NORTH-HOLLAND

Can International Commodity Agreements Work?

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Commodity agreements have been discussed for many years. However, only two agreements (for cocoa and rubber) have been concluded that do not rule out success in advance. Using an annual model of the cocoa market, the viability of the instruments agreed upon is analyzed, and ways and means to improve the functioning of commodity agreements are explored.

Key Words: Commodity agreement; Price stabilization; Earnings stabilization; Buffer stock policy; Withholding.

1. INTRODUCTION

International commodity agreements that aim for welfare improvement through revenue stabilization are still a major policy issue of UNCTAD. Revenue stabilization through price stabilization has been an important research issue in the economic literature for a long time also. In the literature two types of stabilization policies are distinguished. The first one is a band width rule or price range. The price range has as a disadvantage that it restricts the price variation to a prespecified range, and does normally not take into account effects that force the price out of the range. The second type is a price adjustment rule, which means that the buffer stock manager keeps the price as close as possible to a prespecified long term reference or target price path. This kind of rule results from an optimal control formulation of the problem.

Starting point for much of the theoretical analysis is the Waugh–Oi–Massell model, in which the arithmetic mean of the price can be used as reference price. This model has been extended in many directions. The main conclusion is that an overall welfare gain can be achieved by stabilizing prices through buffer stock operations,

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and that the net gain per country increases with domestic variance in disturbances and decreases with foreign disturbances (Devadoss, 1992). Devadoss shows also that in a linear world with distortionary interventions in producing and consuming countries, causing greater world price variation, international price stabilization leads to overall welfare gains also. He restricts his analysis to linear models with additive disturbances, because the introduction of nonlinearities in demand and supply in a multicountry model with multiplicative disturbances prohibits definite inference.

If the analysis is extended to nonlinear models with multiplicative random disturbance terms, conclusions on who is going to benefit are less straightforward, but the gain for the world remains positive (Turnovsky, 1976; Schmits, 1984). Turnovsky (1976, 1978) also shows that in a nonlinear model with multiplicative disturbances, the issue of demand and/or supply induced disturbances is less relevant. He concludes that in general the stabilized price at which the buffer stock is self-liquidating (its expected size will remain constant over time) is not the arithmetic mean. Nguyen (1979, 1980) showed that in case of a linear model formulated in growth rates the geometric mean rather than the arithmetic mean should be used as reference path for price stabilization.

Lee and Blandford (1980) perform an optimal control analysis for price and revenue stabilization. They stress the need to take account of the systematic trend of the price-setting target rice path, because otherwise the stabilization attempts are doomed to fail. They conclude that substantial market intervention is required for a significant reduction in price instability. Ghosh, Gilbert, and Hughes Hallett (1982, 1987), and Hughes Hallett (1986) explore the same problem, but with the market-clearing identity replaced by an explicit price formation mechanism. Their conclusion is that market stabilization is possible, but very expensive. There is substantial earnings stabilization, but in contrast to Lee and Blandford there is no improvement in the level of earnings.

The optimal control solution has to be replaced by a difference game if producing and consuming countries are still strategically active on the international market, although they coordinate their stabilizing efforts through a buffer stock manager (Van Groenendaal and de Zeeuw, 1991). They conclude that the stabilizing efforts are partly offset by the strategic activities, but some of the market participants are still better off. Also Turnovsky (1978) and Newberry and Stiglitz (1982) analyze whether the actions of speculators might jeopardize the desired outcome of actions of the stabilizing authority. Newberry and Stiglitz (1981) argue that the benefits from price stabilization will be small compared to the costs of operating the buffer stock; the benefits are not necessarily distributed in favor of the producers. The market for primary commodities is competitive and complete, because future and risk markets are redundant. This implies that the market equilibrium is Pareto efficient, so that the optimal stabilizing policy only reproduces the storage decisions of risk-neutral competitive speculators with rational price forecasts (Newberry and Stiglitz, 1982).

Note that no definite conclusions with respect to the effect of price and earnings stabilization through buffer stock operations in a realistic setting can be drawn from any of the different types of theoretical analysis.

How about the agreements concluded upon in the past? As was shown by Anderson and Gilbert (1988), five consecutive tin agreements lasted for over 40 years, before the sixth agreement collapsed because "it degenerated into an arrangement for the defence of a non-competitive price floor." The tin disaster and the absence of other long-term effective buffer stock agreements seem to confirm the pessimistic view that many theorists have about the usefulness of buffer stock agreements. The main lesson for buffer stock policy implementation should, however, not be that buffer stock agreements do not work, but that buffer stock intervention should not go against the general tendency of the market or, more precisely, the structural development in market prices. The agreements drafted before the tin disaster were in that respect not flexible enough. Incorporating this lesson into a commodity agreement means that the decision rule for selling out of or buying for the buffer stock should not try to alter the market price trend determined by supply and demand, and should not ignore changes in prices induced by factors from outside the market (spillover effects).

We can conclude that the theoretical and the practical evidence on buffer stock agreements is if not contradictive at least inconclusive. Therefore it is worthwhile to search for heuristic buffer stock rules that are robust in a realistic setting, and that fulfill two requirements: (1) the rule should stabilize long term export earnings at a reasonable cost, and (2) the buffer stock has to be self-liquidating. Because the different theories cannot be applied in a realistic setting due to restrictions imposed on the models used, the only solution method that remains is the formulation of a heuristic rule for buffer stock price stabilization within a realistic commodity market model, simulate its functioning, and check whether the requirements (1) and (2) are met.

