The effectiveness of the international coffee agreement

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THE EFFECTIVENESS OF THE INTERNATIONAL COFFEE AGREEMENT

A simulation study using a quarterly model of the world coffee market

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ABSTRACT

We present the results of a simulation analysis of a quarterly econometric model for the world coffee market. The model has originally been developed by Palm and Vogelvang (1986). The main features of the model will be briefly described, the solution method will be discussed and some insight into the behaviour of the model over the sample period will be given. The impact of a substantial increase in the production of coffee on world market prices and on trade will be studied. Most importantly, we will analyse the impact of several policy measures aimed at reducing an imbalance between supply and demand on the coffee market by decreasing production. The effects of an export quota system imposed by the International Coffee Agreement on prices, trade and export revenues is also analysed. Prices and foreign trade revenues of coffee exporting countries are found to be higher when an export quota system has been effective than when this has not been the case.

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1. INTRODUCTION

In this paper, we present the results of a simulation analysis of a quarterly model for the world coffee market. The model has been developed by Palm and Vogelvang (1986). More details of this study can be found in Vogelvang (1988). In the model, producing and importing countries are assumed to maximise the expected utility of the present value of profits over a two-period time horizon by buying or selling on the spot market and by holding inventories, and by hedging or speculating on the futures market. Expectations are assumed to be rational, i.e. they are equal to the conditional expectation given the model and information up to the current period. The spot and futures markets clear at each time period. The model has been estimated for the period 1971-1982, a period in which the quota system of the International Coffee Agreement (ICA) has almost never been effective.

The aim of the paper is twofold. First, we give some insight into the behaviour of the model over the period of estimation. Second, and more importantly, we analyse the impact of a substantial increase of production on prices, disappearance and inventory formation and of several policy measures aimed at reducing an imbalance between demand and supply on the coffee market by decreasing production. These measures are analysed respectively under the assumption that there is no ICA and that an international quota system has been agreed upon which becomes effective as soon as the spot market price drops below a certain level. Attention is also paid to the impact of the distribution of initial inventories over exporting and importing countries.

The paper shows that it is possible to solve a medium size model for an international commodity market assuming rational behaviour of the agents (countries) under uncertainty. The simulation results are of importance for the discussions about price stabilization through international agreements aimed at restricting trade by a quota system. Our findings lead to the conclusion that the current situation on the international coffee market, which is characterized by an excess of production compared with total world consumption, requires a substantial reduction in production in the coming years to bring supply and demand more into balance.

The paper is organized as follows. In section 2, the structure of the model is briefly outlined. The solution of the model under rational expectations is described in section 3. In section 4, the export quota system is discussed together with its consequences for the solution of the model. Section 5 contains some simulation results for the sample period. In section 6, the model implications of several policy measures aimed at reducing production are presented. Finally concluding remarks are made in section 7.

2. THE MAIN FEATURES OF THE MODEL

The model is a short-term quarterly model, in which the production is assumed to be predetermined. A quarterly model allows to account for developments which take place within the year e.g. the quarterly quota distribution. The model of the world coffee market has been elaborated along the lines of recent developments in the theoretical literature, see e.g. Newbery and Stiglitz (1981). A schematic summary of the theoretical model is given in Table 1. More details on the model can be found in Palm and Vogelvang (1986). The list of variables is as follows :

i	= country i	z_{it}	= wholesale inventories
t	= quarter t	z^r_{it}	= retail inventories
q_{it}	= production	$cons_{it}$	= consumption

exp_{it}	=	exports	p_t	=	spot price
dis_{it}	=	disappearance	p_t^f	=	futures price
imp_{it}	=	imports	p_{it}^r	=	retail price
k_{it}	=	unit processing costs	cp_{it}	=	consumer price index
n_{it}	=	population	y_{it}	=	real disposable income
δ_i	=	discount factor	γ_i	=	$\gamma_i^* \delta_i^2$

γ_i^* = coefficient of constant absolute risk aversion

f_{it} = position on the futures market

b_i, c_i = parameters of the cost function for inventories

α_{ji}, β_i : represent constant parameters

var_i : denotes the variance conditional on information available at period t.

At the microeconomic level we assume that market participants (individual countries in the empirical model) have access to the spot and futures market, and that they have a utility function with constant absolute risk aversion. They are assumed to take a position on these markets in such a way that the expected utility of the present value of profits for the present and next period is maximized. In this way we derive the optimal position for inventory holders at the wholesale and retail level. For price-taking inventory holders the price of storage equation (I.1) [see e.g. Working (1949)] results from the two-period optimisation model, relating the size of inventories to the spread, i.e. to the difference between the futures and the spot price. Large producers are assumed to be price setters facing a downward sloping demand curve. By varying the inventory level, they are able to influence the price level. For a price-setting producer, the maximisation of the expected utility of the present value of profits over two periods leads to a relationship between inventories and the difference between the expected next-period spot price and the futures

