Comparative Study of Estimates of Capital Requirements for Buffer Stock Financing

Commonwealth Secretariat,
Marlborough House,
Pall Mall,
London, SW1Y 5HX.

August, 1977.

Comparative Study of Estimates of Capital Requirements for Buffer Stock Financing

Contents

Comparative Study of Estimates of Capital Requirements for Buffer Stock Financing

Introductory note

1. This paper attempts to bring together the principal estimates of stocking costs for the ten "core" commodities in the Integrated Programme for Commodities and their underlying assumptions and methods. The estimates considered are those made by:

(i) UNCTAD
(ii) OECD
(iii) Ministry of Overseas Development
(iv) Behrman
(v) Commodities Research Unit

2. In so far as the introduction of the buffer stock simply transfers holdings to the new authority no additional costs arise and the relevant measures involved might properly be taken only as the costs of the required increment in stock. However, the question of acquisition costs of the authority itself remains unaffected by this consideration. Moreover, the estimates of tonnages, prices and acquisition costs do not determine the total requirements since operational costs[1] and offsetting savings from common financing are also involved. In this paper, however, the main concern is with the estimates, their variability and the methods of their determination.

3. Estimates were made by considering a period likely to require maximum intervention and calculating directly the sales or purchases needed to achieve an assumed target price; more sophisticated econometric methods involving models and simulations were also used. Both presupposed a demand effect on price in defending the floor and a supply effect on price in defending the ceiling. The impact of buffer stock sales and purchases depends on the relevant elasticities. An elasticity response is assumed or derived from market responses in a base period. A price flexibility relation[2] may be applied to the percentage difference between market and intervention prices to establish the sales or purchases. These provide the basis for the estimate.

4. Central to the calculations is the long run equilibrium price. This is held to be an optimum in respect of allocative and distributive functions, though inequities and inefficiences in practice have directed attention to managed markets. However, provision is generally left, as in the tin agreement, for a central free range since costs of incorrectly determining this price or deliberately aiming off target imply greater capital needs. For this reason preferred estimators involve close approximations to this price to minimise costs.

5. The value of these procedures has been questioned on two main grounds. Firstly, there is the uncertain validity of the applicable relations assumption which allows elasticities and other market responses of the base period to be applied to the simulation period. It has been suggested that price flexibility, for example, cannot be applied indiscriminately from a base period to a simulation period since variable impediments to the quantity effect on price may predominate, as in forward markets or where there are

---

1 Includes storage costs, interest and discount rates, trading profits etc.

2 Percentage change in price resulting from unit percentage change in quantity.

fixed price agreements. Secondly, there are constraints imposed by the dependence of estimates on assumptions, particularly in respect of the trend and structure of the model. These involve issues of econometric method, internal consistency and correspondence with economic theory.

6. The treatment and extent of error margins also raise difficulties. Alternative time paths for these major variables combined with associated corridors of uncertainty explain some of the diversity of results. The different standpoints on these issues are apparent in the OECD suggestion that the UNCTAD estimates might be seen "in a rather wider field of many kinds of uncertainties and arbitrary choices than would appear from the degree and kind of randomness allowed for in their model".

7. Uncertainty in respect of underlying trends and fluctuations limits the validity of the simulations while the trends used to approximate them are themselves dependent on the base period and type of function adopted. They reflect the past data which can prove a worse indicator of the timing and extent of change than simple market signals.

8. The sensitivity of the estimates to different assumptions and circumstances is evident from their differences. These were considerable, for example, for the copper estimates. Low levels were produced by UNCTAD, OECD, and Behrman; high levels by CRU and Smith/Schink. Their differences reflected the elements involved in the calculation including band widths and intervention rules and the issues of trend, time horizon and function; they involved also the initial stock assumptions, prices used for stock valuation and the financing arrangements which underlay the accounting viability of intervention. In particular, the estimates were conditioned by the choice of base period and the extension of its relations into the simulation.

9. Private stocking behaviour was a major parameter in the calculation consistently held to be constant. The copper market provided instances, however, where increased security of supply, in this instance arising from producer stocks, lowered private holdings. Increased supply security may even lead to a reduction in the norms for working stocks.

10. On the other hand, it is conceivable that intervention and greater price stability would facilitate private stocking since insurance by hedging might be less necessary. In the longer term the impact of stability on investment may affect the supply response and permanently affect the structure of the market. If stocking costs are to be minimised the base responses need to be continually updated. However, given a free central range left to market forces and adjustments, possibly triggered by consecutive selling and buying, intervention itself may be neutral in its effect on underlying trend.

11. The viability of intervention is important since continuing trading losses will require increased financing and affect the estimates of capital needs. CRU and Behrman produced negative present values in their simulations indicating a lack of viability in accounting terms. The criteria depended on the net present value of equity cash flows over the simulation. In large part these losses arose from the opportunity costs of capital. The principal offsetting factors were the stability in terms of price and possibly earnings and the assurance for planning given, though not perhaps equally, to participating countries. Redistributive effects provided a major additional factor. For the eight commodities dealt with Behrman calculated annual cash flows of 0.7 million 1975 dollars, largely from consumers to producers,

while greater sums in terms of increased GDP might accrue to developed countries through avoidance of inflationary effects on employment and output. These considerations of balance of advantage are relevant in assessing the capital costs of stockpiling.

Estimates and assumptions

General

12. The following section describes the main estimates and assumptions. The two major estimates of UNCTAD and OECD were not too dissimilar in respect of their mid points, but varied widely in respect of the uncertainty ranges adopted. The ODM values were relatively low; they had inadequate initial stocks and for substantial periods prices moved beyond their limits. The estimates illustrated a possible result of buffer stock intervention where the manager did not enjoy perfect foresight. The Behrman estimates were above those of UNCTAD and OECD. In comparison with UNCTAD data on a commodity basis the stock values of Behrman were greater, particularly for rubber; only two commodities, copper and tin, were exceptions to the rule. If, as was understood, a downward modification might be possible for the Behrman rubber figure then allowing for cotton and sugar the overall Behrman stocks might correspond more closely with those of UNCTAD. The CRU estimates produced an approximate level for copper using the 1974-75 recession to estimate the probable stocks that a buffer stock would need to keep prices within limits. This calculation confirmed an econometric simulation in which many alternative combinations of price band and initial stock were used.

