FOR STABILIZATION OF COMMODITY MARKETS
A DYNAMIC STUDY

by

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CIVIL DES MINES ET DE LA METALLURGIE
(1968)

SACHUSETTS INSTITUTE OF TECHNOLOGY
(1969)

ED IN PARTIAL FULFILLMENT OF THE
JIREMENTS FOR THE DEGREE OF
MASTER OF SCIENCE

at the

JSETTS INSTITUTE OF TECHNOLOGY

1971

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ACKNOWLEDGEMENTS

I would like to express my gratitude to Professor Dennis Meadows, whose guidance and generous encouragement helped me in every phase of this work.

This section would not be complete if I did not mention Miss Jean Maloney, who worked with intense dedication and uttermost competence to help me organize, edit and write this study. Also, Miss Patricia Arscott applied with incredible patience her skills in all the art work.

The computer simulations were performed at the Information Processing Center at M.I.T.

I dedicate this study to my parents, whose many sacrifices allowed me to receive an education from which I would like them to gather the fruits.

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CHAPTER 1

THE PROBLEM OF COMMODITY MARKETS

The importance of commodity income

Few goals are as important for long term prospects for international stability as the living standards of the underdeveloped countries. In most third world countries, availability of imported goods is one of the main limiting factors of economic growth and welfare. To a very large extent, the ability to obtain the necessary imports depends on the flow of foreign exchange generated by exports. In most of the third world countries, the foreign exchange balance does not allow alone the financing of imports. The combined deficit for the developing countries as a group, on the contrary, tends to increase; at the beginning of the decade, it was running at $2 billion a year, $4 billion if excluding oil (see Figure 1-1).

Not only are those countries dependent upon the proceeds of the exports of primary commodities (90 per cent of their exports are derived this way), but also upon a very narrow range of products.[1*] Although the degree of concentration has decreased in the past years in countries as Brazil, Nigeria or Thailand, it is increasing in many others, such as Argentina, Rhodesia or Uruguay. (This indicates that the primary

*Numerical superscripts refer to Reference Index.

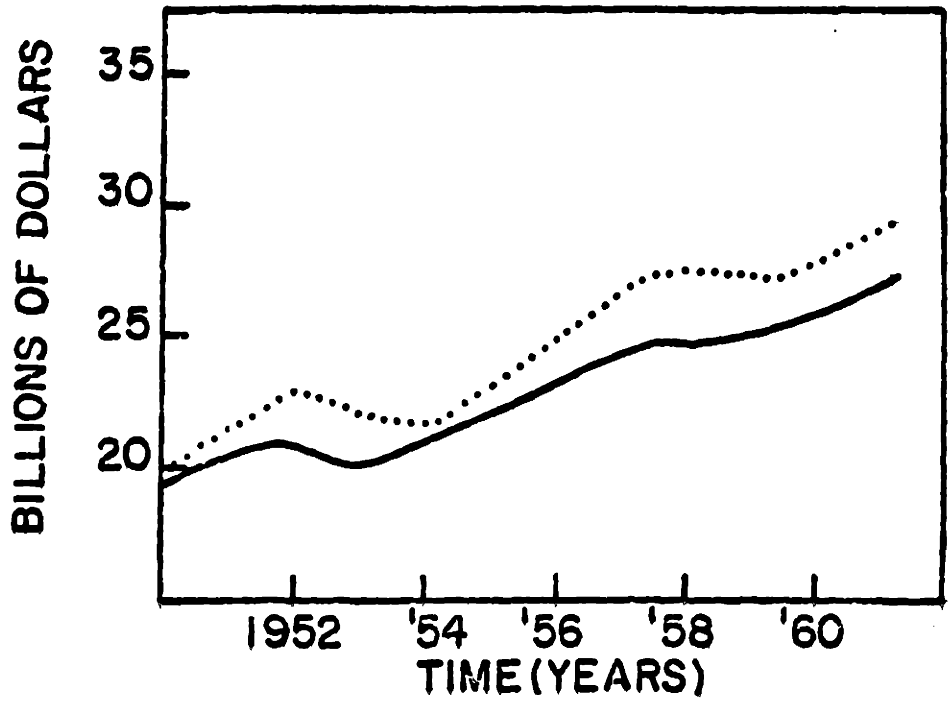


Figure 1-1: Trends in Imports and Exports

for Developing Countries
(Source: Reference 1)

commodity exports pertain also to other than the developing countries). Over 50 per cent of the primary exporting countries derive more than 70 per cent of their earnings from only three items, and about 33 per cent derive more than 80 per cent in that way. Furthermore, among the smaller trading countries, monoculture is more common, so that the extent to which exports and national product depend upon only one or two commodities increases. (Appendix 1 gives details on commodity markets.)

Although the expansion in exports of the third world countries may be expected to come from increased intra-trade and sales of manufactured goods due to industrialization, in the short run (10 to 15 years), experts agree that the increase in foreign exchange earnings will not come from there. This is due to the fact that intra-trade requires by definition a growth of internal markets and incomes in those countries, and that industrialization is contingent upon present earnings.

Therefore, the earnings developed from primary commodity exports are important even in the perspective of a future shift in economic activity in those countries (see Figure 1-2).

Instability in commodity price

Instability of world markets for primary commodities is a general phenomenon: it is not confined to any particular commodity or any

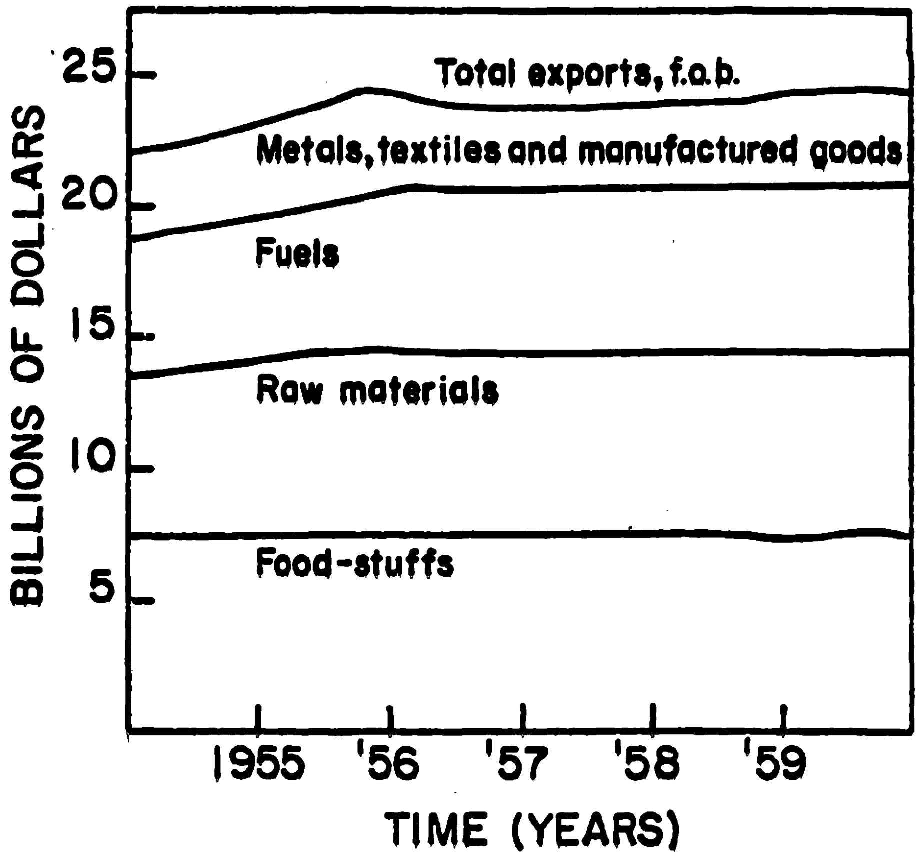


Figure 1-2: Trends in Exports

for Developing Countries (by Major Components)
(Source: Reference 1)

particular country. For example, among the commodities whose price on world markets has been the more unstable in the recent years are lard, wool, zinc, soya beans and oil (greater year to year fluctuations than average) and those commodities come at more than 70 per cent from developed countries.[1] Conversely, several commodities from third world countries have been relatively stable, such as bauxite, crude petroleum, bananas and tea.

In spite of its changing and narrow market, sugar has shown a good stability record, probably because of the stabilization scheme (refer to Chapter 2.) Since the role played by export earnings in their economies depends so much upon a very few commodities, vulnerability of the third world countries to this instability is much higher. The consequences of instability of income for these countries are blatant. Exports earnings are needed for the monetization of the economy in providing employment, in extending the division of labor, in creating local markets and, most importantly, in providing government with an important portion of its revenue. They also furnish the foreign exchange pool which is necessary (foreign loans notwithstanding) to finance acquisition of capital goods, thereby starting the investment process necessary for industrialization. Therefore, fluctuations in the commodity markets can be very harmful. They give rise to instability in incomes and employment, cause irrational behavior from the side of local investors, and undermine any sound budgeting or development policy for the governments involved.

Price behavior

Examination and study of historical data has lead to a consensus at least on the description of the phenomena price variations are considered to result from the combination of the three following components, each of them being more or less important for different commodities and their relative importance shifting with time:[1,2,3]

1. long term trend,
2. medium term fluctuations with some kind of periodicity, and,
3. short term random disturbances.

Figure 1-3 exhibits the price history of mercury since 1910.[4]

It is very easy to recognize the trend element, the cyclic fluctuations which have a periodicity of about 13 years, and the random disturbances due to noise.

1. Long Term Trend

The effects of price fluctuations would be less serious if the relative trade positions of the developing countries were not steadily deteriorating. Export incomes rose 26 per cent from 1956 to 1961.

Commodity income, which accounted for 90 per cent of the developing countries income rose only 10 per cent in the same period. The increase was only 3 per cent if one excludes petroleum and other fuels.[1]

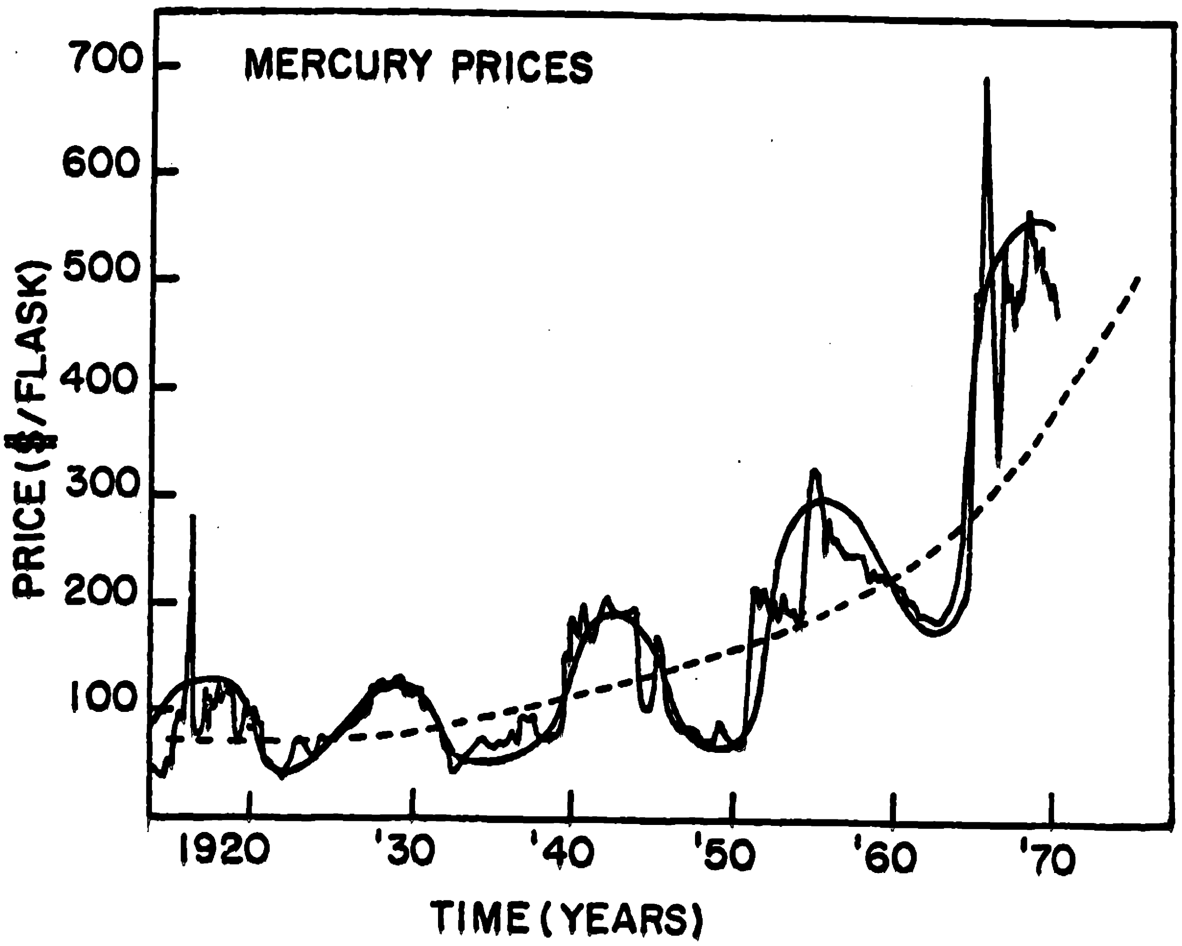


Figure 1-3: Mercury Prices
(Source: Reference 4)

(See Figure 1-1.) Mercury, with its 250 per cent price rise in 15 years is an exception among commodities. Foreign aid and private investment supplement of course. The relative decline in commodities is accentuated by the inflation in the unit prices of manufactured goods.

Many reasons for the income stagnation have been proposed. Demand in the advanced countries for food stuffs grows slowly with income. Advanced technology at the same time provides a higher efficiency for raw materials use and provides synthetic competitors for commodities' traditional markets. Also, the relative undifferentiation of commodities has made it impossible to sustain the higher profit margins characteristic of manufactured goods.

For a given commodity, the trend depends not only upon the general economic situation of the individual country in relation to the other countries (terms of trade), but also on such effects as technical substitution due to technological progress or price influence.

2. Medium Term Cyclical Fluctuations

In a free market without stabilization, especially when competition is severe, producers are compelled to take a short term view of their production policies. This further aggravates the instability of prices and incomes. The effect is amplified by the delays between changes in prices received by them and the induced changes in output. This is known as the cobweb cycle in production: high prices at a given time induce producers to plan for larger outputs but the effect is to decrease prices after a certain time lag when the increased output materializes. This in turn leads to attempts to reduce output, which, if successful, will raise prices at a still later period. The attempts to reduce output may not be completely successful, for each producer will benefit from the fullest utilization of the productive capacity already built up. It is not only the producers in the underdeveloped countries who are responsible for this irreversible build-up; when prices increase, producers and intermediate transformers tend to increase their capacity which continues to be utilized in periods of subsequent lower prices.

The cobweb effect has a general value, and is known as the cobweb theorem in classical economics.[5] However, for each individual commodity, the basic parameters (elasticities and time lags) vary so that some commodities exhibit a behavior with more apparent cycles. (The cobweb effect is mainly due to the inelasticities of supply and demand.) A thorough study of the cobweb theorem has been done by Dr. Dennis Meadows,[6] of M.I.T. He restated the theorem with more general hypotheses, by breaking down the price formation mechanism into endogeneous elements, which allowed simulation. In essence, he accounted for delays intervening in the following areas:

-formation of producers' price expectations

-determination of the appropriate response

-acquisition or disposal of the productive capital and changes in the corresponding rates of initiating new capacity

-production and maturation of new capacity

-formation of price expectations for the future by consumers

3. Short Term Random Disturbances

Unexpected exogeneous events affecting supply and demand account for random disturbances such as weather, pests, diseases, strikes, wars, political unrest, speculation, etc. Also, many commodities are used into the capital goods sector, which is itself notoriously subject to considerable short term fluctuations (accelerator effect) due to the random changes that characterize the expectations in the developed countries' economies.

Besides the effects of the various influences that tend to induce rapid price movements in commodity prices, the destabilizing effect of national stabilization policies is felt. When the internal stabilization machinery has become the means of administering a system of price supports, the instability that may previously have characterized the domestic market tends to be transferred to the world market. Short falls in supply are made good from it and excesses in supply can be unloaded on it. The higher the proportion of world production disposed of domestically on stabilized markets, the narrower are such residual markets going to be. And the narrower they are, the greater will be the impact of fluctuations in demand and supply,[11] (UNCTAD, Chapter 2). Also speculation, especially for the commodities with important future markets, may have in certain circumstances a destabilizing effect. Under certain conditions, speculators sell their stocks when they expect the price to drop: therefore after any fall in price due to unexpected random exogeneous events, speculators may expect prices to go even lower, and actually sell stocks, accentuating therefore the movement downwards of the price.

General overview of stabilization

International action to try to control or moderate these fluctuations or their effects has been tried for a long time with limited success. Stabilization measures can be general or specific. Actions of a general nature are usually trying to modify the determinants of supply and demand. Policies aimed at stabilizing and insuring a steady growth in developed countries are a way suggested by some economists.[8] Steps to control the natural environment (pests, diseases) and social environment (labor relations to avoid disruptions of production), not to include political stability are also being tried. Also, institutional facilities which could go this way (counter cyclical lending, long term future contracts) have been advocated.

Those and more specific measures are tackled in more detail in Chapter 2.

Fluctuations, instability and economic development

Fluctuations versus instability

Fluctuations are variations, i.e., price from one time period to another time period. Instability indicates that under exogeneous disturbances there will be no tendency to come back to an equilibrium position, when such a thing exists.

Therefore, stable and unstable systems exhibit fluctuation, but only stable systems have a tendency to come back towards an equilibrium state. In the context of commodities fluctuations, this is more a continuum than two distinct states.

Fluctuations in income and economic development

Although it may seem a priori that fluctuations in income are per se bad, this is not recognized as such by all authors. Sir Sydney Caine[15] argues that the problem "is whether on balance it is better to have an absolutely steady income or one that varies substantially from one period to another."

As a whole producers may be expected to behave as individuals, i.e., save more of their income in periods of booms and reinvest it or invest it somewhere else in their country. If they do reinvest in their own production facilities, they would not be doing anything but feeding in the cobweb mechanism. If they can invest in other ventures in their country, one has to assume that full employment is not achieved. This hypothesis has been denied par Wallich,[3] who claims that in a period of booms, when savings from exports are at their peak, the countries' resources are already fully employed[11] in the sense in which full employment can be said of underdeveloped countries. Therefore there is no such thing as idle resources to be mobilized to employ the boom time savings.

It is difficult to make general statements in this matter, and both Wallich's statement and Adler's,[17] which claims that there is in fact an employed sector in boom times for commodities in which the extra boom savings can be reinvested. Neither in the individual countries nor at the general level is there any data presently available to answer the following questions:

What is the effect of unusual increase of income of primary commodity producers on consumption, savings and investments (and with decrease)?

How can it affect, and is it affected by, fiscal policies?

What is the effect of perceived stability in income on those economic functions?

However, it is empirically obvious[2,3] that instability of price leads to inefficient economic behavior, such as speculative reproduction or reduction of planning horizon, not to include inefficient resource planning and budgeting.

Also, it is recognized that more stable price behavior improves production planning and decreases costs.[6,17] The production factors saved in this process can be used in other sectors of the economy, and even create new ones. This explains why price stabilization is in fact considered to be beneficial to the economic development of the producing country, even if this means in effect decreasing the long run earnings in export of this commodity.[17]

Objectives of the study

From the previous considerations it follows that to try to reduce fluctuations in commodity prices and incomes is an efficient way of helping underdeveloped countries in their economic development.

We shall not in this study try to explore more basic alternatives such as income transfer from developed to developing countries, voluntary shifts in the terms of trade through preferential treatment for underdeveloped countries' exports, or creation of cartel-type organizations such as O.P.E.C. aiming at increasing the price of commodities.

We shall rather try to explore and examine how buffer stocks policies can be relevant to stabilize commodity markets, assuming that the present political and economical context precludes any device that would not be in the mutual benefit of producing and consuming countries.

To do that we shall first review all the available experience on stabilization of commodity markets, and the empirical research on buffer stocks. Price stabilization will be explored in relation to income stabilization.

We will then propose a simulation approach to the problem of how to plan and manage such a buffer stock, and what its operating goals ought to be.

CHAPTER 2

COMMODITY MARKET STABILIZATION

International action review

The commodity problem was recognized in the ancient times (Joseph in the Bible used a buffer stock to smooth consumption of wheat in ancient Egypt) and international action has tended to develop since the end of the nineteenth century, with the widening of markets and of economic interdependence through improvement of transportation facilities and expansion of western countries into commodity supplying colonies. The main proliferation of those agreements was actually started in the 1930's after the violent economic upswings due to the Great Depression.

Pre-war period

Those actions were basically producer originated; to defend their prices and markets, they initiated cartel-type agreements: restrictions on production and division of markets were the main principles that guided their price defense policies. Usually those agreements could not last very long for not only production cuts among member countries are difficult to enforce or control, but very often non-member countries were disrupting the price arrangements;

of course, the consumer countries, faced with those cartel actions, were on their side inciting non-member countries to undermine the price structure.

The Habana Charter

After the war, after the beginning of the Habana conference summoned to take steps on stabilization decided during the war, there appeared to be a shift of attitudes: an international control agreement was considered essentially an emergency measure. It was to be used only when there was general agreement among countries which were substantially interested in the commodity, i.e., burdensome surplus, or unexpected unemployment had developed or was expected to develop and that the conditions could not be corrected by the action of market prices (Habana Charter for an International Trade Organization, Chapter 6, Section C, Articles 62 and 63).

Several provisions aimed at protecting the consumers against cartel-type activities. The Habana conference endorsed the idea that intergovernmental arrangements were preferable to producers control arrangements, and that it was necessary to have cooperation of consumers countries in implementing them.

The Habana Charter was not adopted but Chapter VI of it was taken up by the United Nations Economic and Social Council, and in resolution 30 governments were urged to accept its principles. A complex set of machinery was then set. However, this did not result in a big proliferation of such agreements, probably because the world commodity markets situation was much more favorable than before the war for the producing countries. Also the high complexity of the agreement procedure made it practically more difficult, since consensus was to be achieved among a much larger number of countries. As a result, the agreements concluded in the first fifteen years after the War were all essentially the resumption of existing agreements before the war.

Actually, very few agreements were implemented: the 1954 Sugar Agreement, the 1956 Tin Agreement, the 1949, 1953 and 1956 Wheat Agreements, and the 1962 Coffee Agreement.

Alternate approaches to institutional and structural stabilization

Adaptation of future market structures

Some economists have wondered why the future markets could not be used also by the producers to hedge against uncertainty in prices. Obviously, the present futures market, although they allow hedging for consumers and speculating, do not allow any long term hedging for the producers. As described by Porter,[10] "the operations of future markets facilitate the storage of commodities from the time of harvest (production) to the time they are consumed within the crop year, so that seasonal variations of price are considerably reduced." This is achieved by transferring the risks of holding the commodity to those that wish to bear those risks. "But this does not operate so satisfactorily when it is necessary to store the surplus of one crop of one year into the future."[10] Since storage from one year to the other can be costly and is risky, and risk increases directly with the amount of commodity stored, people usually will not be willing to risk the amount of money involved. The risk being important, there has to be a proportionally attractive reward in terms of profit margin between present price and price in the future to attract speculators to do it. This also applies to producers, who would have to take the risk of holding in the expectation of a better price in the future instead of receiving the proceeds at a lower price immediately.

One of the mechanisms involved in the cobweb phenomenon is the reaction of producers and consumers to short range changes in prices. Therefore economists have tried to design ways of avoiding these over-reactions.[12] To apply this problem, it has been proposed[11,12] to change the structure of the future markets by creating distant futures. Then, it would allow a market system with distant future reflecting the perception of the market of long run trend, and near term futures reflecting the short term price expectations and therefore the level of current stock carryover.

Usage of these two markets would allow producers to stabilize their income without interferring with the market price. The use of the long term futures contracts would allow producers committed to the given commodity to hedge and ensure stability of income for this time horizon.

In this perspective, although the producers sell in order to minimize risk, i.e., two years ahead, they are still free to alter planned outputs to meet changes in near term market conditions.

Purchase controls

A variant of this proposal is the multilateral contract whereby contractual obligation, the consumers and producers agree to buy and sell certain given quantities. The price is left free to move within a certain range but the contracting parties must fulfill their obligations for the time period in question. Such an agreement has the advantage of preserving the free market as an allocator of resources and as an indicator of trends, provided that not all commodities are covered by it. There are no technical problems in enforcing it in theory. Difficulties may grow as the agreement is made tighter to make it more effective.

Also, the purchase contract is equivalent to creating a two price system. Therefore it requires domestic controls and some sort of buffer stocks to implement it. It comes very easily to have governments involved in the commodity business.

In extreme cases it becomes a payment from one government to another without physically involving any consumer or producer. A good illustration of the pros and the cons is a brief summary of the history of the Wheat Agreements[1,9,14] from 1949 on; it illustrates the necessity of this kind of agreement to cover a high proportion of the international trade of the commodity involved (see Table 2-1, sheet 1 of 2). In multilateral contracts, the extent of the effectiveness depends on the minimum and maximum prices within which prices are allowed to fluctuate. Membership in those agreements is also very sensitive to price range.

The first post-war International Wheat Agreement occurred from 1949 to 1953. Exporting countries (mainly the United States, Canada and Australia) agreed to sell guaranteed quantities at a maximum price of $1.80 per bushel, while the importing countries committed themselves to buying minimum amounts from $1.50 to $1.20 per bushel over the duration of the agreement. In fact, the market price in the time period covered by the agreement ran consistently above the $1.80 level, so that the Agreement effectively stabilized the price at $1.80. Importers of course fulfilled their obligations at 95 per cent.

Therefore, for the second agreement, the exporting countries raised the range of price from $1.55 to $2.05 per bushel. This lead the United Kingdom to withdraw from the agreement. Quota guarantees in the second agreement fell to 11 million tons instead of 16 million tons as in the first. Stocks began to accumulate in the major exporting countries and in 1953 the prices fell to only 10 per cent above minimum prices by 1957. The third International Wheat Agreement in 1956 had a price range lowered to $1.50 to $2.00 per bushel, but several other importers withdrew again. Quota guarantees fell to 6 million tons. However, prices remained within the agreement range: the proportion of transactions registered under the guarantee quota provision operating limits declined from 95 per cent of the 16 million ton quotas in the first agreement to 60 per cent of the smaller quotas of 8 million tons in the third agreement in 1957-58. Compared with the 5 million tons sold under guarantee in 1957-58, actual shipments totaled about 15 million tons.

The changes in the balance between commercial demand and exportable supply lead to a radical change in the 1959 Wheat Agreement. Imports and exports quantities ceased to be symmetrical. Quotas were dropped. The importer participants agreed to purchase a minimum of their imports at a minimum price from exporter participants. The latter agreed to supply those quantities. If the price were to go above the ceiling, exporters would supply at the ceiling price an amount equal to their average sales to the given importers in the past four years. No obligation was on importers if the price went below the floor other than their minimum purchasing commitment.

Those modifications succeeded in bringing back into the agreement most of the importing countries that had left it in 1953 and 1956. In 1962 the agreement adopted a price range of \$1.625 to \$2.02 per bushel. The coverage of the agreement was in theory the same as in 1949, but only nominally. At this time a stock management policy was operated by the major exporters (the United States mainly; also Canada, Australia and Argentina). In 1960 the wheat stocks of these countries accumulated during the previous years of depressed prices were 54 million tons (the U.S.A. alone had 35 million tons) equivalent to almost one year's production.[11] The United States, by holding such a buffer from which the outflow on the commercial market was restricted to the amount saleable within the range of the agreement, was acting in effect as a buffer stock stabilizing agency.[11,1]

Commodity reserve currency

It has been proposed, in order to remedy to barriers to international trade set by liquidity problems to adopt a commodity standard. In such a system, the supply of currency and the prices of other goods in terms of the commodity currency are entirely determined in the market by the demand for the commodity for monetary uses and other uses, and by the supply of the commodity which is ultimately governed by the costs of production.

This is relevant to our problem, since it would indeed have a stabilizing effect for commodity producers in the long run. However, because current output of a commodity is generally a small fraction of the existing stock in this perspective, deviations from equilibrium could be substantive, and a relatively long time would be necessary to correct them.[15]

It seems therefore that the advantages of a commodity reserve currency are relevant only to long-run stabilization.

National stabilization schemes

Quotas

Quotas, probably the most used device to date, are theoretically bad because they imply misallocation of resources. They protect inefficient producers, freeze markets and keep, very probably, the supply below the optimum level. However, they recommend themselves because they avoid accumulation of stocks, which, psychologically at least appears wasteful; they require no financing whatsoever, they do not call for any heavy administering body to make operating decisions, and above all, they can be enforced without agreement with the consumers.

Besides their uneconomic character, they also lack short term flexibility. Above all they are, even more than other stabilizing tools, vulnerable to non-participating country disruptions, as illustrated by the history of the Coffee Agreements.[9,18] (See Table 2-1, sheet 2 of 2.)

Before 1962 the many international coffee agreements, and the 1963 Coffee Agreement inspired by the United Nations had been frustrated first by the activities of non-member exporters, i.e., West and Central Africa. Since 1962, the agreements have secured the commitment by major importing countries to require certificates of origin on all coffee imports. This measure is designed to protect exporters from outside competition.

The coffee agreements provide for the annual reallocation of quotas based on projected demand and on the individual performance of the member countries in exercising effective production control.

In order to allow to such an agreement follow-up increases in productivity and entrance into the group of new members, some mechanism must be provided that will replace the price system in its resource allocation function. In the case of coffee, where a free market has not existed for many years, it is a difficult thing to devise indicators of productor efficiency that could not be manipulated by governments and would therefore be a reliable indicator for quota distribution.

Therefore, it appears that export restricting schemes, in order to survive in the long run, must enforce policies in the individual

Commodity	Entry into force	Duration years	Participation	Instruments of control	Remarks
Wheat	1933 . .	2	Major exporters and importers	Export quotas; acreage restrictions	Poor compliance; outdated by bad harvests. Wheat Advisory Committee established
	1942[a] . .	0[a]	Argentina, Australia, Canada, United States (exporters) and United Kingdom	Export quotas; production control; buffer pool, maximum and minimum exporter stocks; maximum and minimum prices	Draft Convention set up an International Wheat Council
	1949 . .	4	Major exporters (except Argentina) and importers	Guaranteed export and import quotas at the limits of a specified price range	Multilateral contract. Price range: $1.50-$1.80 per bushel, declining over the four years to $1.20-$1.80
	1953 . .	3	Major exporters (except Argentina) and importers (except United Kingdom)	As in 1949-1953	Price range: $1.55-$2.05 per bushel
	1956 . .	3	Major exporters and importers (except United Kingdom)	As in 1953-1956	Price range: $1.50-$2.00 per bushel
	1959 . .	3	Major exporters, major importers	Reciprocal buying and selling obligations within the price range; exporters undertake to sell minimum quantities at upper price limit	Obligations at the price limits no longer symmetrical. Price range: $1.50-$1.90 per bushel
	1962 . .	3	As in 1959, plus the Soviet Union	As in 1959-1962	Price range: $1.625-$2.025 per bushel
Sugar	1902 . .	[b]	Major producers (except Argentina and Russia)	Prohibition of beet subsidies for production or export	United Kingdom to impose a countervailing tariff on subsidized exports[b]
	1931 . .	[c]	Major exporting interests (particularly in Cuba and Java) accounting for less than half of world production	Export quotas	Undermined by expansion among non-participants
	1937 . .	[d]	Almost all sugar producing countries, including major importers	Export quotas; exporters' stocks limited to a minimum of 10 per cent of quota and an end-of-season maximum of 25 per cent of production	United Kingdom to limit domestic production and United States to grant imports a specified share of its market. International Sugar Council set up
	1954 . .	5	15 exporting countries and major importing countries	Export quotas; exporters' stock minima and maxima	Agreement subject to review in third year. Price range: 3.25-4.00 cents per pound
	1959 . .	5	26 exporting countries and major importing countries	As in 1954-1959	Operative clauses suspended in 1962
Coffee	1940 . .	4	United States and Latin American producers	Export quotas	Export quotas for markets other than the United States were fixed but remained inoperative.
	1957 . .	1	Latin American producers .	Export quotas	
	1958 . .	1	As in 1957	As in 1957	
	1959 . .	1	Latin American and principal African producers	Export quotas	

Table 2-1: International Commodity Agreements (Sheet 1 of 2)

Commodity	Entry into force	Duration years	Participation	Instruments of control	Remarks
Coffee *(continued)*					
	1960 . .	1	As in 1959	As in 1959	
	1961 . .	1	As in 1960	As in 1960	
	1962 . .	5	Virtually all producers and major importers	Export quotas; importers agree not to buy from non-participants	International Coffee Council set up; Agreement subject to review in 1964/65
Tea	1935 . .	5	Major Asian exporters; producer representation	Export quotas	
	1938 . .	5	As in 1933 but with government participation	As in 1933	
	1943 . .	5	As in 1938	As in 1938	
	1948 . .	2	As in 1943 plus Pakistan	As in 1943	Quotas not fully used
	1950 . .	5	As in 1948 plus Japan	As in 1948	Quotas not fully used
Rubber.	1934 . .	5	All producing countries except Brazil and Liberia	Production and export quotas; prohibition of new planting. Export quotas fixed each quarter as a percentage of basic production quotas	International Rubber Regulation Committee established. Representatives of rubber users as advisory members
	1939 . .	5	As in 1934	Ban on new planting lifted	International Rubber Study Group established
Tin	1920 . .	[illegible]	Malaya and Netherlands East Indies	Accumulation and liquidation of the Bandung Pool of "surplus" tin	
	1931 . .	2	Bolivia, Malaya, Netherlands East Indies, Nigeria and, later, Thailand	Export quotas; International Tin Pool constituted	International Tin Committee set up to administer a Tin Restriction Scheme
	1933 . .	3	As in 1931, plus Belgian Congo, Indo-China, Netherlands, Portugal and the United Kingdom	Export quotas; buffer stock 1934-1935	Netherlands and the United Kingdom "consumer" delegates in consultative capacity
	1936 . .	3	As in 1933	Export quotas; buffer stock 1938-1939	As in 1933
	1942 . .	5	As in 1936	Export quotas (nominal)	United States also participated through non-voting consumer and government delegates
	1956 . .	5	All major producers and consumers (except the United States)	Export quotas; buffer stock and price range	International Tin Council set up. Price range: £640 (later £730) to £880 per long ton
	1960 . .	5	As in 1956	As in 1956	Price range: £790 to £960: later £850 to £1,000

Table 2-1: International Commodity Agreements (Sheet 2 of 2)

member countries that will control production levels so as to avoid any structural disequilibrium between production and consumption. The alternative to such a policy is accumulation of huge stockpiles, as in Colombia or Brazil, where the stock level is more than an 18 month supply at the current levels of demand.