The objective of this article is to see if one of the most flexible agreements so far (the 1986 cocoa agreement) meets the requirements, and if not, in what way the buffer stock agreement can be improved. (Because of the similarity between the 1986 cocoa and the 1987 rubber agreement, we restrict our empirical analysis to the 1986 cocoa agreement.) The 1986 cocoa agreement is a mixture of both types of stabilization policies mentioned before. The price range is a ±40-cent (U.S.) band around a reference price, and there are two instruments to keep the price within this range. There are also two instruments to adjust the reference or target price. The questions we want to answer here are, do these instruments enable the buffer stock manager to reduce the variance of the cocoa price under all market conditions, and is it possible to formulate a better rule for stabilizing prices?

The remainder of this paper is organized as follows. In Section 2 we will briefly discuss the features of the 1986 cocoa agreement. In Section 3 an annual model of the cocoa market and its main features are presented. In Section 4 the 1986 cocoa agreement is simulated and the instruments are tuned. In Section 5 the model is used to formulate some heuristic rules for market intervention, which are then compared with the agreement. The final section contains conclusions.

2. THE NEW STYLE COMMODITY AGREEMENTS

This year the supply-demand balance for cocoa might move into deficit for the first time since 1984. The reason for this is that cocoa prices are low due to sustained excess production and large stocks. As a result, production is no longer increasing, whereas consumption does (although to a lesser extent than previously expected due to the unfavorable economic situation in the former Soviet Union and Eastern Europe). If this change in market conditions will prolong over a longer period of time, the export earnings of the cocoa producing countries will improve. However, this improvement would not be the result the 1986 cocoa agreement; the agreement was never fully utilized due to a dispute over the use of one of its instruments (withholding) between producing and consuming countries in the spring of 1988.

On the occasion of its adoption in July 1986, Kenneth Dadzie, Secretary General of UNCTAD, described the International Cocoa Agreement as "the first of a new generation of International Commodity Agreements" (ICA) (UNCTAD, 1986a). The justification for such a bold statement is that, for the first time in history, the objective of an ICA was exclusively geared towards the reduction of price fluctuations around the long-term market-determined trend. Stabilization of prices (and as a consequence export earnings) was the sole objective of this agreement (see Article 1 of the 1986 cocoa agreement (UNCTAD, 1986b)).

The cocoa agreements of 1972 and 1975 were not effective at all because the cocoa price never was within the agreed price range. The agreement of 1980 only had a minor impact, although the buffer stock manager bought 100,000 metric tons in the 1981/82 season. The main reason for the ineffectiveness of the agreements was that they did not contain provisions for (semi)automatic revisions of the price range whenever necessary. The rubber agreement of 1979 was the first commodity agreement with a semiautomatic adjustment of the range, partly related to changes in the size of the buffer stock. In the 1987 Rubber Agreement, the mechanism of semiautomatic adjustment of the price range is strengthened considerably also. For a comprehensive discussion on the functioning of international commodity agreements, see Gilbert (1987).

The decisive factor in shaping the character of the latest cocoa and rubber agreements was the collapse of the tin agreement in 1985, due to prolonged attempts to maintain the tin prices at an artificially high level. As a direct consequence of this failure, the UNCTAD Committee on Commodities decided on new guidelines for commodity agreements. The major point of these guidelines was that future agreements should be designed in such a way that they stabilize prices without distorting long-term market trends, in the interests of producers and consumers (UNCTAD, 1986a).

The 1986 cocoa agreement is characterized by a relatively wide price range, two stabilization instruments, and a high degree of price flexibility (UNCTAD, 1986b). In the agreement the upper and lower intervention prices ("must sell" and "must buy" prices) are set at a distance of 40 U.S. cents from the reference price of 227 U.S. cents per kilo (SDR 1.935 at the time of adoption of the agreement). This means a range of ± 17.6 percent from the reference price, which is smaller than the ± 20-percent range in the 1979 rubber agreement (UNCTAD, 1980), but wider than the range of the 1980 cocoa agreement ($\pm 15.4\%$) (UNCTAD, 1982).

The principal instrument in the 1986 cocoa agreement is a *buffer stock* of 250,000 metric tons. The stock resulting from the 1980 agreement (100,000 MT), and a capital of U.S. $250 million were transferred to the new agreement. Additional funds for buffer stock operations continue to come from a levy of 2 U.S. cents per pound. The buffer stock manager has some freedom with respect to selling and buying, through the introduction of a "may buy" and "may sell" prices at ± 14.5 percent of the reference price.

An interesting feature in the 1986 agreement is a *withholding* scheme (equivalent to the contingency buffer stock in the 1987 rubber agreement (UNCTAD, 1987)). This is essentially a system of national stocks (kept in store by the buffer stock manager) up to a maximum of 120,000 metric tons. The scheme was meant to become operative (in tranches of 30,000 MT) once the buffer had reached 200,000 metric tons, or the manager would run out of funds. However, the Cocoa Council can (and did in 1988) decide against the use of the scheme by special vote. The impact of withholding is the same as buying by the buffer stock manager. However, there is a significant difference in the unloading of these two types of stocks. Stocks from the buffer are sold whenever the price reaches the upper intervention level. Withholdings are already released at the reference price; so, only the lower half of the price range is relevant for this instrument.

The most important new feature of the 1986 cocoa agreement is the flexibility of the price range due to two types of semiautomatic adjustment of the intervention prices. The first type relates to an *annual price review*. In case the average indicator price over the preceding year has been outside the range, the intervention price is increased (decreased) to such an extent that the indicator price will come at a distance of 6 U.S. cents from the intervention price within the range. The maximum adjustment is set at 13 U.S. cents per kilo, unless the Cocoa Council decides otherwise by special vote.

The second type of semiautomatic adjustment is triggered by *a change in the size of the actually held buffer stock of 75,000 metric tons within a six-month period*. In that case the adjustment of the intervention price is 13 U.S. cents per kilo. Taking both semiautomatic adjustments into account the 1986 cocoa agreement contains the most flexible adjustment of the price range that had ever been incorporated in a commodity agreement.