Table 1

A summary of the theoretical model

Variable / Country i	Production q_{it}	Consumption: $cons_{it}$ Disappearance: dis_{it}	Inventory z_{it}	Export exp_{it}	Retail price p^r_{it}
Producer (Exporting country)	predetermined	consumption predetermined disappearance: $dis_{it} = cons_{it} + \nabla z^r_{it}$ (I.3)	wholesale $z_{it} = \max\left(\frac{p^f_t - p_t - b_i}{2c_i}; \bar{z}_{it}\right)$ (I.1) [or (*) for a price setter] retail z^r_{it} = predetermined	$exp_{it} = q_{it} - dis_{it} - \nabla z_{it}$ (I.5)	-
Importing country	$q_{it} = 0$	consumption $cons_{it} = a_{oi} n_{it} + a_{1i}\left(\frac{n_{it}\, p^r_{it}}{cp_{it}}\right) + a_{2i}\, n_{it} \ln\left(\frac{y_{it}}{n_{it}}\right)$ (I.4) disappearance $dis_{it} = cons_{it} + \nabla z^r_{it}$	wholesale $z_{it} = \max\left(\frac{p^f_t - p_t - b_i}{2c_i}; \bar{z}_{it}\right)$ (I.1) retail $z^r_{it} = \max\left(\frac{\delta_i E_i p^r_{it+1} - p^r_{it} - b_i}{2c_i + \gamma_i\, var_i(p^r_{it+1})}; \bar{z}^r_{it}\right)$ (I.2)	$exp_{it} = - imp_{it} = - dis_{it} - \nabla z_{it}$ (I.6)	$p^r_{it} = (1 + m_i)[k_{it} + \beta_i(L) p_t]$ (I.7)
Market clearing	Spot market $\sum_i exp_{it} = 0 \iff \sum_i (q_{it} - cons_{it} - \nabla z_{it} - \nabla z^r_{it}) = 0$ (I.8) Futures market $\sum_i f_{it} = 0 \iff \sum_i \left\{\left[\frac{p^f_t - \delta_i E_i p_{t+1}}{\gamma_i\, var_i(p_{t+1})}\right] + z_{it} + \frac{cov_i(p_{t+1}\, q_{it+1}, p_{t+1})}{var_i\, (p_{t+1})}\right\} = 0$ (I.9)				

(*) for individual countries :

$$z_{it} = \max\left\{\frac{1}{2(\phi_{i1} + c_i)}\left[2\phi_{i1}(q_{it} + z_{it-1}) - \phi_{i1} f_{it-1} + p^f_t - b_i - \phi_{i0} + \delta\frac{\partial E p_{t+1}}{\partial z_{it}}\left[\frac{\delta E p_{t+1} - p^f_t - \gamma_i cov_i(p_{t+1}\, q_{it+1}, p_{t+1})}{\gamma_i var_i(p_{t+1})}\right]\right]; \bar{z}_{it}\right\}$$

price, while the inventories of the other inventory holders also have an influence on his position. At the retail level, too, a price of storage equation results from arbitrage between the present and the next period. The retail inventories are related to the difference between the expected and the current retail price (I.2).

Disappearance (I.3) is equal to consumption and the change in retail inventories. Consumption per capita (I.4) is assumed to depend on the relative price of coffee with respect to the consumer price index and on per capita income. A semi-logarithmic specification has been chosen in order to force the income elasticity to decrease when consumption increases.

Exports by producers (I.5) are by definition equal to production minus disappearance minus the variation in wholesale inventories. For non-producing importing countries the same definition applies (I.6) with production being zero.

The retail price is related to the spot-market price through a cost function (I.7) where the unit costs k_{it} of roasting coffee are assumed to be proportional to the general price level, η_i denotes the profit margin (constant) and $\beta_i(L)$ is a polynomial in the lag operator L such that $\beta_i(1) = 1$.

Spot and futures prices adjust to clear the spot and futures market at each period (see equations (I.8) and (I.9)), and expectations are assumed to be rational.

The following countries have been included in the model. On the production side, it concerns Brazil and Colombia (being price setters), groups of countries producing respectively Unwashed Arabicas, Other Milds, Colombian

Milds and Robustas. On the consumption side, the U.S.A. and the European member countries of the International Coffee Organization (ICO) have been modelled individually. It should be noted that the specification for the wholesale inventories had to be extended by assuming a partial adjustment scheme in which the desired level of the inventories is modelled by equation (I.1). Also, as the market for the various sorts of coffee has been modelled, the market-clearing conditions (I.8) and (I.9) are solved for the Composite Indicator Price 1968, a weighted average of the spot prices, (CIP-'68) and the futures price of the New York market.
Prices of the other sorts are assumed to be related to the price of Unwashed Arabicas and the New York futures price through an error correction model with a constant term reflecting the difference in quality between the various sorts of coffee. The general conclusion was that the estimation results are fairly well in agreement with the theoretical model.