Another alternative is to divert the returns generated by higher prices toward other uses, diverting them from the individual producers. This means that there may be export tax levies as in Brazil or a differential rate of exchange for coffee growers as in Colombia.

National Buffer Funds

Elimination of short and medium run fluctuations can be achieved by purely national action and without distortion of the free market price function.

By means of a flexible tax and subsidy, a country can establish a fund which buffers domestic producers against world market fluctuations. It would sell its commodities for whatever price would be given by the market, paying or taxing its producers in function of the profit or loss incurred by the buffer fund. It would therefore accumulate exchange reserves in good times and draw them down in bad times. The stabilized price at which the fund agency would buy from the producers would be either readjusted periodically or continuously, varying with the perceived trend. Such a policy would not do anything to stabilize the world's price, except that in the market it would replace a large number of small producers by a huge seller, the agency, and therefore, replace the free market by some kind of oligopoly. However, the domestic economy and imports will behave as if the price had been stabilized.

The drawbacks of the method are numerous:

-it needs some overall market discipline that the international measures could provide. Also, in building up an oligopolistic structure, it could contribute to disequilibrate the world markets in cases of inappropriate retention of production by the fund.

-politically, it may be quite difficult to implement the taxation of producers in periods of rising prices.

-the impact on supply of such stabilization schemes may favor the countries not using this method. Therefore here again, some kind of consensus for implementation is necessary.

In spite of these disadvantages, this method can be used by any country without waiting for the conclusion of an international agreement. As many countries are in fact[3] practising a kind of support of domestic agricultural prices, or are trying to conduct an anti-cyclical policy in their foreign exchange reserves without usually too much success, this policy could certainly be much more successful for them.

Such buffer funds are used by the West African marketing boards. As pointed out by Bauer-Paish,[20] because the reference price of the Marketing Board did not try to follow the upward trend in the post-war years; they accumulated important surpluses in the fund that were clearly uneconomic. In their proposal in 1952, Bauer and Paish suggested a formula to determine the working price of the fund (see Chapter 3). It did not have any practical implication for implementation as for now.

International action

Countercyclical Lending

As seen earlier, we expect from what is denoted as commodity agreement that it helps producing countries in terms of development and consuming countries in terms of raw material supply stability. If, furthermore, consuming countries are for other reasons disposed to a transfer of income to the producing countries, a very effective international solution for stabilization can be achieved through countercyclical lending.

First, in the abstract, the governments of the consuming countries might as well impose a tax on consumers and give the proceeds to the producing countries. The effect on the economies of the two countries would be identical. The other extreme would be just to decide to pay a higher price for the commodity. Apart from the psychological reasons that may prevent producers from accepting such a free gift, this would not be a very efficient way globally. This would artificially increase the income of a given group of producers in the country. Given the social structure of most developing countries, it would probably not lead to increase the income of the most needing producers. In any case, the majority of the population would not benefit equally from this transfer of income.

Second, this increase in price of the commodity would, in absence of restrictions on production or on entry into the field, lead to an increase in production of this commodity, which is one of the things we want to avoid.

Third, this income transfer would be in the form of transfer, not of reinvestible capital. Most of it would probably go into consumption instead of being saved. While in case of a loan, or a grant, the same income transfer would result in many more investments.

Fourth, the income transfer through higher prices would still suffer from the instability due to fluctuations in quantity, while a loan could be tailored to both fluctuations, prices and quantities.

A very good advocacy for countercyclical loans is made by Wallich,[3] who states that ordinarily, developmental financing can be carried out more effectively by overt income transfers rather than by the concealed form of better terms of trade. "I would suggest that countercyclical loans and grants be designed to compensate for raw materials fluctuations."[3]

Buffer Pools

From the theoretical point of view, buffer stocks are the ideal stabilization device. They are very much like the classical open market operations of a central bank, and they do not interfere at all with the working of a market. They are simply designed to change the balance of supply and demand. The following chapter discusses in detail the issues involved. But let us now examine the experience to date with buffer stocks. There have been in actuality only two working buffer stocks at the international level designed to stabilize commodity price fluctuations: sugar and tin, in the form of a centralized buffer for tin, and a decentralized buffer for sugar.

Tin

The Tin Buffer has been managed independently by the International Tin Council. Selling was mandatory above the price ceiling, optional in the upper third of the price range. Symmetrically, buying was mandatory below the floor, optional in the lower third of the price range. The stock was financed entirely at the beginning, in metal or cash, by the exporter members at the level of $50 million (25,000 long tons).

The decline in prices after the end of 1956 did contribute to the build up of the buffer, and it reached its maximum level at the end of 1958 (see Figure 2-1). It has to be noted that even at this level it never reached more than 33 per cent of the level of commercial stocks.

Backing up the operations of the buffer stock was instituted a system of quotas at the disposal of the Council. The quotas represented historical shares of world trade subject to modification if required.

Those instruments proved insufficient to prevent violent swings in the market. In 1958 a recession in the United States coincided with an end of stockpiling initiated at the time of the Korean War, and a flux of exports from the Soviet Union and Red China. The buffer stock began to buy extensively, and even quotas were reinforced. Importing countries also set quotas to avoid collapse of prices. The Soviet Union slowed down its sales; producing countries had to extend a loan to the buffer to sustain its operation. In spite of all those efforts, the price went below the floor price. This collapse was short lived, and by the end of 1958, there was the beginning of a reversal of this trend. The quota measures were being felt, East

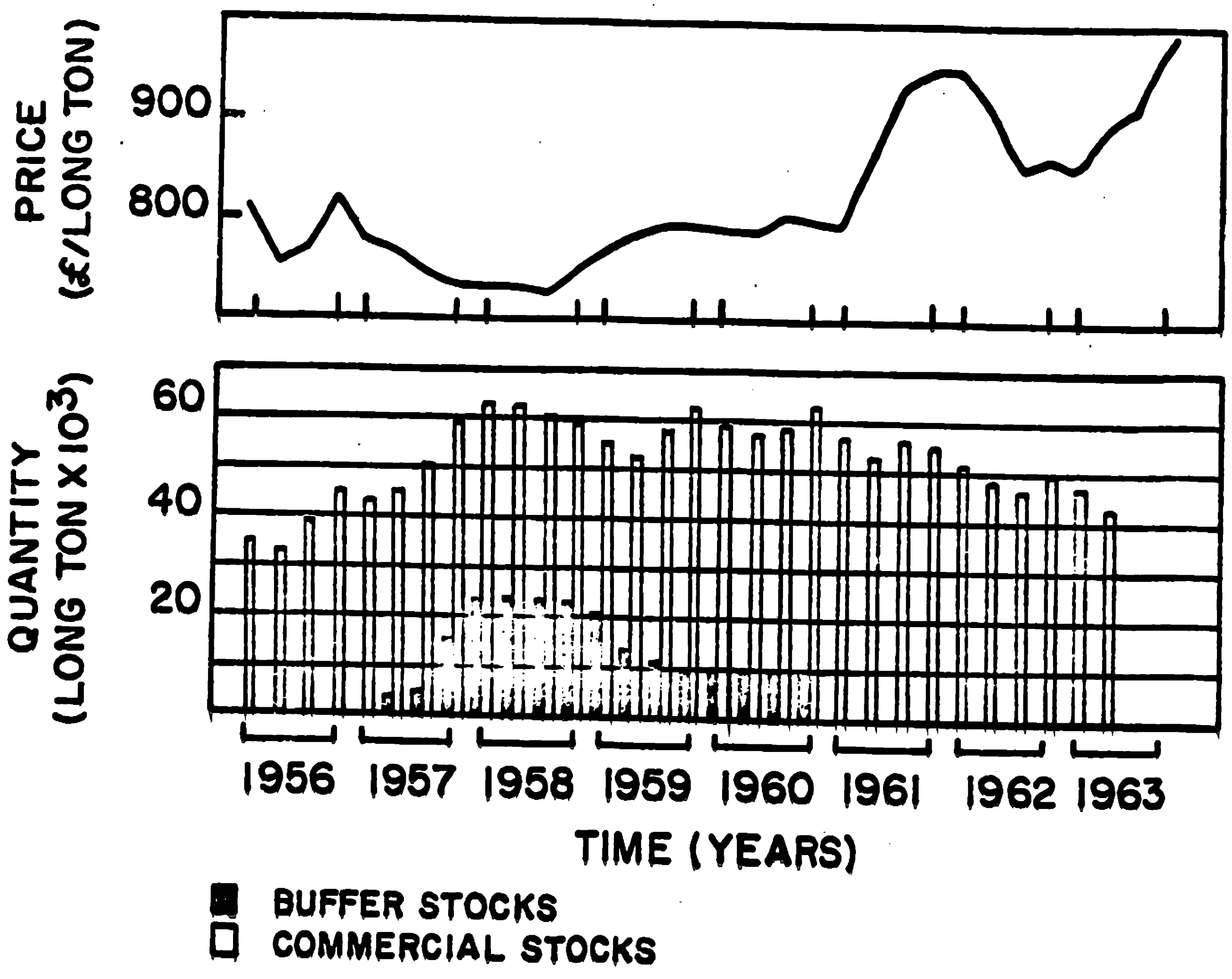


Figure 2-1: Tin: Prices and Stock Movements
(Source: Reference 2)

Bloc shipments were decreased, and the situation went towards shortage rather than surplus. In 1962, the supplied quantity was still 10 per cent below the pre-restriction level. Then, it appeared that control had passed into the hands of the United States, who had not even been participating in the Agreement. Their stocks in 1961 were three times the annual world export figure, and far in excess of any strategic requirement.

As in the case of wheat mentioned earlier in this chapter, control had finally passed into the hands of a buffer stock controlled by the United States.

Sugar

The buffer stocks of sugar are held by the producers as part of their obligations, instead of being held centrally as in the case of tin. Measured at the time before the harvest has to go to the mill, their minimum has been fixed at 10 per cent to 15 per cent of the basic export quotas, and their maximum at 20 per cent of the preceding year's production (see Figure 2-2).

Therefore, the higher the export/production ratio, the greater the control formula is constraining. Stock range was much smaller for countries as Cuba or the

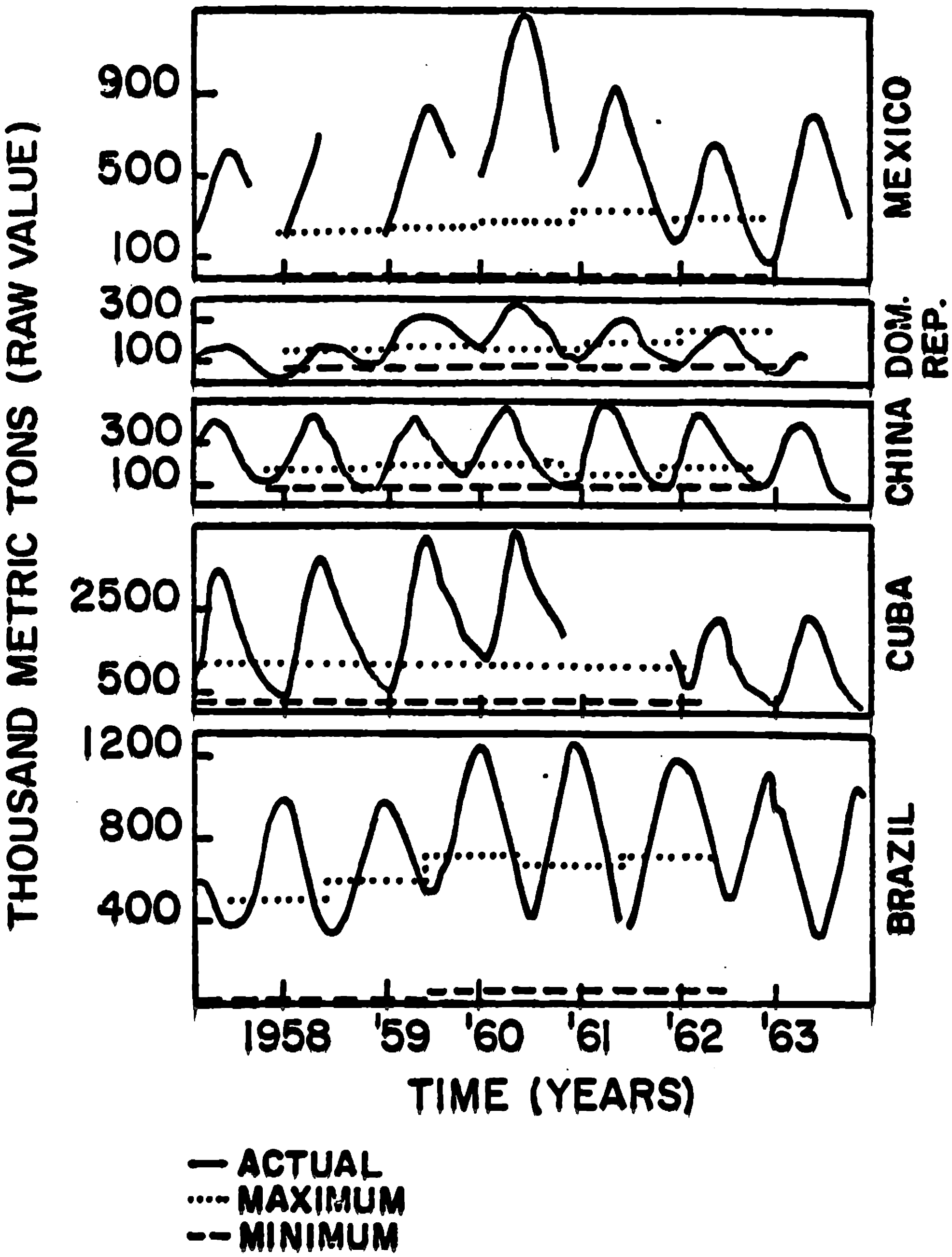


Figure 2-2: Sugar Stocks: Action and Bounds

Set by the International Sugar Agreement
(Source: Reference 4)

Dominican Republic than countries like Mexico or Brazil. This form of restriction was least applicable to marginal net exporters: carry over stocks were frequently above their limit for countries like India or Italy. They are using at the same time basic free market quotas, allocated to 26 of the thirty exporter members.

The stock range was from a minimum of about 820,000 tons to a maximum of about 6,600,000 tons (in terms of money, from $47 million to about $470 million).

Most exporting countries managed to hold their carry over stocks within the required range, though at the beginning of the period, they happened to drop below the floor (Dominican Republic, Haiti, Peru).

The reasons for failure of those two buffer stock agreements are to be found in the relationship between price set by the buffer pool and credibility of its ability to defend it. While in theory the stock needs to be only large enough to either make good an average shortfall or take in an average surplus of production, it has in practice to be large enough to convince buyers and sellers that it disposes of sufficient resources to enable it to achieve its purpose. Thus, they will know that the price range determined by the Buffer Stock Agency will be defended no matter what, and therefore, the resources applied by the buffer stock being large enough to make credible success of intervention, it will discourage speculation (refer to Chapter 3.)

CHAPTER 3

BUFFER STOCK ISSUES

Objectives of a buffer stock

The operation of a buffer stock depends upon its objective. It is generally assumed that the purpose of a buffer stock is to stabilize commodity prices. However, a buffer stock can be operated for many different purposes, such as:

a) stabilizing prices received by producers. (This objective serves to help producers plan production more efficiently over a longer period of time.)

b) stabilizing the export earnings of producing countries, and

c) increasing the average price received by producers for their exports of a commodity over some given period of time.

As we have started to suggest before, and will explore further, these objectives are not necessarily compatible. Therefore a reference decision must be made about the relative priorities of these objectives. One consideration in making such a decision is the fact that they may be achieved by other means: independently or in conjunction with a buffer stock. For instance, a buffer stock can be operated so as to stabilize prices for producers up to some reasonable level. (Refer to Figure 5-19.) It is shown that the cost of stabilizing prices would be prohibitive, but prices can also be stabilized by state marketing boards or a system of variable export taxes in producing countries maintaining internal prices at a constant level independently of external prices.

A buffer stock operating so as to stabilize prices may, under certain conditions, have the effect of destabilizing the foreign exchange earnings of producing countries. Thus the two objectives would be incompatible under those conditions. However, they may be reconciled if the country is able to use such facilities as the IMF (Compensatory Financing Facility) to stabilize earnings, simultaneously with a buffer stock to stabilize prices. In the analysis we shall be concerned only with a self-liquidating stock, in the sense that there is no net change in the size of the buffer stock as a result of its operations in a given period.

Price stabilization

It is commonly accepted that price stabilization is advantageous both for producing and for consuming countries. As already mentioned rationalization of production and investment planning would lead to a lowering of costs of which both producing and consuming countries could take advantage. An international device could be used, the good of which would be simply to stabilize price (without any other connotation); it is a great advantage that it does lead to benefits for both producers and consumers.

Price and quantity correlation

The success of any attempt to influence market price will be influenced by the relation between the sale price and the quantity sold. It has been found that for some commodities short term price and quantity tend to vary in the same direction.[1,3,8] This is particularly true with a number of fuels and raw materials (petroleum, bauxite, aluminum, zinc, abaca, cotton, wool, rubber), some of the interchangeable fats and oils (palm kernels, soja beans and ground nuts) and some of the temperate farm products for which demand on the world market varies in counter phase with domestic production (wheat, lard and butter, pork and mutton) as well as for coffee, tea and tobacco.[1]

The positive correlation of price and quantity has been confirmed by Kitamura and Shu Chin Yan[25] for all Asian exports in 1958 except for rice, copra and coconut oil, by Porter[27] for cotton in Egypt, and by the United Nations experts for a number of commodities in 1965. Goreux[28] proposed a very interesting classification where minerals are positively correlated, while agricultural commodities are negatively correlated.

Results of classical statistical inference must be continuously interpreted when feedback relations are involved. It is relevant in this context to quote the statistical results of a United Nations experts' study in 1952.[21] For the study of fluctuations in commodity income, price alone explains 19 per cent of the variance and quantity changes. (Price fluctuations remain at 39 per cent.) However, this United Nations study demonstrates also that such a negative view of the influence of price would have to be based on a hardly credible hypothesis: anmely that the present gap between commodity consumption and demand would continue even if price were to be stabilized. This gap is of course the demand for increased inventories, which depends upon the expectations in price in the future. It appears that for the commodities in which price and quantity are correlated positively, increases in prices lead consumers to expect further increase and try to protect themselves by building up inventories. In economic terminology, the demand schedule shifts with changes in price expectations.[8, 23] If prices were stabilized, this gap would therefore probably shrink, if not disappear. The analysis of price and quantities for many major commodities (positively correlated or not) shows that if analysis is made on the basis of quantity consumed instead of commodity demanded and bought, price fluctuations are shown to have accounted for well over 50 per cent of the total income instability (measure of degree of fluctuation).[3]

For the commodities which exhibit a negative correlation between price and quantity, it is still true that to stabilize fluctuations of price would stabilize fluctuations in quantities. The difference is only that for commodities with a positive correlation, there is an obvious interest in price stabilization even at the average recorded price,[25] which would already increase total income received by them.

Sundrum[28] derived a static analysis where he proves that theoretically, in all practical cases, income is stabilized by price stabilization. (For a definition of stabilization refer to Chapter 3, section: Need for Stabilization.) Kitamura[26] also developed a theoretical argument in which he shows that price stabilization leads to a greater income stability for producers. His argument is quite brilliant, but he proves his point only in the example of some kind of collective action from the producers, which is not must often the case, where many small producers are competing.

It seems that the empirical evidence described is sufficient to justify both out joining the common school of thought, and agreeing that price stabilization is an efficient way to smooth fluctuations of producers' income.

However, it seems difficult to decide a priori, without any experimenting or simulating, whether or not a stabilized price is going to lead to increased average income received. In Chapter 1 we discussed whether stability of incomes is a good thing per se in its effects on the ultimate goal of economic development. Now we may ask more specifically, does a stabilized price lead not only to a stabilized income, but also to a higher average income? It has been argued,[10,20] that stabilization of price is paid for by the producer in the form of a smaller average income received. This argument demonstrates that prices being stabilized, consumers probably would use more efficient purchasing policies for stocks purposes.[6] This would probably decrease their costs. Thus the producers would receive a lower average income. For the same reason, the stabilization of prices decreases producers' costs.[3,17] It is therefore quite likely that price stabilization by reducing production costs on one side, and inventory costs on the other side, is going to be advantageous to everybody in some sense.

Operating goals of a buffer stock operation

For this, it is more convenient to break down commodities into the two basic classes: minerals and fuels, and agricultural products.

Minerals and fuels

As production restrictions can be implemented quite easily, there is not much need for a buffer stock: as pointed out by Goreux,[28] "by turning the tap of an oil well, there is no need for a buffer stock. The buffer stock is the oil reserve at the bottom of the well." If, as it is possible for many metals production cuts can be implemented in a matter of months, then a buffer stock may constitute a convenient stop gap or production control. For the producers, there is a cost in frequently changing the level of production, because it involves changes in the capacity of utilization. This is a rationale for cushioning small variations in the market balance by buffer stock operations.

If the industry is concerned with price declines, the size of the buffer stock can be small. The optimum size depends upon the trade off between the cost of adjusting the volume of production more frequently and the cost of carrying larger stocks.

If the industry is also concerned with price peaks, the problem becomes more complex. Quotas allow one to decrease output when needed, not to increase it over the available productive capacity. This brings the buffer stock into a new role, being not only a stop gap for production control, but also providing a reserve of commodity when the industry cannot meet demand at full capacity. The optimal size of the buffer will then depend upon the trade off between the cost of maintaining stocks versus maintaining unused productive capacity. Also a factor to account for is how much the industry is concerned with avoiding sharp price increases. The dangers of price increases are two-fold: in initiating the cobweb effect by inducing some producers to build up capacity, and by bringing the danger of substitution on the demand side.

The examination[1,24] of past industry behavior seems to indicate that industry is much more concerned with price declines and therefore would be satisfied with only a small stock. Empirical evidence also shows that industry is more willing to accept unused capacity rather than to carry along a buffer stock to iron out peaks and troughs. Thus the natural inclinations of the industry would be self-defeating; one would run the risk of having it either produce for the buffer stock instead of restricting output, thereby ruining the stocks' financial resources. Or, by restricting output, dry down the stock level and break the price ceiling.

Agricultural products

It is to be noted that for all practical purposes tree crops only are of interest in the use of buffers. Among the agricultural commodities selected by UNCTAD[1] for candidates to a buffer stock, cotton, wheat, corn and rice are not included. The first three were excluded because in the past the United States buffer stocks have been large enough to play the actual role of buffer stock, and that it is expected that the same situation will continue in the future. No reason is included for rice, and in the future, it may well be qualifying also for a buffer stock.[28] Therefore, the agricultural commodities of interest for the buffer stock issues are: coffee, cocoa, coconut and copra, and rubber. For tree crops, it is a general feature to have a production response very small in the short term and very large in the long run.

If there is no structural disequilibrium between demand and supply, the price fluctuations which are usually quite wide reflect random fluctuations of production, mainly due to weather. (In agricultural commodities, there is usually a negative correlation between price and volume traded fluctuations). An international buffer stock is appropriate to cushion those fluctuations by accumulating stocks in a peak crop year, and selling them in short crop years. In the case of those random fluctuations, the use of a buffer stock alone is quite possible.

However steps have to be taken to prevent the buffer stock from being used as a substitute for structural adjustments which might lead to larger problems than it was designed to solve, i.e., the coffee stocks that Brazil was carrying at the beginning of the sixties might have never been reabsorbed if the stocks, instead of being a physical and financial burden for Brazil itself, had been supported by an international agency.

Theoretical necessity of buffer stocks as a stabilizing agent

As evidenced in Chapter 2, the instruments used to keep price within a certain range are much more oriented towards regulation of supply than regulation of demand. Regulation of supply is indeed much easier to achieve: expansion of consumption is a long term matter. It involves either changes in the quality of the product offered, technological changes bringing about new applications for the given commodity, rises in the income of population, or a long run perceived decrease in price.

A decrease in consumption is easier in theory to induce by international action. In practice, it involves serious problems, such as convincing and policing simultaneously all the countries involved to substitute temporarily another commodity for their marginal uses.

Therefore the short run demand curve is kinked around the current equilibrium point and the influence of prices on quantity sold is much stronger upwards (price increase) than downwards.

Therefore, any serious attempt on the demand side has to be aimed at the other component of demand, demand for inventories, that lends itself to rapid adjustments.[8,17,25] Therefore, the essential way of doing those short term adjustments is to use buffer stocks.

Empirical evidence is to be found in recent experience: twice in fifteen years, de facto international buffer stock policies have been taking over the short term stabilizing effect from defective agreements. In the case of wheat, it supplemented multilateral purchase contracts; in the case of tin, a mixed system of buffer stocks and quotas (refer to Chapter 2.)

Effects of international buffer stocks on privately held stocks

Causes of privately held stocks

If neither producers nor consumers hold stocks of a commodity over time, the quantity produced in one season is to be consumed in the same season. Hence fluctuations in the conditions of demand and supply are fully reflected in fluctuations in prices. If, however, in the case of commodities where this is feasible, stocks can be held over time, the quantity consumed at one time need not be the quantity produced at that time. Such stocks help to adjust production to actual consumption. However, the holding of stocks involves some financial costs. In general, producers of primary commodities do not have the financial resources to hold stocks. Therefore, the quantity supplied on the market varies with fluctuations in production. Consumers, or dealers in consuming countries, have greater financial resources and are therefore able to hold stocks. Some part of the stock is required for what may be called transaction purposes; they are bought in the relatively short periods when they are sold by producers, i.e., the harvest time for agricultural products, and used gradually over a longer period of time according to requirements for consumption or for manufacture. This part of the stocks may be described as working stocks and the amount of these stocks depends largely on technological relationships and the level of consumption.

A part of these stocks is also held for speculative purposes by dealers in consuming countries. Thus if the supply of a commodity at any time is large, relative to demand, leading to a low price, a part of the supply may be held for consumption at a later time, when supply may be small relative to demand. If such speculative stocks are increased at times of low prices and reduced at times of high prices, such speculative transactions may lead to more stable prices than otherwise. The objective of such a speculative transaction by private dealers is to profit by the opportunity of buying at low prices and selling at high prices. Although the objective of such transactions is not to stabilize prices, such transactions would lead towards greater stability of prices. This does not necessarily mean that prices would be completely stabilized by the holding of such stocks by consumers.

The interests of consumers in holding stocks is to adjust purchases over time so as to minimize the cost of those purchases. To the extent that they are successful in this objective, the interests of the producers suffer.

It is also possible that under certain conditions, speculative transactions will have a negative effect of destabilizing prices. Following a price rise, speculators may be expecting further increases, and buy stocks; this will induce prices to go higher than they would have gone otherwise. It will also lead to a fall when the speculative component dies out, creating even more oscillations. It has in fact been argued[8] that this effect of speculative transactions has been an important cause of price instability of primary commodities.

Effect of an international buffer stock

Buffers have a psychological impact. It appears wasteful to maintain a stock of commodity in storage, while scarcity of resources hinders development and welfare often permitting only survival for starved citizens of underdeveloped countries. Considered in isolation, this is a waste. But if this achieves greater stability in international commodity markets, it is bound to produce substantial and measurable benefits in terms of long term development of the developing countries.

Furthermore, it has been argued that buffer stocks do not necessarily constitute a net increase of the average holdings of commodity in the world.[8] Stocks exist in any case, but normally by those with speculative or precautionary purposes which accentuate the cyclical swings of prices and incomes. Adding the institution of this buffer stock would just bring some common discipline, by imposing a steadying pattern on the movement of stocks of primary products.

One may also say that a more practical point is that increased commodity stocks, contributing as they do to international liquidity, should make possible more long range policies of domestic expansion and reduce the concern for foreign exchange balance. This line of argument[25] is actually suggesting that buffer stocks are a necessary step towards commodity standards (refer to Chapter 2).

Need for definition of stabilization

Stabilization has been until now in this study extensively referred to as stabilization of prices, of proceeds, and of foreign earning balances without any clear definition of what was meant by it. The intuitive concept is quite clear, and it is easy by simply looking at historical charts to recognize relative stabilities of two given commodities.

The importance of a proper definition does not only lie in the intellectual clarity of the argument, but because it gives us the possibility of defining a measure of efficiency of our operation. One has to think in terms of cost-effectiveness, and therefore be able to arrive at determining what level of stabilization can be achieved at a given cost level. If the community considers that price fluctuations have to be smoothed by a buffer stock, or any other device, it considers that this is a service. The community should be prepared to pay a price for this service. This could define the demand for stabilization, i.e., the utility, expressing in dollars what the community is prepared to pay to obtain various levels of stabilization.

The supply curve corresponding to this demand is the curve, obtained in this study by simulation, showing the cost necessary to finance operations that will yield a given level of stabilization.

Consideration of those two curves can help the buffer stock agency to determine what degree of stabilization it ought to be aiming at, and therefore budget its operations. (See Figure 3-1.) The concept of stabilization is "meaningless without reference to a specific period over which the buffer agency's accumulated forced savings and their subsequent disbursements balance."[20]

As the future prices are uncertain, it may be argued that the larger the surplus, the greater the ability of the organization to weather storms. Without a stated finite period over which stable prices are to be achieved there is no reason not to arrive at the absurdity of ever accumulating reserves.

Second, stabilization is meaningless without some reference to the relation between the price envisaged under stabilization and the open market level. The lower the absolute level received by the producer, the longer it can be maintained: a zero price would also be the insurance for maximum safety and stability.

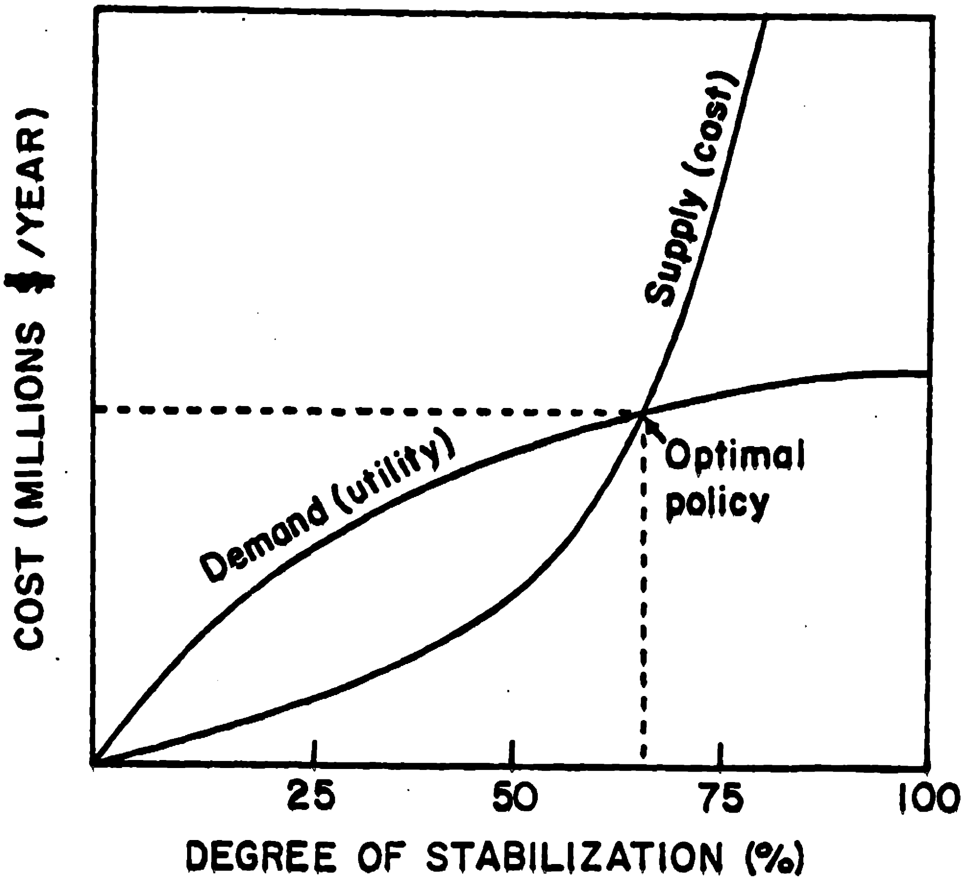


Figure 3-1: Optimal Cost Stabilization Mix

Third, stabilization of incomes may be referring to relative shares rather than absolute total incomes, that is, to the maintenance of the portion of a certain class of producers relative to other groups in the economy. Indeed, it is what has been meant by stabilization in agricultural policies of countries such as France.

However, usually, stabilization of incomes is simply meant as the maintenance of a certain level, i.e., the establishment of a floor for incomes. Some other times, it refers to raising the income received by producers, especially agricultural producers.

Fourth, there are also fundamental difficulties of measurement and definition in the concept of stability. It is not clear whether a large number of frequent and small changes represents a greater or smaller improvement in stability than a smaller number of large and discontinuous jumps, such as are often found in stabilization schemes when the reference prices are readjusted periodically.

All those considerations lead us to adopt the following operational definition: the measure of stability is the standard deviation of the price around a three year moving average.

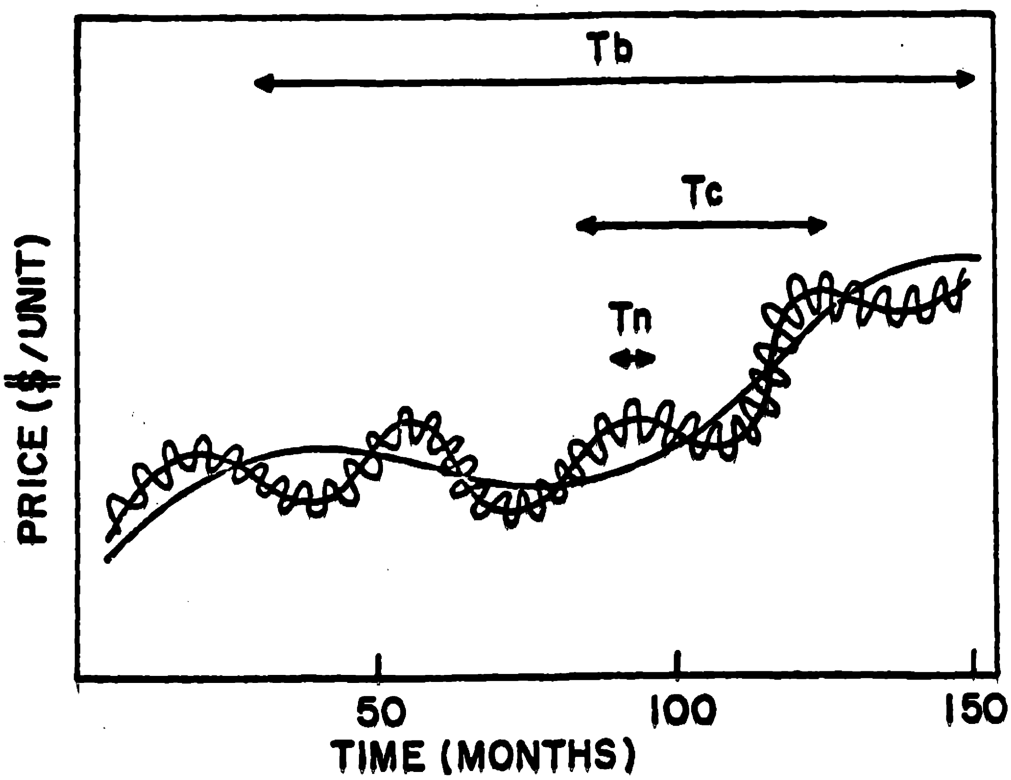
Other definitions are possible, such as the algebraic area between the price curve and the moving average curve.