13. A number of reasons have already been given for the differences between the real cost equivalents of the tonnage estimates in the calculations reviewed. Two, in particular, may understate these differences. Firstly, higher transaction and storage costs are associated with the higher tonnage estimates and, secondly, provision should be made for proportionate reserves to ensure against speculative attacks by the market.

14. The common approach of the models was to establish a range about an intermediate price itself within the extreme deviations and, no matter what the initial position, to provide for adjustments to contain the equilibrium. The limitations of buffer stock resources would tend to ensure these adjustments were made and its stabilising function maintained.

15. While stocks related to mid point estimates would be insufficient to meet all contingencies, future uncertainties compel a realistic approach. Assuming market signals cannot be disregarded in a viable operation it seems unlikely that intervention authorities would dissipate their resources. At the worst they would end up with all cash or all stock and the initial position of a free market would be restored. If the mid points of the UNCTAD and OECD models were accepted the overall requirements of 10"core"commodities would in terms of 1976 prices and dollars be in the region of 7 to 8 billion.

Sensitivity of the estimates

16. The capital requirements of the"core"commodities were affected by a number of parameters, a limited number of which is reviewed here; those concerned were secular price trends, short period fluctuations, market speculation, holding time and cyclical movements.

17. Estimates of capital needs are sensitive to secular price trends. A general decline for a particular portfolio of commodities would place a severe burden on requirements for price support. Sudden changes in trend are not accommodated by the time variables in the models which represent only the influence of base period movements. An undetected increase in underlying prices would place market prices above the targets of the model and requirements for price support would vanish. Of the eight "core" commodities dealt with by Behrman only copper and tin showed a positive slope to the secular regression of deflated price on time. An increase in trend would be revealed by updating the calculation or by consecutive intervention to defend the ceiling.

18. The use of annual data tends to understate capital needs since within year price variations and the costs associated with these are ignored. For some commodities the estimates are likely to be particularly affected by this kind of short period fluctuation. Moreover, since the size of adequate stocks cannot be known with certainty in advance the estimates are dependent on the likelihood of speculative attacks. Only the financing of very large stocks could overcome this problem.

19. Capital needs are responsive to holding times for stocks. Longer times would increase requirements and reduce the rate of return. On the other hand, wider band widths would reverse this relationship. Five year holding times were thought possible for products reflecting general cyclical movements since purchases early in the cycle might need to be held through most of the period until prices recovered. Models incorporating lag structures may indicate long holding times while demand and supply relationships may also result in long periods when the buffer stock neither buys nor sells.

20. Estimates of acquisition costs are particularly sensitive to the timing of buffer stock programmes in relation to general movements. They would be least at the bottom of the cycle. The reverse situation would obtain in an upswing. At this period also the need for stocking might appear less urgent.

UNCTAD estimate

21. This description relates to the main simulation by UNCTAD yielding estimates of maximum stocks necessary to maintain prices within plus or minus 10% of 1971-75 average prices and 1974-78 average prices, both in terms of 1976 constant dollars. A simpler approach was also adopted to estimate the savings arising from Common Fund financing and for this purpose it was understood that linear trends were taken for supply, demand and price: the simulation period was 1957-73 and a zero price band for both fixed and variable target prices was used.[1]

22. The major UNCTAD estimates for the ten "core" commodities based on 1971-75 prices shown in Appendix table 1 ranged between 6.1 and 7.4 billion 1976 dollars without common financing and between 4.6 and 5.5 billion dollars allowing for offsetting savings. The costs in Appendix table 2 which were based partly on prices projected up to 1978 were somewhat smaller. The three major commodities were copper, sugar and coffee, the costs for which at the 80% confidence level were in billion dollars 1.6, 1.4 and 0.9, respectively: the commodities next in importance were cotton 0.6, cocoa 0.5 and rubber 0.4. The smallest costs were those for tin, tea

---

1 Document TD/B/IPC/CF/L2 dated 29th December 1976. The major simulations appeared in annex II; the others in annex I.

and sisal each of which was less than 0.2 billion dollars. It should be noted that the lower limits of the price bands were used for valuation.

23. The UNCTAD model covered the ten "core" commodities whose relations were described by the structural equations, and an identity equation containing the term for buffer stock purchases. The model was described as a simultaneous system; ordinary least squares estimates were used. The model appeared as an auto-regressive system. The supply equation was made stochastic by the addition of a normally distributed random variable with zero mean and standard deviation equal to that observed in the 1953-73 base period. Monte Carlo simulations were performed for the 1979-83 period, yielding 1,500 values of the main variables.

24. To start the model forecasts were made of initial prices and growth rates of demand; the model was not used to estimate these initial values. The stock estimates were expressed in terms of 80 per cent and 95 per cent confidence limits.

25. A simplified general indication of the equations is given here in terms of the explanatory variables only, without co-efficients.

UNCTAD equation number	
(4)	$d_t = f[y_t + p_t + [y_t + d_{t-1}]]$
(annual) (8)	$q_t = f[p_{t-1} - p_{t-2} + z_t + q_{t-1}]$
(perennial) (14)	$q_t = f[p_t - p_{t-1} + \underline{p_{t-k-1}} - \underline{p_{t-k-2}} + q_{t-1}]$
	N.B. The underlined terms were dropped.
(16)	$p_t = f[s_t + d_t + p_{t-1} + p_{t-2}]$
(17)	$s_t \equiv s_{t-1} + q_t - d_t + \lambda w_t$

d_t = consumption

y_t = income

p_t = price

q_t = production

q_t^* = planned production

z_t = exogenous variable (s) influencing q_t^*

s_t = stocks, including those held by the stocking authorities, at end of period

w_t = net purchases for stock by the stocking authorities during period

λ is an adjustment factor (see below)

26. Difficulties have arisen with the identity equation as given here. It is possible to interpret s_t and $-\lambda w_t$ so that it can be written as indicated below.

w_t = Net purchases for stock by the stocking authorities during period t

$-\lambda w_t$ = That part of w_t not yet moved into warehouses

s_t = Stocks in warehouses at end of period; includes that part of w_t moved into warehouses

q_t = Production in period t

d_t = Demand in period t

$s_{t-1} - \lambda w_{t-1}$ = Total stocks at beginning of period

Identity equation : Total stocks = $s_t - \lambda w_t \equiv s_{t-1} - \lambda w_{t-1} + q_t - d_t$

λ is defined by UNCTAD in the context of the demand equation (para. 7 of document L2) as the coefficient rate of adjustment which is normally $0<\lambda<1$. Here λ is defined as $-1<\lambda<0$.