A not unimportant novelty of the 1986 agreement is that all prices are expressed in SDRs. Using the SDR as a denominator instead of the U.S. dollar has the advantage that the prices of the agreement are less distorted by changes of the dollar vis-à-vis the major other currencies in the world. A substantial appreciation or depreciation of the dollar influences the nominal cocoa prices expressed in dollars. By using the SDR as a denominator, price changes are mitigated. Theoretically one should use a basket of the currencies of all major consumer countries, with weights for the currencies according to their shares in cocoa consumption; also see Yeats (1987). However, the SDR is an acceptable substitute as unit of account.

3. A MODEL OF THE COCOA MARKET

Next we formulate a model for the cocoa market. Cocoa beans are produced in (often very poor) developing countries, and cocoa products are mainly consumed in developed countries. This dichotomy is used to model the world cocoa market, with producers and consumers interpreted as countries or regions. Regions are arranged in such a way that the amount of beans imported by a cocoa-producing region and the amount of beans exported by a consuming region can be neglected.[1] Suan Tan (1984) reviews the theory underlying the construction of this type of model.

The producing countries or regions are Cameroon, Ghana, Nigeria, Ivory Coast, the rest of Africa, Brazil, the rest of South America, and Asia and Oceania. The (normal) production of cocoa beans, *QR*, is based on two factors: the area planted and the (average) production per acre. In contrast to Akiyama and Duncan (1982), who introduce two different relations, one for acreage and one for yields, only one relation for the production of cocoa beans per country or region is introduced in our model. The reason for this is that the data for acreage are unreliable (FAO, 1985). Besides, under fairly realistic assumptions it is not necessary to introduce two relations (Bateman 1965; Ady 1968). The decision on acreage and production is based on the development (or expectations) of long-term real producer prices, *PFI/PC*, as an indicator for profit expectations. This leads to the specification

[1] Instead of cocoa beans, bean equivalents are used to avoid the need for separate markets for intermediary products, such as cocoa butter, cocoa cake, and cocoa powder, etc. The Cocoa Council conversion factors were used to achieve this. Most data originate from FAO's *Cocoa Statistics*; Gill and Duffus's *Cocoa Market Reports*; and the ICCO's *Quarterly Bulletin of Cocoa Statistics*.

$$\Delta ln(QR_t) = \beta_0 + \sum_{p=0}^{8} \beta_{p+1} ln\left(\frac{PFI_{t-p}}{PC_{t-p}}\right) + \beta_9 ln(QR_{t-1}). \tag{1}$$

Note that our specification can be interpreted as a reduced form formulation also (Kalaitzandonakes and Shonkwiler, 1992).

The consuming regions are North America, Western Europe, Eastern Europe (including the former Soviet Union), and the rest of the developed world. As a measure for cocoa consumption, grindings are used, adding the imports of powder, paste, and butter converted into bean equivalents. (In this way we cover the change in imports from beans to intermediary products also, especially in the trade between North America and Brazil.) Cocoa consumption per capita, CC/POP, is based on real gross per capita income, $GNPR/POP$, and real cocoa prices. The real import price, PI/PC, is used to represent the real cocoa price. The real price of sugar, PS/PC, is introduced to account for possible substitution or complementary products. The specification used is

$$ln\left(\frac{CC_t}{POP_t}\right) = \gamma_0 + \gamma_1 ln\left(\frac{GNPR/PC_t}{POP_t}\right) + \gamma_2 ln\left(\frac{PI_t}{PC_t}\right) + \gamma_3 ln\left(\frac{PS_t}{PC_t}\right) + \gamma_4 ln\left(\frac{CC_{t-1}}{POP_{t-1}}\right). \tag{2}$$

The price system for the different countries and regions contains relations for producer prices in home currency, PFI, and relations for export and import prices in U.S. cents, PE respectively PI. Note that the link between producer prices and export prices is the main link to signal market information to farmers. In some African countries this link is rather weak because of government intervention (Deaton, 1993). The export and import prices are linked to the world market price for cocoa, $PICCO$. For all price equations an autoregressive distributed lag model of the first order is used. By restricting the parameters, we tested what functional form is appropriate, that is, an error-correction mechanism, adaptive expectations, and so forth. The resulting specifications are

$$PFI_t = \kappa_1 PE_t RE_t + \kappa_2 PE_{t-1} RE_{t-1} + \kappa_3 PFI_{t-1} \tag{3}$$

$$PE_t = \kappa_1 PICCO_t + \kappa_2 PICCO_{t-1} + \kappa_3 PE_{t-1} \tag{4}$$

$$PI_t = \kappa_1 PICCO_t + \kappa_2 PICCO_{t-1} + \kappa_3 PI_{t-1}. \tag{5}$$

Total supply, $QRWT$, is the sum of production per country or region, and total demand, $CCWT$, is the sum of demand for grindings per region. The definition for total demand for grindings also includes a small autonomous component, *CCRR*, to account for imports in countries or regions that are not modeled explicitly. Differences in supply and demand will also induce changes in free stocks, *STWT*, in the calculation of which we account for 1-percent transportation losses.

$$QRWT_t = \sum_{i=1}^{8} QR_{ti} \qquad \text{total supply} \quad (6)$$

$$CCWT_t = \sum_{j=1}^{4} CC_{tj} + CCRR_t \qquad \text{total demand} \quad (7)$$

$$STWT_t = STWT_{t-1} + (0.99\, QRWT_t - CCWT_t) \qquad \text{total stocks} \quad (8)$$