The definition we adopted reflects our value judgment that extreme variation has to be hardily penalized. The three year figure for the moving average is in agreement with the United Nations experts' definition.

Regulating goals of the buffer stock operation

It has been seen in Chapter 1 that the price variations are the superposition of three components: long run trends, medium term cobweb cyclical fluctuations, and short term disturbances. Things do become even more intricate when the long term trend itself exhibits periodical oscillations (see Figure 3-2).

Actually, the problem is mainly in the definition of what is meant by long, medium or short term. Obviously, the business cycles in the developed countries do impose some periodicity in the trends in demand. As there are different periods for business cycles (major business cycle: period 8.25 years; Kuznets cycles in construction and other series: 15-25 years),[5] the question becomes one of comparing the period of these business cycles to the period of the cobweb cycles. For example, in cocoa, the cobweb period seems to be around thirty years, and this definitely cannot be called medium term, compared with either the period in the business cycle or the time dimension of short term disturbances.



T_b = period of exogeneous business cycle (eight years)

T_c = period of cobweb cycle

T_n = period of noise

Stabilization is feasible for the noise cycle and the cobweb cycle since both have periods smaller than five to eight years.

Figure 3-2: Stabilization Objectives versus Period of Cyclic Phenomena

(See Appendix 4)

Also, the short term disturbances very often do have some periodicity: weather, strikes, political tension, etc. are all periodic or at least pseudo-periodic phenomena. Therefore if the cobweb period is very short, it will not be distinguishable from those random elements. It is actually what happens in most non-commodity markets, where the conditions of elasticity and the delays involved are such that the cobweb period is indiscernible.

In short, it is only for convenience that we refer to the random disturbances as short term,cobweb fluctuations as medium term and trend oscillations as long term, if they exist. In each given case, it will be relevant to compare the period of the cobweb phenomenon and that of the random disturbances to each other, and to the time horizon.

A wide consensus which exists is that the short term disturbances should be smoothed. Signals given in raw materials markets are so misleading or extreme that it is extremely legitimate to counteract them.[3] It has been recognized by all economists that "erratic short term swings in price, however accurately they reflect current or spot forces working on the market serve little or no useful purpose as a guide for production, investments decisions or global resource allocation."[17]

Also, medium term fluctuations ought to be smoothed, as long as medium term means a time horizon of about five years, which is the maximum figure to be admitted from the literature. For instance, with tin, where the cobweb effect is very slightly pronounced, it makes sense to recommend smoothing of short and medium term fluctuations.[29] For cocoa, the cobweb cycle period being too long, it is conceivable to use buffer stocks only to stabilize the random disturbances, since accumulating stocks for fifteen years is clearly unrealistic. For example, stocks would have to be accumulated for half the cycle, in this case the cycle's period is 30 years.

Buffer stocks and trends

Desirability of changing trends

It is the general consensus that buffer stocks,and actually any means of stabilization,should not try to modify the long term trend. As best expressed by Wallich:[3] "it is not compatible with a free market to modify the long run trend of prices, the true signal that prices are designed to give."

This is however technically difficult to achieve, because, "changes in the value of money or structural changes in underlying factors of supply and demand may lead to loose the long term trend."[20] For example, to try to ignore the change in long term prospects for silk when it started to be replaced by nylon and other synthetics would have led to allocating resources in a very inefficient way. This is extensively discussed by Swerling.[31]

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Furthermore, not only should the buffer stock try to change the trend, but it ought to use adaptive price goals in order to follow slow structural changes in supply and demand.[30] Another example of this necessity is given by Swerling.[31] Java, twenty years ago, experienced a sudden and continuous decrease of its cane exports with the introduction of new high yield cane. If there had been a buffer stock working with the Javanese cane, and had it been basing its reference price on past prices only without any forecasting, it would not have perceived the new trend of consumer switch to the new cane breed, and would have found itself being almost the only buyer of Javanese cane. Adaptive goals are impossible, not only because operation by the buffer stock may impede development, but also because the very existence of a buffer stock is at stake: the agency in the course of time could find itself saddled with obsolete commodities or obsolete grades. While the foodstuffs are not in principle liable to this danger, it may very well be the case for any industrial materials that technological change can make obsolete. Also, agricultural goods may spoil if stored for extended periods.

<u>Feasibility of changing the long term trend</u>

It is not possible to change the long run trends for the simple reason that trying to apply a pure buffer stock policy to change trend would, either exhaust the financial resources of the buffer stock agency if the trend is downwards and it tries to stop it, or it would exhaust its physical resources if it tries to stop a trend upwards. This is for example what happened to the tin buffer stock. This point is illustrated through simulations analyses in Chapter 5. Goreux[30] also showed on the case of cocoa that buffer stocks alone cannot change the trend.

Influence of stabilization on the trend

It is clear that for both types of commodities (agricultural with price and quantity negatively correlated, mineral commodities with price and quantity positively correlated) that stabilization around a trend would make the trend different than it would have been otherwise. "Stabilization of positively correlated commodities will increase their supply greater than, and hence their average price lower than, would otherwise have been the case. For negatively correlated commodities, the opposite will be true."[3]

Therefore, stabilization will change the trend just by the fact that supply and demand curves shift because of expectations, they will move towards a more stable position which will, with changes in time, express the trend. (See Figure 3-3.)

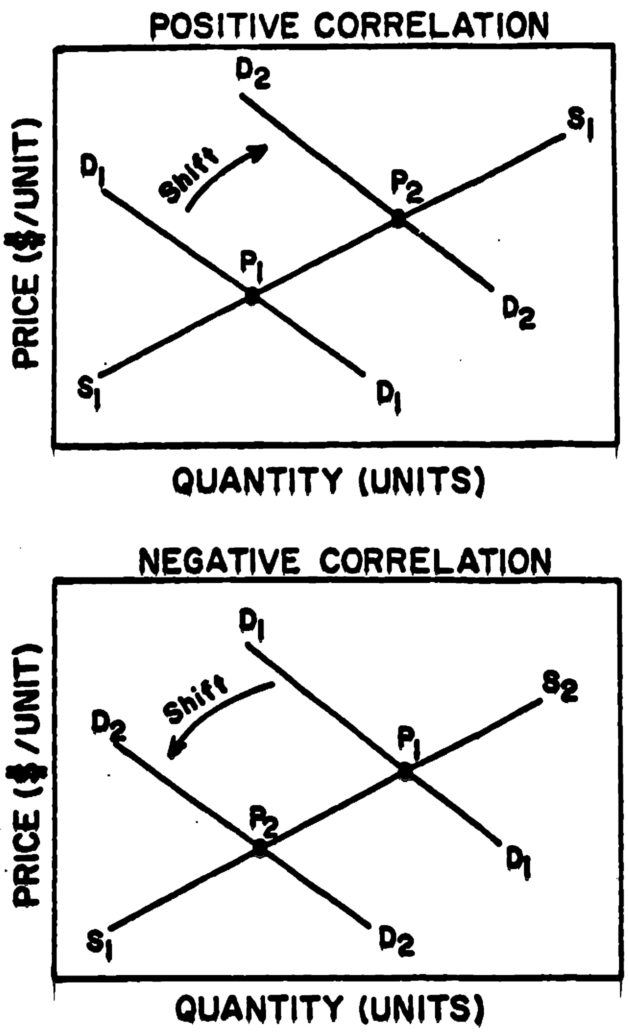


Figure 3-3: Shifts of Demand

with Changes of Price Expectations

Schemes to ensure compatibility with trend

To date, only two schemes have been proposed to incorporate the trend in the buffer stock operation. The first was proposed by Bauer and Paish[20] in 1952. Although they were concerned with a device for buffer funds and not buffer stocks, the principle of their formula is important, since it represents the first attempt ever made to define a reference price accounting for the trend. They proposed to work the Cocoa Buffer fund:

$$S_t = \frac{P_t}{X} + \frac{1}{n}\,\frac{P_{t-1}Q_{t-1} + \ldots + P_{t-n}Q_{t-n} - \dfrac{\bar{P}_{t-1}Q_{t-1}+\ldots+\bar{P}_{t-n}Q_{t-n}}{X}}{\bar{Q}_t}$$

where S_t = reference price for stock operation

P = market price

$\bar{P}_t$ = forecasted market price for year t

Q = volume marketed

$\bar{Q}_t$ = forecasted volume marketed for year t

$\frac{1}{X}$ = fraction of export proceeds paid out the given year (i.e., included in calculation of producer price)

n = number of years on which proceeds are averaged for smoothing and fluctuation

(n and X were determined by Bauer and Paish by considerations of political feasibility and then selected in this range by a rough simulation).

Besides advantages relevant only for buffer funds, this formula has the advantage of self-adjusting for forecast errors, and self-liquidating over the time period n. It also presents the following properties:

- includes information on the long range trend
- accounts for structural changes and exceptional events, since a forecast is included in the formula (use of expected prices) so that there is a provision for not letting any structural imbalance between the reference price and the long term equilibrium price.

Goreux has used this basic idea for his proposal of buffer stocks. However, his formula is more focused on forecasts than on redistributed incomes, since he designed precisely for the case of buffer stocks.

In his study on cocoa,[30] he proposed a five year moving average. This average includes the last two years, the forecasted price for the present year, and the forecasted prices for the two years to come.

$$P^* = \frac{(P_{t-2} + P_{t-1} + \tilde{P}_t + \tilde{P}_{t+1} + \tilde{P}_{t+2})}{5}$$

where P = price

$\tilde{P}$ = forecasted price

t = current year

The forecasts can be done:

-using econometric studies on the given commodity (Goreux did a very thorough econometric study of cocoa, where he determined a price forecast formula for price, based on the two previous years:

$$P_t = aP_{t-2} + bP_{t-1}$$

where $a = 0.7$

$b = 0.3$ (See Reference 30.)

-biases of the Agency doing the regulating operation including estimations of the near future structural changes in demand due to technological change or unexpected random noises, or to the political context (stockpiling of important countries as the United States or the United Kingdom, disruptive sales of other countries, etc.)

This proposal represents the most advanced formula trying to account for all the factors affecting reference price. It does meet all of the requirements enumerated in this chapter.

At this stage, we have to insist, together with Goreux, on the importance of a good forecasting. A bad forecasting method may lead to a policy for the stock that would destabilize rather than stabilize, as shown by Goreux in his simulations on cocoa.[30] It is of course true for other cases, as will be shown in the coming chapter.

Another important point to remind the reader of is the choice of five years as the averaging period in Goreux's formula. As mentioned earlier, it has to be clearly specified for the buffer objectives what fluctuations it is trying to smooth. In the case of cocoa, the cobweb period being twenty years, Goreux concluded that the cost of operation for smoothing around the long term trend would be too expensive and that therefore, the objective of the buffer stock operation would be to smooth fluctuations around the line composed by the trend added to the cobweb average line. Only short term fluctuations have in those conditions to be ironed out. A smoothing period of five years is appropriate, since the cobweb period being twenty years and the trend line showing no periodicity, it may be safely assumed that averaging five years will yield this line. And this will constitute a good reference line to aim at for ironing out short term fluctuations.

For a given commodity, the periods of the cobweb cycle, of the disturbances (if there is one to recognize) and the components of the trend (if they are sensitive to the developed countries' business cycles) have to be examined in order to determine the time horizon of the smoothing function. Then, this will determine:

- whether only short term disturbances or also the cobweb cycles are to be regulated
- the smoothing period to use for the reference price: it has to be greater than at least a complete period of the variations to iron out, and smaller than the period of the line we do not want to modify (trend alone or trend plus cobweb). This point is developed by Forrester[37] (in Industrial Dynamics, Appendix G).

Implementation problems

Environmental aspects

a. Disruption by non-participant countries

The importance of including many nations in any international stabilization agreement is also applicable to the case of buffer stocks. It derives from the possibility of disruptive sales by non-participant countries, which may put a dangerous strain on the resources of the buffer stock. Such has been the case in the unexpected sales of tin by the Soviet Union in 1957, which led the price of tin to go below the floor, leading to a very quick collapse of the tin buffer. At the same time, the Soviet Union also sold important quantities of aluminum which also disturbed the market of the latter. Those sales were not made in a malicious way. This illustrates that disruption is a threat to account for.

Aubrey[32] mentions the fears raised in the late fifties when the Red Bloc initiated purchases of rubber, wool, cotton, sugar, rice and wheat: "The Bloc's oligopolistic capabilities of buying rice and cotton have aroused a lot of apprehension."

b. Stockpiling in the United States and in the United Kingdom

The presence in the United States and in a number of other industrial countries of important stocks of a wide range of commodities is a factor of importance, that the experts of the United Nations quote as very important. Those stocks were accumulated during the strategic stockpiling rush in the 1950 decade (Korean, Suez and Cuba) and because of some domestic stabilization schemes that resulted in accumulation of important stocks of commodity (i.e., wheat). For the commodities of this type, a buffer stock would not be very well advised since the buffer stock function is already carried by the United States. However, in the long run, as the idea of buffer stock progresses, it will be a good thing for the international agency to take over the role of buffer stocks, since the goals of the United States or of any country holding and managing those stocks do not necessarily have to coincide with those of the international community as a whole.

Start up problems

a. Definitional problems

The main definitional problem is to decide which commodities to apply the buffer to: commodities are not homogeneous, and some are more important for the developed countries than others (fuels, raw materials, food, versus clothing materials.) Furthermore, as seen in Chapter 1, not all primary commodity producing countries are developing countries. For example, it would not seem more useful to stabilize income of lard producers before stabilizing income of cocoa or rubber producers. The problem remains to be decided among the developing countries and the commodities they rely upon, which are the ones that ought to be selected first. What will be the criteria that the stabilizing agency should apply to select the first commodity to start and experiment also on?

In theory one could conceive a universal buffer fund, where all commodities would be represented. The main advantage would be self-sufficiency, through diversification, since that is its very definition. This fund could use the profits derived from operation on one commodity to compensate for the loss on others. This is true, since UNCTAD recognized that not all prices vary in the same direction.

b. Strategical problem

The problem of the physical location of the buffer stock is not trivial. If the physical buffer is centralized, there will be no potential problem with controlling that anybody is transgressing the agreement; however, this implies delays in transferring the commodity to its markets, and also hazards.[31] For a number of commodities, including most of the metals, fuels, rubber, etc., there has in effect been some stockpiling for strategic purposes. How to decide where the stock will be involves obvious problems. Therefore, it is to be expected that to protect itself against political and strategic hazards, most countries would either refuse to back the buffer stock in materials or financial resources,[33] or simply adopt policies that would have a disruptive effect, or give lip service to the idea of the stock and still accumulate secret stockpiles,[31] which potentially have a disruptive effect on the market, as the example of tin indicates.

Financing

The very nature of the operations conducted by the fund make it desirable for it to be started during a depression in prices.[8] This is because it would be difficult to initiate policies of stock holdings in times of inflation, and the Agency would have to convince the financial backers of doing so in such a context, while in a context of depression, it may have problems to convince them to finance a device that will have the effect of preventing consumers from taking advantage of depressed prices.[12]

Political problems

The agency in charge of administering the buffer stock will have to have the support and prestige necessary to have the member countries accept open-ended commitments. Yet it is necessary to have open-ended commitments because, as we have seen in the cases of tin, it is a requirement for the better stock to be credible, so that producers and consumers trust that the price will effectively be kept within the price range, so that they do not resort to speculation that will endanger the resources of the Agency. Also, it is necessary to have available enough resources to withstand attacks of speculation in case of necessity. In other words, to be able to mobilize infinite resources, for all intensive purposes, to defend the price range. To this effect, open-ended commitments from all members are needed: a realistic parallel would be the operation of the Bank of England for the whole nineteenth century, where the price of gold did not vary, because everybody recognized that the resources the Bank of England could muster if necessary were almost infinite, so that there was no point in speculating on the price of gold.[12]

For a commodity, the market is of course smaller, and therefore, a smaller volume of resources would probably be necessary. The problem involved here is that politically, from the experience of United Nations influence, it is difficult to imagine how such open-ended commitments to the stock managers could be obtained from the individual governments.[10] It would also be difficult internally for those governments to impose the lowering of prices to their producers following the buffer stock operations. (See the problems of the agricultural common market in Europe.) Also, independence of the stock administrators may be questioned by some countries.

Financial issues

The first and probably most important issue is to decide where the money will be coming from. Until now, most of the stabilizing schemes have left the financing of stocks to the producing countries. Globally this is not necessarily the method likely to yield optimal results, either in equity or in resource allocations.

The accumulation of stocks in a net exporting country does not reflect so much the changes in the commodity situation as much as the production and price policies being pursued in the importing countries; otherwise those stocks could be sold there. A proper distribution of responsibilities for financing and managing stocks and production restraints to keep stockpiling from making unreasonable dimensions ought to be tailored to each particular case. Funds will be necessary at two particular levels:

- to start up the buffer stock
- to cover operating costs, through payments at regular intervals.

An analysis of the financial requirements has therefore to come before implementing the device.

One could argue that by buying when prices are low (by reference to the desired level) and selling when prices are high, the buffer agency is bound to make a profit. (This is true for the Agency because, disposing in theory of infinite resources when necessary, it is certain of keeping the price within the price range it sets for its operations. Therefore this profit it makes is justified by the constraint that it has to have infinite amounts of resources, at least available. This reasoning does not apply to a speculator; in the current situation, before buffer stocks, he takes a risk, since he does not have certainty upon the price it will eventually come to. After implementation of the buffer stock, it will not pay for an investor to speculate since although by doing exactly what the buffer stock does he is bound to realize the same profits, for him transaction or storage costs would probably cancel the expected profit. So, the Agency will realize a certain profit on its open market operations if it is managed in such a way that it is self-liquidating over a reasonable period. This is another point that favors the managing of the stock in a self-liquidating way.

The costs involved are the transaction costs, the physical storage costs and the cost of capital. The cost is based of course not on the actual interest rate paid by the agency for concessional loans, but on the opportunity cost of capital; the reason is that we are interested in the effect on development of the intermational countries.

The first two costs have been found to be negligible in such an analysis by Goreux.[28] Therefore it is argued by some advocates of buffer stocks that after a start up period, the buffer stock would be able to repay its debts and become self sufficient.[28]

The example of tin does not, according to an analysis by Goreux, confirm this argumentation. The tin buffer stock redistributed $22.7 million in profits in the first eight years of operation. This could qualify a buffer stock as a high return investment project. However, the contributions received by the Agency from the member countries were free of interest, and the redistributed profits were therefore equivalent, according to Goreux' calculations, to a 5.5 per cent interest. Taking the opportunity cost of capital in these countries at 10 per cent the cost of opportunities foregone would have been $20 million, assuming of course that there were opportunities for such investment in the given countries. In addition, in the second half of its period, when the strategic stock of the United States had taken over its role, the international stock was practically inoperative. Except for a few months, its stock was depleted.[28] The cash contributions were therefore invested in short term securities. Of the $12.3 million redistributed in profits, $11.6 million accounted for the interest received on those short term securities. Also, tin was a case where production controls were enforced quite easily, which is not the case of the second type of commodity, agricultural ones.

The definition of what kind of stabilization objectives the Agency managing the buffer should have has been described in a previous section.

Only a good simulation model can give an estimate of the annual and initial layout costs for the operations. The cost can be covered in several different ways:

-member countries can provide an initial capital to the Agency: if this is done interest free, the cost to them of these contributions is the opportunity cost of the capital times the capital provided to the Agency.

-supporting agencies can make concessional loans to the buffer stock agency; then, the contribution of the member countries that finance the supporting agencies is equal to the amount of these grants included in these loans.

-member countries can be required to pay an annual contribution to operating expenses, just as citizens of a country pay for public services.

-any combination of those three forms is more likely to emerge in practice.

The level of stabilization desired should determine the cost of the operation desired, rather than the financing available. Therefore, the contributions, loans and grants should not be affected by past outlays. For the same reason, the rate of return of these investments should not depend upon the cost of capital borrowed from IDA (0.75 per cent) or from IBRD (7 per cent). It will, to give an incentive to the buffer managers for efficiency and a limit to the member countries contribution horizon, be well advised to have these loans on a five year repurchasing basis.[28]

Nature of World Bank loan

It seems quite natural to think of the World Bank for providing additional loans when needed. There are two kinds of loans available for such a purpose: IBRD loans or IDA credits. The objective of such loans would be to give breathing space to the Agency and their availability should not be considered as an incentive to keep too high a level of stock indefinitely. Therefore the rate charged to the managers of the buffer stock ought to be high, so to incite them to manage efficiently their stocks. Therefore, the normal rate of 7 per cent for IBRD refinancing loans has been chosen by the World Bank study on financial requirements.[28] A time limit of five years has been set for reimbursements in this feasibility study. As an incentive for good stock management, this study proposes a 3 per cent rate of the first five years of lending; then, to raise this rate to 7 per cent during the next five years; and eventually, to refuse renewal of the loan after ten years.

The World Bank viewpoint has been expressed in the same study: the problem for the bank in financing those operations is not in the magnitude of the disbursement but in the uncertainty of those disbursements. All that could happen if the level of bank involvement is substantial would be that the buffer would have to raise the level of its liquidities on a permanent basis:

-the IBRD can keep most of its balance in short term securities, of which it is expected that the rate of return is not very different from the rate at which the bank borrows long term.

-IDA credits are much more sensitive to uncertainty in disbursements. IDA contributions are released by the Part I countries only at time of disbursement.

As IDA credits are hard to obtain, the solution proposed is: create a special IDA tranche consisting of a line of credit on the Part I countries for buffer stock purposes. Make clear that only one third of the credit is expected to be used on them. Use fully the IDA funds obtained, because they are difficult to obtain and therefore should be fully exploited. And exclude the use of those credits for buffer stock refinancing loans.

The IMF drawing facilities can be supplemented by commercial loans. Since no collateral is required on IMF drawings, the stocks bought with IMF loans could be used as collateral for borrowing from commercial banks.

Currency problem

A potential problem is the currency in which to perform the operations. If the Agency is financed from dollar sources, there is a danger that producing countries would prefer to sell to it at its fixed buying price rather than to other countries at a price which is higher in terms of unconvertible currencies valued at the official rates. The Agency may therefore find itself accumulating unsalable stocks. If the Agency is prepared to sell for inconvertible currencies the original dollar fund will be eventually transformed into useless inconvertible currencies. If those currencies are made convertible to allow the stock to use them for further operations, the purchase of commodities from the buffer stock agency will involve a drain of dollars from the stock to the purchaser; purchasers might be able to avoid it only by purchasing from other countries at a higher price of inconvertible currencies.

Technical problems

There are a few technical problems and questions involved in the design and management of the stock. As those problems will be discussed and simulated in Chapter 5, here we will only give the reader a list of what they are:

-Determination of reference price: use of a forecast rule

-Determination of the price range: what is the width of the band where the buffer stock has to react. The wider it is, the less costly the operation is, but the less accurately it notices changes and reacts to them. Also for a given commodity, a certain level of tolerance can be given by the interested countries.

-Determination of the magnitude of intervention: to correct variances of price from the reference price, the Agency will buy or sell to the limit of its financial and physical resources. Moreover since there are lags involved in the price setting process, the intervention has to be progressive, and in some way, progressive and adapted to the evolution of price.

By how much does the agency want to react for a given deviation of price; on how many interventions does it want to fraction this intervention in order to avoid overreacting?

-As the situation makes the buffer stock come closer to exhaustion of its resources, either physical or financial, should it modify its policies for intervention in order to postpone the time of collapse, or should it just keep the same policy until its resources are exhausted? Is there any short term difference in the way regulation is achieved?

-How important is the magnitude of disturbance the buffer stock is prepared to deal with? As a function of this, what should be the level of safety stocks to keep?

-What is the influence on overall stabilization of increased cost of operation due to stronger reaction to variances?

-What is the influence of noise frequency on the operation? How does it influence cost?

-What is the influence of a good choice of the smoothing parameters in the setting of the reference price?

-What is the influence of a better forecasting in cases of structural changes, or trend?

-What is the cost involved at different levels of stabilization, in trying to stabilize a long cobweb cycle?

CHAPTER 4

SIMULATION OF COMMODITY MARKETS

Introduction

As we have seen in the previous chapters, a wide range of disagreement exists among economists on the important issues on stabilization.

A major reason is that it is very difficult to make a priori general and predictive statements on the consequence of a stabilization policy, where all variables are complexly interrelated. Another problem is that most authors consider that each commodity constitutes a case in itself, and very few general statements are made.

As experimentation is not possible on real systems in this field without potentially dangerous consequences, it seems that simulation is tempting. However, only a very few attempts have been make, and to our knowledge there are only two major contributions: the models of Goreux of cocoa stabilization policies and Meadows' general model of commodity cobweb cycles.

The model of Goreux

Goreux derived a dynamic and stochastic model of the cocoa world market, using econometric methods. The dynamic element reflects simultaneously time lags in the demand, supply responses in the price changes, and the impact on the current level of stocks accumulated. The stochastic element reflects random disturbances in the structural equations:

-A nonlinear, econometric model, very complete, is used to describe the system.

-A series of projection models is used to simulate the impact of alternative stabilization rules, with particular attention to the sensitivity of rules to forecasting errors.

-The objectives were to improve the average level of earnings, to break the medium term cycle, and reduce the amplitude of short term variations.

The findings were the following ones:

1. It does not make sense to try to modify the long term trend in prices by buffer policies alone.

2. Anticyclical planting policies are the most natural and efficient ways of breaking the medium cycle (probably induced by the business cycles in the consuming countries?). However the time phasing of such anticyclical measures is very sensitive to errors in long term forecasting. Increasing the medium and short term production response to prices provides another way of breaking the medium cycle, less efficient than the previous one, but much less demanding in terms of forecasting abilities.

3. The enforcement of uniform expert levies or import taxes can efficiently raise export earnings and dampen the cycle, provided two conditions are fulfilled:

- The proceeds of the levy have to be used exclusively to promote development in sectors other than cocoa.
- The rate of this tax should be highly progressive: nothing in the trough, and big in the peaks.

4. An international buffer stock can substantially reduce short term fluctuations at low cost provided the policy is not to interfere with the long term movements. The following rule of intervention is proposed: the reference price is the moving average of price the two previous years, and current forecasts for price this year and the next two years. The agency starts to sell whenever the difference between market price and reference price exceeds a given margin, for example, plus or minus 1.5 per cent. The intervention is progressive and its magnitude should depend upon the level of stocks already accumulated.

The application of this rule was tested on a simulated thirty-three year period with three types of stochastic models simulating the cocoa world market.

With the long term (thirty years cobweb cycle) being dampened through anticyclical production and tax policies, the buffer stock operation proved to be feasible even in the case of systematic forecasting errors. In this case, with a level of stock equal in average to 5 per cent of world annual production, the amplitude of the fluctuations was reduced by some 50 per cent.

The financial feasibility study shows also that at a 96 per cent probability level, the agency should reimburse its initial funding in five years (see Chapter 3).

Review of Goreux methodology and findings

The methodology used by Goreux is extremely valuable, and so are his findings. Specifically, he exhibits several strong points that are to be stressed:

- his idea of using simulation methods not for applied predictive purposes, but for comparing the time behavior of prices and incomes under alternate policies
- his recognition of the difference between short term and long term policies as for feasibility of buffer stocks
- his explicit recognition and analysis of the sensitivity of such a device to any kind of forecasting errors
- his use of an adaptive reference price that follows up the trend of prices.

However, the very methodology of this model implies some weakness which may hamper its further application to the field:

1. The value of a parameter in a model can be basically obtained by two methods:

a. Measuring elements in the real system, or estimating them through the Delphi method or any other that seems appropriate in a given case.

b. By statistical inference from time series in the real world.

While the former method is less accurate a priori, it allows a much greater flexibility in specifying the structure of the model under conditions different from those for which data are available. For example, should a new cocoa tree be discovered that maturates in half the time of the present one, the Goreux model could not give any relevant information on the impact of this on the cocoa cycle period or stabilization devices, since its econometric equations are based on past data and no data would be available with this new kind of tree. If one decided then to use the Goreux model with one estimated equation, keeping the other ones, the whole point of collection and analysis of the other equations would probably disappear.

2. Similarly, the Goreux model precludes any kind of sensitivity analysis on the values of the key parameters, which is useful to test the credibility of validation of the model.

3. It seems that the model of Goreux could also be improved to include a couple of interactions between the control system and policy decisions, such as:

- the effect of stabilization on the supply schedule: the quantity offered should increase at a given price with more stabilization
- the decrease of stocks of consumers who shift the burden of stockholding to the agency
- price stability may decrease the incentives for some technological advances that through improvement of productivity or substitution of synthetics, decrease the level of consumption.

The cobweb model of Meadows

While Goreux proceeds from the thorough study of the cocoa case, Meadows adopted the opposite approach: he did a very complete study of the cobweb cycle, and managed to reformulate the classical cobweb theorem in such a way that it now accounts for the real world.

The static cobweb theorem

The Cobweb Theorem is familiar to all economists;[5] it tries to explain the periodic behavior of commodity prices. Its limiting hypothesis are due to its essentially static nature:

- producers act as if their decisions will not influence prices in the future
- producers do consider the last existing price of the market as to be the prevailing price indefinitely in the future
- production, consumption and inventory decisions can be summarized

by supply and demand schedules, which are both only a function of price

- the continuous evolution of an economic system can be meaningfully divided into segments each equal in length between initiation of production and ultimate availability of the commodity
- price adjusts in each period so that supply and demand are equated for the period
- one irrevocable production decision is made in each period on the basis of, and only of, the current expected price which is the current price
- production initiated in one period is only and wholly available in the next.

This description is not a priori realistic. However, following a line of argument by M. Friedman,[34] only the predictive value is relevant, not the realism of hypotheses. If those hypotheses lead to a valid representation of the real world, the model is to be considered as valid.

Unfortunately, this is not the case: the static cobweb theorem predicts a period equal to twice the production time (see Figure 4-1). This is not true for the well known hog cycle in the United States, where the period of the cycle is forty-eight months instead of twenty-four predicted by the static cobweb based on a production delay of twelve months.

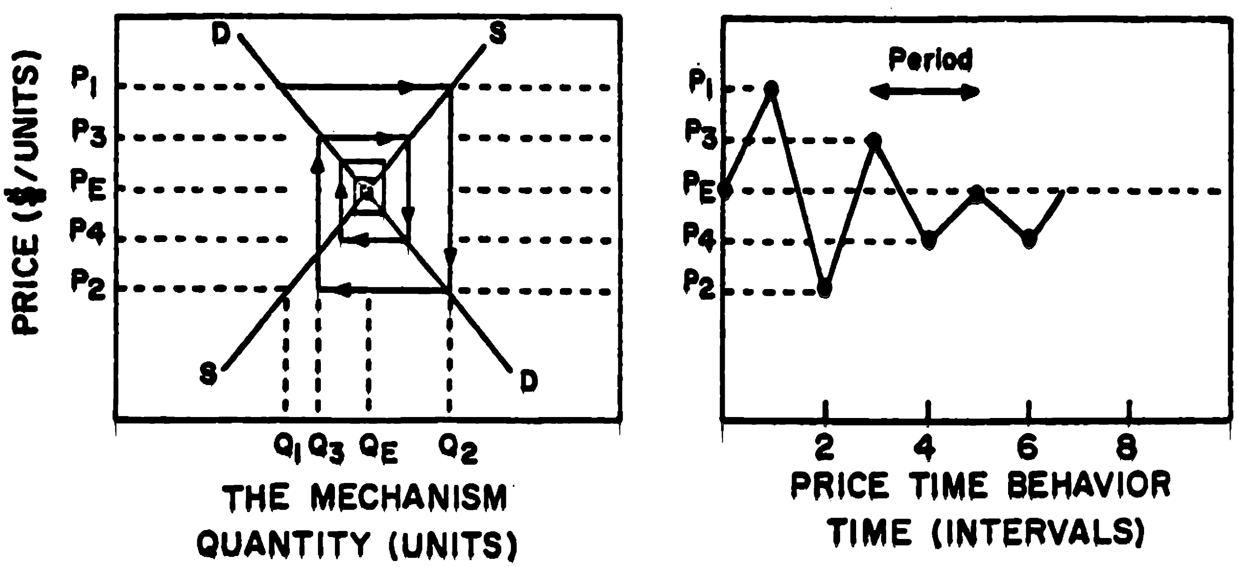


Figure 4-1: Classical Cobweb Theory

The dynamic cobweb theorem

In moving from static mathematical analysis to simulation, all practical constraints on the complexity of the economic model are lifted:

-producers may use any function of current and past prices to form their expectations about prices in the future

-in the short term, an inventory of processed commodity exists in order to decouple production and consumption in the short run

-the methodology shifts from a "time interval" to a rate form of analysis. Production and consumption are supposed to adjust continuously to price changes, not abruptly from the equilibrium point from one period to another

-price is determined by those who hold inventories through interaction with producers and consumers. Price will depend upon marginal cost of carrying inventories versus marginal revenue of selling it (see Figures 4-2 and 4-2a).

-delays important in the behavior of real commodities are explicitly included:

formation of producer's price expectations

determination of the appropriate response

acquisition of the productive capital

production or maturation of the commodity

forecasting of producer's future prices

forecasting of consumption rate

recognizing detail prices.