27. In addition to this basic system additional equations describing the financial operations of the commodity organisations were formulated. These were used to assess the viability of the arrangements and the savings possible from common financing.

28. The parameters were estimated on the basis of annual data. Their signs were mainly as expected. The magnitudes also seemed reasonable. The statistical fit of the equations was in general acceptable.

29. The models were subject to continued revision and re-specification and the caution was given that they should not be taken as being in any sense final.

The following additional assumptions were evident:

(i) Perfect foresight (The minimum adequate initial stocks to keep prices within limits were known. The trend also was known).

(ii) Applicable corresponding relations (i.e. the elasticities etc. of the base period were applicable to the simulation period).

(iii) Adequate initial stocks.

(iv) No supply management.

(v) Ten "core" commodities were covered. The base period was 1953-73; the simulation period 1979-83. Target prices were (i) 1971-75 average and (ii) 1974-78 average. These were deflated (1976 dollars). The price band was plus or minus 10 per cent.

(vi) No forward operations.

(vii) The models made no allowance for the absorption by the international stock to be set up of part or all of those existing or privately held stocks which were in excess of normal requirements. It was assumed no more than normal stocks would be in the system in 1979

OECD estimate

30. The mid point estimates of OECD for the ten "core" commodities produced a total of $8.3 billion at 1976 prices. Coffee, sugar and copper were the main items at 3.4, 1.3 and 1.0 billion dollars respectively; these were followed by cotton 0.9 and cocoa 0.6. Costs for the remaining commodities each equalled 0.4 billion dollars or less. Details of costs are given in Appendix table 4 in terms of January-March 1976 and 1976-81 prices.

31. The econometric method adopted by OECD attached uncertainty ranges to the estimates taking into account stochastic elements for a greater part of the model than in other simulations. The assumption was made that deviations from secular trends of supply and demand might be considered as random normal variables. Extreme deviations which intervention could not reasonably hope to contain were defined. A target range was established with acceptable deviations. This represented about half the original range.

32. Such a reduction was not necessarily desirable since it might leave excessive fluctuations for cocoa, rubber and copper. Moreover, for tea, cotton and jute, the deviations might be too small.

33. The estimated tonnages were valued at January-March 1976 prices and at forecast prices for 1976-81. This calculation reflected OECD hypotheses on the price targets. It assumed also that in a six year period 1976-81 deviations would cumulate on one side of the trend line during a cyclical upswing or downswing.

34. In arriving at forecast prices a view was taken of moderate increases for copper, tin, cotton and apparently for tea and jute. Declines were forecast for sisal, sugar and cocoa. Rather higher prices were anticipated for coffee and apparently rubber. These assumptions were thought to be conservative.

35. OECD suggested a number of commodities viz. cotton, sugar and hard fibres, might be omitted from a hypothetical calculation. For the remaining commodities a target range of 20% could be applied to a group with substantial fluctuations; for the others a 10% range was envisaged. The general approach to the estimating problems involved may be judged by the extract from the OECD document given here.

36. "All relationships between variables on commodity markets have more or less sizeable margins of error, and these margins are cumulative. Depending on which ranges one admits, and which mid-point estimates one takes for granted, various interval widths result for the buffer stock estimates. Uncertainty ranges may thus be narrowed down or expanded.

37. The method used for OECD Secretariat estimates is based on differences between output and consumption on the one hand, and the width of price fluctuations on the other. In a first approach to 10 commodities the model uses not more than three variables and their relationships. With less of a time constraint, the method may perhaps be refined somewhat. This would require other explanatory variables, e.g. stock figures, data on market intervention, if any, and on the details of price formation. However, such additional information may not be available for all 10 commodities. On the other hand, even the variables used have deficiencies. Consumption is quite often not directly available, but has to be imputed by using gross imports, or imports corrected by stock changes, or other proxies.

Prices may give a general indication rather than correspond to those actually used in contracts.

38. Buffer stock estimates still face another problem which makes them hypothetical: they are made without taking account of the situation at the time such stocks are to be introduced, and of the reaction of market participants to their being set up. If a high producer surplus overhangs the market, the initial size of the buffer stock may well have to be larger than what is necessary over a period of a full cycle".

Ministry of Overseas Development estimate [1]

39. The ODM stock estimates for seven"core"commodities, cotton, tea and sugar being excluded, produced a total of 0.5 billion dollars when moving averages were used and 2.2 billion dollars when linear trends were adopted. On the basis of the latter data the costs taken for cocoa were the main item at 1.0 billion dollars followed by coffee and rubber both at 0.4 and sisal at 0.3. Costs of the remaining commodities were less than 0.1 billion dollars. Details of the costs were given in Appendix table 5 in terms of prices equal to the mean of market and intervention levels.

40. The basis of calculation of the ODM estimates was as follows: The percentage by which historical market price exceeded or was less than the simulated buffer stock intervention price was calculated. A fixed price elasticity estimated for the commodity in question was applied to this calculated percentage to yield the percentage change in quantity required to move from the market price to the intervention price. The percentage change in quantity was applied to an estimate of the quantity of world exports of the commodity in question to yield the amount to be bought or sold. The amount to be bought or sold was valued at the average of the market price and the intervention price.

41. The 1 and 2 simulations shown in Table I were based on the cost of maintaining prices within + 10% of the trend over varying periods between 1957 and 1975 depending on the commodity. ODM1 used moving averages of lengths between 36 and 60 months. ODM2 used a linear trend through the period of the data. Both therefore assumed perfect foresight on the part of the buffer stock manager.

42. Estimates were made of the number of months the buffer stock would have been unable to hold these target prices due to a lack of stocks.

---

1 Source: unpublished paper.

Table I - ODM stock estimates: periods when target prices were not held

	ODM1	ODM2	
	No. of months unable to hold target price	No. of months unable to hold target price	Total number of months in simulation
Cocoa	4	17	232
Coffee	7	6	222
Jute	7	12	242
Sisal	11	62	231
Rubber	4	13	171
Copper	14	31	159
Tin	11	23	159

43. It will be apparent that the estimates are considerably lower than any of the others noted in this paper. This is for two reasons. Firstly, the other estimates assume that the buffer stock manager has access to all the stocks he will need throughout the period, whereas in the ODM estimates the buffer stock manager is constrained by the amount of stock he has previously acquired. This has the result that for several commodities the buffer stock manager is inactive for quite some time at the beginning of the given period and frequently finds that he has insufficient stock to maintain the ceiling price. Secondly, the use of moving averages calculated on a monthly basis in ODM1 means that the type of stabilisation aimed for is essentially short run, and the target prices move much more closely in line with the historical market prices than they do under other methods of determining the trend prices.