The world market price for cocoa, *PICCO*, depends on the difference between world supply and demand. We assume that consuming regions keep a fraction of their demand for grindings in stock to assure uninterrupted production of cocoa products. This desired level of stock is set equal to the average level of stocks over the past, which is 30 percent of total demand *CCWT*. In as far as last year's stocks differ from the desired level, this difference will have a negative effect on the price for cocoa. In a situation of changing demand, this will also induce a change in the demand for stocks by $0.30\Delta CCWT$, which has to be added to the demand for consumption *CCWT* in order to obtain total demand. Because markets are not independent the commodity price index, *CPI*, is included to account for spillover effects from other markets. (Indicators for the instability of monetary variables did not have a significant influence in the estimation results.) The relation for *PICCO* is

$$ln(PICCO_t) = \alpha_0 + \alpha_1 ln(CPI_t) - \alpha_2 \frac{QRWT_t - (CCWT_t + 0.30\Delta CCWT_t)}{CCWT_{t-1}} - \alpha_3 \frac{STWT_{t-1} - 0.30 CCWT_{t-1}}{CCWT_{t-1}} + \alpha_4 ln(PICCO_{t-1}). \quad (9)$$

Note that we use price information instead of a market-clearing identity to achieve long-term equilibrium.

The model also includes a submodel for the calculation of the opportunity costs and operational result of buffer stock operations. The opportunity costs are based on the cash-flow from buying and selling cocoa beans by the buffer stock manager, minus the interest on an annual virtual loan to finance the buffer operations, minus the costs of keeping the beans in a warehouse in the United Kingdom (storage, insurance, rotation). The interest accounted for is based on a real interest rate of 5 percent per year. The estimated costs of keeping 1,000 metric tons of cocoa beans in stock are based on information gathered by UNCTAD (UNCTAD, 1975), and private correspondence with the ICCO. The costs are indexed on Manufacturers Unit Value index, MUV. The operational result is equal to the opportunity costs without the annual loan to finance the buffer, but including the interest gained from the surplus funds of the ICCO. These surplus funds are what remains of the contributions—2 U.S. cents per pound—after the buffer stock operations. The operational result is of special interest to the members of the ICCO, because it indicates to what extent the buffer operations need extra finance apart from the arrangements already made.

3A. Implementation of the Agreement in the Model

The two buffer stock instruments and two adjustment mechanisms for the price range (see Section 2) have to be translated into terms of the model. Because the model is based on annual data, our interpretation of the instruments in the agreement will deviate somewhat from their exact content.

The buffer stock can be implemented easily in equations 8 and 9. This is not the case for adjustment of the reference price by 13 U.S. cents per kilo if the buffer stock manager has to sell or buy 75,000 metric tons within six months. In the model this is translated into an adjustment of reference price each time the buffer stock manager sells (buys) 75,000 tons within one year, with a maximum of two adjustments per year. After one adjustment within a period, the simulation is restarted using the adjusted intervention price. No use is made of the "may sell" and "may buy" option.

Withholding has the same effect on prices as a buffer stock mutation. In the model withholding starts, up to a maximum of 120,000 metric tons and without employing tranches, when the maximum buffer of 250,000 metric tons is reached. Withholdings are sold whenever the actual cocoa price exceeds the reference price. The amount sold will keep the actual price equal to the reference price.

Implementation of the annual price review is straightforward. The intervention prices are adjusted each calendar year instead of each cocoa year.

Instead of all the detailed information on the estimation results, only the effects of the world cocoa price, *PICCO*, on production

Table 1: Price Elasticities of Cocoa Production

Country or region	Short run*	Long run†
Cameroon	0.13	0.73
Ghana	0.10	0.38
Ivory Coast	0.42	0.82
Nigeria	0.20	0.47
Brazil	0.25	0.29
Rest of Latin America	0.14	0.28
Asia and Oceania	0.00	0.50
World total	0.23	0.54

*Short run means current and one-year lag.

†Long run means steady state elasticity.

Note: For the region Rest of Africa, we used a dummy equation that describes the development of production over time.

and consumption, and the effect of a change in real gross national income per capita are reported. These effects are given in Tables 1 and Table 2, respectively. Compared to other studies (Akiyama and Duncan, 1982; ICCO, 1984), the results for North America and Western Europe are of the same magnitude. For Eastern Europe and the Soviet Union, the price elasticities obtained differ. This is partially due to differences in the definition of the regions. With respect to the rest of the developed world, the results are close to those obtained by the ICCO, but differ from the results of Akiyama and Duncan. There are, however, no real anomalies between the various results on elasticities, only differences in magnitude.

The short-run price elasticities of production and consumption are quite low (see Tables 1 and 2). The short-run elasticity of production for the world is 50 percent higher than the corresponding

Table 2: Price and Income Elasticities of Cocoa Consumption

	Price		Income	
Area	Short run	Long run	Short run	Long run
North America	−0.19	−0.25	0.21	0.25
Western Europe	−0.11	−0.15	0.25	0.30
Eastern Europe and Soviet Union	−0.14	−0.26	0.44	0.66
Rest of world	−0.26	−0.40	0.42	0.57
World total	−0.16	−0.23	0.30	0.39

elasticity of consumption. The difference in magnitude increases over time. This is due to the fact that in the short-run producers can only react on prices by taking better care of the existing stock of trees. In the long-run, the stock of trees can be adjusted also.

The income elasticities, both in the short-run and the long-run, are low in North America and Europe, which points at saturation of the market. In Eastern Europe and the former Soviet Union, and the rest of the developed world income elasticities are considerably higher.

4. SIMULATING THE 1986 COCOA AGREEMENT

In order to test the strength and weakness of the 1986 cocoa agreement, a number of simulation experiments are performed over a period of 25 years (for the sake of simplicity identified with the period 1994–2018). Because exchange rates are exogenous, it is assumed that they are constant over the simulation period. The development in consumption prices in the different countries and regions are linked to the development in the commodity price index, *CPI*; this to avoid unnecessary complications as a consequence of large differences in the long-term development of exogenous variables. The free simulation of the model performed reasonably well (measured in Theil's inequality coefficient) over the estimation period.

