \text{INV}^i = \text{INV}_{-1}^i + \text{IMP}^i - \text{REEXP}^{i*} - \text{CONS}^i \\ i \in \{1, \dots, 5\}$$

Other identities

$$(11a - 11d) \text{INV}^k = \sum_{p=1}^P \text{INV}^p \quad \text{if country } p \text{ produces coffee type } k \\ k \in \{1, \dots, 4\}$$

$$(12a - 12d) \text{EXP}^k = \sum_{p=1}^P \text{EXP}^p \quad \text{if country } p \text{ produces coffee type } k \\ k \in \{1, \dots, 4\}$$

$$(13) \sum_{p=1}^6 \text{EXP}^p = \sum_{i=1}^6 \text{IMP}^i$$

The following notation has been used:

- P^k : spot price of coffee type k on the New York market (ICO-indicator)
- EP^k : expected spot price of coffee type k for some future point of time
- CDP : composite daily indicator price, 1968 agreement
- ECDP : expected composite daily indicator price
- PR^i : retail price in country i
- PROD^{p*} : production in country p
- Q^{k*} : export quota's of coffee type k
- Q^{p*} : export quota's of producing country p
- Q^{i*} : indication, that quota's are effective, for importing countries, as will be outlined in the next section
- EXP^p : exports from country p to all destinations
- EXP^k : total exports of coffee type k , from producing countries, to all destinations

IMP^i : imports of country i from all sources
 $REEXP^{i*}$: reexports from country i to all destinations
 INV^p, INV^i : inventory in country p or i
 INV^k : total inventories of coffee type k , held by producers
 $CONS^i$: consumption in country i
 TCI^{i*} : total consumption index of country i .

Summarized, the model exists of six structural equations, two definition equations and five identities, in its general specification. In its (dis)aggregated form we have 51 equations. The 51 endogenous variables are:

P^k, EP^k, INV^k, EXP^k $k \in \{1, \dots, 4\}$
 $PR^i, IMP^i, INV^i, CONS^i$ $i \in \{1, \dots, 5\}$
 EXP^p, INV^p $p \in \{1, \dots, 6\}$
 $CDP, ECDP$ and IMP^6 .

The 31 exogenous variables are:

Q^{k*} $k \in \{1, \dots, 4\}$
 $REEXP^{i*}, TCI^{i*}, Q^{i*}$ $i \in \{1, \dots, 5\}$
 $PROD^{p*}, Q^{p*}$ $p \in \{1, \dots, 6\}$.

The prices are measured in dollar cents per pound, the quantities like exports, imports, inventories, quota's, are expressed in bags of 60 kg, and consumption in gram per capita.

Time lags have been specified for some prices and in the identities. The inclusion of time lags for other variables has been left open.

3.3 Discussion of the equations of the model

We go on in this section with a detailed discussion of the model. Production is assumed to be predetermined. This assumption is quite natural for a quarterly model. Production is influenced by policy decisions, like new planting, but it takes several years before the crop is affected. A time-lag of five or more years can be expected. It is possible to consider equation (1) as the solution for p^k of the market clearing condition $EXP^k = IMP^k$, which cannot be explicitly included in the model because IMP^k is not observed. Therefore equation (1) explains the spot price of coffee type k by means of the variables determining supply, EXP^p , and demand, IMP^d .

When specifying equation (1) for one type of coffee, it might be necessary to include one or more prices of other coffee types. But this is only meaningful after knowledge has been obtained about price leadership of one or more types of coffee. Bacha (1968) specifies e.g. the Robusta price as an explanatory variable for the price of Milds (see section 2.2). But if a price leader is present in the coffee market, it will be the price of Unwashed Arabicas or Columbian Milds, as Robusta is an inferior type of coffee compared with these two.

A causality in the other direction, that is also done by Bacha, seems appropriate.

Data on quotas do exist, but just as knowledge of the practice of the ICA, it is still missing at this moment. Both are necessary for the model.

The coherence between quota's, exports and imports has to be investigated when data on quota's and the quota system has been made available.

The supply of storage theory gives also an equation for the spot prices, as was outlined in the former paragraph. This can be an alternative rationale for a spot price equation.

Equation (2), the determination of the expected spot price, has been left open so far. I shall discuss at first the other equations of the model and then return to equation (2) for a comprehensive discussion of possibilities for determining these price expectations.

Equation (3) is a definition. The composite daily indicator price is computed in that way according to the 1968 coffee agreement. According to the 1976 agreement, the CDP is only the mean of the price of Robustas and other Milds. Therefore, an indicator for the "world mar-

ket price" is better obtained by using the CDP-1968.