44. The conclusions to be derived from the ODM work are, therefore, that there is a significant trade-off between stabilisation aims and size of buffer stock required in the practical situation without perfect foresight; even the limited stabilisation aims pursued may not always be achievable in the short run at least.

45. Thus the ODM work does not provide estimates of the necessary sizes of buffer stocks to achieve price stabilisation, but is aimed more towards a study of the practical problems of running buffer stocks. It is therefore not comparable with any of the other estimates noted in the paper.

Behrman estimate

46. The tonnage estimates of Behrman given in Appendix table 6 when valued at 1976 prices indicated a total for the eight"core"commodities, sugar and cotton being excluded, of over $9 billion in respect of the 15 per cent band width. Of this total coffee alone amounted to 4.1 billion dollars while the costs for rubber and cocoa were 2.7 and 1.1, respectively. The copper estimate was relatively low, 0.7 billion dollars, and the costs of each of the remaining commodities were 0.25 billion dollars or less.

47. The bases of the simulations were the simple existing econometric models developed previously. These had supply, demand, price and stock change relations; some relevant elasticities derived from these are given below. Income elasticities were also derived and a variable pattern of response was found for individual countries. In some cases the supply and demand equations were disaggregated into developed, developing and centrally-planned groups; this was necessary because of country differences in market response.

48. The operational rules considered two price bands around the real secular trend based on a 25 year period. The coverage included 8"core" commodities and five others though only the former are considered here. Sugar and cotton were excluded from the simulations.[1]

49. The basic methodology was common in many respects to that in the other calculations reviewed. The relationships derived from the basic period were applied to the simulation period. Using differences between actual and market prices, the calculated trend levels and the market responses arising from the model, estimates of maximum stock tonnages were derived.

50. In addition to the behavioural equations a simple identity equation[2] was used which included the buffer stock sales or purchases variable. Through changing these sales or purchases the buffer stock agency could alter private stock levels, demand and production, although primarily with lags, to keep prices as determined simultaneously by the next relationship within a desired percentage of trend.

51. The shape of the equations reflected the market structure. Simultaneous and recursive relations were incorporated and the parameters involved adjustment and expectational processes.

52. A simplified indication of the supply equation for one commodity viz. cocoa was given elsewhere[3]; this involved expectational processes since responses in variable factor usage to the expected product to factor prices were included. The cocoa price equation used as an explanatory variable the private stock/demand ratio; a secular trend was also incorporated. The corresponding demand equation was a function of deflated price, and involved both current and lagged values; for developing and centrally-planned countries per capita income was also used as an explanatory variable.

---

1 There were particular problems in simulating the marked price fluctuations common in the sugar market and reasons also for suspecting the price equation for cotton. See 'Econometric models of world agricultural commodity markets'. F. Gerard Adams and Jere R. Behrman.

2 Private stocks (end period) equals production minus demand for current use minus buffer stock purchases or sales plus private stocks (beginning period).

3 See page 67.

53. The outcome of the calculation implied that buffer stock programmes affected production levels by the long run price elasticity of supply derived from the model. Similarly it affected demand through the three categories of price elasticity generally calculated.

The following were among the assumptions made:

(i) Applicable corresponding relations.

(ii) A non-stochastic model.

(iii) A simulation period long enough to cover the cycles of the commodities but not so long that success in achieving price stability would lead to structural changes and increased investment and supply capacity.

(iv) Adequate initial stocks.

(v) No supply management.

(vi) Perfect foresight.

(vii) Annual averages for price and other variables.

(viii) Seventeen commodities were covered. The eight"core" commodities were considered in this paper. Sugar and cotton were excluded. The base period covered 1950-75; the simulation period ten years, 1963-72. The target prices were secular trends (1950-75) in real terms. Two band widths were adopted: plus or minus 5 per cent and plus or minus 15 per cent.

(ix) Rates and charges of UNCTAD in real terms were used for calculating present discounted values.

(x) A single operating rule for intervention was used. (Alternatives were possible; an inverse relation could be established, for example, between floor price and buffer stock size.)

(xi) The initial stock was valued at 1962 prices; the final stock at 1973 prices. This caused an upward bias in present discounted value.

54. The sensitivity of the model to a number of variables was examined. In particular, the major determinant of viability was found to be the price bands and the valuation of terminal stocks. Reducing price bands from 15% to 5% more than doubled the negative present discounted value of equity flows. Reducing discount rates had a similar if far smaller effect. The present discounted value of buffer stock operations for the eight"core" commodities excluding the values of terminal stocks was negative. It was positive only when they were included and valued at the price in the post terminal year. The 1973 valuation reflected the high prices that year, but in practice the stocks could not have been sold at those levels since the market would have fallen under the pressure of supplies. In order for the operations including sales of terminal stocks to have a zero present discounted value the sales would need to have been made at prices about two thirds of actual 1973 prices. Even this would have been unlikely and a realistic conclusion was that, allowing for the likely prices that could have been obtained for terminal stocks, losses would have been incurred.

55. The relevant elasticities in the calculations are given below

Table II - Price elasticities of the Behrman model

	Price elasticity of supply 1		Price elasticity of demand
	Short term	Long term	
Cocoa	.0	.3	- .3
Coffee	.0	.3	- .2
Tea	.1 2	.2 2	- .1
Sugar	.0 2	.2 2	- .0
Cotton	.1 2	.1 2	- .4
Jute	.2	.2	- .0
Sisal	.1	.2	- .0
Rubber	.0	.4	- .5
Copper	.0	.1	- .4
Tin	.0	.2	-5.0

1 All countries.

2 Developing countries.

Commodities Research Unit estimate for copper

56. The two approaches adopted by CRU in estimating stock requirements for copper are reviewed here; both were of the same order of magnitude though the second produced a somewhat smaller figure in excess of 2 million tonnes. Details are given in Appendix table 7.

Approach 1.