3. SOLUTION OF THE MODEL

3.1 Solution in case the export quotas are not effective

The entire model of the coffee market as specified and estimated in Palm and Vogelvang (1986) will be solved for the coffee price on the spot and futures market, and for the price expectations. The remaining endogenous variables will first be expressed in terms of prices and predetermined variables and then be substituted in the market clearing equations of the spot and futures market. The equations (I.8) and (I.9) form the starting point from which the prices will be derived. Some assumptions have to be made to obtain operational equations to determine the price variable. These assumptions are :

1) price expectations are rational;

2) the conditional second moments of p_{t+1} are constant over time;

3) given all available information at time t, q_{it+1} and p_{t+1} are independent;

4) each country holds inventories at the wholesale level and has access to the futures market.

The rationale of assumption 2 is simplicity. On a priori grounds, this assumption is not necessarily in agreement with the rational expectation hypothesis. But without this assumption, the equations would be nonlinear in the variables which would at least complicate the solution very much; for an example of a nonlinear rational expectations model see Broze, Grouriéroux and Szafarz (1986). As the simulation results appear to be plausible, there is little reason to abandon this assumption at the present stage of the research.

With the assumptions 2 through 4, equation (I.9) can be written as

$$\nu_1 p_t^f - \nu_2 Ep_{t+1} + Z_t + EQ_{t+1} = 0, \qquad (1)$$

with $\nu_1 = \Sigma_i[1/\{\gamma_i \ var_i(p_{t+1})\}]$ and $\nu_2 = \Sigma_i[\delta_i/\{\gamma_i \ var_i(p_{t+1})\}]$.

Capital letters denote aggregated quantities, e.g., $Z_t = \Sigma_i z_{it}$. Equation (I.8) can be expressed as

$$Q_t + Z_{t-1} - DIS_t - Z_t = 0. \qquad (2)$$

The variables Q_t and Z_{t-1} are predetermined in these equations. For the endogenous variables Z_t and DIS_t their components will be substituted. The world inventory Z_t is the aggregate of all the inventories of individual countries, and therefore is related to futures and spot prices and predetermined variables.

The inventories can be eliminated now because Z_t is expressed as a linear function of p_t, p_t^f and Ep_{t+1} and an aggregate of predetermined variables originating from the inventory equations. Define S_t to be the sum of the above-mentioned aggregated predetermined variables and the expected production. Then equation (1) can be written as

$$\alpha_0 + \alpha_1 p_t^f + \alpha_2 Ep_{t+1} + \alpha_3 p_t + \alpha_4 S_t = u_{t1}. \qquad (3)$$

The disturbance term u_{t1} represents the aggregate of disturbances of the original model. Equation (I.1) expressed in terms of the CIP-'68 for reasons of simplicity and not in terms of prices of the various types of coffee has been substituted for Z_t in (1) to obtain (3).
The disturbance term is assumed to be normally independently distributed. After substitution of (I.7) for p_t^r and the expected value of (I.7) for Ep_{t+1}^r in $cons_{it}$ (I.4) and z_{it}^r (I.2), the total disappearance DIS_t is expressed in a linear function of p_t, Ep_t and Ep_{t+1}, and a number of aggregate predetermined variables from the disappearance and retail price equations, besides lagged values of the price variable. Let H_t be the sum of the aggregate predetermined variables in the disappearance, retail and inventory equations, plus $Q_t + Z_{t-1}$. Then equation (2) can be written as

$$\beta_0 + \beta_1 p_t^f + \beta_2 Ep_{t+1} + \beta_3 Ep_t + \beta_4 p_t + \beta_5 p_{t-1} + \beta_6 H_t = u_{t2}. \qquad (4)$$

The disturbance term u_{t2} has been introduced for the same reason as u_{t1}, and is also assumed to be normally independently distributed.

The price expectations are assumed to be rational, i.e.,

$$Ep_{t+1} = E(p_{t+1} \mid \Phi_{t-1}, \text{model}) \text{ and } Ep_t = E(p_t \mid \Phi_{t-1}, \text{model}), \qquad (5)$$

where Φ_{t-1} denotes the information available at time t-1, and the second moments are assumed to be constant.

The solution equations are now complete. The system in (3), (4) and (5) consists of four equations in the endogenous variables p_t, p_t^f, Ep_t and Ep_{t+1}.

When the parameters of equations (3) and (4) have been estimated and expected prices have been computed using a solution method for rational expectation models, equations (3) and (4) can be solved for p_t and p_t^f. The system will be solved for the CIP-'68 and the futures price in New York. Data on expected production are available. The U.S.D.A. obtains and publishes production estimates in its Foreign Agriculture Circular : World Coffee Situation.

There are various methods to determine rational price expectations (see e.g. Blanchard and Kahn (1980)). A useful treatment for linear rational expectation models can be found in Chow (1983, pp. 356-361). His solution method has been applied here. More specifically, we estimate the parameters of (3) and (4) by the method of instrumental variables using p_{t-1}^f and and p_{t+1} as a proxy for Ep_t and Ep_{t+1} respectively and lagged prices as instruments. Then by eliminating p_t^f from (3) and (4), we obtain the reduced form equation for p_t, which expresses p_t in terms of p_{t-1}, Ep_t, Ep_{t+1} and the predetermined variable $x_t = \alpha_4 \alpha_1^{-1} S_t - \beta_6 \beta_1^{-1} H_t$. The associated final form equation for p_t is a dynamic regression model in which p_t is explained by its own lagged values and by the truly exogenous part of x_t, denoted by $x_t^* = \alpha_4\alpha_1^{-1}S_t^* - \beta_6\beta_1^{-1} H_t^*$, where S_t^* and H_t^* are the exogenous parts of S_t and H_t respectively. Notice that x_t^* is the only exogenous variable that varies in the simulations.