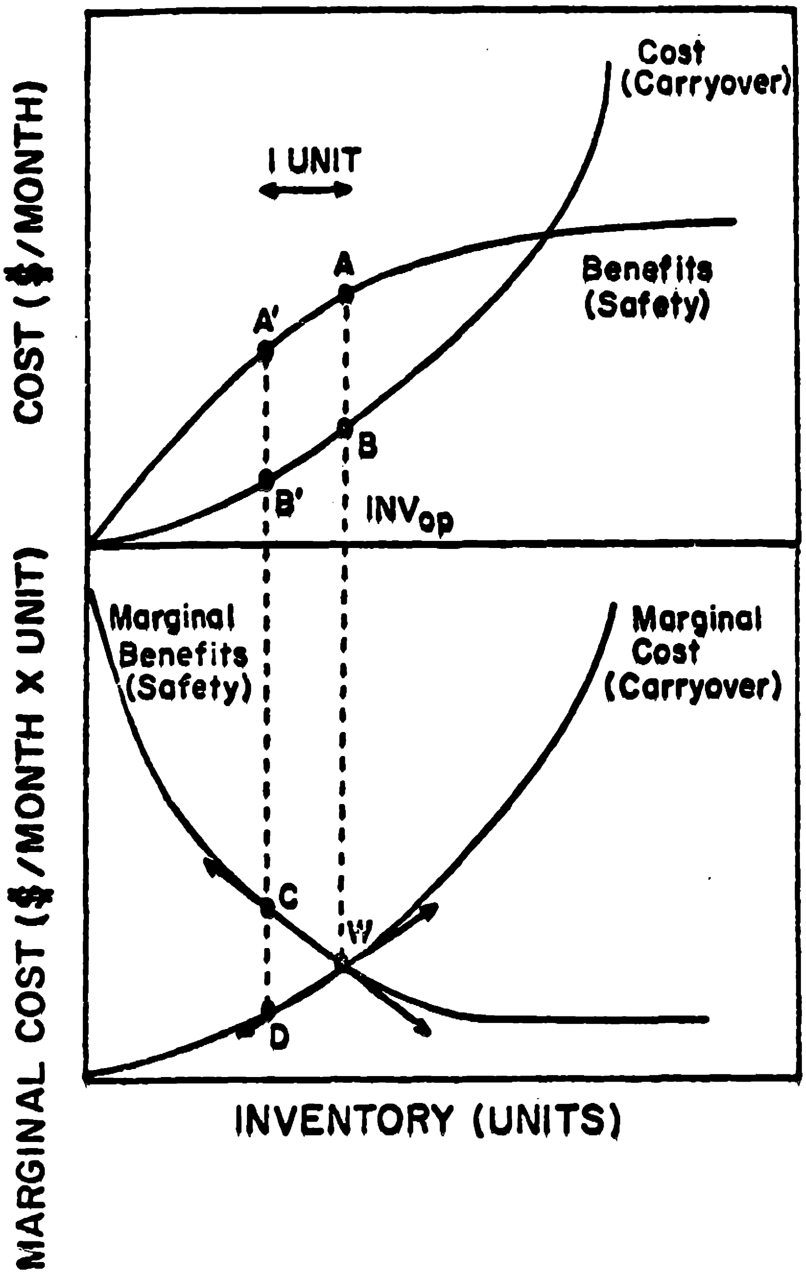


Figure 4-2: Price Asked versus Level of Inventories

(See Appendix 8)

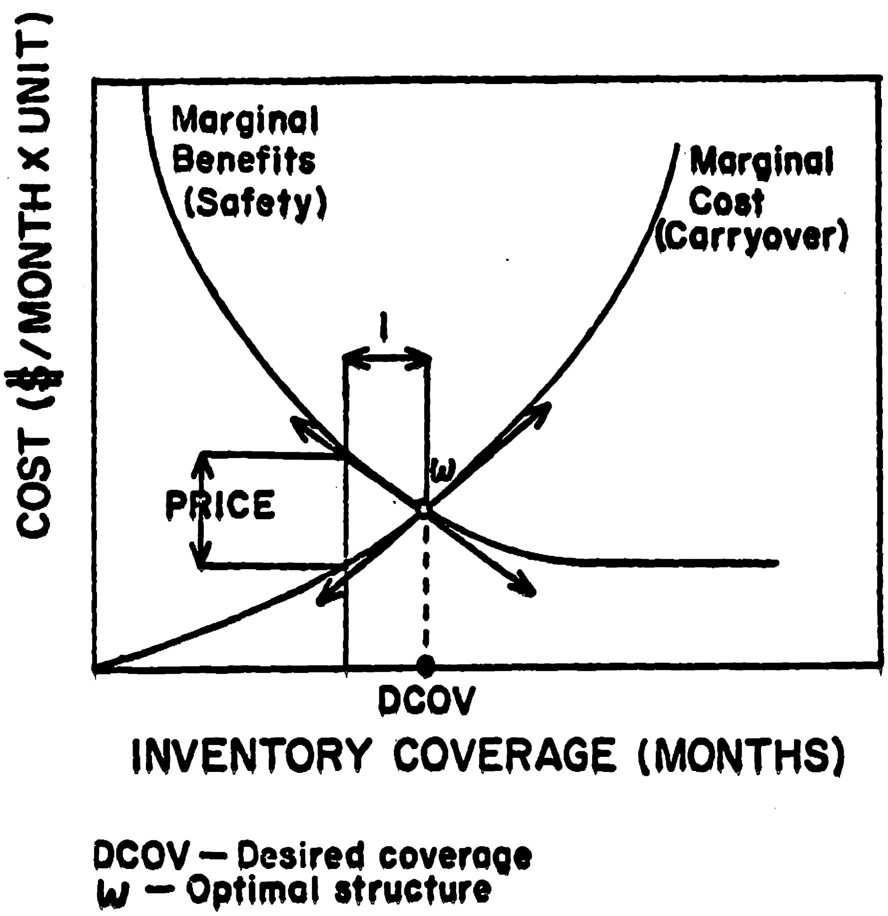


Figure 4-2a: Price Asked versus Inventory Coverage

Figure 4-3 illustrates the basic structure of Meadows' model. In economic terminology the model of Meadows expresses the following analysis:

Long run supply schedule

Production capacity is adjusted by producers as a function of their price expectations for the future. They do plan their reactions to recognized price changes and forecasts so that long run marginal cost of production equals expected long run price.

Short run supply schedule

This is done through the inventory holders. Meadows aggregates the inventory holders, whether they are producers, consumers or speculators.

At a given consumption rate, between inventory level and price in the short run, there is a very strong correlation (see Weymar[35]). As shown in Figure 4-2 there are costs involved in carrying the inventory: physical storage costs, opportunity costs of capital, etc. There is also a benefit (negative cost) associated with the safety that is provided by the presence of stocks. A measure of this safety is the time period covered by the inventory level for a given rate of demand. At a given level of inventories, a change of this level by one unit will change the costs by the difference between the increase of carrying cost and the increase of benefit (negative cost) provided by safety. The price at which the inventory holders will sell is therefore such that it covers

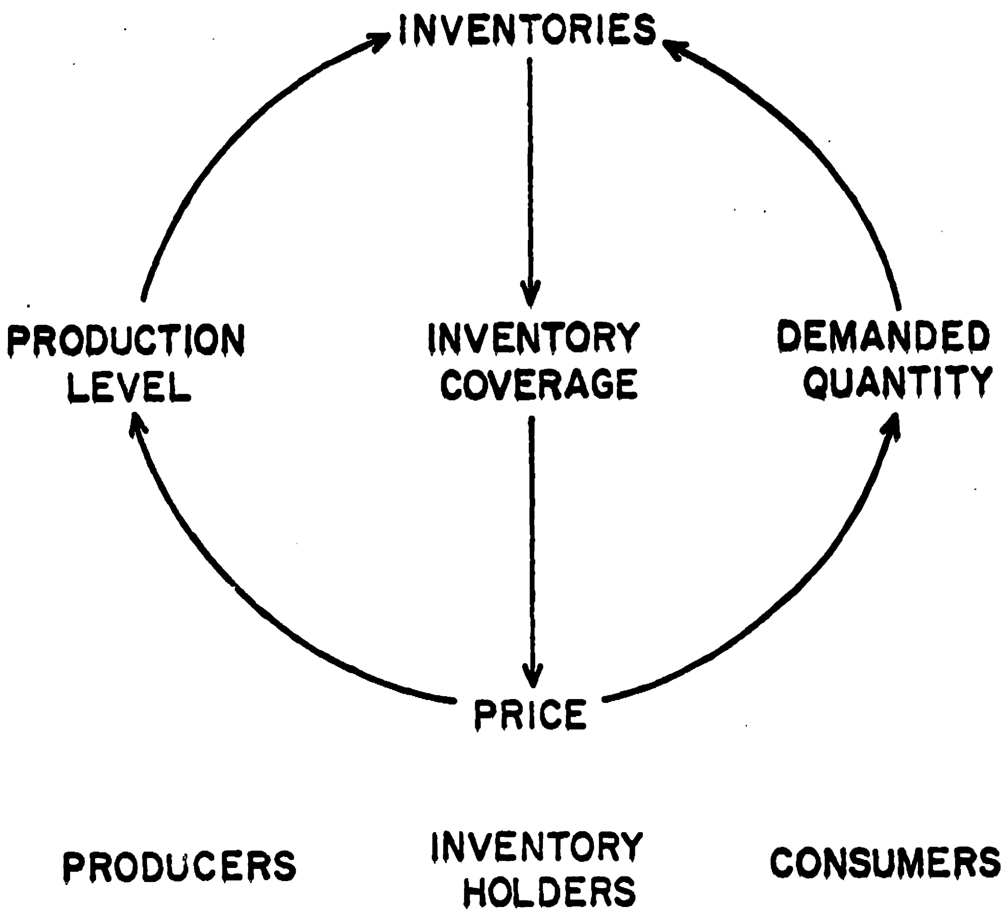


Figure 4-3: Meadows' Model

the change in costs associated, in other words the marginal cost (in algebraic terms) of this decrease of inventory level by one unit. Therefore price and inventory level, at a given level of demand, are very strongly correlated, since there is a causal relationship: price equals marginal cost of carrying inventory minus marginal benefit of safety. (See Figures 4-2 and 4-2a.)

That reasoning was done assuming a constant level of demand. However, the benefit curve is actually relating coverage (inventory scaled by the expected demand) and benefits. On the other hand, costs of carrying inventories are also to scale to the inventory coverage, since the physical facilities of storage have to be adapted to what the desired inventory level (in relation to a desired inventory coverage) is. This desired level is of course the one that equals marginal cost of carrying inventory and marginal benefit of safety.

Therefore it makes more sense to correlate price and inventory coverage; however it is to be expected then that correlation will not be as perfect. Since expected consumption is to some extent a function of price, the relationship between either price and inventory level, or price and inventory divided by expected consumption cannot be exactly parallel. The principle of this relationship holds, however, since one may assume that the physical storage facilities for the commodity are adapted to demand level and to desired coverage ratio, so that the relationship between coverage and cost of carrying corresponds to a reality.

The conclusion is that it is possible to define the short run supply curve as the marginal cost of holding inventories. This is true for all inventory holders, whoever they are, producers, consumers or speculators.

Demand

The demand schedule is actually the sum of two components.

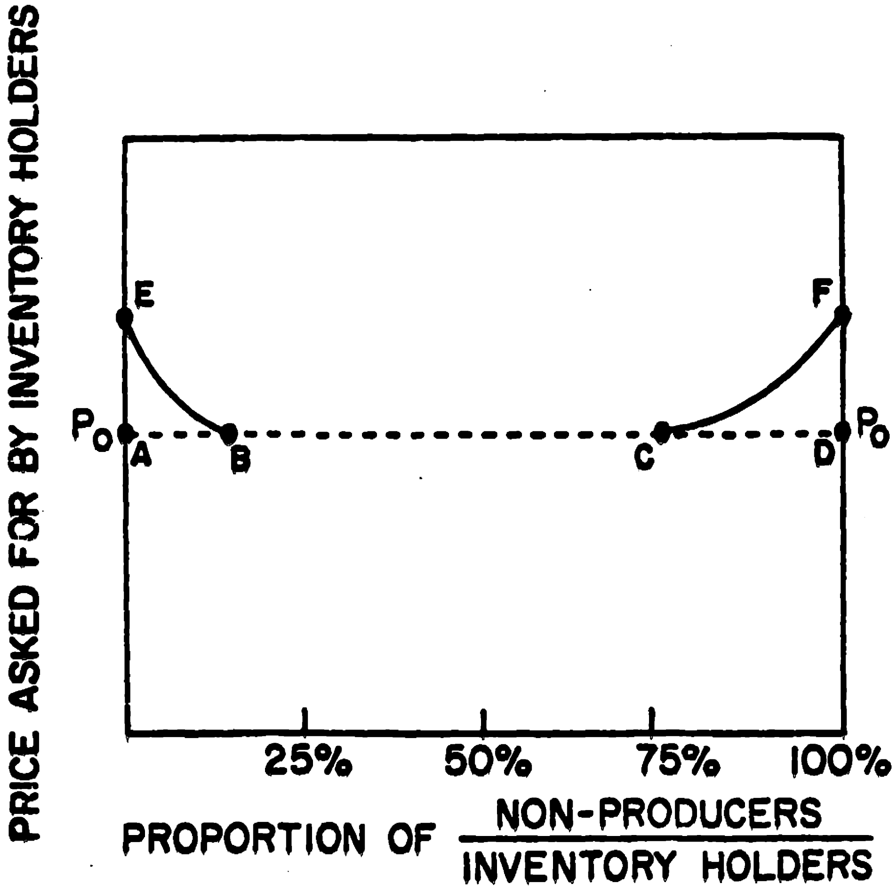
1. Demand for consumption.

It is a direct function of present market price, as expressing that marginal utility equates price.

2. Demand for stocks.

As widely recognized in the previous chapters, the demand for stocks schedule shifts with expectations due to price changes. Meadows aggregated the effect of those stocks with producers' inventories. This corresponds to the following hypothesis:

a. Whatever the mix of inventory holders between purely producer held stock to stocks purely held by speculators, the price-inventory coverage relationship is unchanged. Actually, this relationship is probably expressed by the second curve in Figure 4-4. The hypothesis of Meadows means that, in practice, we will be in a narrow range of mix, and even when we move away from this region, we stay away from the bounds where those problems



Meadows' Model: ABCD

Price asked for as independent of who owns inventories.

Real World

EB: Producers almost Monopolizing sotcks. They ask for a higher price.

BC: Normal situation.

CF: Speculators have taken over existing inventories, asking higher price.

Figure 4-4: Meadows' Hypotheses:

Influence of Nonproducers Holding Inventory occur. This is probably true on the average over the length of time involved in most production cycles; for example, fourteen years for mercury, twenty years for cocoa, four years for pork.

b. In the model, inventories by nonproducers will have an influence only in this section of the process: demand for inventories is determined by the price history, and has only the effect of transferring ownership of some physical inventories from the producers to them. It therefore has, in the way the model analyzes the process, no influence. (See Figure 4-5.)

Review

Meadows developed a new methodology, which he applied to a model that he validated for agricultural commodities: he used it to explain the time behavior of prices of hog, cattle and poultry in the United States. However, he did not validate his model for the other type of commodities, the minerals. This is an important point, since as seen in Chapter 2, minerals exhibit the positive correlation between price and volume representative of the stock formation by nonproducers to protect themselves against further price changes. Therefore, validation for the model of Meadows for a mineral commodity is necessary, if one is to use his model for further applications, since it would allow us to test the validity of his assumption on price-inventory coverage relationship.

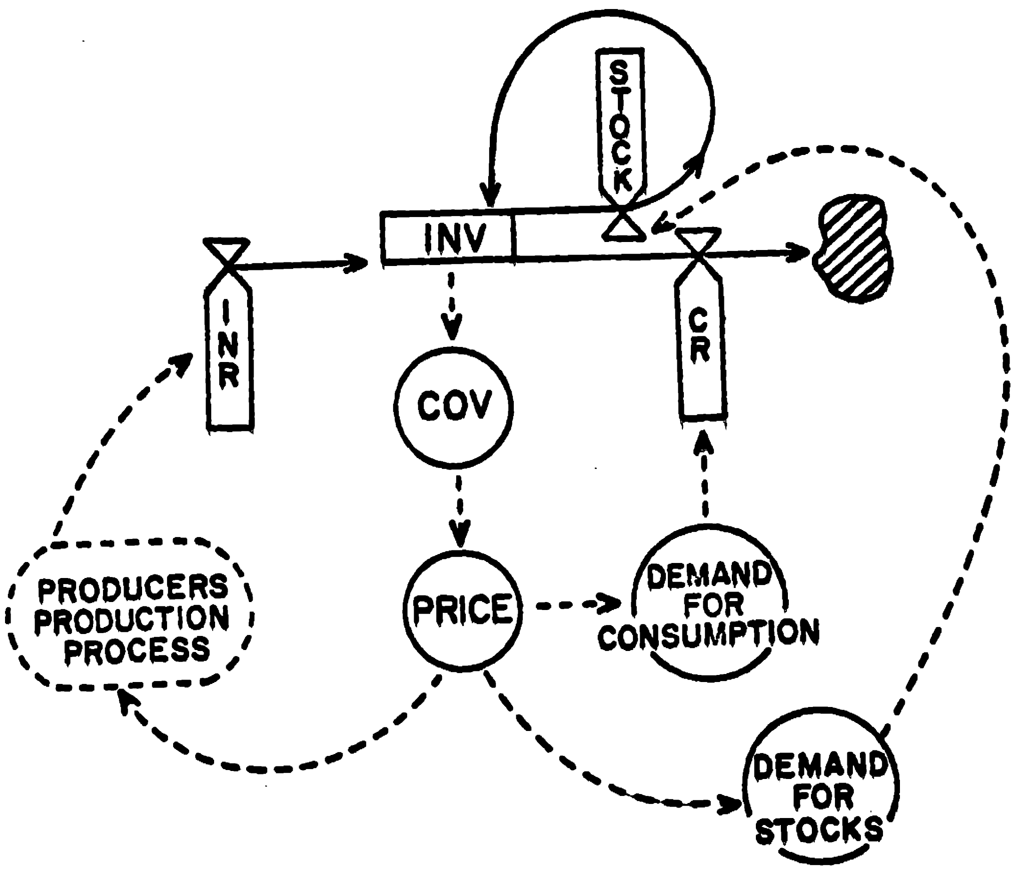


Figure 4-5: Meadows' Hypothesis on Inventory Ownership

(See Appendix 5)

His major contribution is to have developed a new methodology to tackle commodity problems:

- Simulation should be made the dominant mode of commodity research.
- He showed explicitly that the ranking of policy alternative is generally sensitive to only a few assumptions in the model. For instance, in the case of this cobweb model, the crucial hypothesis is the one concerning the private inventory coverage relationship.
- Since equilibrium is never reached in practice, transient behavior in economic systems is much more relevant, as are the stability characteristics of the system, for example, period damping factor.
- Dynamic, nonlinear complex economic systems models required to evaluate systems are possible.

The validation of Meadows' model

The original model is given in Appendix 9. The reader is referred to Meadows[6] to have a complete description of the model. Here it will be tested for its ability to explain the market price periodicity of the mercury commodity market . (See Figure 1-3.)

Concept of model validity

Forrester[36] has presented a complete discussion of validation of socio-economic models. His main points are as follows: a model is useless unless it represents some simplification of reality. Validity is therefore only a relative concept. As random influences are important in practice, there is not much point in trying to achieve point predictions for individual parameters in the system. A more useful criterion of validity may be a comparison of the dynamic behaviors of the model and the real system. Phase relationships, relative magnitudes, periods and rates of parameter change are important.

Complex systems problems are generally expressed in terms of some undesirable behavior phenomena. Therefore the model should reproduce at least the behavior phenomena it has been constructed to understand or alter. Of course a model must pass that test without any additional assumption not corresponding to the characteristic of the system just being modeled. Therefore, Meadows' model when its coefficients are altered to values representative of mercury has to exhibit the long term periodicity and phase relationships of mercury. The cycle period, as seen in Figure 1-3, is thirteen years.

Mercury

Generalities on the mercury industry

Mercury is a metal with a wide variety of industrial uses, mainly for batteries, mildew proofing paint, and electrolitic preparation of chlorine and caustic soda. Supply is fairly concentrated. The third largest producing countries, Spain, Italy and the Union of Soviet Socialist Republics, account for some 50 per cent of the world supply.

Exploration is not a very important factor in supply. The market for mercury is not perfect. Only 10 per cent of mercury is sold at a firm price; the remaining 90 per cent is sold at the price determined by the marginal 10 per cent, sold at a firm price; therefore there is some oligopolistic price setting involved, and inventories are of great influence since they are influencing a market restricted to 10 per cent. The United States Government (GSA) is a major buyer and seller of mercury for stockpiling purposes.

There also exists a secondary supply: it includes all recyclage (scrap). Demand consists of a great number of small buyers (the largest United States buyer, Mallory Battery Company, accounts for only 18 per cent of United States purchases).[37]

There is as already mentioned a thirteen year cobweb cycle, as evidenced by Figure 1-3, and the phase lag between price and productive capacity is five years; those two facts will allow us to proceed to the validation.

The mercury model

A printing of the model's equations is given in Appendix 10. A flowchart is given in Figure 4-6.

A. Verbal and quantitative description

1. Inventory of mercury

There are many organizations involved in the flow of primary mercury from production to consumption. Each of those entities holds an

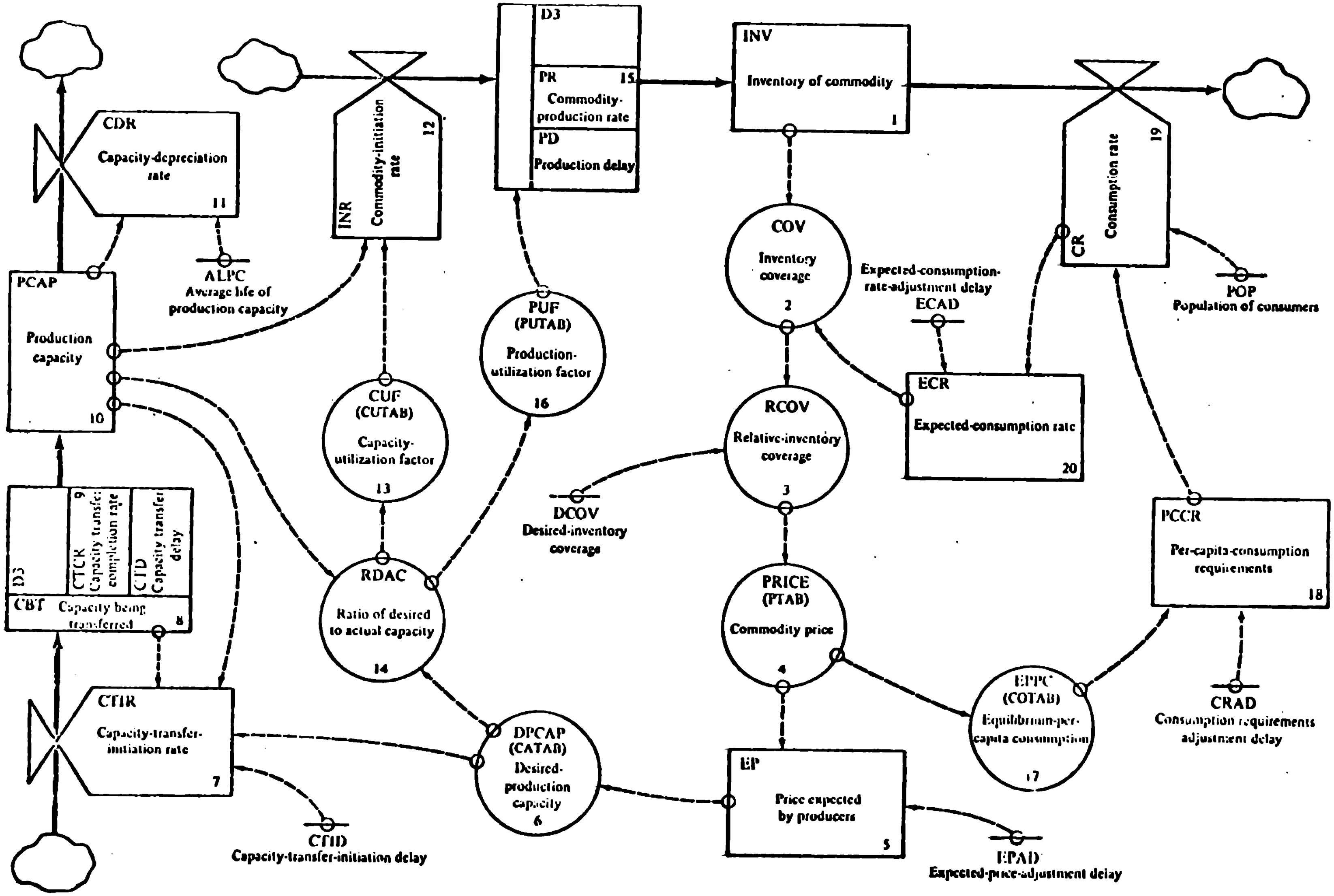


Figure 4-6: Flowchart of Meadow's Model

inventory of mercury in one or more forms: producers' stocks, consumer stocks, dealer stocks, speculators' stock and excess government stocks. In the model all those inventories are aggregated in one huge pool called the inventory of mercury.

The addition to inventory comes from production of primary mercury that increases the pool of available mercury. The decrease of this pool, as assumed by the model, can only come from purchases made for consumption purposes.

INV.K = INV.J + (PR.JK - CR.JK)

INV = INVN

INVN = 136000 flasks Value chosen to start at equilibrium with all other values equals average on one cycle.

INV inventory of mercury; flasks

PR production of primary mercury rate; flasks per month

CR consumption rate of mercury; flasks per month

INVN initial inventory of mercury; flasks (data for 1961, References 37, 38 and 39)

2. Inventory coverage

Inventory coverage is the ratio of current stocks to the expected consumption rate.

COV.K = INV.K/ECR.K

COV coverage provided by inventory; months

ECR expected consumption rate; flasks per month

INV inventory of mercury; flasks

This is ignoring the role of future contracts in providing coverages. However, since those cycles did exist long before the availability of future contracts, and are very long relative to the length of any future contracts, it is a justified simplification.

3. Relative inventory coverage

Relative coverage, the ratio of actual coverage to that desired, measures the relative desirability of current inventory levels. We took the average of inventory coverage during one whole cycle (1951 through 1965) and found that the average stock of mercury was 80,000 flasks; the average consumption rate was 13,500 flasks per month. Therefore if we assume that the desired coverage is the one that the inventory holders held for this complete cycle, desired coverage is 5.93 months.

RCOV.K = COV.K/DCOV

RCOV relative coverage provided by inventory; dimensionless

COV coverage provided by inventory; months

DCOV desired coverage provided by inventory; months

4. Mercury price

As explained extensively in the previous section, we represent the price that inventory holders will accept to sell a unit (flask) of mercury as a function of relative coverage. We cannot expect however to have a perfect correlation, for the reasons exposed in the previous section and also because in the particular case of mercury, we do not take into account in price formation the influence of secondary supply which is perfectly correlated to price actually, as shown in Figure 4-7, but also of releases from government stockpiles. The latter factor has become important since 1951,[35] but those sales have been essentially made to try to stabilize the market. As we do not have the necessary data to represent those in the model, that explains why the correlation between relative coverage computed on the basis of inventory, including consumers', dealers' and producers' stocks only (not the share of government stockpiles used as a buffer stock, so to speak), and price is not perfect. It is however quite satisfactory, as seen in Figure 4-8. Table 4-1 uses data from Reference 37 and 38 for values of stocks, consumption, price. The computations are straightforward. (ECR has been computed using an exponential smoothing on six months on the data.)

It follows:

PRICE.K = TABHL (PTAB, RCOV.K, 0, 5.994, 0.333)

PTAB = 1000/450/280/253/210/195/170/150/130/120/105/90/80/70/60/
50/40/30/20

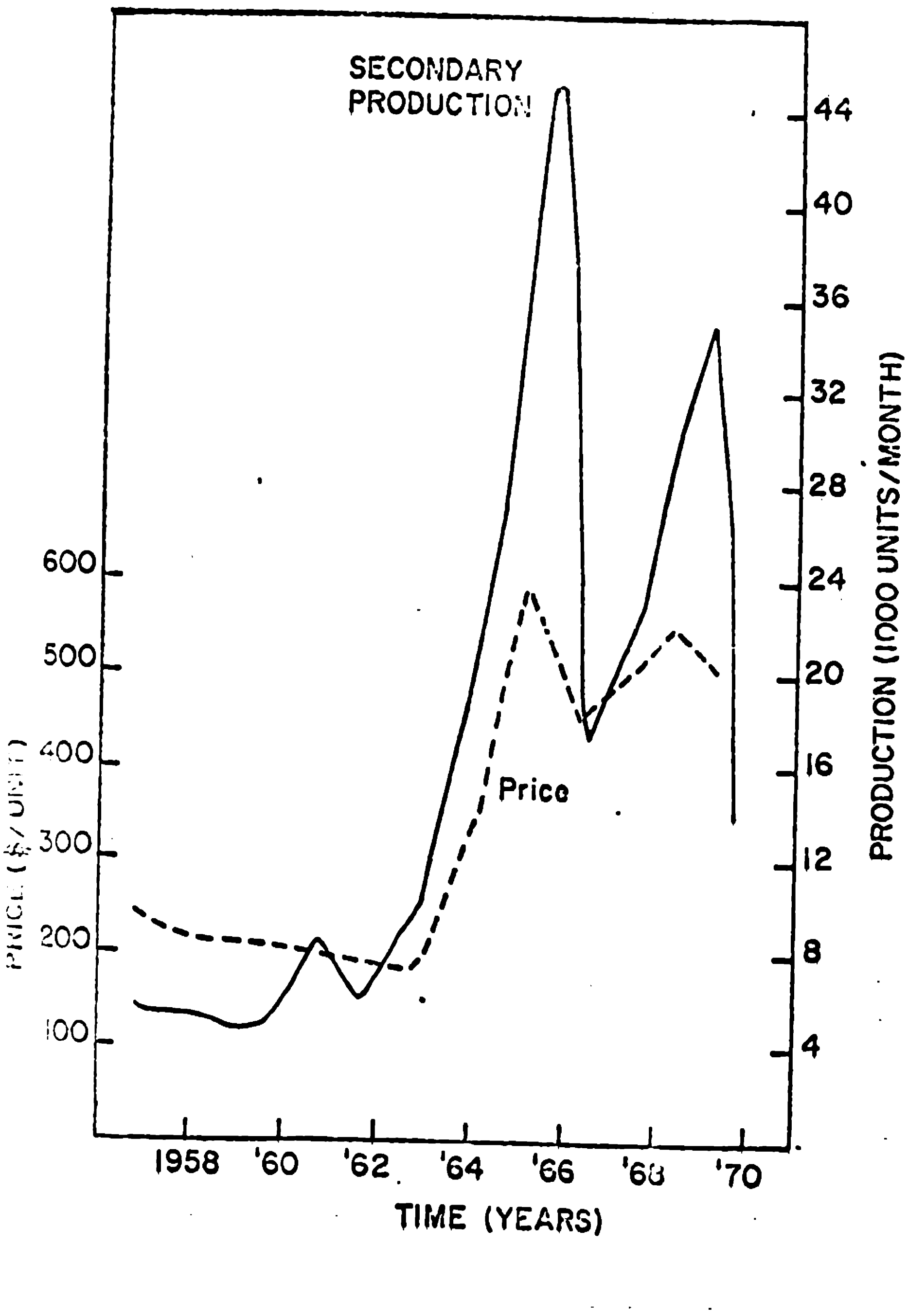


Figure 4-7: Mercury: Correlation of Secondary Production with Price

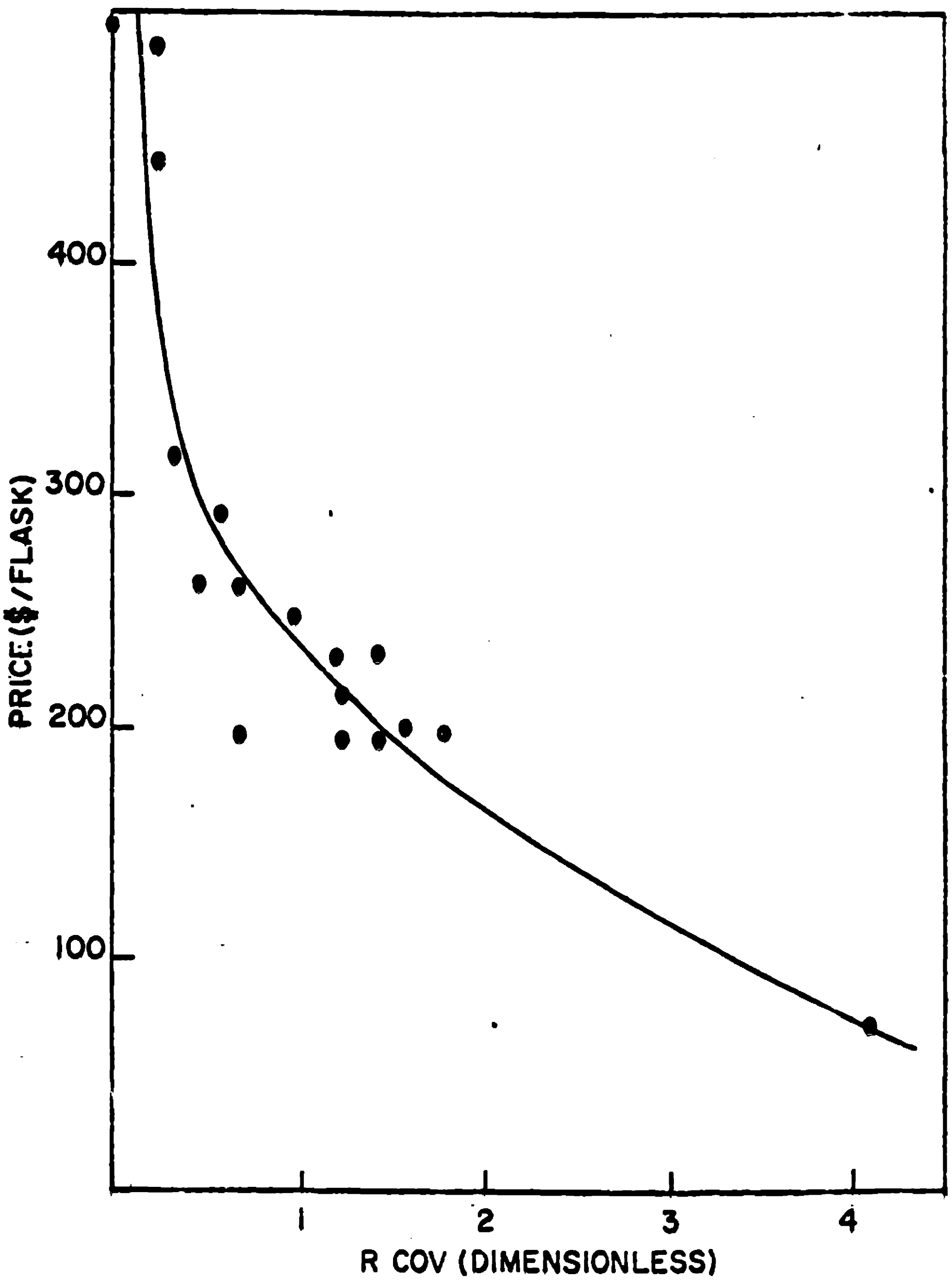


Figure 4-8: Price Inventory Coverage Relationship

Year	Stocks (Thousands of Flasks) Producers, Fl.***	Others,* Fl.	Total,** Fl.	ECR, Fl./mo.	COV, mo.	RCOV****	P, $/Fl.
52	75	50.0	125.0	12.0	10.40	1.60	200
53	45	35.0	80.0	12.1	6.36	1.10	193
54	15	30.0	46.0	12.2	3.85	0.60	264
55	22	15.0	47.0	12.3	3.84	0.58	290
56	4	30.0	34.0	12.4	2.32	0.43	260
57	40	31.5	71.5	12.5	5.70	0.90	247
58	87	20.0	107.0	13.0	8.20	1.25	299
59	90	25.0	117.0	13.2	8.90	1.40	227
60	72	35.0	107.0	13.8	7.80	1.20	210
61	87	30.0	117.0	13.3	8.90	1.40	197
62	99	30.0	125.0	13.5	9.50	1.50	191
63	53	20.0	75.0	14.0	5.30	0.83	190
64	19	25.0	44.0	15.4	2.85	0.45	313
65	12	23.0	35.0	17.5	2.00	0.30	571
66	22	30.0	52.0	20.0	2.60	0.40	441

* Consumers and Dealers
** Government Stockpiles not included
*** Flasks of 75 pounds
**** DCOV = 5.33 months

Table 4-1: Data on Mercury
(Source: Reference 4)

PRICE mercury price; dollars per flask

PTAB table of mercury price; dollars per flask

RCOV relative coverage provided by inventory; dimensionless

5. Producers' expected price for the long run

As clearly demonstrated by Meadows (Chapter 5), producers do use past historical data to form their expectations for future prices. Also Rohlfs[37] states that prices five years old have still an influence, and it is safe to assume that prices ten years old play a negligible influence. Therefore, expressing the forecasting by an exponential smoothing (see Forrester[36]) we could determine the expectations delay; using a Nerlovian expectation model with B = 1/72, i.e., that the expectation adjustment delay is seventy-two months. Setting EPAD = 72 means essentially that prices occurring more than seventy-two months earlier carry essentially no weight.