57. The CRU direct method was designed to ensure sufficient stocks to deal with the worst post-war cycle for copper. Three elements entered into the calculation. It was assumed the authority would need to hold all stocks other than working stocks. These were taken as the difference between stocks at December 1975, the bottom of the cycle, and those in May 1974, the top of the cycle. It was assumed that normal financing of these stocks arising from speculative forward purchases would vanish since the stabilising operations would destroy the contango. The buffer stock would need to hold 1.1 million tonnes.

58. The higher price that the authority maintained would have two effects. Firstly, production would increase; the extra volume that the buffer stock would need to hold was taken as the actual fall in output in 1975 plus an allowance for increased mine capacity. Modifications were made for percentage utilisation and for secondary metal. The output increase amounted to 1.4 million tonnes. Secondly, consumption would fall. Also assumed were (i) a price elasticity of demand of -0.2, subsequently changed to -0.05, (ii) a support price determined arbritarily and smaller than the one dollar per lb. thought necessary to allow new investment and (iii) the consequent percentage rise from historic prices. Over the 18 month recession the consumption fall was put at 0.7 or 0.2 million tonnes. The total holding of the buffer stock would then need to equal 3.0 or 2.5 million tonnes depending on the consumption level chosen.

Approach 2.

59. The CRU econometric model consisted of two components one of which was a conventional supply, demand and price equation system and the other a financial model. The discount rates and financial structure were major elements in the determination of profitability. This was particularly true for the valuation of terminal stocks, since the simulations ended before the recession was over and in every experiment stocks were heavy. Initial stocks were valued at the initial central support price.

60. The base period was 1961-75, quarterly data being used. A constant price structure was maintained in order to abstract from the actual changes in price formation in the LME. This ensured the extent of intervention depended on the supply and demand position independently of the time period.

61. The support price was determined by simple regression. An exponential trend was fitted to deflated price. A moving average was not chosen since it was thought the result would be unduly influenced by the low prices in the early part of the period and subsequent very high prices; this pattern was attributed to the producer pricing policies of those years. Fourteen simulations were performed in the model, the last two relating to quantity stabilisation. In the first six experiments initial stocks were inadequate. It was assumed that the UNCTAD level of 0.8 million tonnes would be enough. Experiments 1 and 2 assumed zero and 0.8 million tonne stocks, respectively. A single plus or minus 10 per cent band width was used. In

the following four experiments it was again assumed that 0.8 million tonnes would be enough but actual initial stocks equalled only 0.2 million tonnes of metal. The GSA (the United States stockpile) was assumed to release metal as it did historically. Four band widths from 15 per cent to 1 per cent were used. In all six simulations the buffer stock was exhausted.

62. The second set of experiments assumed adequate initial stocks in terms of cash and metal; six different band widths were used. In experiment 13 the financial facility was fixed high enough to ensure adequate stocks; in experiment 14 it was set at half the experiment 14 facility. These last two simulations were national quantity stabilisation schemes; both proved less profitable than the other arrangements.

63. The CRU model was thought to understate the estimates for three main reasons: (i) it was not stochastic (ii) it did not fully take into account speculative stocks outside the LME and (iii) the simulation ended in 1975 whereas the recession continued into 1976 when it would have been necessary for increased stocks to have been accumulated if price support was to continue.

64. The issue of sensitivity of the models to varying assumptions and conditions was dealt with in a number of experiments. The CRU model tested these aspects more systematically than any other, though both CRU and ODM simulated the effects of inadequate initial stocks. Some of the results are presented here. CRU found that even by widening the bands present values of equity cash flows never became positive. Varying band width had little effect on price stabilisation since in the inadequate stock experiments when the stock was exhausted the closer the bands the greater the price movements in the uncontrolled market.

65. The inverse relation between price bands and stocks appeared clearly. At a plus or minus 15 per cent band 1.6 million tonnes stock were needed; at a 1 per cent band the level rose to 2.5 million tonnes. Such volumes were not physically available at the beginning of the simulation period.

66. The narrower the price bands the less profitable was the intervention. This situation arose from the small profit margins when transactions took place inside close bands; also from the higher stock levels needed when there was excess supply. However, if initial stocks were inadequate the effect was small. Moreover, given wide price bands the authority remained inactive over a long period while still incurring overhead costs.

67. The characteristics of the CRU model reflected particularly the magnitude of the disturbances in 1974-75, the target price adopted and the extent to which the buffer stock became responsible for former private holdings.

68. In a similar way it was evident that a previous estimate for copper based on the Fisher-Cootes-Bailey model also reflected heavy purchases in the recessionary years in the first part of the base period. This estimate produced results of some 4 million tons at a plus or minus 10 per cent band width and even larger stocks within narrower bands.

Considerations of trend

69. The theoretical central prices of the models followed the time path implicit in the concept of long run equilibrium price. This might be distinguished from series constructed to approximate the ideal though none is known with certainty in advance. In an ex post simulation a minimum variance trend requiring minimal capital resources for the buffer stock could be fitted to a historic time series. A regression over the total period would reflect the length of that period. Many other trends were possible with different functions and periods. Moving averages were commonly adopted.

70. The suitability of the different targets was not predictable and experience of their use differed. The smaller estimates of ODM used moving averages of between 3 and 5 years depending on commodity: the periods involved varied within 1957 and 1975. Their larger estimates used a linear trend. The resulting stock estimates varied widely: for coffee they rose by a factor of more than 13. Estimates based on three to five year periods for seven "core" commodities increased ten times by using ten to fifteen year periods.

71. In the Smith-Schink study on copper five year lagged moving averages produced poor estimates. Results appeared better when a price target fixed for a long period was adopted.

72. Alternative target rules approximating closely to underlying trends and therefore requiring little intervention and relatively small stocks could only be established with good ex ante expectations of the long term movements, notwithstanding a number of possible techniques, including that of spectral analysis, for separating long run fluctuations.[1]

73. A procedure was devised by ODM (a variable parameter crawling peg system)[2] allowing for frequent constant adjustments of target limits with periodic changes to the constant adjustments depending on the number of consecutive months of buffer stock intervention. In exceptional periods of price deviation this system brought targets close to underlying trend but the time lag was considerable. It was thought, therefore, provision should also be made for non-automatic adjustments.

---

[1] Initial application of spectral analysis to tin prices has been examined by the Commonwealth Secretariat.

[2] This system used the formula: new percentage adjustment = $\frac{2 \times z}{y}$

x = Initially allowable percentage adjustment to target.

y = Fixed number of months.

z = Number of months consecutive selling or buying in same direction.