The final form equation for p_t is approximated by an ARMAX-model and estimated by nonlinear least squares after replacing the unknown coefficients in x_t^* by consistent estimates to get $\hat{x}_t^*$. The final form equation is then used to generate the values for Ep_t and Ep_{t+1}. To compute Ep_{t+1}, we need the one-step ahead forecast errors of $\hat{x}_t^*$, which is obtained from a univariate time series model fitted to the series $\hat{x}_t^*$. Finally, the values of Ep_t and Ep_{t+1} are substituted into (3) and (4) which are then solved for p_t and p_t^f (the CIP-'68 and the futures price in New York). Then, prices for the various coffee types and the futures price in London are obtained from the error correction models mentioned above and the definition of the CIP-'68. These prices appear in the equations for the various coffee types and countries.

3.2 Solution in case the quotas are effective

When the exports of coffee by producing countries are restricted by means of export quotas, it follows that $exp_{it} = quota_{it}$ and the inventories of the producing countries are $z_{it}^p = z_{it-1}^p + q_{it} - quota_{it}$. For the aggregate inventories of importing countries, we have $Z_t^I = Z_{t-1}^I + QUOTA_t - DIS_t$, where $QUOTA_t$ denotes aggregate imports. The clearing condition for the spot market (2) remains unchanged.

It is also straightforward to show that the expression for the optimal position on the futures market is not changed if the quota system is introduced. The clearing condition for the futures market is therefore given in (1). When we solve for the rational expectations, we have to split Z_t in (1) and (2) into Z_t^I and Z_t^p respectively. For Z_t^I, we substitute expression (I.1), Z_t^p is carried along as a predetermined variable. The rational expectation solution when quotas are effective is then obtained along the same lines as explained above. Only the variables S_t and H_t have to be redefined to include Z_t^p which is now predetermined.

Before the simulation results are presented, we give a brief description of the way in which the quota system has been incorporated in the simulation study.

4. THE QUOTA SYSTEM MODELLED

The quota system of the ICA-1976 is based on daily developments on the coffee market, see ICO (1976). As the model is a quarterly one, the quota system has to be formulated in terms of restrictions on quarterly variables. Obviously such an approximation will be more inert than the real quota system, because only four decisions a year can be taken. Although quotas come into effect after the composite indicator price has been below the ceiling of the price range during a period of 20 market days, the quota distribution is a quarterly matter.

The quota system has been introduced in the simulation study in the following way. Each exporting member is entitled to a basic quota, according to the provisions of the agreement. The quotas become effective in the quarter after the quarter in which the Composite Indicator Price 1976 (CIP-'76) is at or below 135 $ct per pound, with

$$\text{CIP-'76}_t = \tfrac{1}{2}(p_t^{ROB} + p_t^{OM}).$$

The quarterly quotas are divided into two parts, a fixed and a variable part. The initial allocation is 97.6 per cent of the annual quota, which has been agreed upon in ICO meetings. The fixed part is 70 per cent of this allocation. The variable part is 30 per cent of the total initial allocation. It is allocated to a country, in proportion of its own inventory level to the total inventory level of the relevant coffee type; see ICO (1976).

Quotas are adjusted downwards if the CIP-'76 falls below 120 $ct and again when this price average drops below 115 $ct. If prices rise, quotas are adjusted upwards if the CIP-'76 rises above the level of 135, 150 and 155 $ct respectively. Quotas must be suspended above the last-mentioned level. The size of the adjustment is also decided in ICO meetings. In the simulation experiments the quota adjustments equal 1.4 million bags, an amount decided by the International Coffee Council in the autumn of 1980.

5. THE BEHAVIOUR OF THE MODEL OVER THE SAMPLE PERIOD

To give the reader some insight into the performance of the model, we solved the model for the period 1977^{II} through 1980^{I} and computed standardized root mean square forecast errors (SRMSE) (1) of the variables in the model. The largest sample period for which all variables of the model are observed is the period 1977^{II} through 1980^{I}.

The predetermined variables take the observed values. For each quarter the values of the endogenous variables are determined, to begin with the prices by using the solution equations, then inventories, disappearance and retail prices of the individual countries. Quotas were not effective in the sample period.