To introduce deviations from the model's trend we use trace-driven simulation (Kleijnen and Van Groenendaal, 1992). We calculated the trend in the univariate production models over the past, and took the difference between this trend and the actual values as disturbances. For *CPI* we calculated the deviations from the geometrical trend. The deviations obtained were fed in historical order into the model. In the remainder of this section we will examine the effect of the agreement (and the different instruments available) on the variability in the international cocoa price and on the variability in income.[2] In what follows, the policy results are compared with the result of a free simulation.

[2] As a yardstick for the variability the following instability index is used:

$$\Pi = \frac{\left\{ n^{-1} \sum_{i-1}^{n} [x_t - x_0(1 + \dot{x})^t]^2 \right\}^{\frac{1}{2}}}{x_{\text{mean}}}$$

with $\dot{x} = 0$ and an appropriate x_0 equal to the coefficient of variation. For a general discussion on instability indices, see Offutt and Blandford (1986).

In case of zero growth in *CPI*, the agreement does not affect the world production and consumption of cocoa beans (on average −1,800 MT and −1,600 MT, respectively, on an average annual world production of approximately 1.9 million MT). There is no change in the market shares of the different countries and regions, which implies that the agreement is neutral with respect to production and consumption. On average, income and spending are slightly lower compared to the free simulation, due to a small decline of the cocoa price (−1.4 U.S. cent per kilo). This implies that the agreement is neutral with respect to the nominal variables also. With an average buffer stock of 178,200 metric tons, the buffer stock policy of the agreement seems self-liquidating and in line with the 1986 UNCTAD guidelines as reviewed in Section 2.

Because of the intervention, the instability index of cocoa prices reduces from 36.9 percent (free simulation) to 26.8 percent (see Table 3), a reduction of more than 25 percent. As a corollary, the amplitude of the price range is reduced considerably: the highest price over the 25-year period decreases from 282 to 263 U.S. cents per kilo, and the lowest price increases from 161 to 171 U.S. cents per kilo. The lowest price instability index attainable within the agreement price range of ±40 U.S. cents is 19.3 percent, based on an unlimited buffer, so the degree of price stabilization reached (26.8%) is quite satisfactory. These positive results are obtained despite a really drastic shock in the fifth year of the simulation, comparable to the one in 1965, when world production of cocoa beans increases over 30 percent.

The stabilization of export earnings is less significant. The overall index decreases from 20.1 percent to 17.5 percent, the two largest producers (Brazil and Ivory Coast) gaining the most in terms of stabilization of export earnings. Note that all individual producing countries gain from the agreement in terms of stabilization of export earnings.

This result is achieved with a limited number of interventions. The buffer stock manager, starting with a stock of 100,000 metric tons, buys stocks only once, 150,000 metric tons in 1998, which implies an adjustment of the price range by two times 13 U.S. cents. The price range which was 187–267 U.S. cents at the beginning, becomes 161–241 U.S. cents, and the buffer is at its maximum level for two consecutive years. The buffer stock manager uses the instrument of withholding only in 2005 (64,400 MT) in order to keep the price range constant. In the following two years 39,600 metric tons and 25,000 metric tons are sold, because in these years

Table 3: The Effect of the Agreement on the Variability of Producer Prices and Earnings

	Instability index		Percentage decrease
	Simulation	Agreement	
Prices			
PICCO	36.9%	26.8%	27.3%
PICCO/CPIG	29.1%	24.3%	16.7%
Earnings			
Brazil	20.4%	16.5%	18.9%
Rest of Latin America	24.5%	21.2%	13.4%
Cameroon	27.2%	23.3%	14.3%
Ghana	47.7%	41.6%	12.9%
Ivory Coast	21.5%	17.6%	17.9%
Nigeria	53.0%	47.6%	10.1%
Rest of Africa	30.9%	27.4%	11.4%
Asia and Oceania	9.4%	8.1%	13.7%
Total	20.1%	17.5%	12.9%

the price of cocoa beans becomes larger than the reference price of 201 U.S. cents. The price range remains constant until the year 2016. To keep it constant, the buffer stock manager sells 93,400 metric tons in the period from 2010 to 2013 without triggering an adjustment mechanism. In the year 2008, a total of 75,000 metric tons are sold and the price range becomes 174–254 U.S. cents. In 2017 the remainder of the buffer is sold, which implies a new price range resulting from the fact that more than 75,000 metric tons are sold. However, in that year the price range is also adjusted as a result of the fact that the price of cocoa beans lies outside the range at the end of the year; consequently the price range becomes 200–280 U.S. cents in the year 2018.

It turns out that the 1986 agreement is easily self-supporting. The operational result is on average U.S. $90 million a year. The opportunity costs of the buffer stock operations are on average U.S. $22.7 million a year, which is a rather low price for the stabilization achieved; it is only 0.5 percent of the average value of production. These figures are based on the assumption that the existing 1985 stock of 100,000 metric tons was bought at 1985 prices.

The difference in export earnings between the free simulation and the agreement policy is slightly negative and on average minus U.S. $34 million or −0.007 percent of average annual earnings.