74. The identification of trend in the absence of perfect foresight presented a major problem since the costs of error were high. The Behrman simulation explored the consequences of establishing off trend targets. The targets were increased by 2 per cent. This was equivalent to indexation if the actual trend was - 2 per cent; less if below this rate or more if above this rate. The conclusion was that maximum stocks were at least doubled and generally increased by a factor of five or more.

75. The UNCTAD calculations of AnnexI(L2) used a fixed real target and a moving average real target. In relation to the savings from common financing the first was found "unsustainable" because of the lack of offsetting price movements. The second was feasible. In the major Annex II calculation a return was made to a fixed real target: this would not necessarily coincide with the underlying trend. 1

76. The dependence of the target prices on base periods and on a change from nominal to real terms was considerable. The UNCTAD choice of 1970-74 average nominal prices was a conservative one. The 1972-74 average, for example, would have produced a much higher figure. Moreover, by using real prices a fall of over 20 per cent in the value of money would have led to an increase of over 25 per cent in deflated terms.

77. In the UNCTAD model issues of trend arose again in considering the absence of provisions for target prices beyond 1983. Without indication of intervention for that period the long term capital needs of the proposals could not be assessed. A number of possible arrangements were proposed. If a new target was adopted based on a pre-1983 average it would reflect a period when prices had been managed by intervention; such a target might increasingly be unrelated to underlying trends. Alternatively a new target might be established related to underlying trend if this were possible to determine: this procedure implied discrete jumps at each review. In either case in so far as there were growing disparities between targets reflecting inflation rates, on the one hand, and underlying trends, on the other, capital requirements of a buffer stock would be understated if the off trend objective was pursued.

78. The assessment of trend is significant not only for intervention capacity and associated stock sizes but in determining the relative benefits of intervention arrangements to producers and consumers. When market prices trended downwards and fell below the secular trend aimed at by the buffer stock, support of the floor was necessary: producers benefited from intervention of this kind for rubber, coffee, cocoa and, to a lesser extent, tea. In contrast when prices trended upward, as for tin and copper, producers needed intervention less: in fact attempts to impose a ceiling would deprive them of high market returns.

---

1 The use by UNCTAD of a fixed real target was equivalent to a zero secular trend in real prices; this procedure contrasted with that of Behrman who used real prices but stabilised around the long run real trend which was determined by market forces and varied accordingly.

Conclusion

79. In reviewing the four major global estimates relating to the "core" commodities, it is clear that the ODM calculation is relevant most to the operational aspects of buffer stock financing. The simulated conditions of insufficient resources compelled the adoption of trends closely reflecting actual market prices. The stabilisation achieved was consequently limited, the buffer stock being ineffective for long periods. Given the existing negative secular trends in real prices for most of the "core" commodities, the disadvantages of such partial stabilisation indicate the need for more capital than that assumed in this calculation.

80. In contrast, the other major estimates were concerned more with assessing the likely costs involved, implicitly assuming that in the trade-off between degree of stabilisation and stock size, the need for effective arrangements would weigh more heavily in the balance. For that reason they were intended to be large enough for the buffer stock always, or with a high degree of probability, to keep prices within the defined bounds.

81. The UNCTAD calculation represented an attempt to quantify the costs in order to assess the capital needs of the Integrated Programme for Commodities while that of OECD and Behrman appeared as a response to provide an independent view. UNCTAD utilised a base period not much less than that of Behrman. However, in respect of error margins its estimates were more narrowly derived than those of OECD. They provided for capital sufficient to meet the needs of what was taken to be a 95 per cent confidence level since the insurance costs of providing against more exceptional conditions would have raised the estimates to far higher levels. UNCTAD included a stochastic element in supply only, whereas OECD took into account other random variability also. The Behrman estimates were not stochastic and ignoring disturbance terms was not considered misleading since the underlying relations had relatively small unexplained variances. If a rigorous probability treatment typically gave as wide an error margin as that of OECD, its utility would be minimal. The need to obtain a basis for effective decision compelled a pragmatic approach, the simplest being conditional acceptance of the mid point estimates. In any event certain factors could not easily be accommodated within probability intervals, the ability to regain trend, for example; this latter problem was avoided by assuming perfect foresight.

82. Difficulties in assessing the data were attributed to the statistical procedures adopted though the 1976 UNCTAD model represented a major advance on the earlier estimates and was accompanied by a detailed exposition to demonstrate both results and associated precision. While put forward as an illustrative model, the explanatory power of the structural equations as measured by R^2 appeared generally high. Exceptions were apparent, however, for jute supply and for the price equations of rubber and fibres. In this context it is instructive to compare the cocoa supply equations adopted by Behrman with that of UNCTAD. The former involved a function of lagged price , time and two disturbance terms; the latter involved current and lagged prices and lagged production. Their respective R^2 values were .94 and .91 respectively.

83. Problems arose from the use of OLS estimators in an autoregressive simultaneous system though the practice of UNCTAD in this respect was common in econometric modelling and any other procedure would have been not only costly but might have produced results little different. In principle

such estimators would be acceptable in particular circumstances e.g. in a recursive model. They might also be appropriate for structural equations calculated separately. However, their inappropriate use was held to explain disparities between demand and price relationships in the structural equations. In general the significant relationship in the price equations was with current demand. In the demand equations the significant relationship was a lagged price effect for five of the ten commodities. For the remaining five commodities other variables appeared to have significant explanatory power; income for tin, rubber and jute and lagged demand for tea and sisal. Substitution effects were not explicitly accounted for, but might also be important.

84. Notwithstanding the differences in the bases of the estimates, a reconciliation has been shown to be possible between all three.[1] Such agreement cannot of itself be taken as confirmation of their validity and it has been held that individual UNCTAD estimates may be too low by a factor of three or more (CRU) while the Behrman view also was that the UNCTAD global levels might be too low. The OECD data implied underestimates by UNCTAD particularly if the extreme points of their error ranges were used in the comparison. This lack of agreement,and notably the high and low points of the OECD study, demonstrate the limitations of a fixed view of capital requirements. The results, if accepted as maxima, do not indicate the costs generally to be expected; these must be less. They serve rather to indicate the importance of access to finance and its possible extent in some circumstances.[2] They have implications also for stabilisation policy in terms of price band, target price and supply management. Finally, they are relevant to the conclusion that decisions involving risk and without guarantee of viable return may need to be made on the basis of uncertain estimates of the kind reviewed here.