Generally, the simulated series fit the observed data reasonably well. An analysis of the simulations over the sample period shows that for the price

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(1) The SRMSE is defined as SRMSE = $[\sum_{j=1}^{n} (A_j-F_j)^2 / \sum_{j=1}^{n} A_j^2]^{½}$ with A and F being the actual and the simulated value respectively of a given variable.

expectations and for the spot price realizations, the simulated turning point lags somewhat behind the historical turning points. In this respect, we emphasize that in the quarter 1977^{II}, coffee prices reached their peak after the crop in Brazil had been destroyed during the harvest year 1976-1977. The years 1976-1977 were exceptional for the coffee market, with extreme world market price increases, which are not fully explained by the model. The SRMSE for world market prices is approximately .20. In contrast, the behaviour of the simulated retail coffee prices in importing countries fairly accurately described the observed pattern. The SRMSE for retail prices varies in the range from .02 to .10.

The disappearance variable performs very well too. Most SRMSE's are in the range from .10 to .15. This is due to the fact that it depends mainly on the retail price. The simulated level of the inventories in importing countries is somewhat too high for some countries compared with the observed values (e.g. .25 for Norway, .27 for the U.K. and .30 for the U.S.), but in most cases, the simulated inventory levels are rather close to the observations (SRMSE's in the range from .09 to .20).

The simulation results for the inventories in producing countries vary in quality per country. They are quite well for Colombia, reasonable for the Robusta and Other Milds producing countries, and the least satisfactory for Brazil. The reason for these different outcomes is not clear. The producers of Other Milds and Robusta are aggregates of many countries, and the result confirms our assumption that these countries act in a similar way with a SRMSE of about .20. The model for a price-setting producer performs very well for Colombia, with a SRMSE equal to .07. In spite of the rather good estimation result for the inventory equation of Brazil, the simulation outcome (SRMSE = .31) suggests that the present specification probably needs more refinement due to specific features of the coffee trade of Brazil.

6. THE IMPACT OF POLICY MEASURES AFFECTING THE VOLUME OF PRODUCTION

6.1 Introduction

Several hypothetical situations for the world coffee market will be analysed in this section. Simulation of these situations will give insight into the quantity and price effects of the quota system, and will be informative about the market behaviour with respect to various levels of coffee production, which is exogenous in the model. For one step ahead simulations it does not matter whether the volume of production is exogenous or only predetermined (for instance, it could depend on lagged prices). For dynamic simulations with a conditional model, the exogeneity of production is required. In this section, production is assumed to be a policy variable that will be varied in the simulations. The distribution of inventories over producing and importing countries will also be varied. It will be interesting to analyse differences of the effects in the short run and in the long run. To examine long-term effects the quarterly simulations will have to be run for a longer period.

As a starting point we take the situation in 1979^{IV}. The end of the year 1979 has been chosen because it is the beginning of a period with more or less normal market circumstances, although the price level is still somewhat high. The market had recovered from a period of heavy price changes. From 1979^{IV} on, the model will be simulated over a period of 16 years (64 quarters), a period long enough to investigate the long-term properties of the model. For this simulation period the exogenous variables such as deflators, population and exchange rates will be kept constant at the level of the base quarter 1979^{IV}. Relative coffee prices can therefore be compared with observed nominal prices in 1979^{IV}.

In the seventies world production varied around 71 million bags (of 60 kg), and imports of coffee by member countries were around 56 million bags. Further, non-member countries imported about 6.5 million bags of coffee in these years. So, officially about 62.5 million bags of coffee were imported.

We present the results in terms of world production which includes imports by member and non-member countries and domestic use in coffee-producing countries. World production is set equal to ± 4/3 of total production on behalf of the member countries, which is determined in the model.

6.2 High production level

In a first simulation, world production will be held constant at a level of approximately 100 million bags. The distribution among producing countries is as follows : Colombia 13.7, Ethiopia 4, Brazil 27, Kenya and Tanzania 2.9, Other milds 29.3 and Robustas 21.3 million bags. Production has been spread over the quarters according to the observed seasonal pattern in the harvest of the various producing countries. If there is no coffee agreement, the market collapses as a result of this high sustained production. Prices go to zero and inventories in producing countries tremendously increase so that interventions in the market cannot be avoided.

When there is an ICA, most variables in the model, in particular prices fluctuate in the first simulation periods. The lower price bound is immediately reached and the quota system becomes effective. As a result of the reduction of the quantity brought to the market, prices cross the upperbound and the quota system becomes ineffective.

The alternations result from the simplified translation of the rules of the ICA into formulae in the model. Exports on a yearly basis vary between about 50 to 70 million bags and total export revenue equals on average

about $ 9,000 million. Disappearance equals approximately 10-11 million bags per quarter. Inventories in producing countries double to become 80 to 90 million bags whereas importing countries only marginally increase their inventories. In fact the simulation results are very similar to the actual situation on the coffee market in the 1960's when a high world production level had to be reduced via an international agreement. We simulated the effect of a high production level for various initial values for the coffee inventories and for the production in Brazil. In particular if we analyse an exceptional situation, that is if we set the production in Brazil equal to zero in the first year, 50% and 100% of its size in the preceding simulation in the second and later years respectively, we only find short run effects. The price level is higher during the first and second year. In the long run the results are similar to those of the preceding simulation. Similarly, if we set the inventories in the importing countries equal to zero with inventories in producing countries unchanged or being increased such that total inventories are left unchanged, the results only deviate in the short run from those in the first simulation.
When initial inventories in producing countries are set equal to zero, the deviation is stronger and lasts for about three years.