EPN = 210

EPAD = 72 months

EP.K = EP.J + (DT)(PRICE.J - EP.J)/EPAD

EP expected price by producers; dollars per flask

PRICE price; dollars per flask

EPAD producer expectations adjustment delay; months

6. Expected consumption rate (done by inventory holders)

The expected consumption rate by inventory holders can reasonably be taken as the average monthly consumption over the desired coverage period: six months.

ECR.K = ECR.J + (DT)(CR.JK - ECR.J)/ECAD

ECR expected consumption rate; flasks per month

CR consumption rate; flasks per month

ECAD expectation adjustment delay; months

ECAD = six months

ECRN = 17,000

(Data 1961, Reference 38)

7. Long run supply

Producers try to build up a production capacity so that their long run marginal cost equals expected price. According to Rohlfs[32] the elasticity of the long run supply curve is 0.53. As we also know that the curve goes through the point giving desired productive capacity of 17,000 flasks per month for a price of $210 per month, assuming the elasticity constant we can draw the relationship. (See Figure 4-9.)

Elasticity (constant) = 0.53

Passes through 1961 data point (210, 17,000)

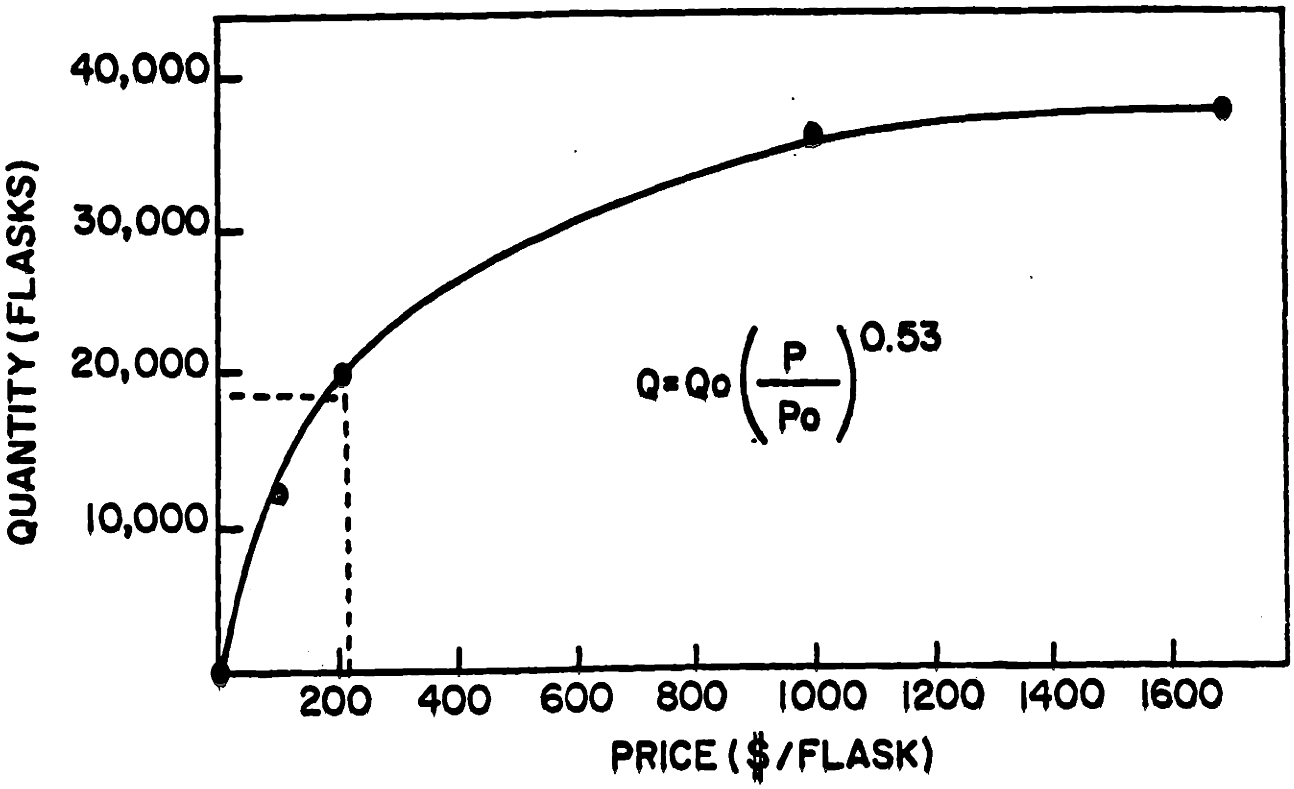


Figure 4-9: Desired Productive Capacity Versus Price

(See Appendices 9 and 10)

DPCAP.K = TABHL (CATAB, EP.K, 100, 1600, 100)

CATAB = 12000/16500/22000/26000/30000/32000/33500/34500/35000/
35400/35750/36050/36300/36550/36750/36950

DPCAP desired productive capacity; flasks per month

EP expected price by producers; dollars per flask

CATAB table of desired production capacity; flasks per month

8. Capacity transfer initiation rate

Additional resources are required to increase productive capacity. Competition for those resources will prevent producers from immediately acting to reestablish capacity. It is assumed that resources will be diverted to help this transfer in proportion to the difference between desired capacity and the sum of capacity already available or being transferred. The degree of competition for the necessary resources determines the transfer initiation delay: it is estimated here at twelve months, which matches the other reaction delays.

CTIR.KL = (DPCAP.K - PCAP.K - CBT.K)/CTID

CTID = 12

CTIR capacity transfer initiation rate; flasks per month squared

DPCAP desired production capacity; flasks per month

PCAP production capacity; flasks per month

CBT capacity being transferred; flasks per month.

CTID capacity transfer initiation delay; months

Because of software limitations, direct reference to the contents of the transfer delay is possible only through an additional level, capacity being transferred.

CBT.K = CBT.J + (DT)(CTIR.JK - CTCR.JK)

CBTN = (CTID[DPCAP - PCAP])/(1 + CTID)

CBT capacity being transferred; flasks per month

CTIR capacity transfer initiation rate; flasks per month squared

CTCR capacity transfer completion rate; flasks per month squared

CBTN initial value of CBT; flasks per month squared

CTID capacity transfer initiation delay; months

DPCAP desired productive capacity; flasks per month

PCAP productive capacity; flasks per month

9. Capacity transfer completion rate

The new capacity will be transformed into production after some transfer delay. Therefore we can say that

CTCR = DELAY3(CTIR.JK, CTD)

CTD = 12

CTCR capacity transfer completion rate; flasks per month squared

CTIR capacity transfer initiation rate; flasks per month squared

CTD delay to open new shafts; months

10. Production capacity

Capacity is measured in terms of potential maximum output per month.

PCAP.K = PCAP.J + (DT)(CTCR.JK - CDR.JK)

PCAPN = 17,000

PCAP production capacity; flasks per month

CTCR capacity transfer completion rate; flasks per month squared

CDR capacity depreciation rate; flasks per month squared

PCAPN initial value of PCAP; flasks per month

(See 1961 data, reference 38)

11. Capacity depreciation rate

CDR.KL = PCAP.K/ALPC

ALPC = 1200

CDR capacity depreciation rate; flasks per month squared

PCAP productive capacity; flasks per month

ALPC average life of mine; months

We assume that depletion is not important over the course of one cycle and we therefore set it approximately equal to zero, that is

ALPC = 1200 months.

12. Initiation rate

Capacity being measured in flasks per month, the initiation rate is simply equal to production capacity multiplied by the capacity utilization factor.

INR.K = (PCAP.K)(CUF.K)

INR initiation rate; flasks per month

PCAP production capacity; flasks per month

CUF capacity utilization factor; dimensionless

13. Utilization factors

Utilization of the mining facilities costs relatively little more than to maintain it running (if one defines production capacity within reasonable bounds, since as one comes close to maximum capacity, costs tend to increase a lot). Therefore producers will tend to use their total production capacity, unless there are extraordinary circumstances. Here we assumed that the productive capacity is used at 100 per cent whatever the ratio of desired to actual capacity.

CUF.K = TABHL (CUTAB, RDAC.K, 0, 5.994, 0.333)

CUF capacity utilization factor; dimensionless

CUTAB table of capacity utilization; dimensionless

RDAC ratio of desired to actual capacity; dimensionless

RDAC = DPCAP.K/PCAP.K

CUTAB = 1/1/1/1/1/1/1/1/1/1/1/1/1

RDAC ratio of desired to actual capacity; dimensionless

DPCAP desired production capacity; flasks per month

PCAP production capacity; flasks per month

CUTAB table of capacity utilization; dimensionless

14. Production rate

Between initiation of mercury production and production, the delay is negligible. We however assumed that an average of one month is necessary to bring it into the inventory pool. We assume that the distribution around this delay is distributed like a third order delay.

PR.KL = DELAY3(INR.JK, PD)

PD = 1

PR production rate; flasks per month

INR initiation rate; flasks per month

PD production delay; months

15. Equilibrium per capita consumption

It is simply the demand curve for mercury. It has been determined by assuming that the elasticity of -0.29 measured by Rohlfs[37] is constant in the range of price of interest, and using the fact that it includes the point: consumption rate 17,000 flasks per month and price 210 (initial equilibrium with 1961 data). (See Figure 4-10.)

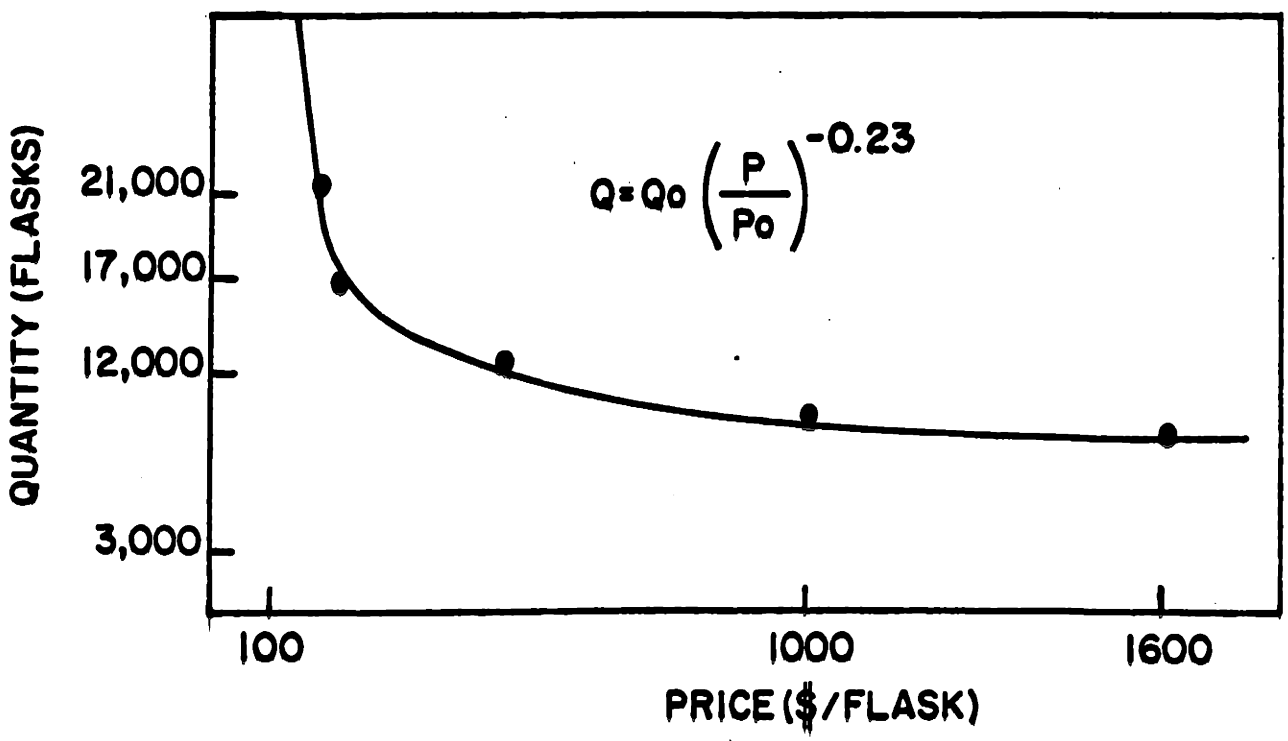


Figure 4-10: Expected Consumption Versus Price

(See Appendices 6 and 7)

Elasticity (constant) = -0.29

Passes through 1961 data point (210, 17,000)

EPCC.K = TABHL(COTAB, PRICE.K, 100, 1600, 100)

COTAB = 21000/17200/15000/14000/13000/12000/11200/10600/10200/
9900/9750/9525/9325/9150/9000/8900

EPCC desired consumption; flasks per month

PRICE unit price; dollars per flask

COTAB table of demand for consumption; flasks per month

16. Consumption requirements

Actually, consumption does not adjust immediately to a change in commodity price. Since consumers do not shop continuously, it will take them some time to recognize that a new commodity price prevails. As mercury is used as an intermediate, process technology forces some delay in taking advantage of a new price. The consumption requirement adjusts continuously toward equilibrium consumption defined by current price. This adjustment is estimated to twenty-four months.[37]

PCCR.K = PCCR.J + (DT)(EPCC.J - PCCR.J)/CRAD

CRAD = 24.

PCCR consumption requirements; flasks per month

CRAD consumption requirement adjustment delay; months

PCCRN initial value of PCCR: flasks per month

17. Consumption rate

Consumption rate is the product of consumption [illegible] and an input function, used to simulate the exogeneous input.

CR.KL = (PCCR.K)(INPUT.K)

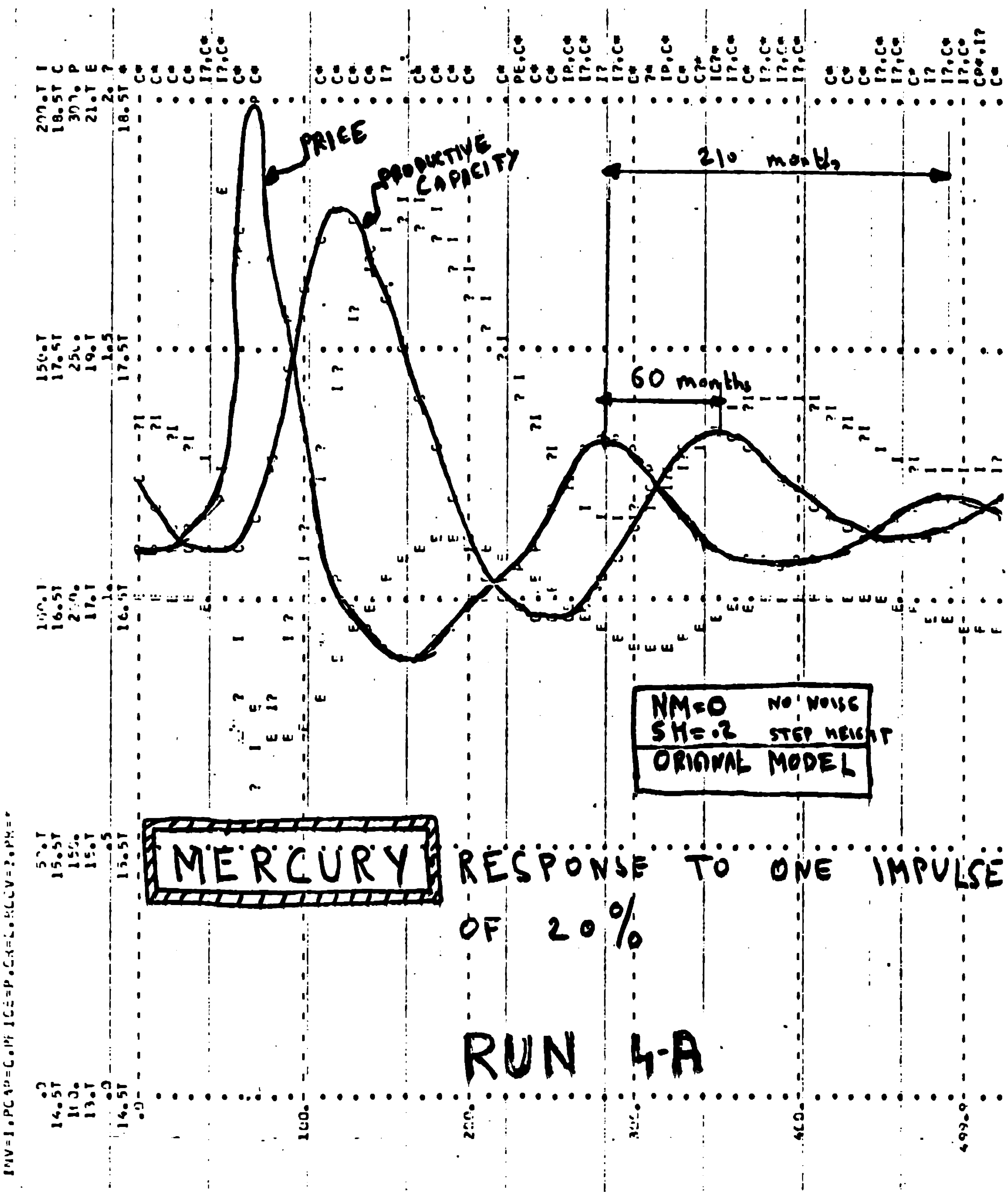
CR	consumption rate;	flasks per month
PCCR	consumption requirements;	flasks per month
INPUT	exogeneous input factor;	dimensionless

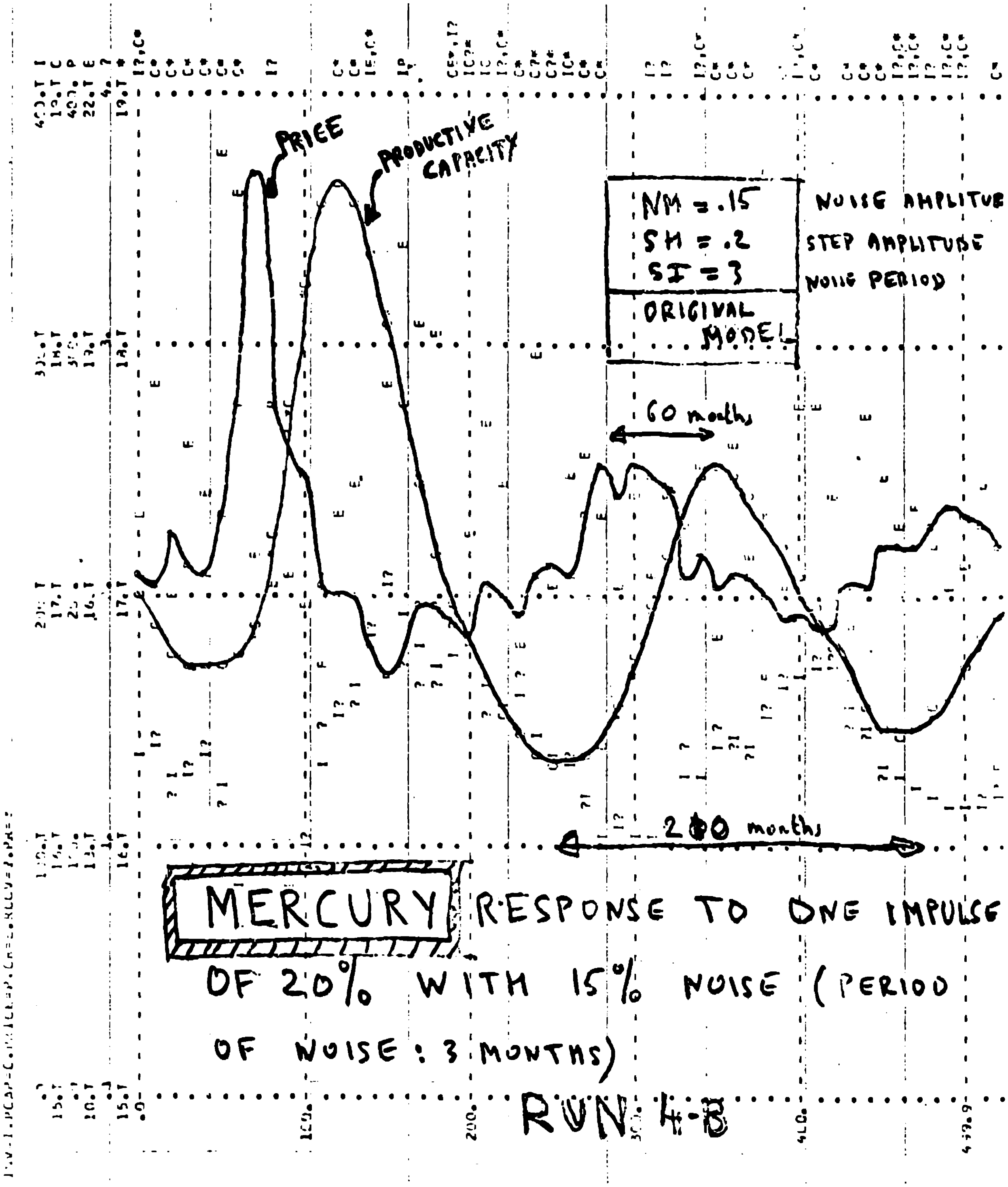
B. Test of the mercury model

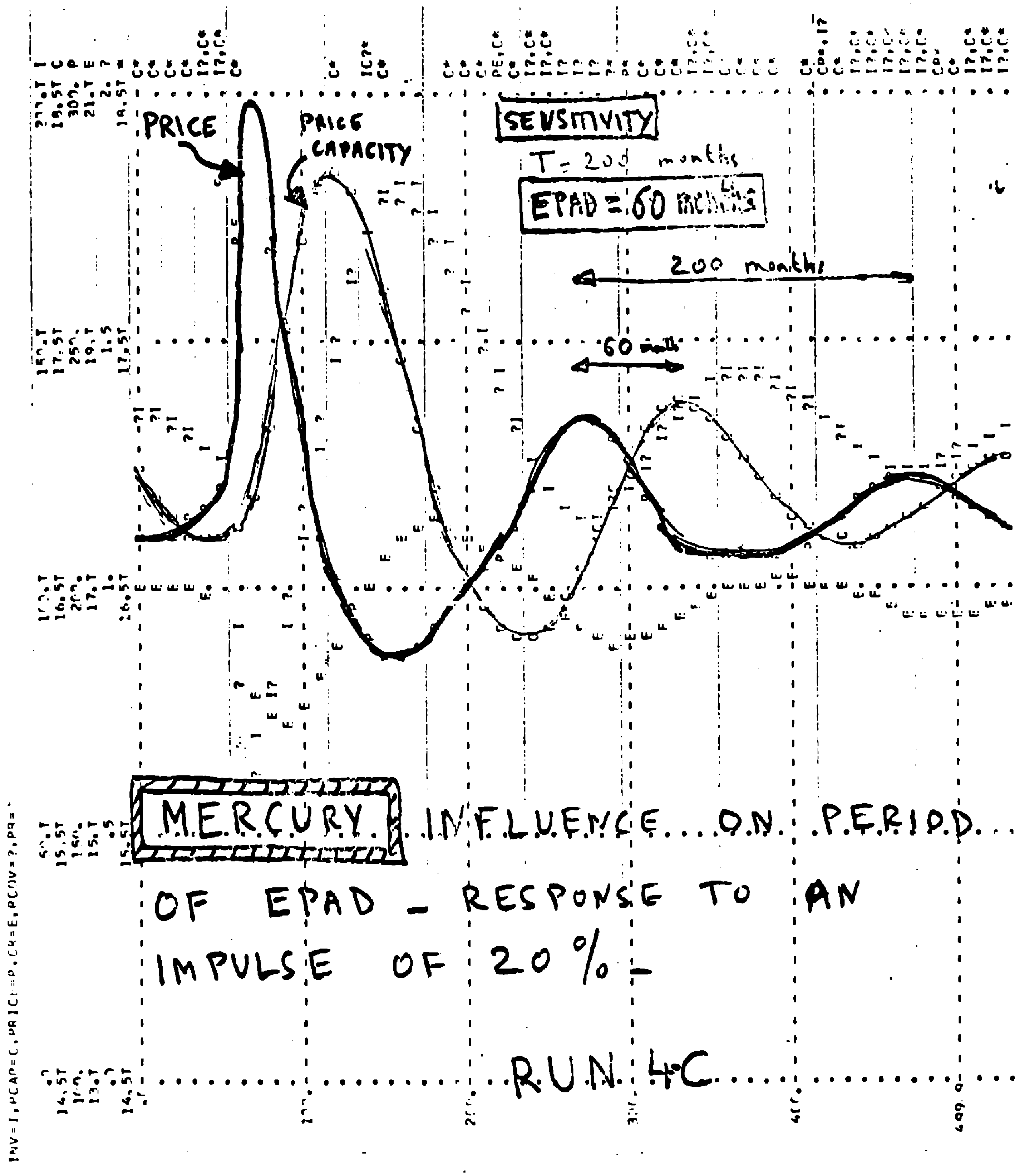
The equations described above, together with specifications of the exogeneous consumption input, are listed in Appendix [illegible].

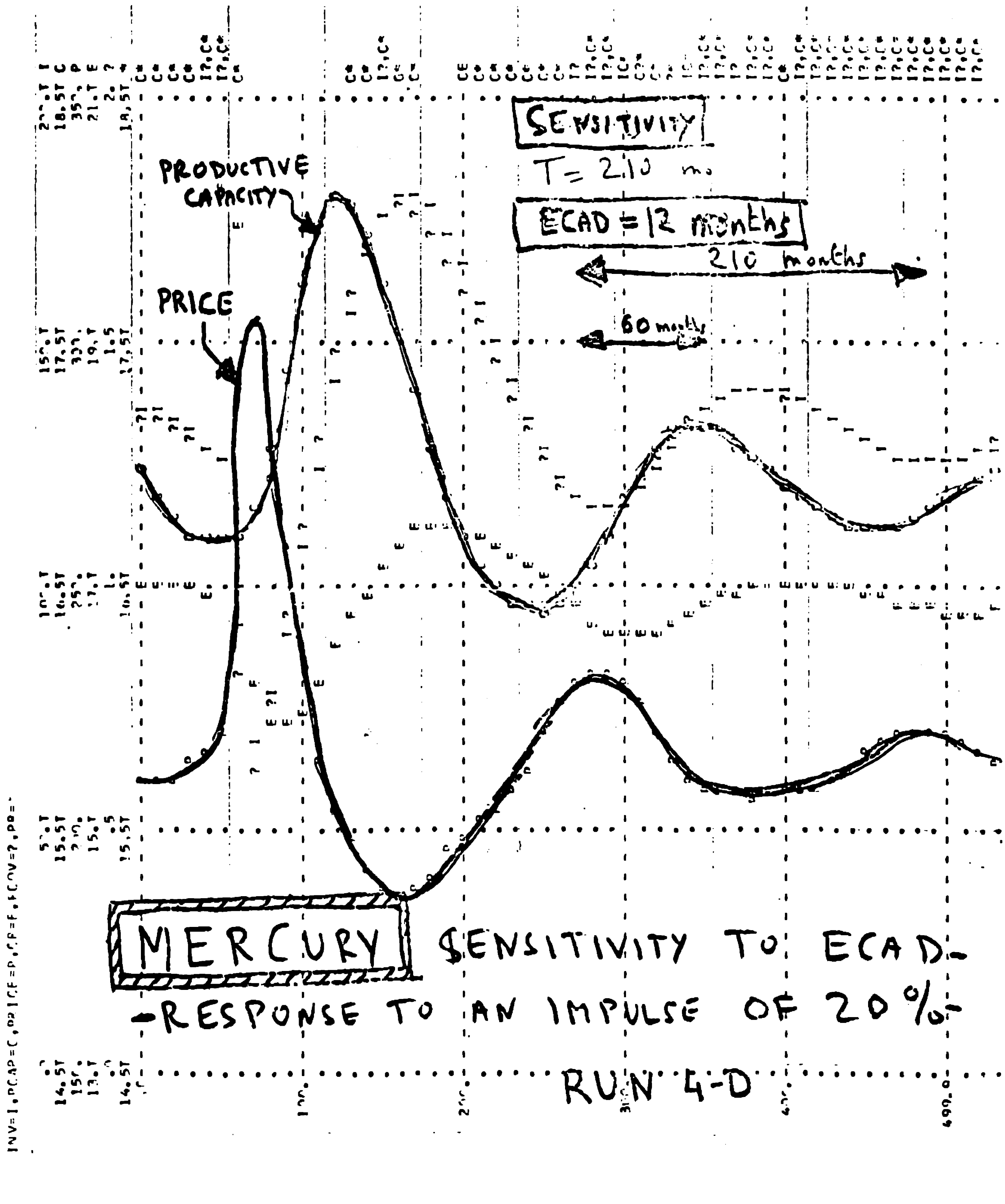
Analysis of the mercury model shows that with an exogeneous consumption factor of 20 per cent a typical production cycle is induced. Its period is two hundred and ten months. The phase lag between price and productive capacity is sixty months. Both are quite similar to the real system, which justifies the approximations done in this model.

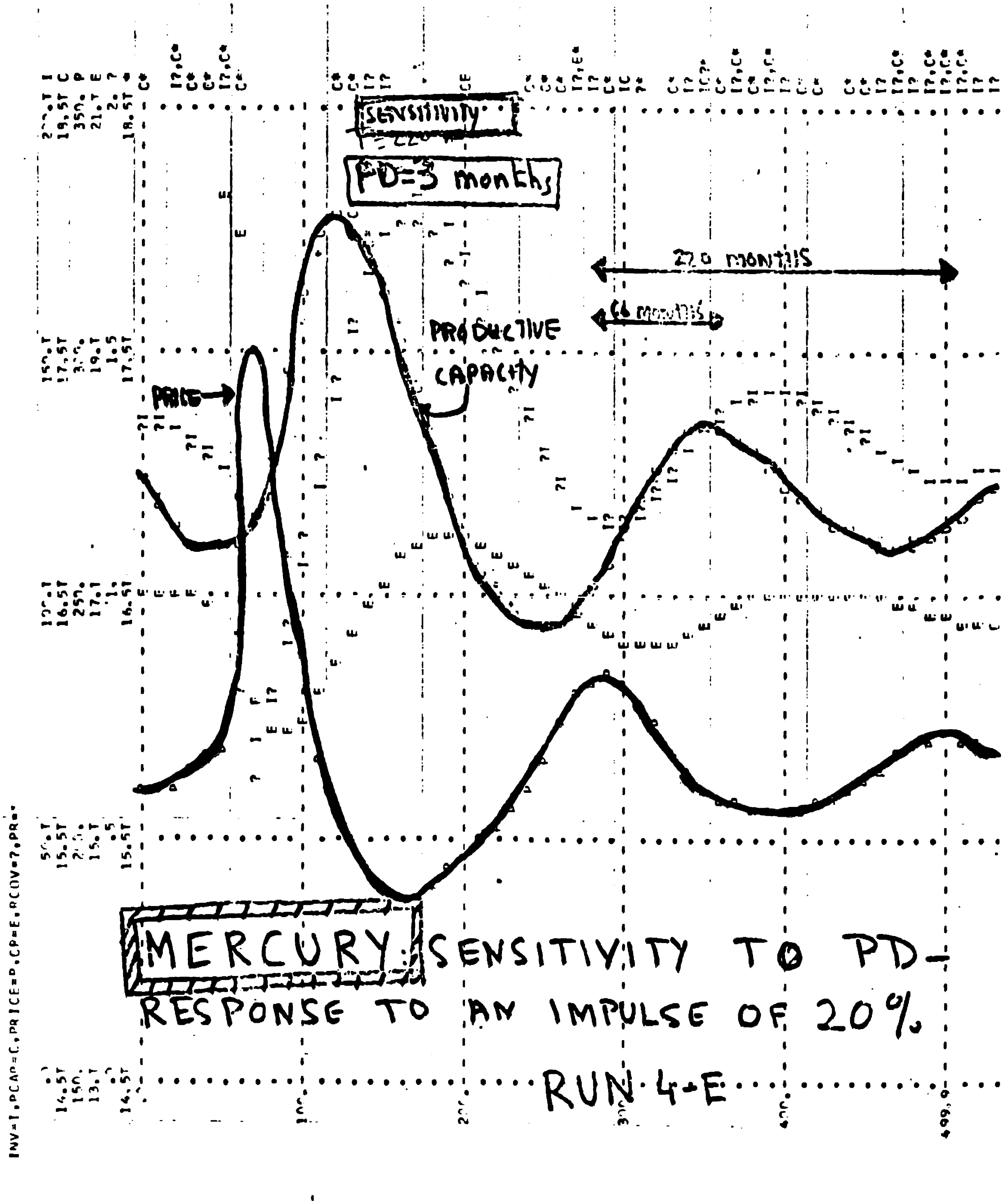
A sensitivity analysis has been performed on the critical parameters used in the model. Runs 4-A to Run 4-G show that the influence on the period is no larger than 15 per cent. The model is therefore considered as validated.