Equation (4) concerns the expected world market price and is computed in the same way as the CDP, but now from the expected spot-prices determined by equation (2).

For the producing countries an export equation (5) and an identity determining inventories (6) are specified. In this identity, a bufferstock variable can be inserted, which will be necessary when policy simulations will be carried out with the model.

The demand for coffee in importing countries consists of the imports (7) and the consumer demand (8). The specification of these equations refer to the studies discussed in the former paragraph. It seems appropriate to include the world market price and the retail price in the consumption equation, as consumers will use the world market price as an indication for the future retail price. The exogenous influences in the consumption equation are variables like trends, prices of substitutes for coffee. Q^i , in the import equation, denotes that quota's are effective, and may be specified as a dummy variable. The rationale for the inclusion of this variable is article 45 of the I.C.A.-1976: "To prevent non-member countries from increasing their exports at the expense of exporting Members, each Member shall, whenever quota's are in effect, limit its annual imports of coffee from non-member countries.....".

Another modification for various equations, might be the specification of net-imports instead of imports and re-exports, as it is not obvious that re-export is a relevant variable for the price formation of coffee. This last aspect is an important criterion for the model as stated at the beginning of this paper.

The major variable in explaining the retail price in equation (9) is the lagged composite daily price. The retail price is expected to follow the development of the coffee price on the world market. In Vogelvang (1980) a correlation coefficient of .65 has been found between the Dutch retail price of coffee and the CDP with a lag of 3 months. This was computed from monthly data in the sample period 1970-1979 (March).

Equation (10) is an identity for the inventories in importing countries.

The equations for the importing countries have been indicated for the first five groups of importing countries. The group of non-member countries are omitted in this block. This is a rather diverse group of countries: USSR, East European countries, Greece, Asian countries, non-producing African and Latin American countries. Therefore, it is not meaningful to specify and estimate structural equations for this whole group.

The imports to these countries are determined through the identity (13), IMP^6 has therefore been mentioned separately in the list of endogenous variables.

Equations (11) and (12) determine the total inventories in, and exports from exporting countries for one type of coffee.

Equation (13) keeps total imports from all sources in balance with total exports to all destinations and determine IMP^6 as was outlined before.

Lastly, I shall discuss some possibilities for the determination of expected spot prices.

Different hypotheses can be postulated as to how price expectations are formed. Here I assume that producers and importing roasters form their expectations in the same way using information on the (expected) market circumstances. Also past prices will be relevant in some circumstances. Factors affecting the crop of coffee in producing countries will dominate the formation of price expectations. Due to the consumption habits, the demand for coffee by importing countries is in fact a stable variable, as long as prices do not change too much. Only in particular market circumstances, e.g. in case of large price changes leading to high prices, will the demand factor become a less stable factor.

Forecasts of the next crop influence the market. When disastrous circumstances arise in the production areas, e.g. many coffee plants are destroyed by heavy frost, bad weather or plant diseases, forecasts for a period, longer than one year, can be made and will influence the market.

I will now describe some possible specifications for the formation of price expectations on the spot market. Usually price expectations are not observed, therefore we have to make assumptions about this formation of price expectations.

A first assumption is the adaptive expectations mechanism:

$$EP_t^k - EP_{t-1}^k = \gamma (P_{t-1}^k - EP_{t-1}^k) \quad 0 < \gamma \leq 1, k \in \{1, \dots, 4\}.$$

It is a very simple assumption which leads to a Koyck-type distributed lag model for the spot price, such as used by Parikh (1974); see section 2.2.

It is also possible to assume that price expectations are determined by a more general lag distribution of the spot price than the geometric distribution. These distributions can also be substituted, estimated and tested with regard to their appropriateness.

A third possibility is to specify and estimate an ARIMA model for the spot prices. This time series model is identical to the solution of a linear simultaneous equation model if the exogenous variables can be considered to be generated by an ARIMA process; see Zellner and Palm (1974). If these conditions are not satisfied, the time series model is an approximation which is easy to handle. This ARIMA model can be estimated by using data with another time interval than quarters, e.g. monthly data can be used.

Predictions of these monthly prices can be averaged to a quarterly forecast, which might yield a more accurate expectation than on a quarterly base.

The fourth method which can be applied is the use of rational expectations. The rational expectations hypothesis can be implemented when the model is linear, as is shown by Wallis (1980).

The non-linearity and/or the size of the model may prevent the implementation of rational expectations, so that a theoretically less satisfactory approach will have to be adopted.