---

[1] See page 53.

[2] The third level of finance referred to in para. 3.26 of the Common Fund, Report of the Commonwealth Technical Group.

Appendix

Table 1 - UNCTAD: stock estimates: using 1971-75 average prices (in 1976 dollars) and ± 10% band width: period covered 1979-83

Ten "core" commodities	Stock requirements		Value of required stock at lower limit of price range	
	confidence limits		confidence limits	
	80%	95%	80%	95%
	million tonnes		billion 1976 dollars	
Cocoa	0.32	0.38	0.51	0.61
Coffee	0.52	0.61	0.86	1.02
Tea	0.09	0.12	0.15	0.18
Sugar	3.78	4.61	1.40	1.71
Cotton	0.44	0.56	0.64	0.81
Jute[1]	0.46	0.49	0.30	0.31
Sisal[1]	0.10	0.11	0.09	0.09
Rubber	0.55	0.66	0.40	0.49
Copper	0.86	1.03	1.61	1.94
Tin	0.03	0.04	0.17	0.24
	7.15	8.61	6.14	7.40
Total assuming common financing			4.58	5.52

1 Fibres and goods.

Table 2 - UNCTAD: stock estimates: using 1974-78 average prices (in 1976 dollars) and ± 10% band width: period covered 1979-83

Ten "core" commodities	Stock requirements		Value of required stock at lower limit of price range	
	confidence limits		confidence limits	
	80%	95%	80%	95%
	million tonnes		billion 1976 dollars	
Cocoa	0.38	0.46	0.63	0.77
Coffee	0.56	0.68	1.03	1.26
Tea	0.09	0.11	0.12	0.14
Sugar	3.88	4.73	1.59	1.93
Cotton	0.40	0.50	0.54	0.67
Jute[1]	0.40	0.42	0.17	0.17
Sisal[1]	0.14	0.15	0.08	0.09
Rubber	0.61	0.75	0.48	0.59
Copper	0.72	0.85	1.15	1.37
Tin	0.03	0.04	0.21	0.27
Total	7.21	8.69	5.99	7.25
Total assuming common financing			4.39	5.31

[1] Fibres and goods.

Table 3 - UNCTAD: stock estimates: illustrative estimates
(December 1974 and June 1975)

Ten "core" commodities	Stock requirements		Low		High		Finance needed for stock acquisition [3]
	Low	High	At average 70-74 nominal prices	At average 70-74 real prices	At average 70-74 nominal prices	At average 70-74 real prices	
	million tonnes		billion dollars				
Cocoa	0.25	0.30	0.28	0.35	0.34	0.42	0.33
Coffee	0.60	1.20	0.73	0.95	1.46	1.90	1.10
Tea	0.04	0.09	0.05	0.06	0.10	0.13	0.09
Sugar	3.00	5.50	0.73	0.85	1.35	1.56	1.20
Cotton	0.54	0.54	0.55	0.69	0.55	0.69	0.60
Jute [1]	..	..	0.10	0.10	0.19	0.19	0.16
Hard fibres	0.12	0.18	0.05	0.06	0.08	0.09	0.06
Rubber	0.35	0.38	0.18	0.22	0.19	0.24	0.21
Copper	0.56	0.74	0.83	1.07	1.10	1.41	1.10
Tin	0.03	0.05	0.14	0.18	0.24	0.30	0.27 [2]
Total	5.49	8.98	3.64	4.53	5.60	6.93	5.12

1 Fibres and goods

2 Includes existing contributions of producers to International Tin Agreement.

3 Arbitrary figure between 1970-74 nominal and real levels.

Table 4 - OECD: stock estimates: period covered 1976-81: target ranges for price variation covered half original ranges 2

Ten "core" commodities	Stock requirements			Acquisition costs					
				Jan-Mar 1976 prices			1976-81 average prices		
	Mid point	Low	High	Mid point	Low	High	Mid point	Low	High
	million tonnes			billion dollars					
Cocoa	0.32	0.10	0.53	0.53	0.17	0.89	0.50	0.16	0.85
Coffee	1.08	0.55	1.61	2.32	1.18	3.46	2.32	1.18	3.46
Tea	0.07	0.06	0.09	0.09	0.07	0.11	0.10	0.09	0.13
Sugar	5.21	2.32	8.10	1.64	0.73	2.55	1.56	0.70	2.43
Cotton	0.50	0.20	0.80	0.76	0.30	1.21	0.83	0.33	1.32
Jute	0.37	0.05	1.09	0.26	0.20	0.33	0.35	0.26	0.43
Hard fibres	0.15	0.12	0.18	0.06	0.06	0.09	0.06	0.05	0.07
Rubber	0.32	0.20	0.44	0.25	0.16	0.35	0.29	0.18	0.40
Copper	0.73	0.26	1.20	0.91	0.33	1.50	1.42	0.51	2.34
Tin 1	0.05	0.04	0.06	0.33	0.26	0.39	0.43	0.34	0.51
Total	9.30	4.50	14.10	7.17	3.46	10.88	7.86	3.80	11.94

1 Including an estimate for existing tin buffer stock.

2 The mid,low and high points relate to the "uncertainty ranges".

Table 5 - ODM: stock estimates: periods between 1957 and 1975 depending on commodity: ± 10% band width

Seven "core" commodities	Moving average trend	Linear trend
	billion dollars	
Cocoa	0.28	1.00
Coffee	0.03	0.40
Jute	0.005	0.03
Sisal	0.02	0.25
Rubber	0.08	0.40
Copper	0.06	0.09
Tin	0.01	0.08
Total	0.48	2.24

Table 6 - Behrman data: stock estimates: using 1950-75 prices (secular trend): period covered 1963-72

Eight "core" commodities	Maximum stocks	
	Band width	
	15%	5%
	million tonnes	
Cocoa	0.56	0.93
Coffee	1.30	3.10
Tea	0.16	0.53
Jute	-	0.01
Sisal	0.23	0.39
Rubber	3.43	4.32
Copper	0.51	1.34
Tin	0.02	0.03
Total	6.21	10.65

Table 7 - Commodities Research Unit: copper stock estimates [1]

	Initial Endowment	Maximum stock held	Width of price band (per cent)
	million tonnes		
Earlier estimate (published March 1976) Direct method		3.0	
Later estimate			
Direct method		2.5	
Econometric method			
International buffer stock simulation			
Experiment No 7	0.8	1.6	15.0
" " 8	1.2	1.7	10.0
" " 9	1.2	1.7	7.5
" " 10	1.5	1.8	5.0
" " 11	1.6	1.9	2.5
" " 12	1.8	2.1	1.0
National quantity stabilisation stockpiling scheme			
Experiment No.14	1.3	2.2	

1 Based on assumption of adequate initial stocks/resources.

N.B. The experiment numbers given are those of CRU.