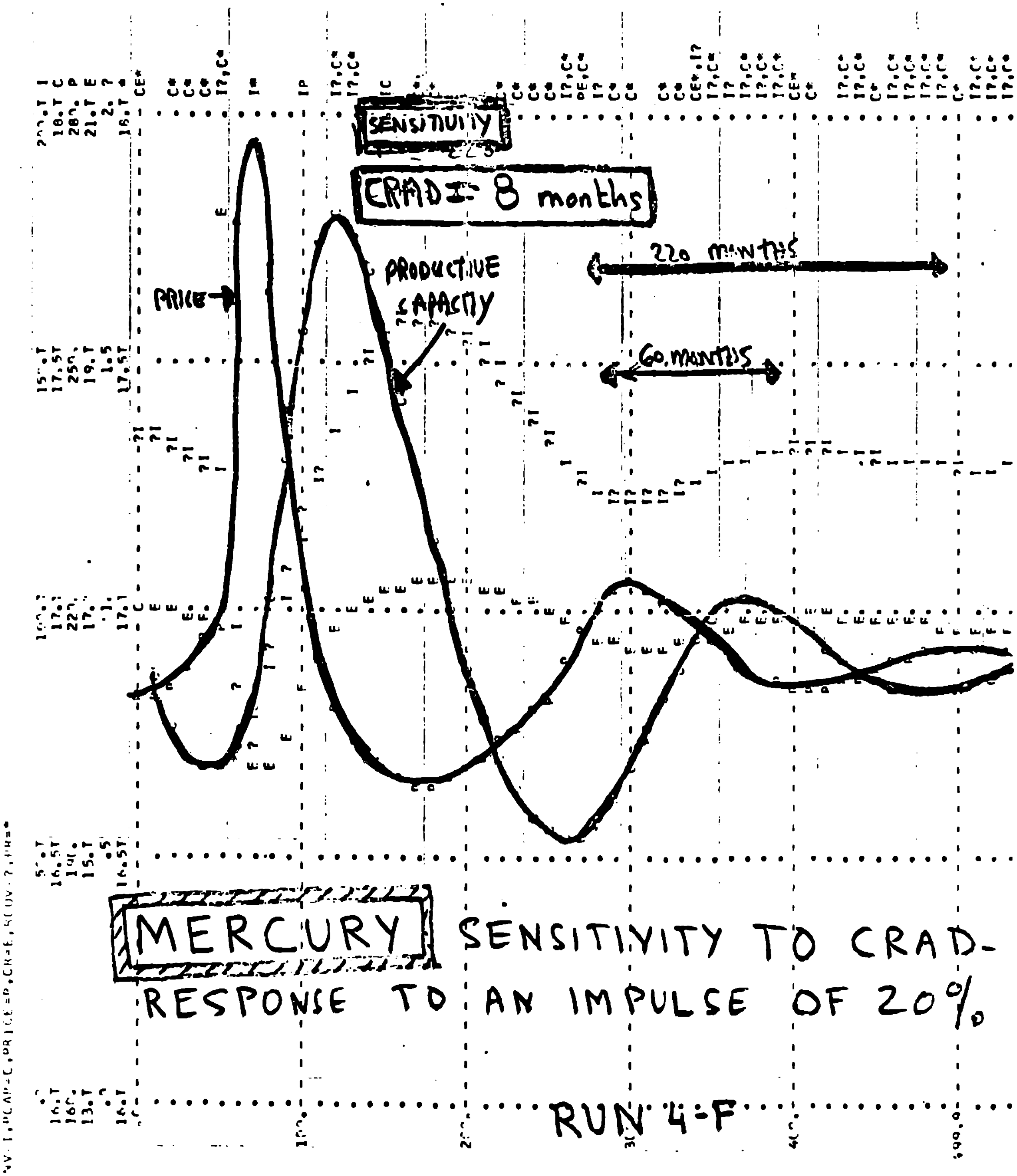

PRICE
PRODUCTIVE CAPACITY
210 months
60 months
NM=0 NO NOISE
SH=.2 STEP HEIGHT
ORIGINAL MODEL
MERCURY
RESPONSE TO ONE IMPULSE OF 20%
RUN 4-A
100.
200.
300.
400.
499.9

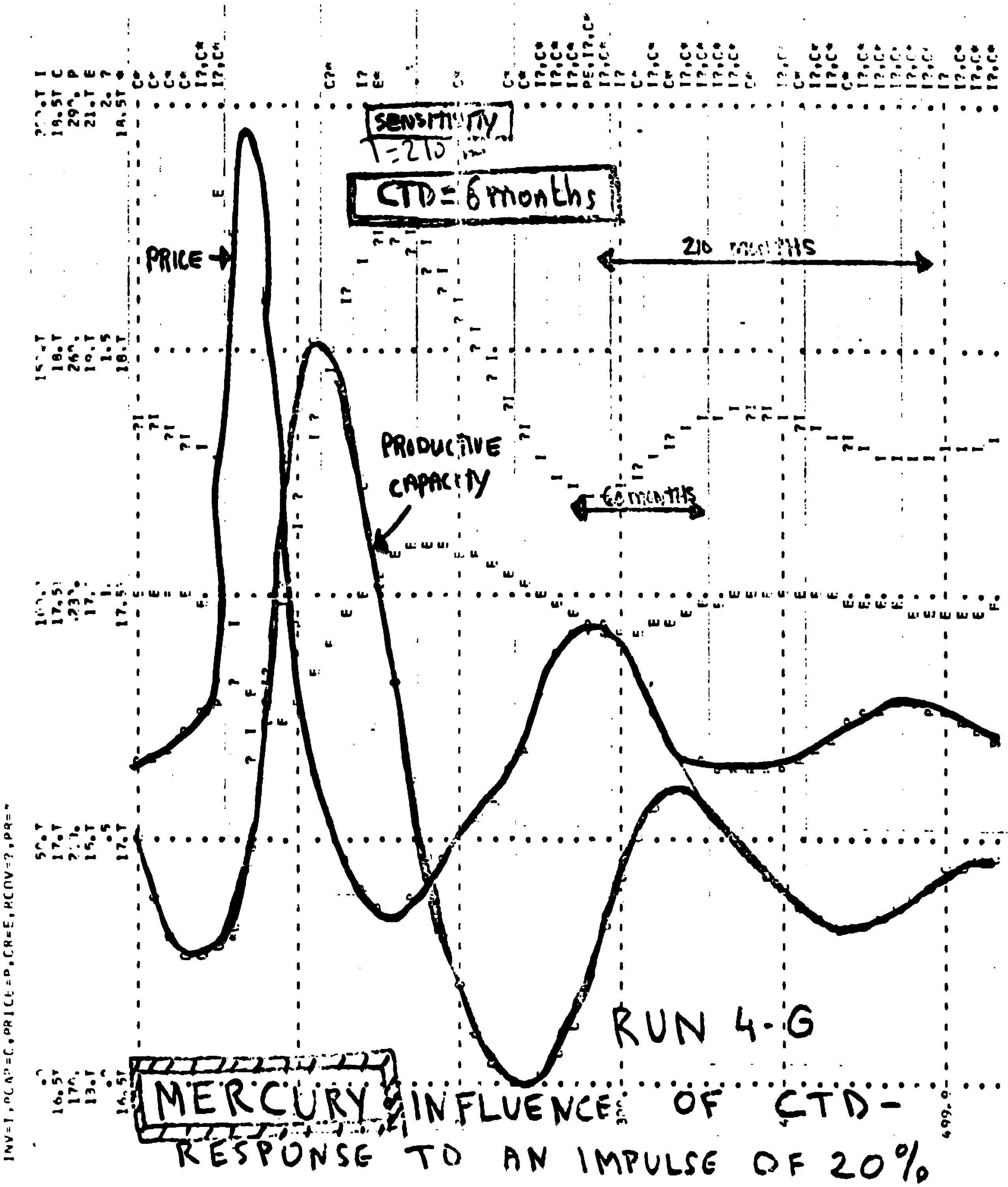

PRICE
PRODUCTIVE CAPACITY
NM = .15
SM = .2
SI = 3
NOISE AMPLITUDE
STEP AMPLITUDE
NOISE PERIOD
ORIGINAL MODEL
60 months
200 months
MERCURY RESPONSE TO ONE IMPULSE OF 20% WITH 15% NOISE (PERIOD OF NOISE: 3 MONTHS)
RUN 4-B


PRICE
PRICE CAPACITY
SENSITIVITY
T = 200 months
EPAD = 60 months
200 months
60 month
MERCURY INFLUENCE ON PERIOD OF EPAD - RESPONSE TO AN IMPULSE OF 20% -
RUN 4C


SENSITIVITY
T = 210 m.
ECAD = 12 months
210 months
60 months
PRODUCTIVE CAPACITY
PRICE
MERCURY SENSITIVITY TO ECAD -
- RESPONSE TO AN IMPULSE OF 20% -
RUN 4-D


SENSITIVITY
PD=3 months
270 MONTHS
66 MONTHS
PRODUCTIVE CAPACITY
PRICE
MERCURY: SENSITIVITY TO PD–
RESPONSE TO AN IMPULSE OF 20%
RUN 4-E


SENSITIVITY
CRAD I = 8 months
220 MONTHS
PRODUCTIVE CAPACITY
PRICE
60 MONTHS
MERCURY SENSITIVITY TO CRAD-
RESPONSE TO AN IMPULSE OF 20%
RUN 4-F


SENSITIVITY
CTD = 6 months
210 MONTHS
PRICE
PRODUCTIVE CAPACITY
6 MONTHS
RUN 4-G
MERCURY
INFLUENCE OF CTD -
RESPONSE TO AN IMPULSE OF 20%

Conclusions

Meadows' model has been validated for the case of mineral commodities, which was necessary to test the validity of all its hypotheses. This model can therefore be used to build a more general model of commodity stabilization schemes, since, duplicating the response of prices to random disturbances, it can be used to simulate how those fluctuations and cobweb phenomena can be smoothed.

CHAPTER 5

MODEL OF BUFFER STOCK OPERATIONS

This chapter defines a model representing the operation of a generalized buffer stock agency, adds this model to the one of Meadows, and validates the total model, determining the best possible operational policy and drawing the conclusions for implementation.

Module for reference price setting

This module essentially is composed of an auxiliary system to compute P*, the buffer reference price. (See Figure 5-1.) If we follow Goreux, P* is defined as follows:

$$P^* = (P_{t-2} + P_{t-1} + \tilde{P}_t + \tilde{P}_{t+1} + \tilde{P}_{t+2})/5$$

Like Goreux, we use a year (twelve months) for the period on which to compute these average or forecasted prices.

Therefore, we have to keep in auxiliary levels the prices of two years (two OZ periods) ago, of one year ago (one OZ period); also, to compute each time the current average price for the present year (present OZ period not finished); and to perform the forecasts for the next year (next OZ period) and for two years (two OZ periods) from now.

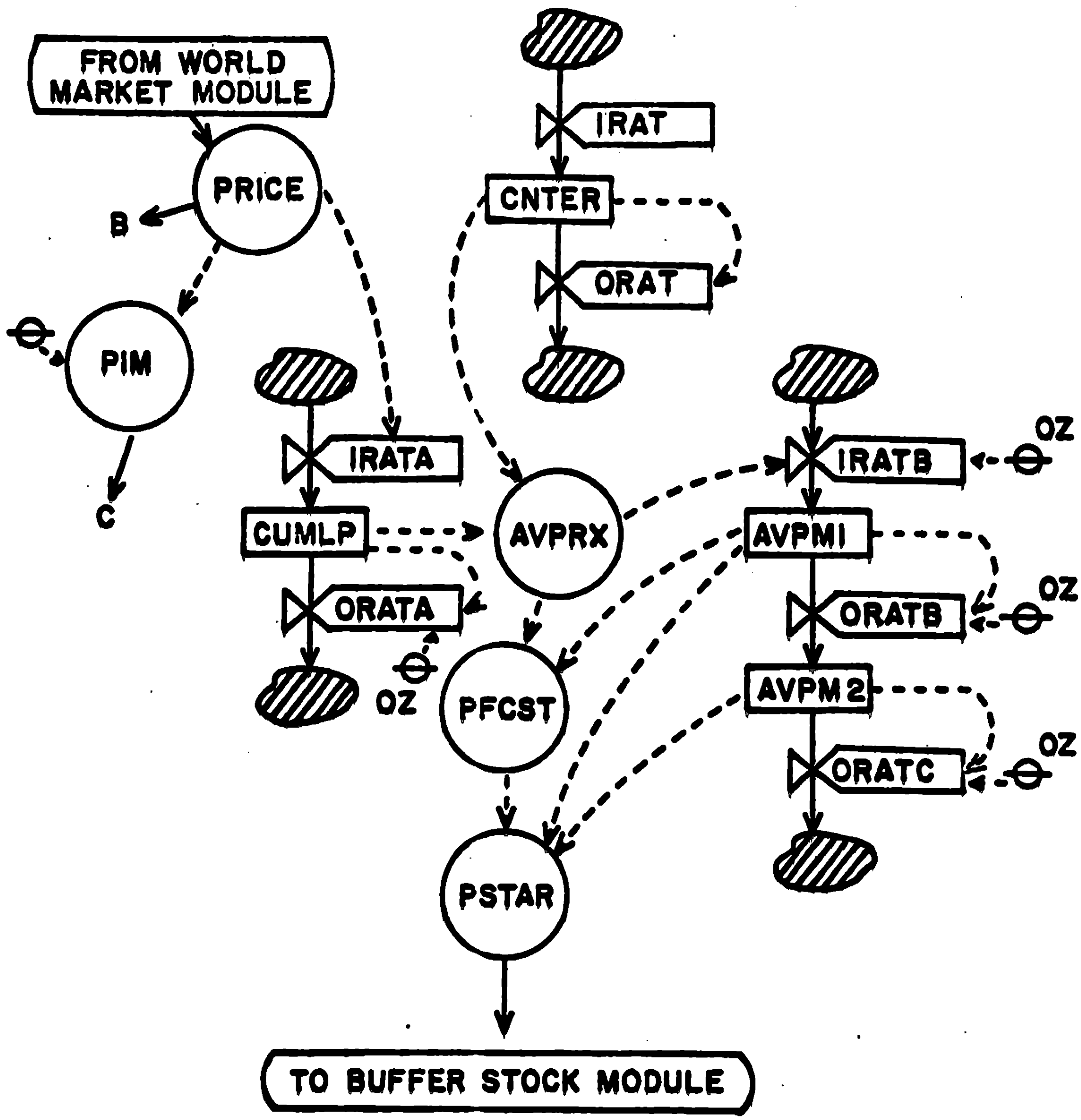


Figure 5-1: MOdule for Setting Reference Price

The forecasts are done by using the formula derived by Goreux in his econometric study for cocoa. They give a good order of magnitude of how the forecast can be practically applied.

$$P_t = \alpha(P_{t-1}) + \beta(P_{t-2})$$

where $\alpha = 0.7$ and $\beta = 0.3$

The principle of this auxiliary module is to cumulate prices in a level, and, every OZ period, to shift them down to another level, that therefore represents prices from a previous period. This is done twice, so that information two years old (two OZ periods) is kept.

Module

1. Counter of iterations since beginning of year

OZ = 12

IRAT.KL = 1/DT

CNTER.K = CNTER.J + (DT)(IRAT.JK - ORAT.JK)

ORAT.KL = PULSE(CNTER.K/DT, OZ, OZ)

DT	time interval; months
ITAT	in rate; $months^{-1}$
ORAT	out rate; $months^{-1}$
OZ	base period for setting of reference price, smoothed on five OZ periods - long term intervals; months
CNTER	counter of number of time intervals elapsed since the beginning of period; dimensionless

This is simply an auxiliary level that keeps track of the number of times prices have been flown into CUMLP (cumulated price). It is re-initialized every OZ period; that is, the length of time for which are defined each of the five prices used for P*.

2. Cumulated price

IRATA.KL = PRICE.K/DT

CUMLP.K = CUMLP.J + (DT)(IRATA.JK - ORATA.JK)

ORATA.KL = PULSE(CUMLP/DT,OZ,OZ)

CUMLPN = PRICE

DT	time interval for simulation; months
IRATA	in rate for cumulation; dollars per month
ORATA	out rate from cumulation; dollars per month
CUMLPN	initial value of the cumulated price; dollars
CUMLP	cumulated price; dollars

This auxiliary level cumulates prices for the current period, each period having a length of OZ.

3. Average price for the period

AVPRX.K = CUMLP.K/CNTER.K

CUMLP	cumulated price; dollars
CNTER	counter of time intervals; dimensionless
AVPRX	average current price; dollars

4. Price of past period

IRATB.KL = PULSE(AVPRX/DT,OZ,OZ)

AVPMI.K = AVPM1.J + (DT)(IRATB.JK - ORAT.B.JK)

ORATB.KL = PULSE(AVPM1/DT)

AVPM1N = PRICE

IRATB in rate for transferring price to APTM1 from AVPRX every OZ period; dollars per month

ORATB out rate from AVPM1 to AVPM2 every OZ period; dollars per month

AVPM1N initial value for AVPM1; dollars per unit

AVPM1 average price for the whole previous OZ long period; dollars per unit

5. Price of two periods ago

AVPM2.K = AVPM2.J + (DT)(ORATB.JK - ORATC.JK)

ORATC.KL = PULSE(AVPM2/DT,OZ,OZ)

AVPM2N = PRICE

ORATC out rate from AVPM2 every OZ period; dollars per month

AVPM2N initial value of AVPM2; dollars per unit

AVPM2 average price of two OZ periods ago; dollars

6. Price forecasts

PP1.K = (ALFA)(AVPRX.K) + (BETA)(AVPM1.K)

ALFA = .7

BETA = .3

PP1 forecasted price for the next OZ period; dollars

AVPRX average price for the current period; dollars

AVPM1 average price for the previous OZ period; dollars

ALFA econometric coefficient from Goreux[2]; dimensionless

BETA econometric coefficient from Goreux[2]; dimensionless

Goreux proposed after a thorough econometric study those coefficiénts for cocoa and a period OZ equals twelve months.

7. Second price forecast

PP2.K = (ALFA)(PP1.K) + (BETA)(AVPRX.K)

PP2 forecasted price for two OZ periods from now; dollars

PP1 forecasted price for the next OZ period; dollars

AVPRX current period average price; dollars

ALFA econometric coefficient; dimensionless

BETA econometric coefficient; dimensionless

8. Setting the reference price

PSTAR.K = (0.2)(AVPM2.K + AVPM1.K + AVPRX.K + PP1.K + PP2.K)

PSTAR	reference price for buffer stock operations; dollars
AVPM2	average price two periods OZ old; dollars
AVPM1	average price one period OZ old; dollars
AVPRX	average current price for present OZ long period; dollars
PP1	forecasted price for next OZ period; dollars
PP2	forecasted price for two OZ periods from now; dollars

Module for buffer stock operations

The principle is the following: a buffer stock and a cash pool constitute the regulating agents. (See Figure 5-2.)

From the reference price and a given range around this price, trigger prices for intervention are set: PMAX and PMIN. If price rises above PMAX the buffer sells, and this results in an inflow of money into the cash pool. If price falls below PMIN the buffer buys, and this results in an outflow of money from the cash pool.

The magnitude of intervention depends upon the price deviation (see Appendix 2) and intervention lasts as long as price is outside the assigned price range and the agency has the necessary stocks or funds.

When the buffer is selling, it sells until the physical buffer reserves are empty. When it buys, it buys as long as there are enough resources in the cash pool: if they cannot meet the cost of inter-

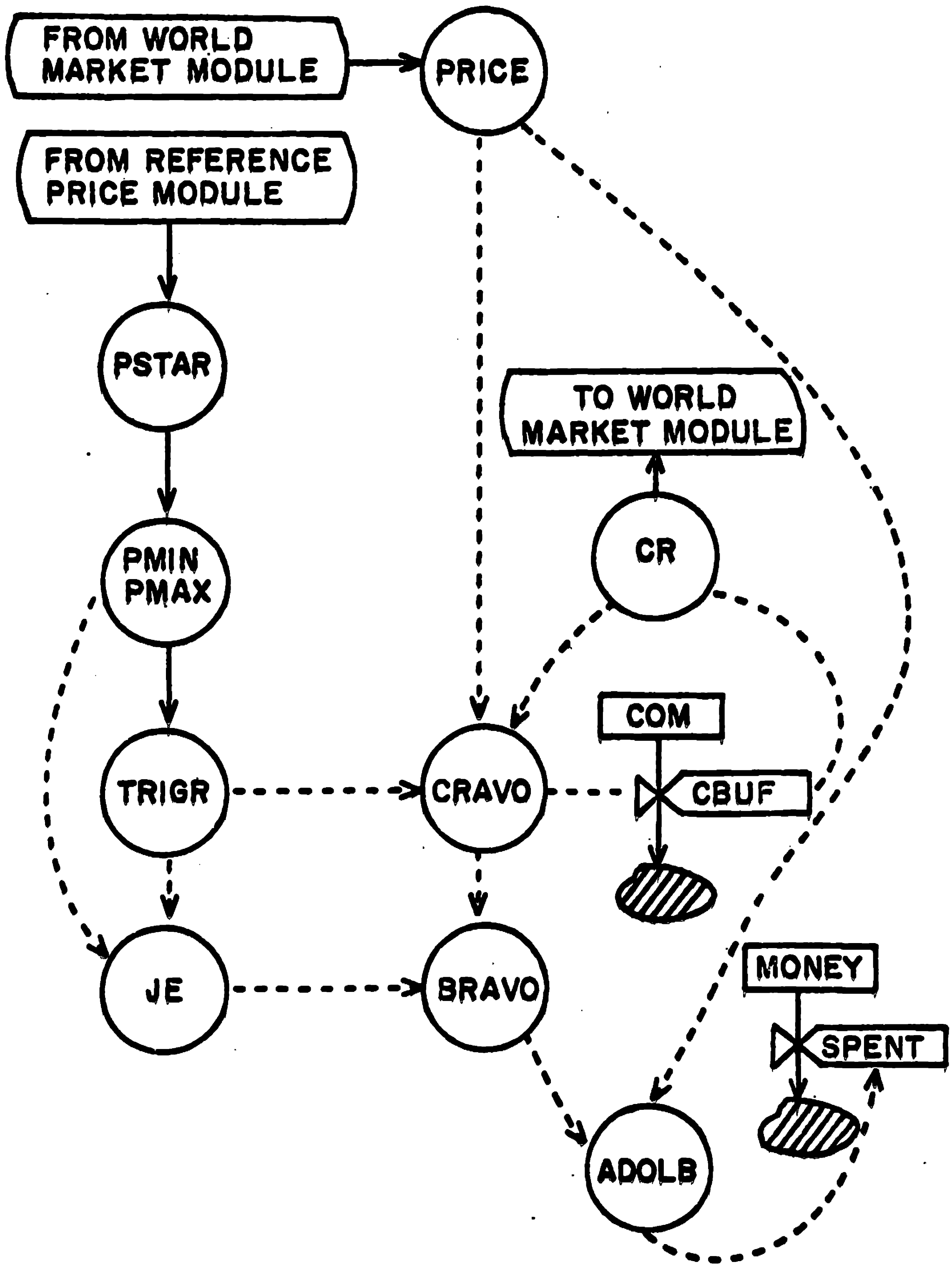


Figure 5-2: Buffer Stock MOdule

vention, it will just buy to exhaustion of its resources. This module uses as an input the reference price from the reference price setting module.

Its output is the actual consumption rate of commodity: the amount actually demanded by consumers (in the world market module) is algebraically combined with the amount bought or sold by the regulating device; the net consumption rate CR is therefore the consumption rate seen by the market (inventory holders that are selling). Intervention is modulated so as to adjust, through its influence on net consumption of inventories, the inventory level; in turn, as seen in the world market module, this will, through coverage, adjust price.

1. Buffer stock

COM.K = COM.J + (DT)(- CBUF.JK)

COMN = 10,000

COM buffer stock; units

COMN initial value for buffer stock; units

CBUF change in buffer stock; units per month

By convention, CBUF is positive when the buffer is selling, negative when it is buying.

2. Cash pool

MONEY.K = MONEY.J + (DT)(- SPENT.JK)

MONEYN = (PRICE)(PCAP)(24)

MONEY cash pool; dollars

MONEYN initial vlaue of the cash pool; dollars

SPENT rate of spending of cash pool; dollars per month

By convention, SPENT is positive when the buffer is buying, negative when it is selling. This is to account for the fact that CBUF and SPENT are of opposite signs.

3. Triggering mechanism

PMAX.K = (PSTAR.K)(1 + RANGE/2)

PMIN.K = (PSTAR.K)(1 - RANGE/2)

RANGE = 1.5/100

PMAX upper limit of range; dollars per unit

PMIN lower limit of range; dollars per unit

RANGE width of range; per cent

TRIGR.K = CLIP(PMAX.K,T1.K,S1.K,0)

T1.K = CLIP(PRICE.K,PMIN.K,S2.K,0)

TRIGR trigger price for intervention; dollars per unit

PMAX upper limit of range; dollars per unit

PMIN llower bound of range; dollars per unit

PRICE price of unit; dollars per unit

S1 deviation of price from upper bound; dollars per unit

S2 deviation of price from lower bound; dollars per unit

T1 auxiliary function for defining TRIGR; dollars per unit

This section assigns as goal to price adjustment the upper bound if price is above the range, the lower bound of the range if price is below the range. This is because if there is a trend in price, this will assure a quicker adjustment to trend by not bringing back the price all the way to the reference line, but only by bringing it back within the range, on the side indicating the trend.

4. Definition of intervention

JE.K = (S1.K)(S2.K)

JE auxiliary variable; dollars per unit squared

S1 deviation of price from upper bound of range; dollars per unit

S2 deviation of price from lower bound of range; dollars per unit

JE is used to define whether the price is within the range or not.

5. Magnitude of intervention

CRAVO.K = (X)(DY)(CR.JK)(PRICE.K - TRIGR.K)/(PRICE.K)

DY = 25

X = 1

BRAVO.K = CLIP(CRAVO.K,0,JE.K,0)

CRAVO desired intervention magnitude; units per month

BRAVO actual desired intervention; units per month

X flag to signal that the buffer stock module is linked to the rest of the program; dimensionless on; dimensionless

er unit

derived in Appendix 2.

tisfactory range

or CRAVO.

as

on for one simulation

le to buy with

month

on (in physical

ill determine

DY coefficient of magnitude of intervention; dimensionless

CR net consumption rate; units per month

PRICE price per unit; dollars per unit

TRIGR price goal of intervention; dollars per unit

The equation for the desired intervention is derived in Appendix 2. According to whether price is or is not within the satisfactory range measured by JE, the actual desired intervention is 0 or CRAVO.

6. Auxiliary variables for physical limitations

A1.K = (BRAVO)(PRICE.K)(DT)

A2.K = (MONEY.K)(PRICE.K)(DT)

A1 measure of money involved in intervention for one simulation interval; dollars

A2 measure of quantity of commodity possible to buy with resources of cash pool; units

BRAVO actual desired intervention; units per month

PRICE price per unit; dollars per unit

MONEY cash resources of buffer; dollars

DT interval for simulation; months

Comparison of desired resources for intervention (in physical commodity or money) with those physical limitations will determine the actual scope of intervention.

7. Change in cash pool

SPENT.K = CLIP(SPEN1.K,SPEN2.K,BRAVO.K,0)

SPEN1.K = CLIP(0,- ADOLB.K,0,COM.K)

SPEN2.K = CLIP(-ADOLB.K,MONEY.K,MONEY.K, - A1.K)

SPENT change in cash pool; dollars per month

BRAVO actual desired intervention; units per month

ADOLB cost (or income) associated to intervention; dollars per month

COM buffer stock level; units

MONEY level of cash pool; dollars

A1 money involved for intervention during one time interval of simulation; dollars

SPEN1 auxiliary functions to define SPENT; dollars per month

SPEN2 auxiliary function to define SPENT; dollars per month

This expresses simply that, if there is enough money in the cash pool to cover the expenses of intervention, intervention will be equal to the actual desired intervention BRAVO; if there is not enough money in the cash pool to do so, intervention will be limited to the available cash resources until exhaustion of those.

8. Change in physical buffer stock

CBUF.K = CLIP(CBUF1.K,CBUF2.K,BRAVO.K,0)

CBU1.K = CLIP(0,BRAVO.K,0,COM.K)

CBU2.K = CLIP(BRAVO.K, - A2.K,MONEY.K, - A1.K)

CBUF change in buffer stock level; units per month

CBU1 auxiliary function to define CBUF; units per month

CBU2 auxiliary function to define CBUF; units per month

BRAVO actual desired intervention; units per month

COM level of buffer stock; units

A1.K measure of money involved in intervention for one simulation interval; dollars per month

A2.K measure of quantity possible to buy with cash pool resources; units

This simply says that if the buffer agency wants to sell it can only sell to the limit of its physical holdings, and that if it wants to buy, it has to be limited by the cash resources it has.

9. Link to free market module

JAN.K = CLIP(CBU1.K,CBU2.K,BRAVO.K,0)

CR.KL = ACR.K - JAN.K

JAN auxiliary function defining algebraically physical intervention of the buffer; units per month

ACR actual consumption rate corresponding to actual market demand; units per month

CR net consumption rate as seen by the inventory holders; units per month

World free market module (See Figure 5-3)

We have used Meadows' general commodity model here. We will use the general model to test our main results, in order not to limit our conclusions to a given commodity. Use of a particular commodity to draw conclusions might obscure the generality of the results. There is no methodological objection to do so, since the general commodity model is by now considered as definitely validated for commodity fluctuations (Refer to Chapter 4).

The only modification in Meadows' model to make it become a module for the buffer stock model is the following one:

The demand for consumption rate in this module is

CR.K =(POP)(PCCR.K) (INPUT.K)

expressing that the total demand for consumption is proportional to population, exogeneous influences on consumption, and expected per capita consumption requirements that depend themselves upon the price.

We use this gross demand and call it ACR.K (actual consumption rate), and consumption rate, the net rate of depletion of the inventory, is called CR.KL, and results from the composition of this gross component of demand and the intervention of the buffer stock device.

For the model of tin we also will adapt the capacity utilization function to account for quotas.

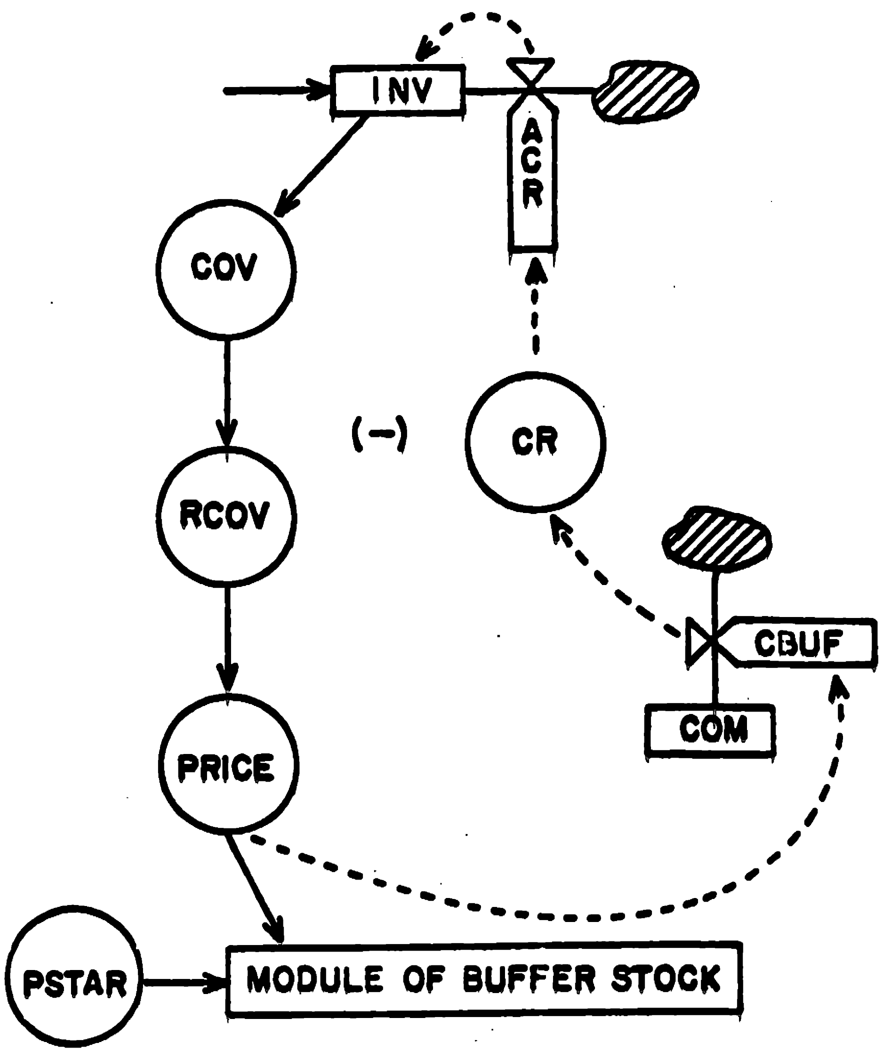


Figure 5-3: Link with World Market Module

Module of cost of operations

This is essentially a computational module. Cash flows are discounted at the opportunity cost of capital, taken as equal to 10 per cent per year or 0.8 per cent per month.

The cost of operation is essentially the discounted present value of the amount of interest lost by immobilization of the capital in the form of idle stocks, plus the present value of the cash flows corresponding to buying and selling operations. The cost of storage is supposed to be included in the 10 per cent opportunity cost, and the cost of transaction is neglected, as does also Goreux.[2]

Therefore

$$\text{COST} = \sum_{t=0}^{T} \frac{(\text{COM})(\text{PRICE})(8\%) \pm \text{SPENT}}{(1 + 0.008)^t}$$

$$\text{TINCOM} = \sum_{t=0}^{T} \frac{\text{INCOM}}{(1 + 0.008)^t}$$

t expressed in months

1. Income received by producers

INCOM.K = (PRICE.K)(ACR.K) - (PRICE.K)(BRAVO.K)

INCOM income received by producers; dollars per month

PRICE price per unit; dollars per unit

ACR gross consumption rate; units per month

BRAVO intervention of buffer rate; units per month

2. Total income received by producers

TINCM.K = TINCM.J + (DT)(RVNU.JK)

TINCMN = 0

TINCM   total cumulated income received by producers; dollars

TINCMN initial value of cumulative income received; dollars

RVNU   discounted revenue; dollars per month

3. Discounted revenue

RVNU.KL = (INCOM.K)/(ZY.K)

RVNU   discounted revenue; dollars per month

INCOM   actual income received; dollars per month

ZY   auxiliary function representing $(1 + i)^t$; dimensionless

4. Auxiliary function for discounting

YX.K = 1.008

YY.K = (TIME.K)(LOGN[YX.K])

ZY.K = EXP(YY.K)

YX auxiliary variable; dimensionless

YY auxiliary function; dimensionless

ZY auxiliary function; dimensionless

Because of software limitation, these three auxiliary variables are necessary to compute $(1 + i)^t$.