For a commodity that is also traded on a futures market another possibility is present for the expectation formation: by using the futures price. In the former paragraph different aspects of price relationships among futures and spotprices were described. The futures price is certainly a variable with predictive properties for the future spotprice, see e.g. Kofi (1973).

It might be assumed that information concerning the market situation is reflected in the futures price. However, one should be careful when using the futures price as a measure of the expected spotprice.

As Danthine (1978) indicates: the futures price was stated as a biased estimate of the spot price; see section 2.3.

At present, the choice of a specification of the expected spot price will be provisionally left open.

So far, a description of the equations has been given of a basic model for the world coffee market.

In the introduction of this paper, two objectives of this study have been mentioned: the explanation of price formation, and policy simulation. Both can be done with this model. The emphasis on prices in this section underlines the first objective. For policy purposes, different possibilities exist. At first, the quota variable, which has been inserted in three equations of the model, can be used as a policy instrument to analyse the effects of I.C.O.-measures. Effects of consumer actions, such as boycotts, on the spot-price go through equations (8), (10), (7), (13) and (12). Simulations can be done by slightly modifying the model by the inclusion of a policy variable in equation (8).

Producer actions like export limitations can be inserted in the model in the same way by including a policy variable in equation (5). This can also be done by making use of the buffer stocks in equation (6). The spot price is influenced then through the identities (6) and (12). Effects of futures trading by producing countries can be analysed by means of including futures prices in equation (2).

I call the presented model a basic model as no distinction has been made yet in the functional form of the equations for the different regions of the coffee economy. On the basis of this concept, further refining of the model will take place.

3.4 The data

In this section a short description of available data will be given. All the data, necessary for the estimation of the model, has not been collected yet, but their sources in which they are published are known, see appendix B. For lack of availability, the Annual Coffee Statistics of the Pan American Coffee Bureau have not yet been used. This Bureau, which does not exist anymore, has published the Annual till 1975 and furnished in those years the most complete quantity of data. Today, this is done by the I.C.O. with regard to the statistical tables.

These four publications (and the Annual Coffee Statistics) are the most important publications that provide coffee data.

The longest period for which the main variables are available on a quarterly basis is from the 4th quarter of 1971 until the 4th quarter of 1979. It is very probable that earlier data can also be obtained. When in the following description a sample period is not mentioned, it concerns the periode 1971^{IV} to 1979^{IV}. Similarly, when the source of data is not mentioned explicitly, they are taken from the I.C.O.- bulletins.

Monthly prices of the four main types of coffee on the New York market are available from 1947-1979. Retail prices are available for most importing countries in national currency and \$ct/lb since 1976^I. Export figures exist per exporting member to all destinations, just as import figures exist per importing member from all sources. Inventories in importing countries are known at the end of each quarter. Opening stocks of producing countries at the beginning of the crop year are published.

For Brazil, monthly inventories are known from the Annual Report. Consumption series for the importing countries are defined as the disappearance. Disappearance is the net import of all forms of coffee, adjusted for changes in visible inventories.

Production estimates are published quarterly by the U.S.D.A. Most of them have still to be collected.

From this summary of the data exploration, it should be clear that the objective stated in this paper can be realized, although various data still have to be collected.

4 Summary and conclusions

In this paper a quarterly econometric model for the world coffee market has been proposed. Two objectives have been formulated:

1. Analysis of the price formation of coffee on the world market, and testing of specific hypotheses concerning the behaviour of producers and consumers;
2. Simulations of the impact of different policies of the I.C.A and the producing countries.

On behalf of the construction of an econometric model for the world coffee market a survey has been given of some existing coffee models and of a number of studies on commodity market analysis with regard to price formation. The model presented in this paper is designed for a detailed analysis of the price formation of coffee and for short-run policy simulations. An outline of the structure of the model has been given. Many refinements, concerning the functional form and dynamics of the model, and assumptions about the stochastic properties (disturbances) of the model, are still required. This will be done in the next stage of the research, before a first version of the model will be estimated.

Appendix A

table A1. Exports to all destinations by exporting member, grouped
by coffee type.

table A2. Imports from all sources by importing member.

Source: Quarterly Statistical Bulletin, I:C.O.