6.3 Decreasing the production level to stabilize the market

It is now natural to investigate to what extent world production has to be lowered to reach a situation in which the ICA becomes ineffective and coffee prices and trade become stable. When world production is decreased by 10% from 100 million bags to a constant level of 70 million bags after five years, the quota system becomes ineffective and prices become almost stable but slightly decreasing. A reduction by an additional 10% of production in the sixth year, leads to slowly increasing prices. These findings are illustrated in the Figures 1 to 6 where the outcome for aggregate inventories in producing and importing countries, total exports, total disappearance, the CIP-'68 and total export earnings are plotted.

A few interesting conclusions emerge from these findings. When there is an ICA (the dashed line), the price level and export earnings are higher than in the situation without ICA (the solid line), whereas exported quantities, disappearance and inventories are lower. All series quickly reach a roughly constant level when world production remains at a level of 70 million bags. In the long run, with the ICA, exports become 43.7 million bags which are sold at a price of $ 1.58 per lb yielding earnings of about $ 9,145 million. In the case where there is no ICA, the level of exports is about 43.8 million bags in the long run, the world market price is about $ 1.11 per lb, yielding total export revenues of $ 6,439 million.
These findings are similar to those of Herrmann (1988), who reports a price increase of about 30% resulting from the conclusion of an ICA (to be compared with an price increase of about 42% in our case). The difference in export earnings in his study fluctuates in the range of $ 1,700 to 1,900 million bags, which is less than the $ 2,706 million reported above.
Notice that the differences might be explained by the fact that he does not model the impact of uncertainty on decisions in his model and that he disaggregates his model according to countries and distinguishes between ICO-member and non-member countries. In his analysis of the coffee market, the ICA roughly leads to a loss in revenue of about $ 2,200 million for importing member countries, and a gain of $ 140 and $ 1,700 - 1,900 million for importing non-member countries and producing countries respectively.
One should realize that there are costs involved for producing countries to earn the extra revenue from exports. As illustrated in Figure 1, producing countries will temporarily increase the inventory level when there is an