Table 8 - Stock tonnages in terms of 1976 and 1977 prices [1]

	1976 prices		Jan-May 1977 prices (in 1976 dollars)		
	Interval estimates		Interval estimates		
	billion dollars				
UNCTAD					
10 "core" commodities	6.22	7.56	7.83	9.42	80% or 95%
8 "core" commodities	4.48	5.36	6.38	7.61	confidence level
OECD					
10 "core" commodities	4.05	12.63	5.57	17.17	Limits of uncertainty ranges
8 "core" commodities	3.11	9.15	4.80	14.30	
Behrman data					
8 "core" commodities	9.15	18.11	13.48	28.20	15% or 5% band widths
ODM data					
7 "core" commodities	0.48	2.24	(0.71)	(3.29)	Moving average and linear trends
Further estimates [2]					
10 "core" commodities	9.8		13.2		

1 In general the data have been revalued by the Commonwealth Secretariat at the prices indicated. This procedure was applied, for example, to the UNCTAD tonnages in Appendix table 1. N.B. ODM used an average of market and intervention prices: for indicative purposes the January-May 1977 figures shown here were calculated by multiplying the 1976 ODM estimates by the percentage increase of January-May 1977 market prices (deflated) over 1976 market prices.

The data does not necessarily represent acquisition costs. Nor does it allow for savings from common financing.

2 Indicative only: includes some mid point estimates.

Table 9 - Further estimates of buffer stock tonnages and values for the 10 "core" commodities

	Quantity	Value	Source
Cocoa	1. 250,000 tonnes	1 $512 million 2 $862 million	International Cocoa Agreement Tonnage specified in the agreement.
Coffee	1. 15 - 25 million bags (900,000 - 1,500,000 tonnes)	1 $2,827 - 4,712 million 2 $5,244 - 8,741 million	International Coffee Organisation This total related to a possible International Guarantee Stock to be held in exporting countries. It represented one third to one half of annual demand of 50-60 million bags.
Tea	1. 70,000 - 140,000 tonnes 2. 50,000 tonnes	1 $108 - 215 million 2 $200 - 400 million	Based on 10% to 20% world trade levels. Tea Trade Committee (unofficial estimate)
Sugar	Minimum stock 1,750,000 tonnes Additional stock 720,000 tonnes 2,470,000 tonnes		International Sugar Organisation These estimates were proposed in the negotiations for a successor agreement to that covering the period 1968-73. The minimum stock would be held at all times though available for release when prices rose: it represented 14.6% of exports. Developing countries proposed a lower figure of 10% of exports; this was used in the lower limit of the range given here. The additional special stocks were to be built up when quotas were reduced and were to be released when quotas were increased. The total represented 6% of exports. The total stock range derived in this way corresponded to a range of 16-21% of world exports of 12 million tons.
	1. Total stock range 1,920,000 - 2,470,000 tonnes	1 $492 - 632 million 2 $351 - 452 million	
	2. (i) 3,000,000 tonnes		(i) Estimate proposed by United States after breakdown of ISO talks in May. The stock is to be held by exporters and financed by export levy.
	(ii) 2,000,000 - 2,500,000 tonnes		(ii) Estimates on above basis proposed by some producers.
Cotton	1. 350,000 tonnes = 2.5 million bales	1 $966 million 2 $955 million	UNCTAD These estimates thought too low.
	2. 3.0 million bales	$700 million. Plus carrying cost of $75 million per year.	Assuming price range 50-75 cents per lb.
Jute	1. 500,000 tonnes (fibre and goods)	$136 - 182 million 1 $148 million 2 $139 million	UNCTAD September 1976 Excluding carrying costs. The tonnage estimate represents a theoretical volume which it might be necessary to purchase in a limited period. Relevant considerations for the jute estimates were as follows: 1. World output 3 million tons (including output of a major producer that did not participate significantly in world trade). 2. World output 2 million tons (excluding output of this producer). On this figure the stock output ratio was 10%. Allowing for jute goods the ratio was over 20%. 3. World trade 0.7 million tons
	2. 154,000 tonnes (fibre) 181,000 tonnes (goods) 335,000 tonnes This level would rise to 495,000 tonnes with reduced price range and increased level of confidence.		February 1977
	3. 175,000 - 200,000 tonnes (fibre) 225,000 - 250,000 tonnes (goods) 400,000 - 450,000 tonnes	$130 - 150 million.	

Table 9 - Further estimates of buffer stock tonnages and values for the 10"core"commodities (contd.)

	Quantity	Value	Source
Sisal and Henequen	1. 150,000 - 180,000 tonnes	1 $70 - 84 million 2 $71 - 85 million	UNCTAD November 1976
Rubber			UNCTAD
	1. 350,000 tonnes	1 $274 million 2 $261 million	Producer estimate A lower price was envisaged based on production costs. The ceiling price would be set so as to maintain the competitive position of natural rubber.
	2. 400,000 tonnes	1 $313 million 2 $298 million	Alternative estimate: based on past supply/demand imbalances which ranged from -3% to +5%.
	3. 350,000 tons	£.140 million	Association of Natural Rubber Producing Countries Valued at £400 a ton.
Copper	1. 700,000 tons	£.560 million	German Development Institute 1975 Valued at £800 a ton
Tin	1. 40,000 tonnes	1 $306 million 2 $365 million	International Tin Agreement Tonnage specified in the agreement.
Total 10"core"commodities 3		1 $9,800 million 2 $13,200 million	

1 Based on 1976 market prices.

2 Based on January-March 1977 market prices (in 1976 dollars).

3 Indicative only. Where tonnage ranges given mid points were used. Based on first estimated tonnages given in the table for each commodity, with the exception of copper for which CRU estimates were used taking the following ranges:
1 $2,820 - 3,173 million, 2 $2,632 - 2,961 million.

N.B. Many of the estimates given here arose from the UNCTAD Preparatory Meetings held in connection with the Integrated Programme for Commodities.