Table A.1

EXPORTS TO ALL DESTINATIONS: BY EXPORTING MEMBER
1975 TO 1979

(000 bags)

Exporting Member	1975	1976	1977	1978	1979	1978				
						IV	I	II	III	IV
TOTAL	57,874	58,522	46,921	55,815	62,263	15,076	16,222	16,964	14,656	14,422
Colombian Milds	10,132	8,530	7,616	11,262	13,257	3,366	3,840	3,094	3,165	3,157
Colombia	8,175	6,289	5,323	9,034	11,131	2,957	3,157	2,486	2,831	2,657
Kenya	1,104	1,262	1,534	1,415	1,279	291	363	328	250	338
Tanzania	853	979	759	813	847	118	320	280	84	162
Other Milds	15,723	16,475	14,578	15,804	19,346	3,692	5,680	5,352	3,863	4,453
Burundi	421	366	282	385	463	94	2	26	331	104
Costa Rica	1,274	1,091	1,187	1,412	1,625	375	608	336	244	438
Dominican Republic	531	700	738	459	726	108	140	133	81	372
Ecuador	1,072	1,531	923	1,638	1,418	319	296	246	497	380
El Salvador	3,062	2,666	3,015	2,347	3,390	407	1,143	1,347	484	416
Guatemala	2,158	2,142	2,173	2,204	2,582	711	848	741	257	735
Haiti	315	419	289	257	361	46	69	78	43	171
Honduras	812	722	599	958	1,101	104	530	300	117	154
India	993	833	912	1,071	1,029	253	230	301	277	221
Jamaica	20	18	17	9	15	2	5	4	3	3
Malawi	1	3	2	3	6	-	1	-	3	2
Mexico	2,392	2,751	1,783	1,970	2,990	559	1,022	974	516	478
Nicaragua	674	802	802	887	923	166	330	367	64	161
Panama	26	25	19	39	48	7	15	11	5	18
Papua New Guinea	595	799	626	769	826	137	96	210	365	155
Peru	720	703	741	892	1,157	299	175	165	433	384
Rwanda	428	606	282	268	555	52	79	83	136	257
Venezuela	229	298	188	236	131	53	91	30	7	4
Unwashed Arabicas	15,712	16,921	11,025	13,886	13,602	4,783	2,981	3,820	3,151	3,651
Bolivia	86	78	78	92	114	6	4	37	54	20
Brazil	14,604	15,602	10,083	12,551	12,010	4,628	2,623	3,215	2,751	3,421
Ethiopia	923	1,190	833	1,156	1,448	138	339	564	340	204
Paraguay	99	51	31	87	30	11	15	4	6	6
Robustas	16,307	16,596	13,702	14,863	16,058	3,235	3,721	4,698	4,477	3,161
Angola	2,665	1,395	1,039	1,297	963	335	186	283	208	286
Chana	44	61	54	17	22	3	2	3	8	9
Guinea	55	17	33	11	33	0	0	4	8	21
Indonesia	2,168	2,106	2,515	3,460	3,607	935	696	1,571	693	648
Liberia	69	70	165	146	140	24	20	38	60	23
Nigeria	20	91	46	20	34	19	10	3	20	-
OAMCAP	(7,158)	(8,791)	(6,317)	(6,622)	(7,605)	(1,077)	(1,561)	(2,202)	(2,492)	(1,349)
Benin	37	29	10	3	1	2	0	1	0	0
Cameroon	1,623	1,641	1,159	1,378	1,718	270	229	462	598	429
Central African Rep.	166	145	150	153	101	16	28	31	28	14
Congo	12	30	30	63	95	25	22	32	24	16
Gabon	2	4	3	3	6	-	1	2	1	1
Ivory Coast	4,096	5,547	4,021	4,093	4,620	526	1,030	1,376	1,681	533
Madagascar	1,089	1,216	844	823	899	219	220	256	127	296
Togo	133	179	100	106	165	19	31	42	33	60
Sierra Leone	106	53	153	92	222	0	97	104	17	4
Trinidad and Tobago	55	45	41	28	35	4	13	12	7	3
Uganda	2,943	2,552	2,200	1,895	2,371	585	860	273	635	602
Zaire	1,024	1,415	1,139	1,275	1,026	253	276	205	329	216
Green	55,797	55,728	44,728	53,021	58,835	14,159	15,484	16,074	13,777	13,500
(Processed)	(2,077)	(2,794)	(2,193)	(2,794)	(3,428)	(917)	(738)	(890)	(878)	(922)
Roasted	233	314	231	150	195	13	52	82	22	39
Soluble	1,844	2,479	1,957	2,608	3,233	904	686	808	856	883
To importing Members	51,744	52,338	42,401	50,270	56,413	13,628	14,783	15,093	13,316	13,221
To other destinations	6,130	6,184	4,520	5,545	5,850	1,448	1,439	1,871	1,340	1,201
Brazil	14,604	15,602	10,083	12,551	12,010	4,628	2,623	3,215	2,751	3,421
Colombia	8,175	6,289	5,323	9,034	11,131	2,957	3,157	2,486	2,831	2,657
Other Arabicas	18,788	20,035	17,813	19,367	23,064	4,256	6,721	6,565	4,597	5,183
Robustas	16,307	16,596	13,702	14,863	16,058	3,235	3,721	4,698	4,477	3,161