Table 4: The Simulation Results

	Result			
Policy	**Instability index prices**	**Instability index export earnings**	**Operational result (million U.S.$)**	**Opportunity costs (million U.S.$)**
Zero-percent inflation				
Free simulation	36.9%	20.1%	–	–
Agreement	26.8%	17.5%	92.1	22.7
Maximum buffer	19.3%	12.6%	60.4	117.1
Less flexible	21.7%	14.4%	54.5	31.5
± 30 U.S. cents	24.5%	18.4%	92.4	22.3
± 20 U.S. cents	20.9%	16.4%	101.8	12.9
± 10 U.S. cents	20.1%	15.4%	89.5	25.3
Internal growth (5%)	16.6%	15.4%	102.6	11.9
One-percent inflation				
Free simulation	37.9%	19.8%	–	–
Agreement	28.7%	18.9%	138.8	14.7
± 20 U.S. cents	24.2%	18.7%	160.5	−7.1
Internal growth (5%)	16.0%	15.5%	136.6	16.1
Three-percent inflation				
Free simulation	38.1%	19.1%	–	–
Agreement	29.4%	18.2%	294.7	−39.4
± 20 U.S. cents	23.0%	18.2%	291.9	−36.5
Internal growth (5%)	18.6%	16.9%	211.5	40.2

4A. Variations on the Agreement Policy

Several factors indicate that the functioning of the 1986 agreement can be improved upon. First, the buffer stock is not very active (6 out of 25 periods). Second, the withholding instrument is hardly used. Third, the mechanism of adjustment of the price range at the end of the calendar year is used only once. All this means that the flexibility (13 U.S. cents) triggered by changes of 75,000 metric tons in the size of the buffer stock, and activated four times under the agreement policy, is too high given the price range of ± 40 U.S. cents. There are two ways in which this flexibility can be reduced, by smaller adjustments of the reference price, and by reducing the price range.

First, the flexibility is reduced by 50 percent (from 13 U.S. cents to 6.5 U.S. cents per kilo). This results in a better performance (see Table 4, "less flexible"). This better result is attained at limited additional opportunity costs (U.S. $9 million per year). The instability index for cocoa prices drops to 21.7 percent and the index for income to 14.4 percent. Both values are close to the minimum values that can be attained by a maximum buffer (Table 4, "maximum buffer"). As under the agreement, this alternative policy stabilizes the income of every individual country/region and has hardly any influence on total income, production, consumption, and average cocoa prices. Also in this case the buffer seems self-liquidating. The very positive outcome of this variation on the agreement is not due to the fact that the buffer is more active. Rather, this case demonstrates the possible effect of the withholding scheme. This scheme is active in 12 out of the 25 years. However, it functions only in the lower half of the price range. Therefore, during this period, the prices are in fact kept within a range of 40 U.S. cents under the reference price.

Further sensitivity analysis of the 75,000-metric ton price adjustment showed that the result could not be improved upon. There is also a good balance between flexibility and size of the instruments. Increasing the maximum buffer stock and/or the maximum withholdings does not lead to better results.

An alternative for a reduction of flexibility is a narrowing of the price range. The most significant result was reached after reducing the range to ± 20 U.S. cents. The result of this reduction is almost equal to the result of the variation on the agreement with reduced flexibility (see Table 4, 0% inflation and ± 20 U.S. cents). The only, but important, difference is that the costs of stabilization are much lower, amounting to less than U.S. $12.9 million per year, and the operational result nearly doubles. Further reduction of the price range leads to a slightly better result, but at the expense of doubling the real costs of the agreement. This is in line with the theoretical result that narrowing the band too much increases the costs. (Turnovsky, 1978, and Newberry and Stiglitz, 1982, emphasize that in a theoretical setting, perfect price stability is either not feasible or infinitely costly.)

The results of a policy with a price range of ± 20 U.S. cents cannot be improved upon by changes in the mix of instruments. The result does not depend on an active withholding mechanism. The buffer is very active and – at least as important – the price adjustment mechanism becomes operational quite frequently. As with the other variations discussed, the policy is neutral with respect to the long-run market trend.

4B. The Agreement in an Inflationary World

Until now the operation of the agreement has been analyzed in an inflation-free world. In an inflationary world, the instruments of the 1986 agreement become ineffective after a number of years. In case of an annual increase in the trend of the commodity price index, *CPI*, of 1 percent per year, the buffer manager buys 130,000 metric tons in 1998, which keeps the price within the range for a total period of 12 years. Then inflation catches up with the price range. The price range is gradually increased in the following years, and the buffer is empty within two years (after the 12th year). The buffer remains empty and becomes ineffective. *This implies that the agreement is not neutral with respect to spillover effects from other markets.* Because of the operations of the buffer stock, the price instability index still declines from 37.9 percent to 28.7 percent, but earnings are only marginally stabilized (see Table 4).

In case the rate of inflation doubles or triples, the period after which the agreement becomes ineffective is 10 and 7 years, respectively. So the higher the rate of inflation, the sooner the agreement becomes ineffective. The stabilizing effect is therefore less, even if we apply the optimal mix of instruments established above (Table 4, ±20 U.S. cents). These findings throw some light on how the agreement would have functioned in the past. In the 1960s up to 1972, with a trend growth in *CPI* of 1.3 percent, the agreement could have functioned to a limited extent. In the period 1972–1982, however, with a trend growth of almost 7 percent, the agreement would have been totally ineffective, as confirmed by experiments over the past. The results indicate that even a moderate rate of inflation paralyzes the functioning of the agreement, Consequently, given the structure of the agreement, it will be necessary to renegotiate the price range regularly. With 1-percent inflation, renegotiation is necessary every 5 years, and in case of 3 percent inflation, at least every 3 years. The question is, can these renegotiations be avoided?

5. A HEURISTIC RULE FOR INTERVENTION

The policy implicit in the goals of an agreement can be formulated as a simple closed-loop buffer stock rule of the form

$$\begin{aligned} \Delta(BST_t) &= f_1(PICCO_t, PICCO_t^*) \\ PICCO_t^* &= g_1(PICCO_{t-1}, \Delta(BST_{t-1}), CPI_t^e). \end{aligned} \qquad (10)$$

where $PICCO_t^*$ is the target price; $\Delta(BST_t)$, the change in the buffer stock; and CPI_t^e, the expected commodity price index. This approach seems more realistic than applying optimal control, given the practical constraints the buffer stock manager has to deal with. A disadvantage is that it is not possible to prove that such an agreement leads to optimal results; it can only be shown that over a longer period of time it is satisfying.