Figure 1 : Inventories Producing Countries

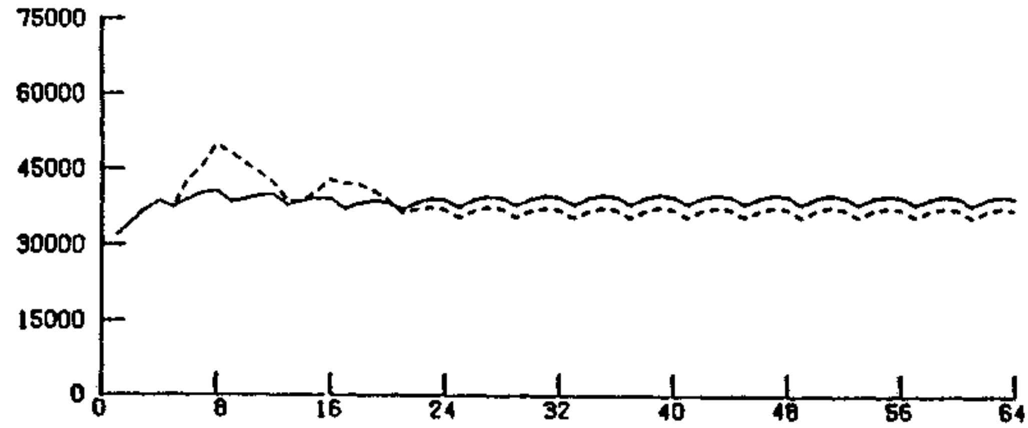


Figure 2 : Inventories Importing Countries

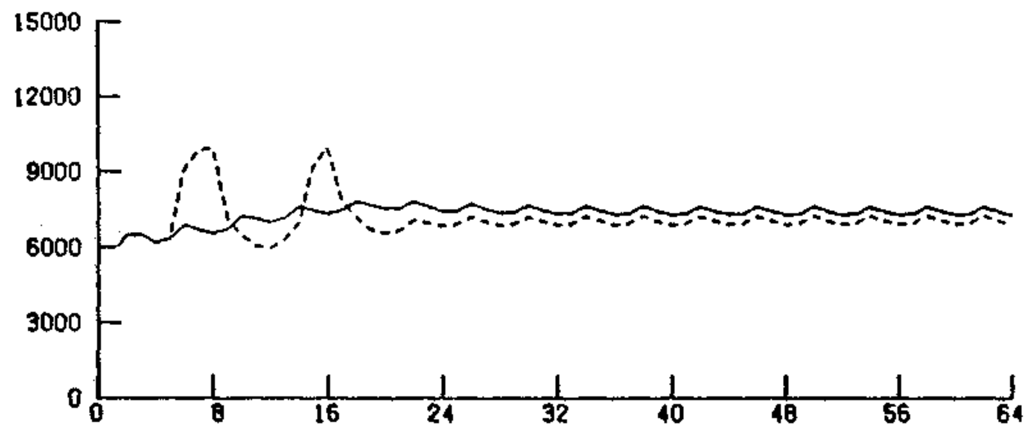


Figure 3 : Exports

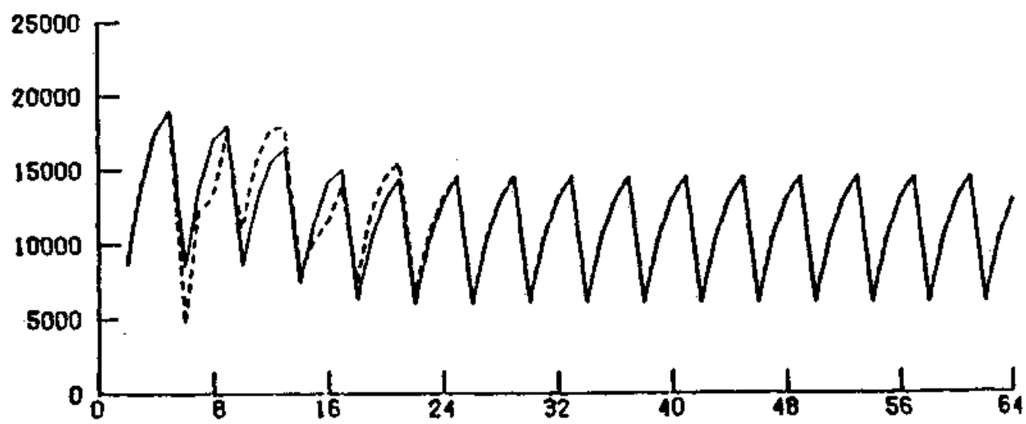


Figure 4 : Disappearance

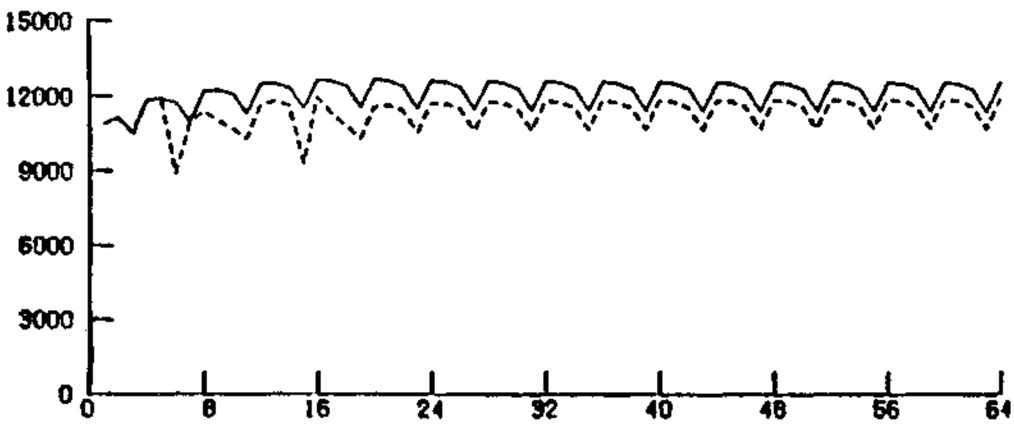


Figure 5 : CIP-1968

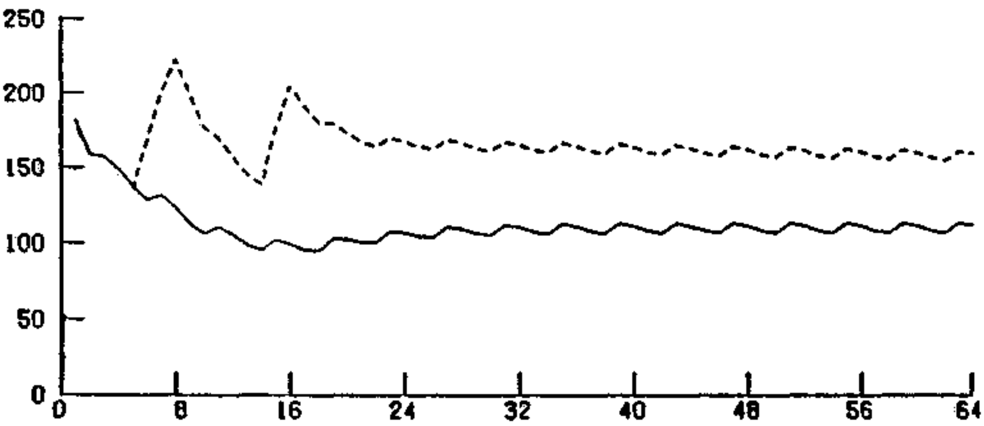
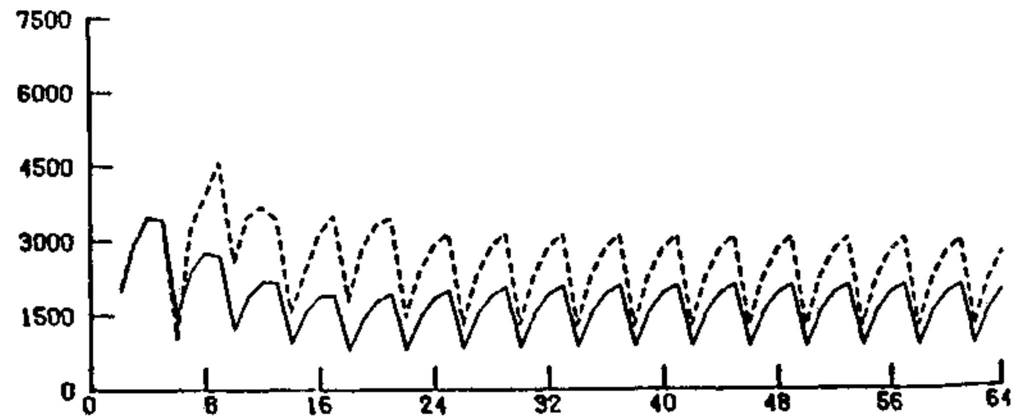