- Less than 500 bags

Table A.2

IMPORTS FROM ALL SOURCES: BY IMPORTING MEMBER
1975 TO 1979

(000 bags)

Importing Member	1975	1976	1977	1978	1979	1978	1979			
						IV	I	II	III	IV
TOTAL	57,528	59,607	49,318	54,877	62,849	15,556	15,239	16,672	15,565	15,374
U.S.A.	21,722	21,712	16,541	19,785	21,446	5,673	5,184	5,820	5,214	5,228
E.E.C.	22,741	23,551	20,762	22,957	26,482	6,290	6,394	6,804	6,796	6,490
Belgium/Luxembourg	1,553	1,546	1,242	1,447	1,765	406	432	447	455	432
Denmark	1,119	1,103	871	1,003	1,006	282	254	226	267	258
F.R. of Germany	6,344	6,658	6,516	6,924	8,147	1,989	1,789	2,084	2,098	2,176
France	5,295	5,267	4,861	5,442	5,728	1,430	1,537	1,495	1,423	1,273
Ireland	41	62	39	50	71	13	19	19	17	16
Italy	3,399	3,588	3,076	3,265	3,831	914	949	881	925	1,077
Netherlands	2,791	2,985	2,232	2,675	2,955	676	735	755	773	693
United Kingdom	2,199	2,342	1,925	2,151	2,979	580	679	897	838	565
Other Members	13,065	14,344	12,015	12,135	14,921	3,593	3,661	4,048	3,555	3,656
Australia	442	533	449	446	612	135	123	143	180	165
Austria	620	666	513	612	751	144	186	170	221	174
Canada	1,778	1,702	1,433	1,693	1,793	482	424	479	478	412
Cyprus	25	28	22	26	37 ^{1/}	4	13	8	10	6 ^{1/}
Finland	1,003	1,174	817	896	1,110	220	334	357	210	209
Hong Kong	293	300	211	61	92	22	13	21	17	41
Hungary	545	632	714	371	558	115	125	183	84	165
Israel	180 ^{2/}	295	160	197	178 ^{2/}	54 ^{2/}	46 ^{2/}	46 ^{2/}	44 ^{2/}	44 ^{2/}
Japan	2,034	2,657	2,479	1,873	3,338	641	748	983	894	714
New Zealand	90	94	66	97	117	27	18	29	27	42
Norway	648	689	552	683	693	201	179	148	186	180
Portugal	255	342	206	178	202 ^{2/}	73	65	51	13	72 ^{2/}
Spain	1,296	1,566	1,392	1,759	1,753	570	429	433	422	469
Sweden	1,931	2,038	1,218	1,585	1,728	476	400	442	370	517
Switzerland	1,151	1,017	951	886	989	245	256	302	207	224
Yugoslavia	774	611	832	772	970	184	302	253	192	222
Green (Processed)	53,389	54,637	44,735	50,084	56,366	14,186	13,848	14,851	13,784	13,903
Roasted	(4,139)	(4,970)	(4,583)	(4,793)	(6,463)	(1,370)	(1,391)	(1,821)	(1,781)	(1,471)
Soluble	977	1,110	1,134	1,132	1,512	238	262	496	421	334
	3,137	3,818	3,393	3,572	4,838	1,103	1,093	1,301	1,329	1,115
From										
- Exporting Members	53,843	55,371	45,949	51,246	58,558	14,465	14,320	15,461	14,436	14,341
- Importing Members	3,236	3,657	2,994	3,040	3,735	927	814	1,093	948	880
- Non-members	435	552	364	578	535	161	102	115	172	146
- Unspecified origins and designated territories	14	27	11	13	21	3	3	3	9	7

^{1/} Includes estimates provided by the Member
^{2/} Estimated

Appendix B

Sources of data

1. Quarterly Statistical Bulletin on Coffee, published by the International Coffee Organization (London), Vol. 1 (1977) - Vol. 3 (1979).
2. Coffee Annual, published by George Gordon Paton & Co., New York, 1974-1977.
3. Annual Report, published by the Nederlandse Vereniging voor de Koffiehandel, Amsterdam, 1960-1976.
4. Foreign Agriculture Circular, Coffee, published by the U.S. Dept. of Agriculture, Washington, 1977-1980 (irregular).
5. Annual Coffee Statistics, published by the Pan-American Coffee Bureau, New York.

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