5. Time

TIME.K = TIME.J + (DT)(T.JK)

TIMEN = 0

T.KL = 1

TIME time elapsed since the beginning of simulation; months

T rate to define time

6. Cost of operation

CLIPI.K = CLIP(SPEN1.K,SPEN2.K,BRAVO.K,0)

LO.K = (PRICE.K)(COM.K)(0.008) + CLIPI.K

CLIPI auxiliary to define the amount of money spent or cashed in through interventions; dollars per month

SPEN1 auxiliary for amount of cash flow; dollars per month

SPEN2 auxiliary for amount of cash flow; dollars per month

BRAVO actual desired intervention; units per month

LO cost of operation at time t; dollars per month

COM level of physical buffer stock; units

PRICE price per unit; dollars per unit

7. Discounted cost

BANK.KL = LO.K/ZY.K

BANK discounted cost of operation at time t; dollars per month

LO cost of operation at time t; dollars per month

ZY auxiliary for $(1 + i)^t$; dimensionless

8. Total cumulative discounted cost

COST.K = COST.J + (DT)(BANK.JK)

COSTN = 0

COST total cumulated and discounted cost; dollars

COSTN initial value of COST; dollars

Module of measure of stability

Stability has been defined as the standard deviation of the monthly average price to a moving average on thirty-six months, approximative period of the cobweb cycle for the present free market model.

1. Monthly average

P1M.K = P1M.J + (DT)(PRICE.J - P1M.J)/1

P1MN = PRICE

PRICE price per unit; dollars per unit

P1M averaged on one month price; dollars per unit

P1MN initial value of P1M; dollars per unit

2. Counter of total time for the simulation

COTER.K = COTER.J + (DT)(ITER.JK)

COTERN = 0

ITER.KL = 1

COTER counter of total time; months

DT time interval for simulation; months

COTERN initial value of COTER; months

ITER rate to count intervals; dimensionless

3. Price deviation from moving average

AP.K = P1M.K - SSTAR.K

AP price deviation; dollars per unit

P1M monthly price average; dollars per unit

SSTAR reference moving average price; dollars per unit

4. Reference moving average price

SSTAR.K = SSTAR.J + (DT)(PRICE.JK - SSTAR.JK)/LENTH

LENTH = 36

SSTAR = PRICE

SSTAR moving average price for reference; dollars per unit

PRICE price per unit; dollars per unit

LENTH smoothing time for moving average; months

5. Deviation of income received by producers

AB.K = (AP.K)(CR.JK)

AB deviation from average income; dollars per month

6. Measure of variance of price

PITY.K = PITY.J + (DT)(IPY.JK)

PITYN = 0

IPY.KL = (AP.K)(AP.K)

QPITY.K = PITY.K/COTER.K

PITY price variance; dollars per unit squared times months

PITYN initial price variance; dollars per unit squared times months

IPY increase in variance; dollars per unit squared

QPITY variance

7. Measure of income variance

IITY.K = IITY.J + (DT)(IIITY.JK)

IITYN = 0

IIITY.KL = (AB.K)(AB.K)

QIITY.K = IITY.K/COTER.K

IITY income variance; dollars per unit squared times months

IITYN initial value for measure of income variance; dollars per unit squared times months

IIITY increase in variance measure; dollars per unit squared

QIITY variance of income; dollars per unit squared

Module of periodically readjusted pegged price

In the duplication of the tin experiment, we will need to reproduce the policy of readjusting the pegged reference price after evidence that the fixed pegged price system was inappropriate.

1. Magnitude of readjustment

BENE.K = BENE.J + (DT)(R.JK - RO.JK)

BENEN = 0

BENE magnitude of readjustment; dollars per unit

R addition to magnitude of readjustment; dollars per unit times months

RO decrease of magnitude of price adjustment; dollars per unit times months

2. Reference trend line for new pegged price adjustment

RSTAR.K = (5PSTAR.K + AVPM3.K + AVPM4.K/7)

RSTAR trend line for readjustment; dollars per unit

PSTAR reference price for buffer stock operation (five years smoothed): dollars per unit

AVPM3 average price of three years ago; dollars per unit

AVPM4 average price of four years ago; dollars per unit

3. Readjusted pegged reference price

USTAR.K = 50 + BENE.K

USTAR readjusted pegged price; dollars per unit

BENE magnitude of readjustment; dollars per unit

4. Triggering for first readjustment

COMP.K = (15%)(COMN)

MD.K = COM.K - COMP.K

COMP triggering level of buffer stock; units

COMN initial value of buffer stock; units

COM level of buffer stock; units

MD indicator of relative level of buffer stock; units

5. Definition of first readjustment

ANFIN.K = CLIP(0,ENFIN.K,MD.K,0)

ANFIN auxiliary variable for magnitude of pegged price adjustment; dollars per unit times months

ENFIN auxiliary variable; dollars per unit times months

MD indicator of relative level of buffer stock; units

6. Auxiliary for first readjustment

ENFIN.K = (RSTAR.K - 50)/DT

ENFIN auxiliary for first adjustment; dollars per unit times months

RSTAR reference trend line (seven years); dollars per unit

DT time interval for simulation; months

7. Readjusting of pegged price

7.1 R.KL = PULSE(ANFIN.K,36,36)

R increase to magnitude of pegged price readjustment; dollars per unit times months

ANFIN auxiliary for magnitude of pegged price adjustment; dollars per unit times months

After the first readjustment, the pegged prices are automatically readjusted every three years (thirty-six months). The first readjustment happens when, and only when, the buffer stock physical reserves fall below 15 per cent of initial level.

7.2 RO.KL = PULSE(BENE.K/DT,36,36)

Also, the old value of pegged price adjustment is cancelled at regular time intervals. We did not include the provision for readjustment downwards if the stock increases excessively because it is not relevant to duplicate the tin experiment.

Module for quotas

Quotas are used to adjust the price in a very similar way to the buffer stock in this model. When a downward deviation occurs for price, the open loop analysis (see Appendix 3) indicates the magnitude of quota intervention in order to limit productive capacity so as to decrease inventory, coverage and relative coverage and therefore induce an increase in price and readjust it upwards. It is assumed that every three months the quotas' coefficients are reset as is the case for tin.

This module has actually been used only in the run where the tin experiment is simulated. (See Figure 5-4.)

1. Quota coefficient

LANDA.K = LANDA.J + (DT)(IANDA.JK - OANDA.JK)

LANDAN = 1

LANDA quota multiplier coefficient; dimensionless

IANDA inflow of a new coefficient; month^{-1}

OANDA outflow of the old coefficient; month^{-1}

LANDAN initial value of LANDA: month^{-1}

2. Desired quota multiplier coefficient

BN.K = 1 + (V)(PRICE.K - TRIGR.K)/PRICE.K

V = 2.5

BN desired quota coefficient; dimensionless

V coefficient; dimensionless

PRICE price per unit; dollars per month

TRIGR reference price for adjusting; dollars per unit

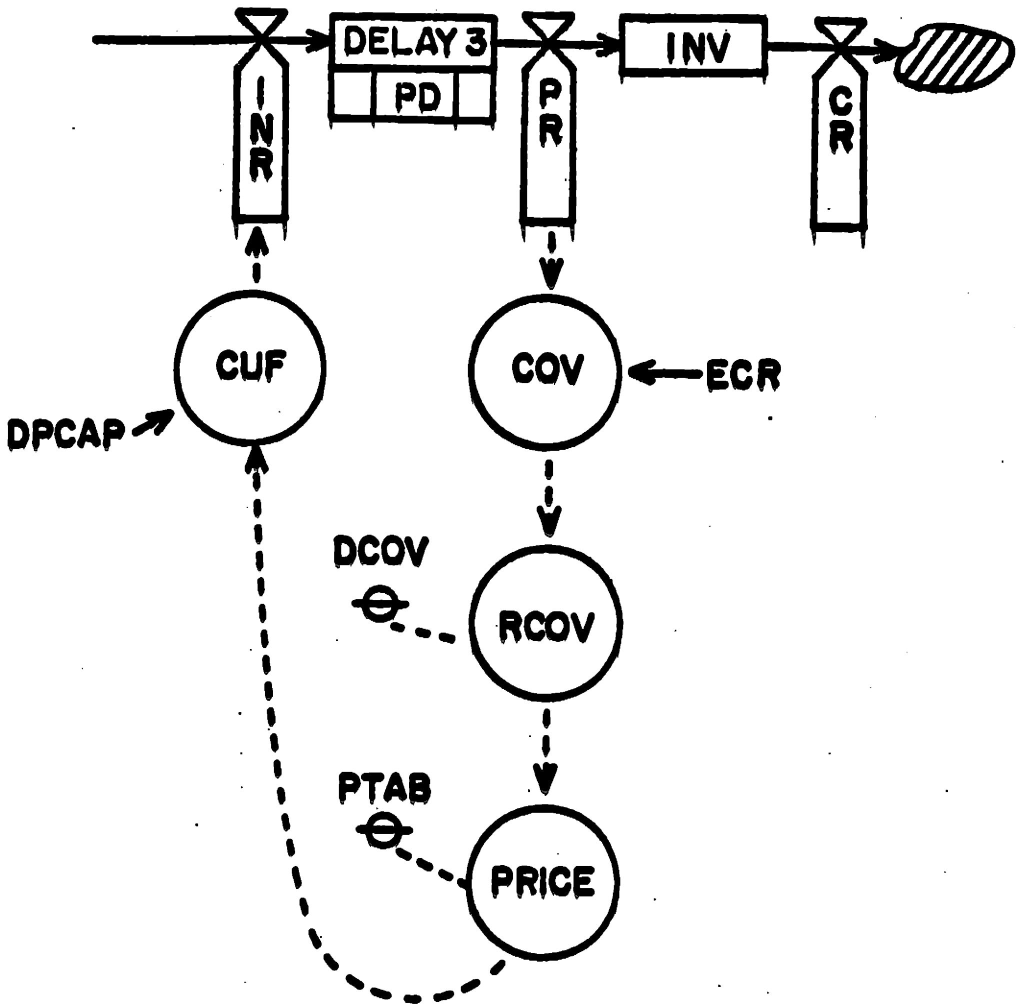


Figure 5-4: Module for Quota Intervention

This formula has also been determined in such a way that it corrects through inventory, coverage and relative coverage the detected price deviations. (See Appendix 3 for the open loop analysis leading to this formula.)

3. Actual desired quota coefficient

XANDA.K = CLIP(1,BN.K,S2.K,0)

XANDA actual desired quota multiplier coefficient; dimensionless

BN desired quota multiplier coefficient; dimensionless

S2 deviation of price from lower bound of range; dollars per unit

4. Updating of the quota multiplier coefficient

4.1 OANDA.KL = PULSE(LANDA.K/DT,3,3)

OANDA rate of outflow from quota coefficient; month^{-1}

LANDA quota multiplier coefficient; dimensionless

DT time interval for simulation; months

4.2 IANDA.KL = PULSE(XANDA.K/DT,3,3)

IANDA inflow to quota coefficient; month^{-1}

XANDA actual desired quota coefficient; dimensionless

DT time interval for simulation; months

Every three months, the quota coefficient LANDA is readjusted. The old value is withdrawn from LANDA through OANDA, and the actual desired new coefficient is entered through IANDA.

5. Link with free market

CUF.K = (LANDA.K)(ZUF.K)(QUOTA) + (1 - QUOTA)(ZUF.K)

QUOTA = 1

CUF capacity utilization factor; dimensionless

LANDA quota coefficient; dimensionless

ZUF theoretical production capacity utilization factor; dimensionless

QUOTA flag indicating that quotas do work; dimensionless

The replication of the tin buffer

The purpose of this section is two-fold: first, to bring validation to the buffer model by showing that it can explain the sequence of events of the tin buffer experiment (refer to Chapter 3); secondly, to show that a buffer stock operation using our policy would have reached better results. (See Appendix 11.)

The inputs

The exogeneous input to consumption in this series has been taken similarly to the one that occurred in the vicinity of 1958: after a period of decreasing trend in consumption, a sudden increase in the level of consumption, followed by a reversal of trend (see Figure 5-5).

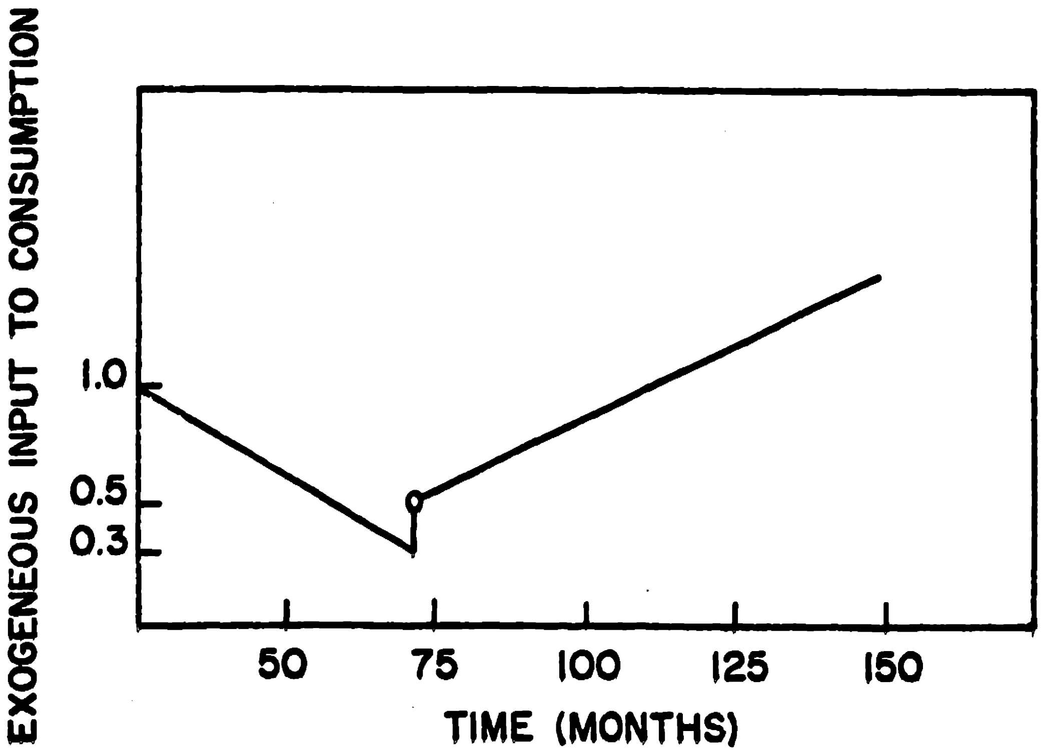


Figure 5-5: Exogeneous Input to Consumption

Description and analysis of runs

Run 5-A

This run expresses what would happen, in face of the exogeneous input, if no stabilization device is used. (See Run 5-A.)

As seen in Figure 5-6, the price variance and the income variance first increase strongly when the step and the reversal of trend occur, due to the cobweb cycles induced by those incidents, then they gradually stabilize as time increases.

Now we shall define three measures of stabilization to analyze the effect of given policies:

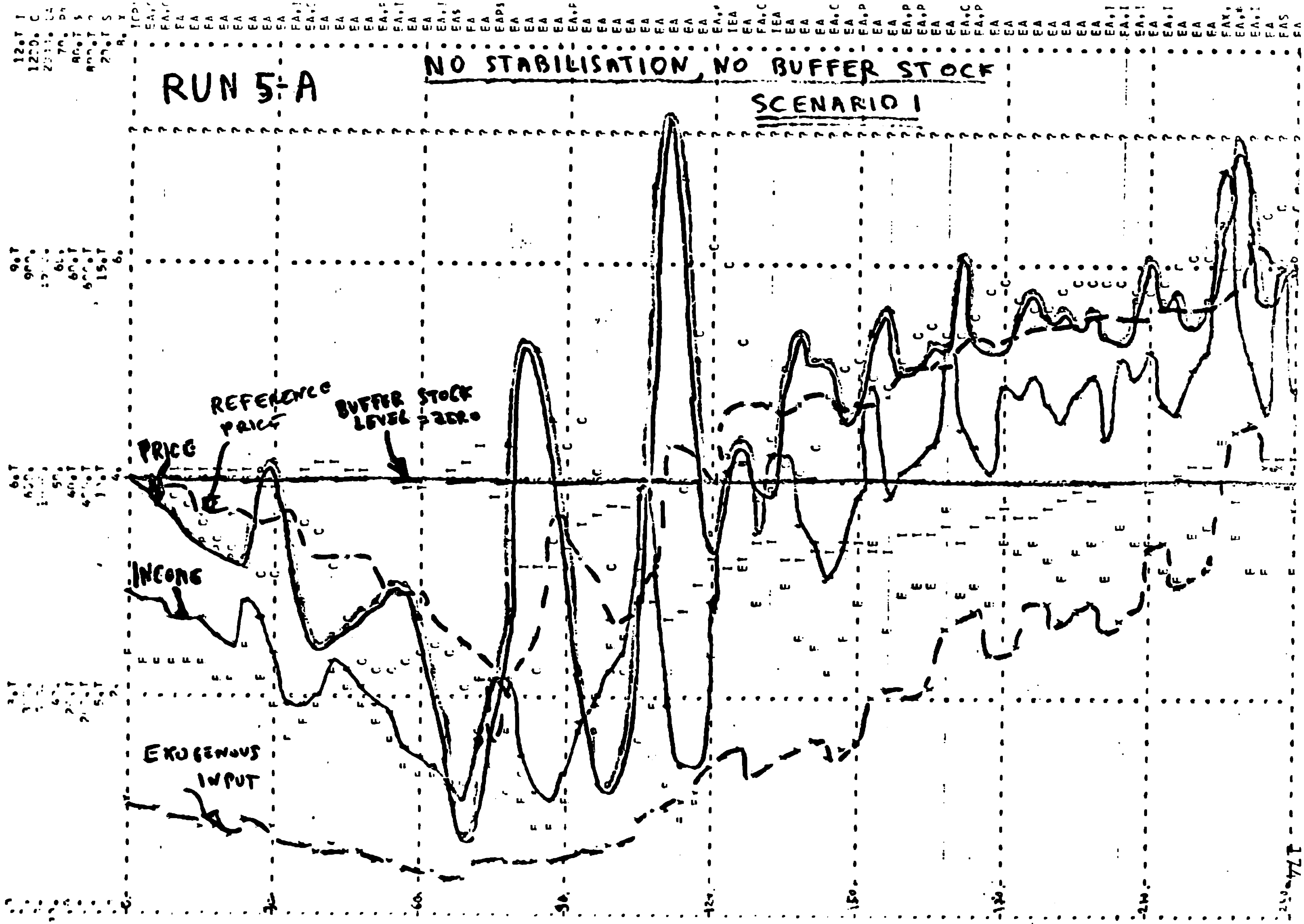
1. Degree of price stabilization $SP = \frac{\sigma_{P,0} - \sigma_P}{\sigma_{P,0}}$

where $\sigma_{P,0}$ is the price standard deviation for the reference run (same history, no stabilization device)

σ_P is the price standard deviation for the given simulation run (with a stabilization device)

SP will be expressed in per cent for more convenience.

It is seen that a device that would reduce price variance to zero would be characterised by a 100 per cent degree of price stabilization; the case when the price standard deviation is the same as when no stabilization is applied. No regulation is measured by a price stabilization degree of 0 per cent.



RUN 5-A
NO STABILISATION, NO BUFFER STOCK
SCENARIO I
PRICE
REFERENCE PRICE
BUFFER STOCK LEVEL = ZERO
INCOME
EXOGENOUS INPUT

It is to be noted that SP is a cumulative measure since σ_P is: it only allows us to measure stabilization from the start of the simulation up to a given point in time.

2. Degree of income stabilization $SI = \frac{\sigma_{I,0} - \sigma_I}{\sigma_{I,0}}$

where $\sigma_{I,0}$ is the income standard deviation for the no regulation case

σ_I is the income standard deviation for a given device simulation run

As seen in Chapter 3, this measure is less relevant to us than SP. This is because the model does not include explicitly the shift in demand for stock by consumer reaction to changes in price expectations.

3. The final cost effectiveness

It is simply defined as the ratio of degree of price stabilization to cost measured at the end of the simulation period. This index is not very significant, since actually cost and degree of stabilization have to be related eventually by the utility function of the stabilizing agency.

$$CEFF = \frac{SP}{COST} \times 10^5$$

Although only SP is a relevant measure for all our purposes, SI and CEFF may be interesting indicators of the effectiveness and efficiency of a device.

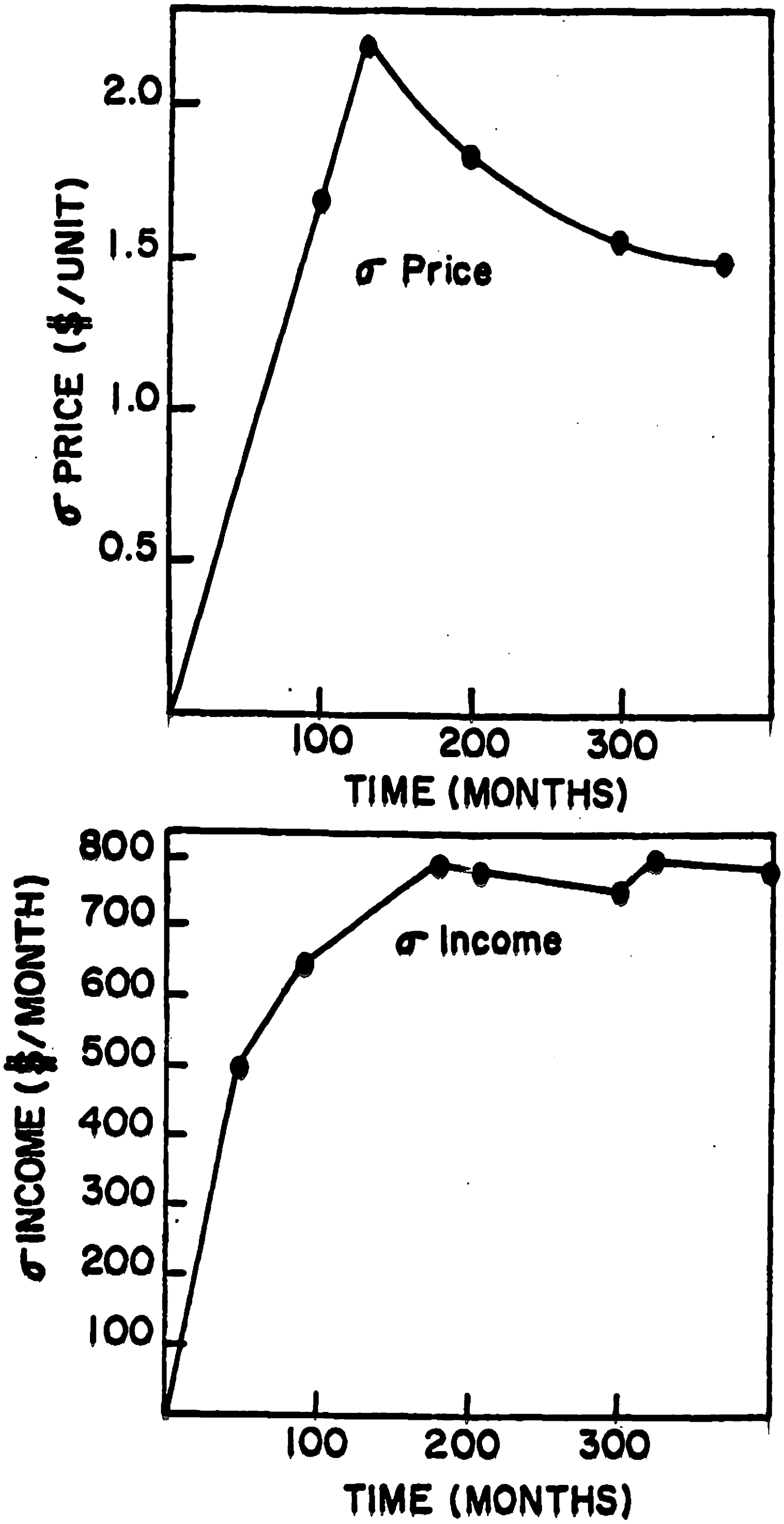


Figure 5-6: Analysis of Run A

(Reference Run with Scenario One)

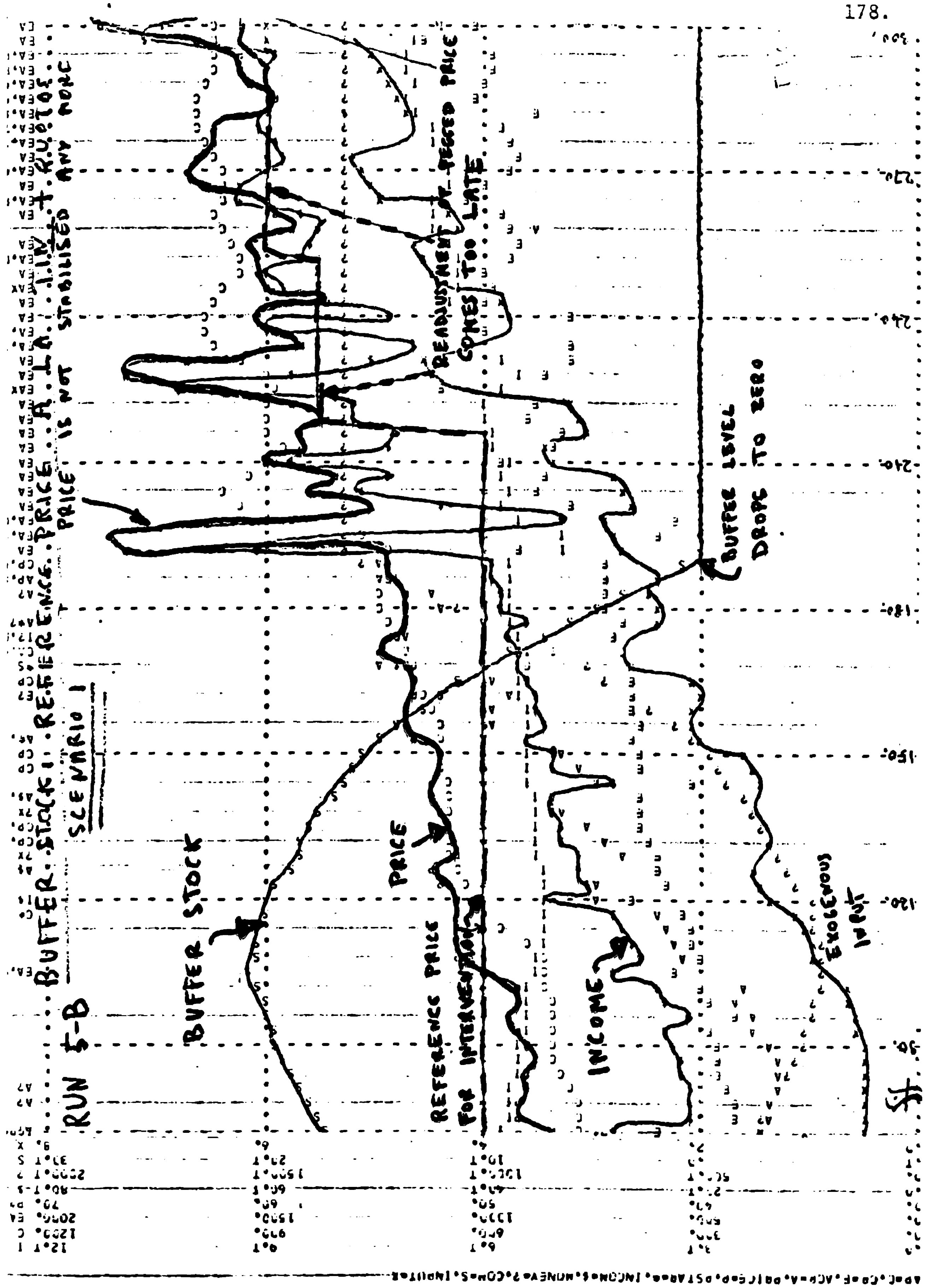
Run 5-B

This run constitutes a further validation of our model since it duplicates the sequence of events following the same exogeneous inputs to consumption as happened in the real world for tin in 1958. Although the world market module in our model has not been modified to the parameters of tin, the duplication may be considered as satisfactory since the structure being the same, the same sequence of exogeneous influences leads to the same sequence of consequences as for the behavior of the variables of importance. (See Run 5-B and Figure 5-7.)

There is a buffer stock supplemented by a quota system. The reference price for intervention is, as was in the real case, pegged.

During the period of decreasing trend in consumption, the buffer stock is purchasing important quantities of commodity to sustain the decided upon, pegged price. Stabilization achieved is quite impressive (88 per cent for this period). Then as the step increase in consumption, followed by the reversed trend occurs, the stabilizing agency still tries to bring back price to the pegged reference price, instead of recognizing the trend and trying to adapt reference price. This leads to an exhaustion of the physical holdings of the buffer stock which occurs at month 180. (Stabilization SP is still 72 per cent.)

After exhaustion of the buffer stock, it is too late to replete the stock without accentuating the upwards movement of prices, and the noise type disturbances that occur in consumption cannot be ironed out any


RUN 5-B
SCENARIO 1
PRICE IS NOT STABILISED ANY MORE
BUFFER STOCK
PRICE
REFERENCE PRICE FOR INTERVENTION
INCOME
EXOGENOUS INPUT
BUFFER LEVEL DROPS TO ZERO
READJUSTMENT OF PEGGED PRICE COMES TOO LATE

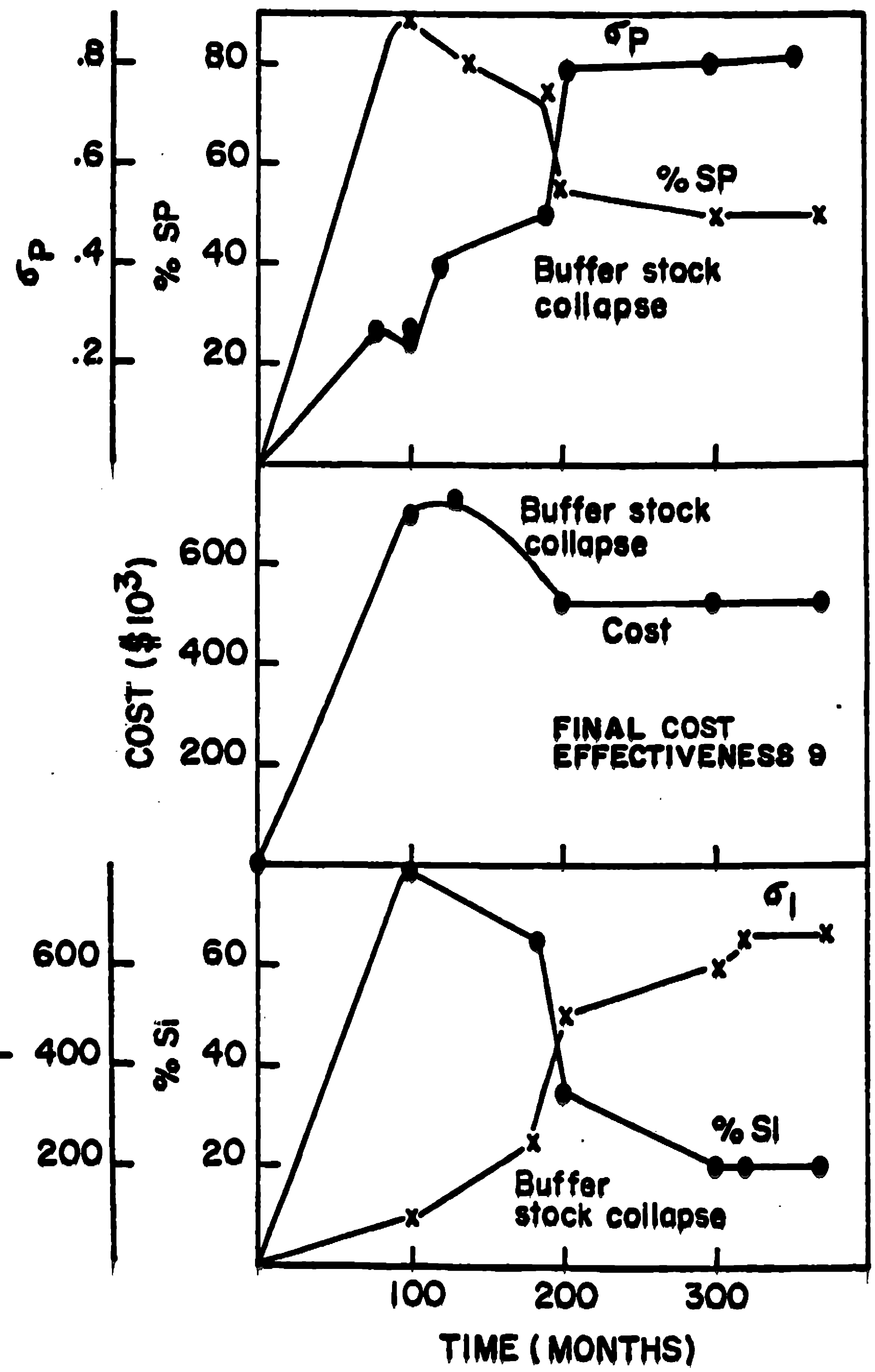


Figure 5-7: Analysis of Run B

(Duplication of the Tin Experiment with Scenario One) more: price standard deviation (σ_P) increases from .47 to .78, while the degree of stabilization drops from 75 per cent to 58 per cent. From now on, the regulating effect of the agency practically disappears, and the final 50 per cent of overall stabilization is only a rememberance of the strong stabilizing effect at the beginning.

When the agency realizes that the stock is getting depleted it tries to readjust the pegged price, and from then on decides to readjust the pegged price for quota and buffer stock intervention, but this occurs too late to prevent the stock level from dropping to zero.