In order to do this we translate the principle, that a decision rule should adjust for fluctuations in supply and demand in such a way that it does not effect the price trend induced by structural changes in supply and/or demand, into variables of the model. To reduce the variance of the price, two conditions have to be met (see Equation 9):

$$QRWT_t - (CCWT_t + 0.30\Delta(CCWT_t)) = \Delta(BST1_t), \quad (11)$$

$$STWT_{t-1} - 0.30CCWT_{t-1} = \Delta(BST2_t). \quad (12)$$

Equation 11 implies short-term market equilibrium, whereas equations 11 and 12 together imply long-term market equilibrium, because stocks are kept at their desired level also. Note that if $QRWT_t$ increases with time and $CCWT_t$ stays constant, the positive effect of $\Delta(BST1_t)$ is offset by a negative $\Delta(BST2_t)$ one year later. Therefore the buffer stock is self-liquidating in the long term. The total buffer stock mutation necessary to achieve the desired target of long-term market equilibrium is

$$\Delta(BST_t) = \Delta(BST1_t) + \Delta(BST2_t). \quad (13)$$

This condition is the target for the buffer stock manager. Implementation in Equation (9) leads to a pragmatic target price which is recalculated every period

$$PICCO_t^* = exp\{\alpha_0 + \alpha_1 ln(CPI_t^e) + \alpha_4 ln(PICCO_{t-1})\}. \quad (14)$$

Since the adjustment $\Delta(BST_t)$ is based on market conditions of the market for cocoa beans only, this rule for evaluating the target price from year to year is called the rule of "internal growth."

5A. Application of the Rule of Internal Growth

If the buffer stock manager bases his policy on Equations 13 and 14, long-term market equilibrium is achieved. In order to apply this rule, it is assumed that the expected commodity price index, CPI^e, is equal to the actual commodity price index, CPI. It turns out that in terms of variability reduction the rule of "internal growth" is superior to the agreement under all circumstances, even if we use the optimal tuning of the instruments (see Table 4).

A band of ±5 percent around $PICCO_t$ is used before the policy is activated. This for practical reasons, not every minor difference in demand and supply has to be taken into account; only larger fluctuations are of interest. A smaller band also increases again the costs; a larger band has a less-stabilizing effect. Note that earnings too are stabilized to a greater extent; only the optimal agreement policy, in case there is no inflation, achieves the same stabilizing effect. Moreover, in the case of zero growth, the opportunity costs of this policy are lower, U.S. $11.9 million instead of U.S. $22.7 million. The maximum buffer is 338,800 metric tons; this maximum buffer is less than 40 percent of the size of the maximum buffer under the agreement with no restriction on the size of the buffer. The minimum buffer is zero metric ton, and as a result the policy is ineffective three times in the first half of the simulation period. The average buffer is 131,500 metric tons, so the policy is self-liquidating.

If we apply the rule of internal growth, but restrict the buffer size to 250,000 metric tons and allow for withholding, the policy still works. The results remain almost the same as with no restrictions on the buffer, which is logical because the maximum buffer required is less than the sum of the maximum buffer and maximum withholdings. The difference in average annual export earnings between the free simulation and our policy is minus U.S. $17 million only, or 0.0035 percent of average earnings.

In an inflationary world, the results under a rule of internal growth do not deteriorate; stabilization is reached, although at a certain price (see Table 4). This is in sharp contrast with the agreement, which becomes ineffective after a limited number of years. Our rule of internal growth is neutral with respect to the long-term trend of the world cocoa market and does not go against the trend in *CPI*. Neither production nor consumption or stocks are significantly influenced by this stabilization policy.

6. CONCLUSIONS

The semiautomatic price adjustment mechanism and the two intervention instruments of the 1986 cocoa agreement augur well for its success if it would have been applied. Our analysis shows that the instruments in the agreement can have a substantial stabilizing effect on prices and export earnings. The operational result of the buffer stock under various circumstances indicates that no additional funding would have been required to finance the buffer stock operations. The opportunity costs are also relatively low. Our analysis indicates, moreover, that the effectiveness of the instruments can considerably be enhanced by halving the width of the price range. An essential precondition for success of an agreement based on the same type of instruments is, however, that its potential flexibility is fully utilized. The dispute over price adjustment and withholdings that arose in the spring of 1988 between producers and consumers is, therefore, most unfortunate.

However, even only moderate inflation of world commodity prices will make the agreement ineffective after a some time. (The same conclusion holds for deflation.) Consequently, periodical and most likely cumbersome renegotiations of the price range are necessary. As the past has shown, such renegotiations, which are always needed when market conditions are unfavorable for either consumers or products, paralyze an agreement.

The functioning of agreements can be improved by the application of our rule of internal growth, which is neutral with respect to spillover effects from other markets but neutralizes the market's own disturbances. Price stabilization can be reached to a higher degree, and periodical renegotiation of the price range or the reference price would no longer be necessary.

The rule requires less information on future prices than an optimal-control or difference-game solution does. Compared with former price-range rules, our fast adaption of the reference price avoids buffer stock operations based on changes in the price trend that cannot be altered.

Our analysis shows that stabilization of prices and, to a lesser extent, of export earnings can be achieved at moderate costs and with limited interventions. This is opposite to previous findings (Lee and Blandford, 1980).

We also found that there is no substantial difference in export earnings between the cocoa agreement policy, our own policy rule, and the free simulation. This is in line with the results of Ghosh et al. (1982, 1987), and Hughes Hallett (1986), but in sharp contrast with the familiar Waugh–Oi–Massell results.