Figure 6 : Export Earnings



ICA. In the long run however, inventories will be at a lower level compared with a non-quota regime and the extra income will more than compensate the initial costs.

Finally, we will summarize the medium and long-run impact of a reduction of the coffee production on the main variables in the model. In Table 2, we give the elasticities for various variables when the quota system does not become effective.

Table 2: Medium and long-run elasticities with respect to production under stable market conditions.

	after 3 years	after 10 years
CIP-68	-1.35	-4.59
Retail price Netherlands	- .77	-2.77
Retail price USA	- .88	-3.39
Inventories producing countries	.48	1.10
Inventories importing countries	- .06	.52
Exports	.85	.82
Export earnings	- .39	-3.39
Disappearance	.22	.83

Table 2 shows that a reduction of the coffee production is favourable for the producing countries in the long run, but certainly not for the importing countries. The former countries realize much higher export earnings in the long run. The increase of the coffee price amply compensates for the decrease in disappearance.

6.4 Low production level

When production is held constant at a level of 70 million bags, the price-level is almost stable. It very slowly decreases from ± $ 1.65 to ± $ 1.50 in 50 periods and the ICA does not become effective.

After 12 years, the CIP-'68 becomes $ 1.46, total annual exports to member countries become 44.650 million bags. Export earnings become $ 8,730 million. For disappearance, inventories in importing countries and inventories in exporting countries, we find a yearly average of 45.950, 7 and 37 million bags respectively. The pattern of the simulations is fairly robust with respect to the size of total inventories and its distribution among producing and importing countries in the initial period. As expected, a reduction of the size of the initial inventories leads to a higher price level in the long run, whereas a redistribution of inventories from importing countries to exporting countries or vice versa holding total inventories unchanged also has a positive effect on the price level in the short and medium run. But the order of magnitude of this effect is much smaller than when the size of the total inventories is reduced. For disappearance (or total demand) similar conclusions are reached but as expected with opposite sign.

7. CONCLUDING REMARKS

In this paper, we simulated an econometric model for the international coffee market under various circumstances. The rational price expectations were calculated by using the solution method as presented by Chow (1983) assuming that the second moments of future values of the endogenous variables are constant. We compared the simulated values for the sample period 1977^{II} - 1980^{I} to the observations. With the exception of the price simulations in the years 1977-79, in which heavy fluctuations occurred in the coffee market, the performance of the model is quite satisfactory. Overall, the results appear to be plausible. The determination of turning points of the spot price and of the inventories in Brazil need further investigation. The simulations for other variables are good. The simulations for retail prices in general, and for inventories in Colombia perform very well.

The simulation experiments for various hypothetical circumstances are very instructive and allow us to draw some policy relevant conclusions. These experiments are concerned with the effects of the ICA, when coffee production is at a high level. When production remains at a high level, the coffee market will collapse whether an ICA is concluded or not. When there is an ICA, the price will settled at the lower bound agreed upon in the ICA, but the increase of inventories will necessitate an intervention leading to a reduction of total production. The ICA will only be workable if it is accompanied by restraint on the supply side.

When production is decreased to a level of 70 million bags, the market becomes stable. The ICA appears to be favorable to producing countries who earn more revenues from their exports which are smaller in quantity but sold at a higher price. The increase in revenue (we abstract from possible negative effects of the increased price variability) of exporting countries leads to a welfare transfer from importing member countries to exporting countries. Our finding is very much in line with the conclusions reached by Herrmann (1988) who used a more disaggregate but theoretically less sophisticated model to study the effects of the ICA on the coffee market. It becomes also clear that the ICA does not lead to higher coffee consumption by importing member countries.

Recently, in October 1988, after two weeks of negotiations, the ICO agreed on a maximum export level of 56 million bags for the coffee year 1988-89 for bringing the world market price between $ 1.20 - 1.40, as the average price had been decreased to $ 1.14 because of the over supply of coffee. In 1987, it was already agreed that production should be substantially reduced in the next years. Our simulation results show that such an export quantity, together with a reduction of total coffee production to this level, may be successful in reaching a stable situation in the long run.

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