Application of the rule of internal growth requires information on development and effect of other markets on the cocoa market for the current period. In our model this means that the buffer manager needs a good indicator for the development of commodity price index, *CPI*. Further research on the exact relation within commodity markets and between commodity markets and other markets is needed first. We used an annual model for the cocoa market to test our policy. More realistic models, however, are required before our tests can be applied.

REFERENCES

Ady, P. (1968) Supply Functions in Tropical Agriculture, *Institute of Economics and Statistics Bulletin*, 30: 157–188.

Akiyama, T., and Duncan, R. C. (1982) Analysis of the World Cocoa Market. World Bank Staff Commodity Working Papers 8, Washington DC.

Anderson, R.W., and Gilbert, C. L. (1988) Commodity Agreements and Commodity Markets: Lessons from Tin, *The Economic Journal*, 98: 1–15.

Bateman, M. J. (1965) Aggregate and Regional Supply Functions for Ghanaian Cocoa, 1946–1963, *Journal of Farm Economics*, 47: 384–401.

Deaton, A.S. (1993) Commodity Prices, Stabilization, and Growth in Africa. Research Program in Development Studies, Princeton University and Institute for Policy Reform.

Devadoss S. (1992) Market Interventions, International Price Stabilization, and Welfare Implications, *American Journal of Agricultural Economics*, 74: 281–289.

FAO (1985) *FAO Production Yearbook*. FAO Statistics Series 70, Rome.

FAO (various issues) *FAO Cocoa Statistics*. Rome.

FAO (various issues) *Quarterly Bulletin of Cocoa Statistics*. Rome.

Ghosh, S., Gilbert, C.L., and Hughes Hallett, A.J. (1982) Optimal Stabilization of the Copper Market: The Problem of Information, *Resources Policy* 8: 201–214.

Ghosh, S., Gilbert, C.L., and Hughes Hallett, A.J. (1987) *Stabilizing Speculative Commodity Market*. Oxford: Clarendon Press.

Gilbert, C.L. (1987) International Commodity Agreements: Design and Performance, *World Development*, 15: 591–616.

Gill and Duffus. (various issues) *Cocoa Market Reports*. London: Gill and Duffus Group PLC.

Gill and Duffus. (various issues) *Gill and Duffus Cocoa Statistics*. London: Gill and Duffus Group PLC.

Hughes Hallett, A.J. (1986) Commodity Market Stabilisation and the "North-South" Income Transfers: An Emperical Investigation, *Journal of Development Economics*, 24: 293–316.

ICCO (1984) An Analysis of the World Cocoa Economy. International Cocoa Organization PCA/3/6 London.

ICCO (various issues) *Quarterly Bulletin of Cocoa Statistics*, London.

Kalaitzandonakes, N.G. ,and Shonkwiler, J.S. (1992) A State Space Approach to Perennial Crop Supply Analysis, *American Journal of Agricultural Economics*, 74: 343–352.

Kleijnen, J.P.C., and Van Groenendaal, W.J.H. (1992) *Simulation: A Statistical Perspective*. Chichester, England: John Wiley & Sons.

Lee, S., and Blandford, D. (1980) An Analysis of International Buffer Stocks or Cocoa and Copper Through Dynamic Organization, *Journal of Policy Modeling*, 2: 371–388.

Newbery, D.M.G., and Stiglitz, J.E. (1981) *The Theory of Commodity Price Stabilization: A Study in the Economics of Risk*. Oxford: Oxford University Press.

Newbery, D.M.G., and Stiglitz, J.E. (1982) Optimal Commodity Stock-Piling Rules. *Oxford Economic Papers*, 34: 403–427.

Nguyen, D.T. (1979) The Implications of Price Stabilization for Short-Term Instability and Long-Term Level of LDCs' Export Earnings. *The Quarterly Journal of Economics*, XCIII: 149-154.

Nguyen, D.T. (1980) Partial Price Stabilization and Export Earning Instability, *Oxford Economic Papers*, 32: 341-352.

Offutt, S.E., and Blandford, D. (1986) Commodity Market Instability: Empirical Techniques for Analysis, *Resources Policy* 12: 62-72.

Schmits, A. (1984) Commodity Price Stabilization: The theory and Its Application. World Bank Staff Working Papers, No. 668, World Bank, Washington, DC.

Suan Tan, C. (1984) World Rubber Market Structure and Stabilization. World Bank Staff Working Papers, No. 10, Washington DC.

Turnovsky, S.J. (1976) The Distribution of Welfare Gains from Price Stabilization: The Case of Multiplicative Disturbances, *International Economic Review*, 17: 133-148.

Turnovsky, S. J. (1978), The Distribution of Welfare Gains from Price Stabilization: A Survey of Some Theoretical Issues. In *Stabilizing World Commodity Markets*. (F.G. Adams and S.A. Klein). Lexington Books.

UNCTAD (1975) An Integrated Programme for Commodities. UNCTAD TD/B/C.1/198, Geneva.

UNCTAD (1980) International Rubber Agreement 1979. UNCTAD TD/Rubber 15, Geneva.

UNCTAD (1982) International Cocoa Agreement 1980. UNCTAD TD/Cocoa 6/7/rev. 1, Geneva.

UNCTAD (1986a) UNCTAD Bulletin No. 224, July/August.

UNCTAD (1986b) International Cocoa Agreement 1986. TD/Cocoa.7/L.8, Geneva, 1986.

UNCTAD (1987) International Natural Rubber Agreement. UNCTAD TD/Rubber 2/16, Geneva.

Van Groenendaal, W.J.H., and de Zeeuw, A.J. (1991) Control, Coordination and Conflict on International Commodity Markets, *Economic Modelling*, 8: 90-101.

Yeats, A. J. (1987) A Note on the Functioning of International Commodity Price Stabilization Agreements in Periods of Fluctuating Monetary Exchange Rates, *Journal of Development Studies*, 23: 382-401.