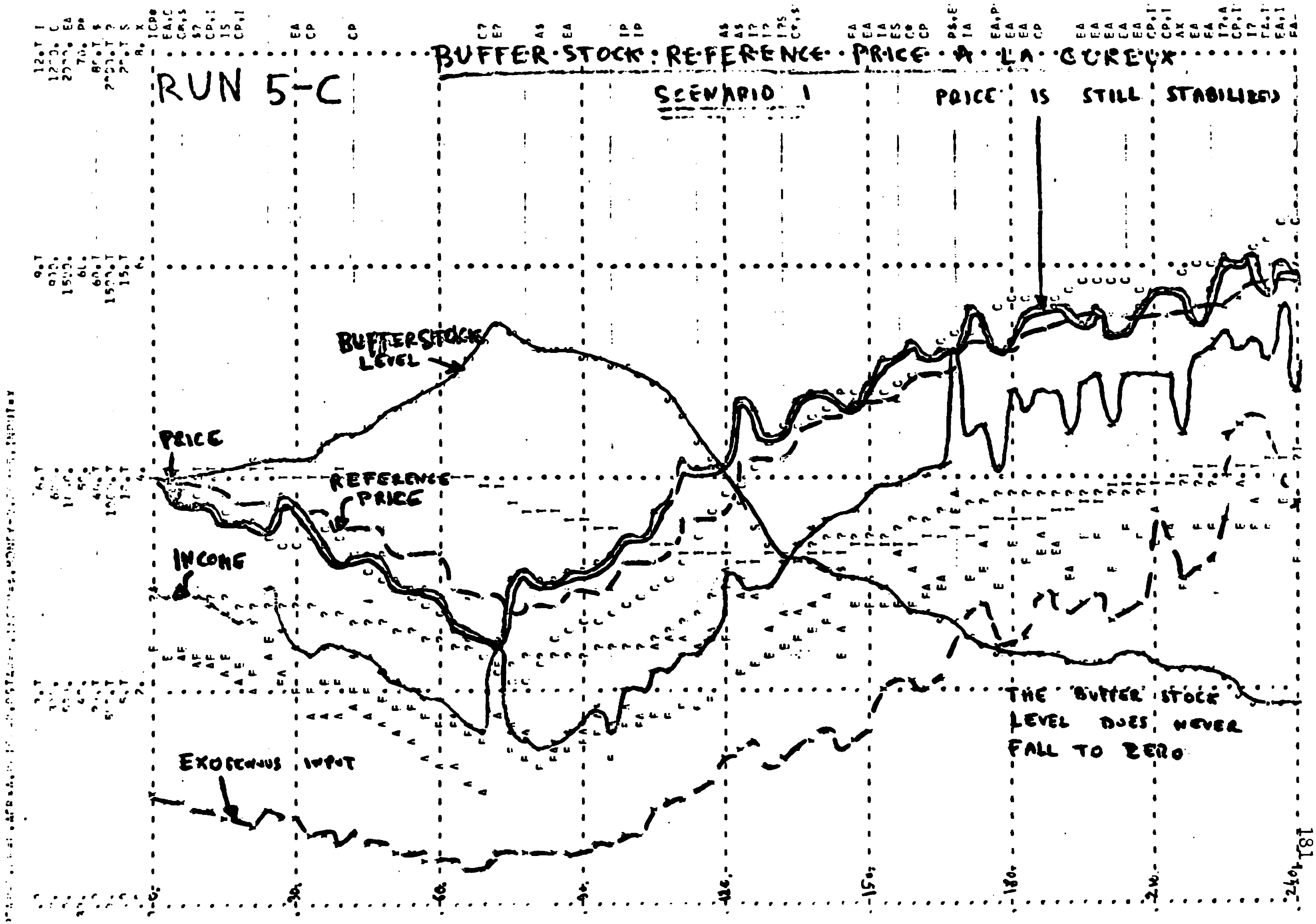
This is illustrated by Figure 5-7.

Also income stabilization follows a route parallel to price stabilization. The final cost effectiveness is CEFF = 9.

Run 5-C

This simulation is to compare the previous duplication of the tin experiment with what would have happened had the policy for reference price been different: here, the reference price is taken according to the five years rule of Goreux.[2] This applies to quota reference price as well as to buffer stock. (See Run 5-C.)

Until month 180, the behavior of the variables is pretty much similar to those in the previous run. When month 180 occurs, the buffer stock has still enough reserves, since, unlike the previous case, it did recognize the changes in trend and therefore did not


BUFFER STOCK: REFERENCE PRICE A LA CUREUX
RUN 5-C
SCENARIO 1
PRICE IS STILL STABILIZED
BUFFERSTOCK LEVEL
PRICE
REFERENCE PRICE
INCOME
EXOGENOUS INPUT
THE BUFFER STOCK LEVEL DOES NEVER FALL TO ZERO
0.
30.
60.
90.
120.
150.
180.
210.
240.

exhaust its resources to try to come back to an irrealistic reference price. Therefore stabilization of external noise type disturbances is still effective.

At month 100, SP is 65 per cent (50, month 200) which goes on until the end of the simulation. SI is pretty much parallel to SP. Final cost effectiveness is 13.5.

As shown in Figure 5-11, it seems that before month 180, the pegged price method has been producing better results in terms of stabilization than the present method. After month 180, the global SP of both methods are equivalent; but SP being a cumulative measure, one has to keep in mind that it carries the previous history with it, and an SP of 50 per cent following a peak of 88 per cent expresses a much higher instability in the last period than an SP of 50 per cent following SP's around 65 per cent. (See Figure 5-8.)

The conclusion is that, if the reference prices had been readjusted periodically to keep up with the trend, but not continuously as is done in the present simulation, the stabilization effect might have been higher.

The reason is that a more stable reference price allows on the long run a more realistic reference information and therefore allows a better control, provided it is not allowed to lose contact with the trend. A readjustment of the reference price every three months, the

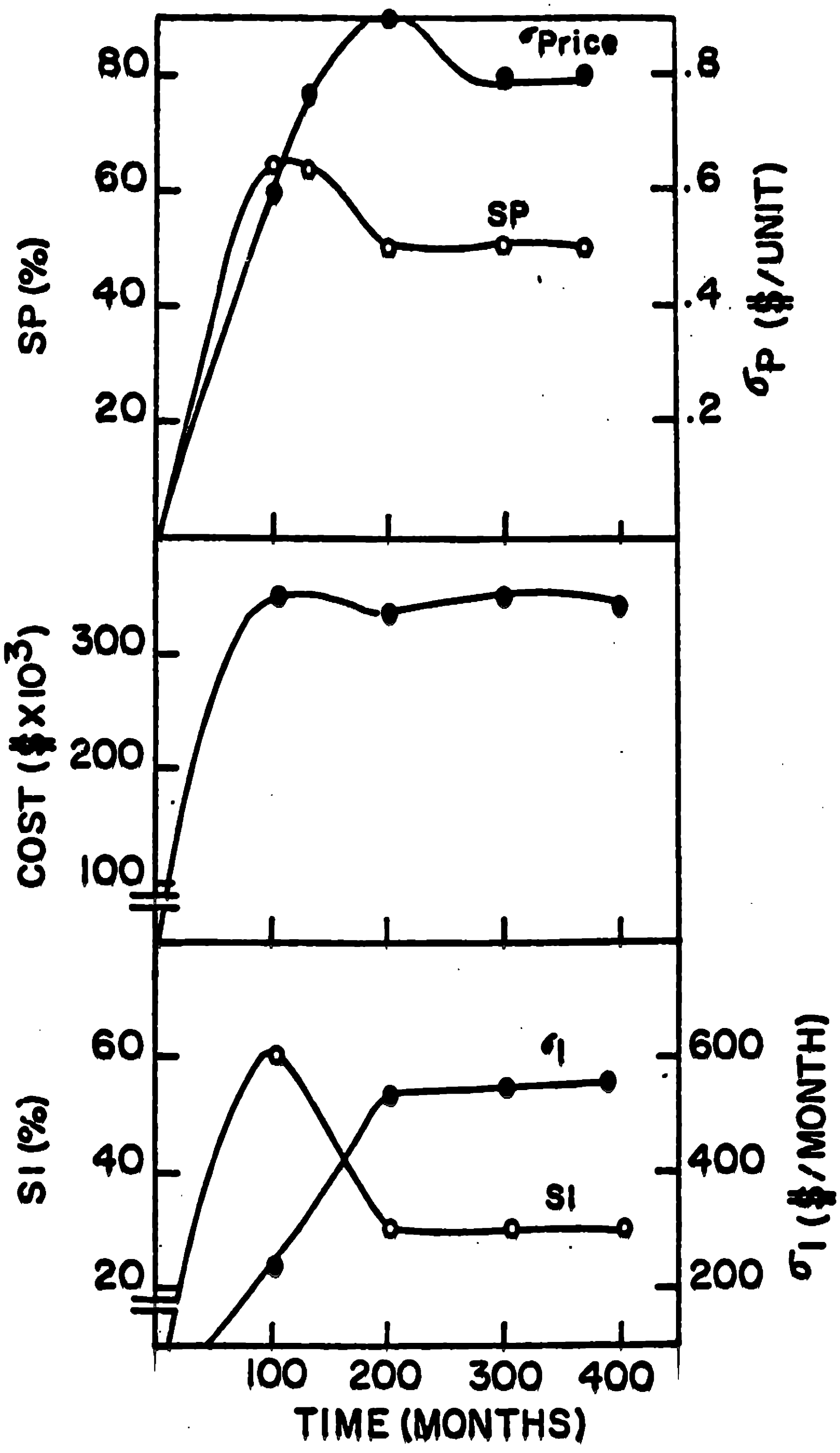


Figure 5-8: Analysis of Run C

(Test of Goreux' Reference Price Rule with Scenario One) reference price being computed by using the Goreux formula, would probably give better results for stabilization.

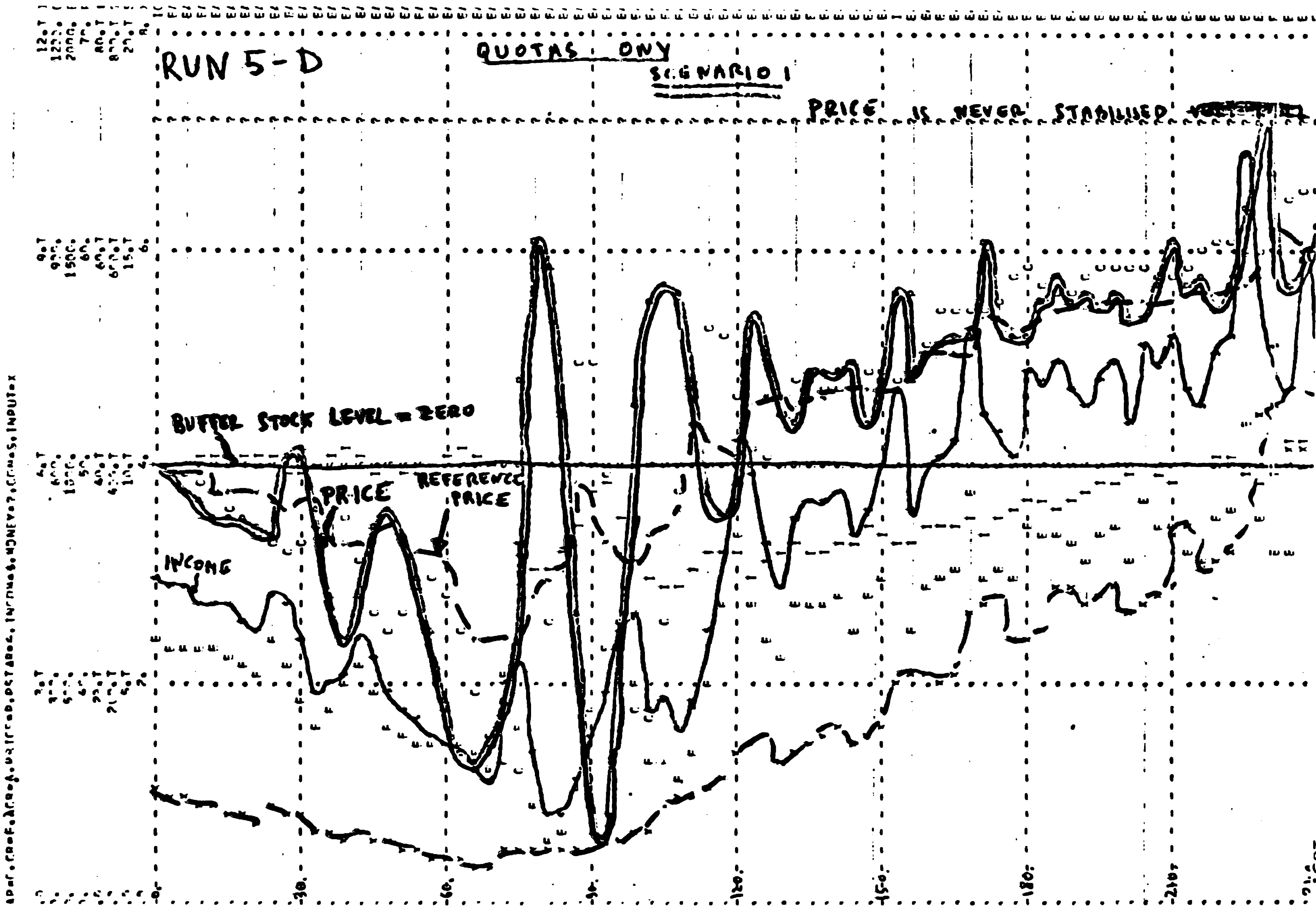
However, because of psychological reasons, this would be self-defeating: speculators would be acting in respect to their expectations of what the next readjustment of the buffer agency would be. To maintain stability of price in the wake of those speculators' transactions would require a more important pool of resources for the agency, in order to prevent itself from being overrun by speculation (analogy with international monetary problems).

Therefore, although less efficient than pegged reference price (only as long as the resources of the buffer are not exhausted), a moving average constantly free to float is more desirable. Furthermore, this whole section demonstrates the danger of a pegged price in the presence of unperceived trends.

Run 5-D

In this simulation, we simply test the stabilizing effects of a moderate quotas program on the same sequence of external events as the previous cases. The reference price for stabilization is determined by Goreux' rule, and readjusted every three months. (See Run 5-D.)

As seen in Figure 5-9, the degree of stabilization introduced by this particular quota policy is not very high: a 5 per cent price stabilization is obtained, at zero cost, all along the simulation.


RUN 5-D
QUOTAS ONY
SCENARIO 1
PRICE IS NEVER STABILISED
BUFFER STOCK LEVEL = ZERO
PRICE
REFERENCE PRICE
INCOME
0.
30.
60.
90.
120.
150.
180.
210.

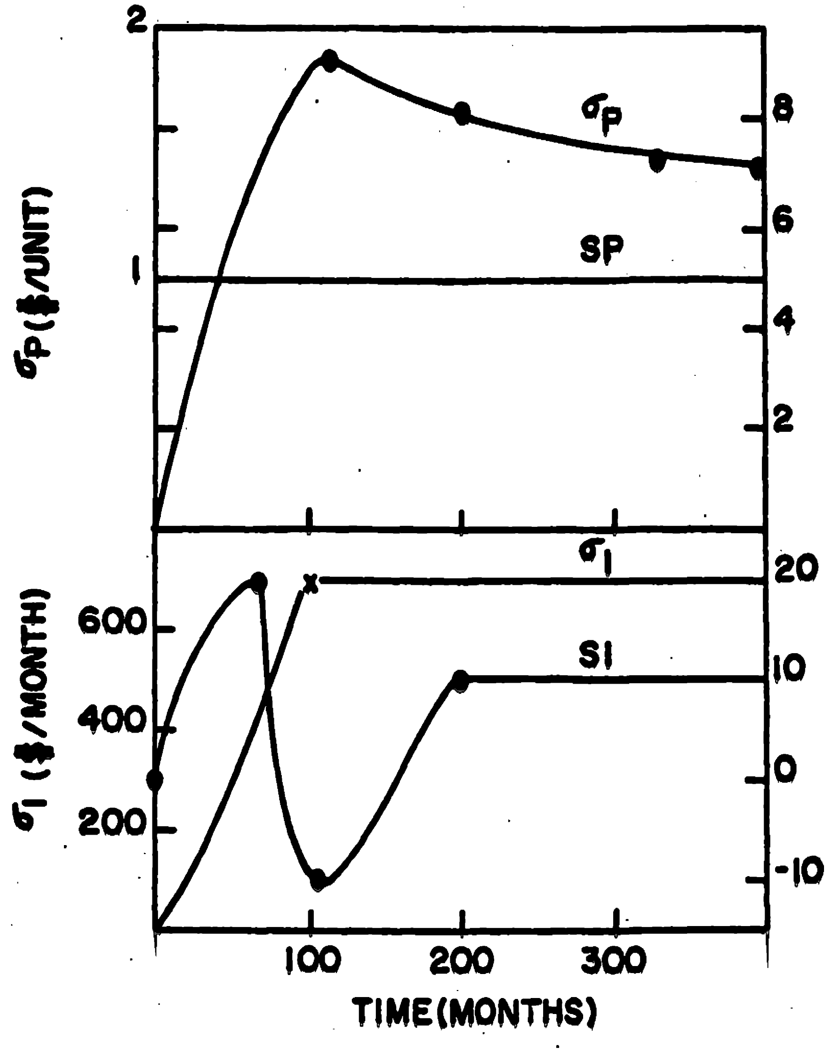


Figure 5-9: Analysis of Run D

(Stabilization Through Quotas Only with Scenario One)

The effect on income does not follow completely, and a negative stabilization occurs at time 100, which corroborates that a quota policy should have a careful price policy if it is not very energetic, since effect of restraint on production is felt with delays leading to results sometimes opposite to those expected.

This series of simulations is summarized in Figure 5-10, where it appears that, as discussed in the analysis of Run 5-B, a periodically adjustable reference price based on Goreux' formula should give the best results, but, as seen for Run 5-C, it is not wise. The fact that policy A (pegged reference price) is equivalent after three hundred seventy-two months, policy A being better as long as the buffer stock has not collapsed, is essentially due to the scenario chosen (exogeneous input). A different scenario can be constructed to compare those policies under different circumstances. (See Runs 5-E, 5-F and 5-G.)

Runs E, F, and G simulate responses when:

1. no stabilization scheme is used: reference run
2. the readjustable pegged reference price is used
3. a rule a la Goreux for reference price is used

The exogeneous input is similar to the input in the previous series, with a larger slope of the upward trend. Behavior of price and income is quite similar to the previous runs. (See Figures 5-11 and 5-12.)

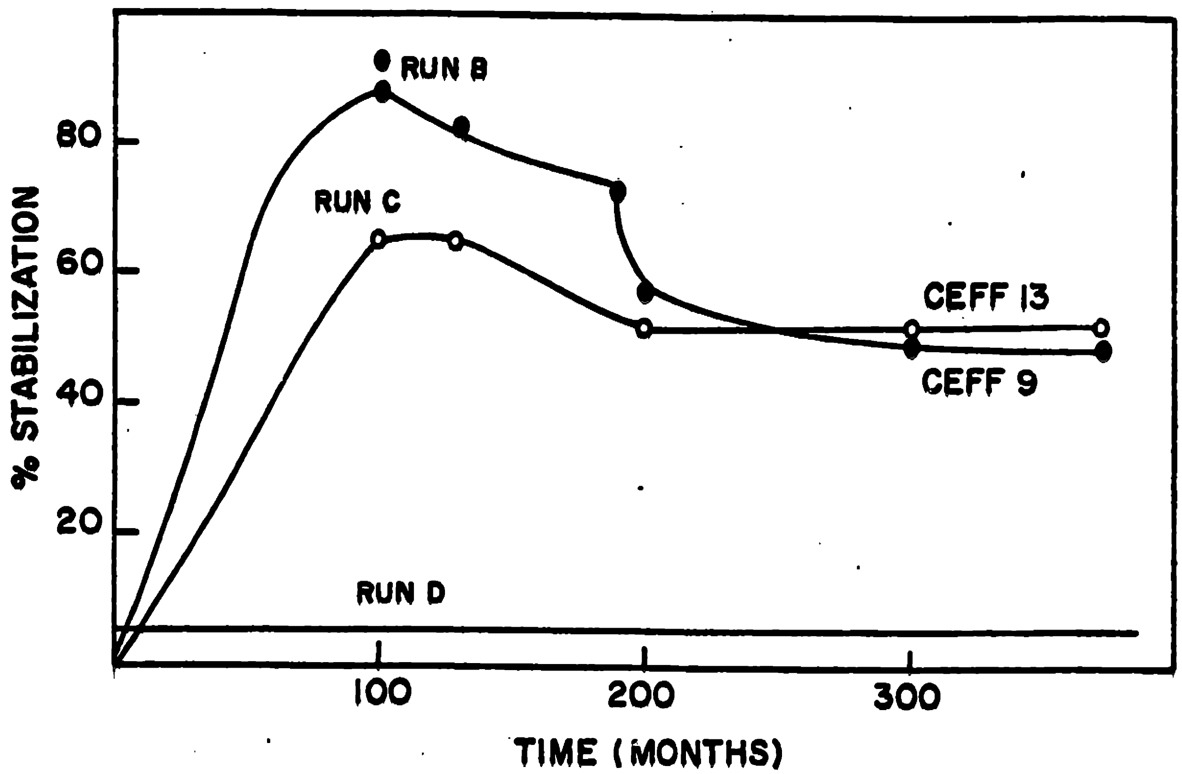
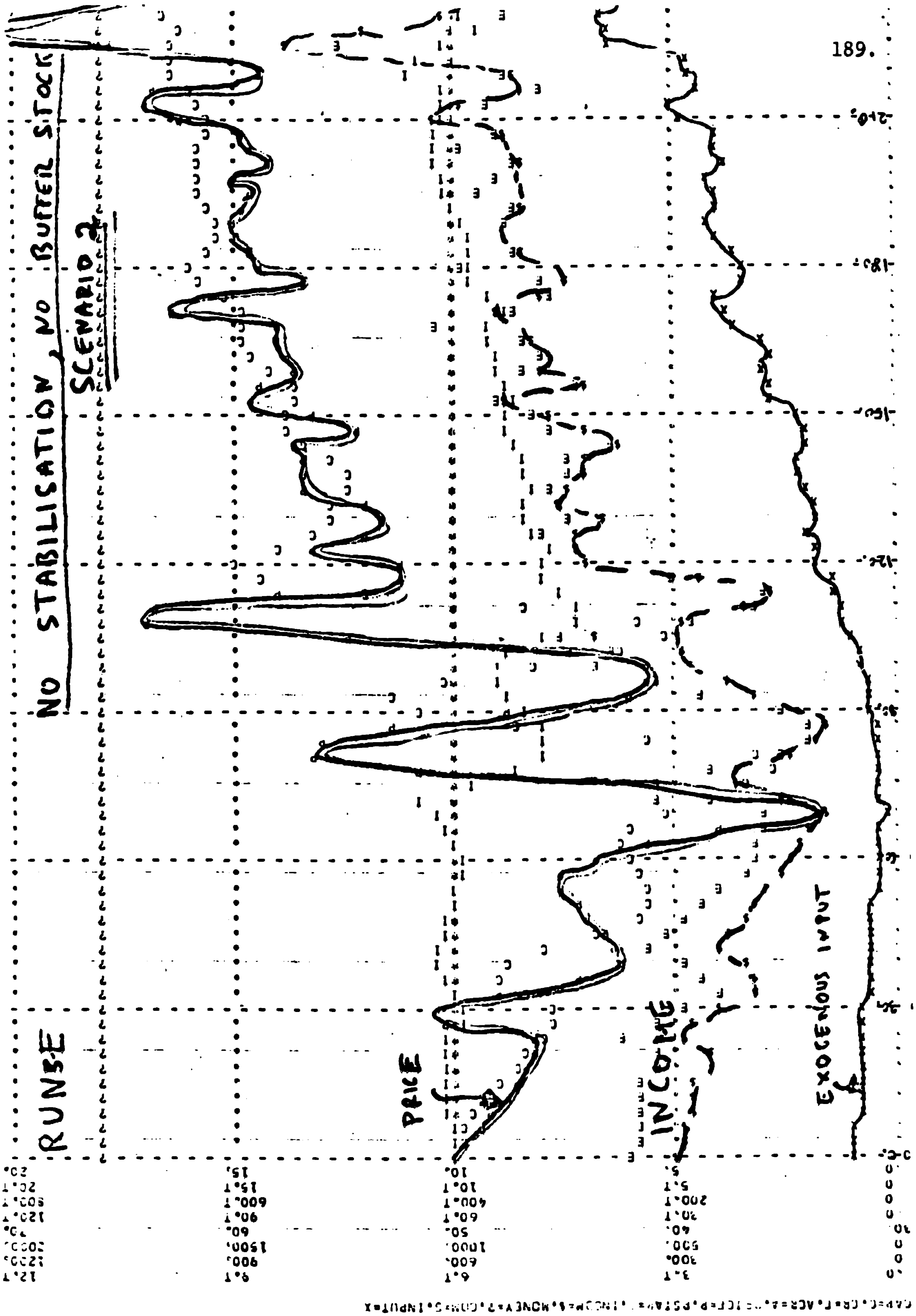
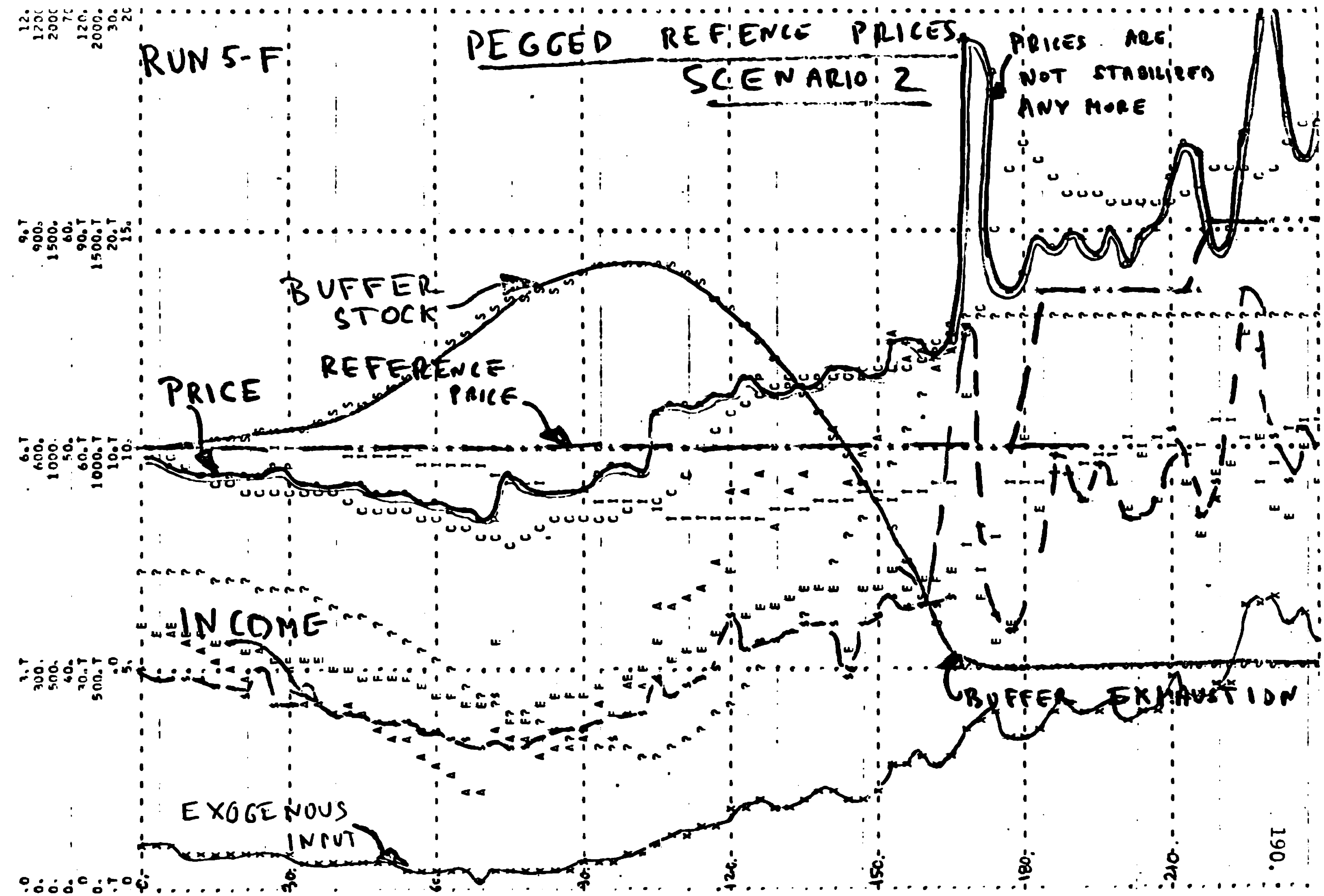
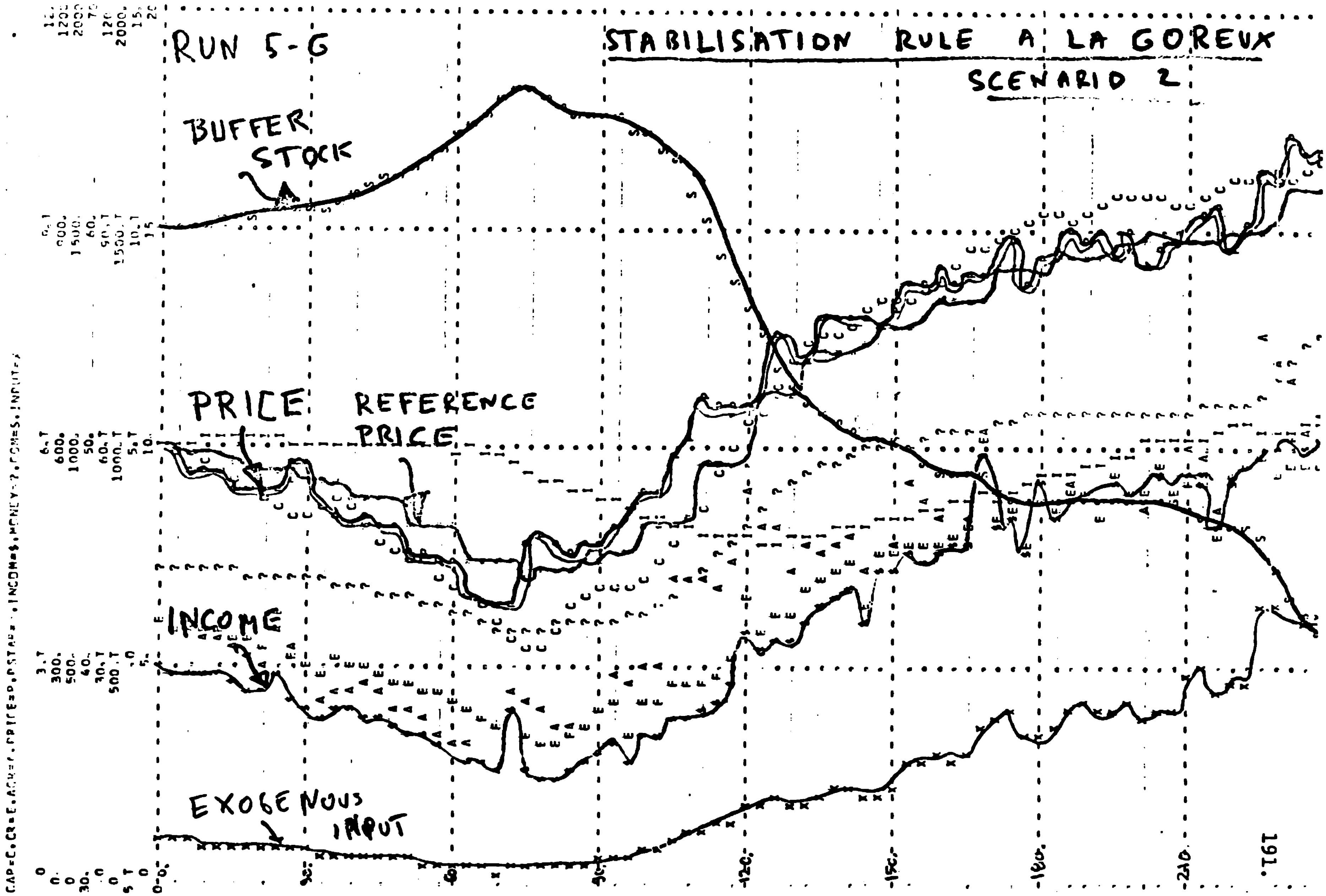


Figure 5-10: Comparison of Goreux' Rule versus Pegged Reference Price

(Scenario One)


NO STABILISATION, NO BUFFER STOCK
SCENARIO 2
RUN 5E
PRICE
INCOME
EXOGENOUS INPUT


RUN 5-F
PEGGED REFENCE PRICES
SCENARIO 2
PRICES ARE NOT STABILIZED ANY MORE
BUFFER STOCK
REFERENCE PRICE
PRICE
INCOME
EXOGENOUS INPUT
BUFFER EXHAUSTION
0.
30.
60.
90.
120.
150.
180.
210.


RUN 5-G
STABILISATION RULE A LA GOREUX
SCENARIO 2
BUFFER STOCK
PRICE
REFERENCE PRICE
INCOME
EXOGENOUS INPUT
0.0
30.
60.
90.
120.
150.
180.
210.

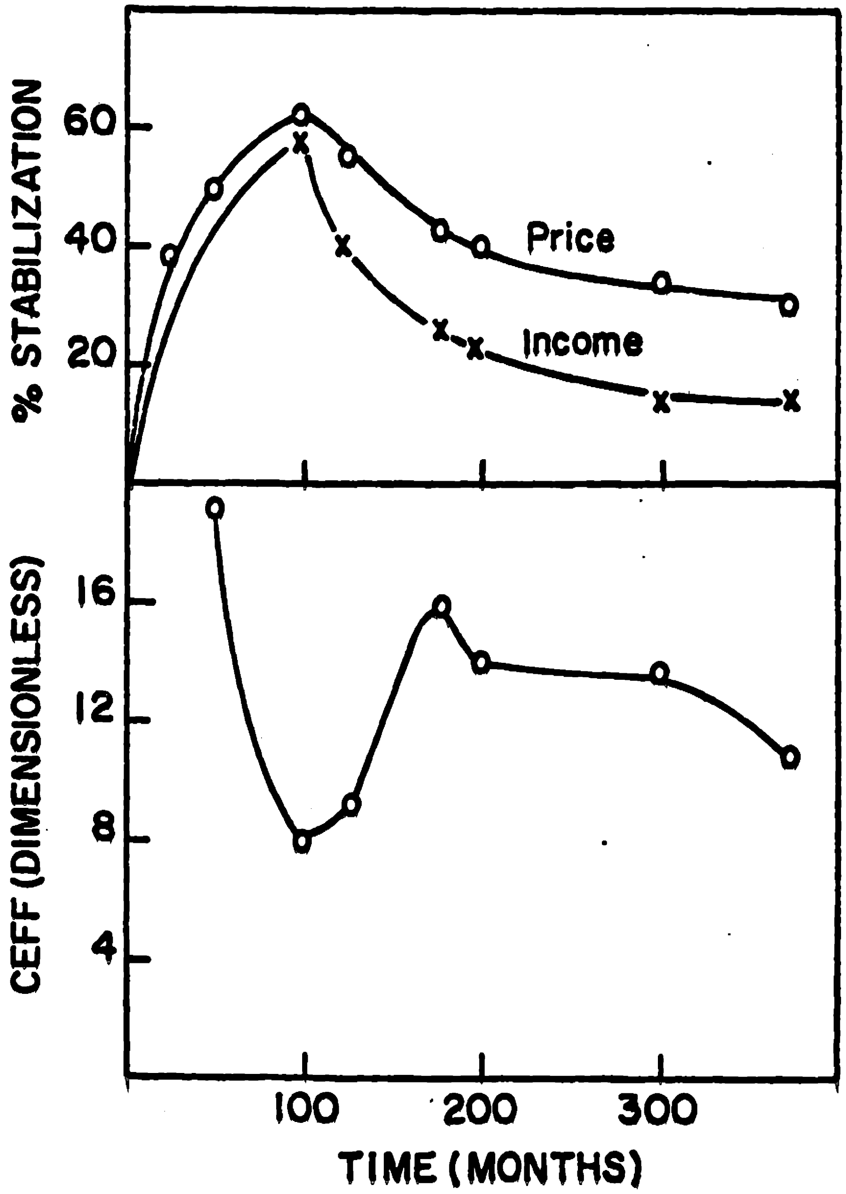


Figure 5-11: Analysis of Run E

(Test of Goreux' Reference Price Rule with Scenario Two)

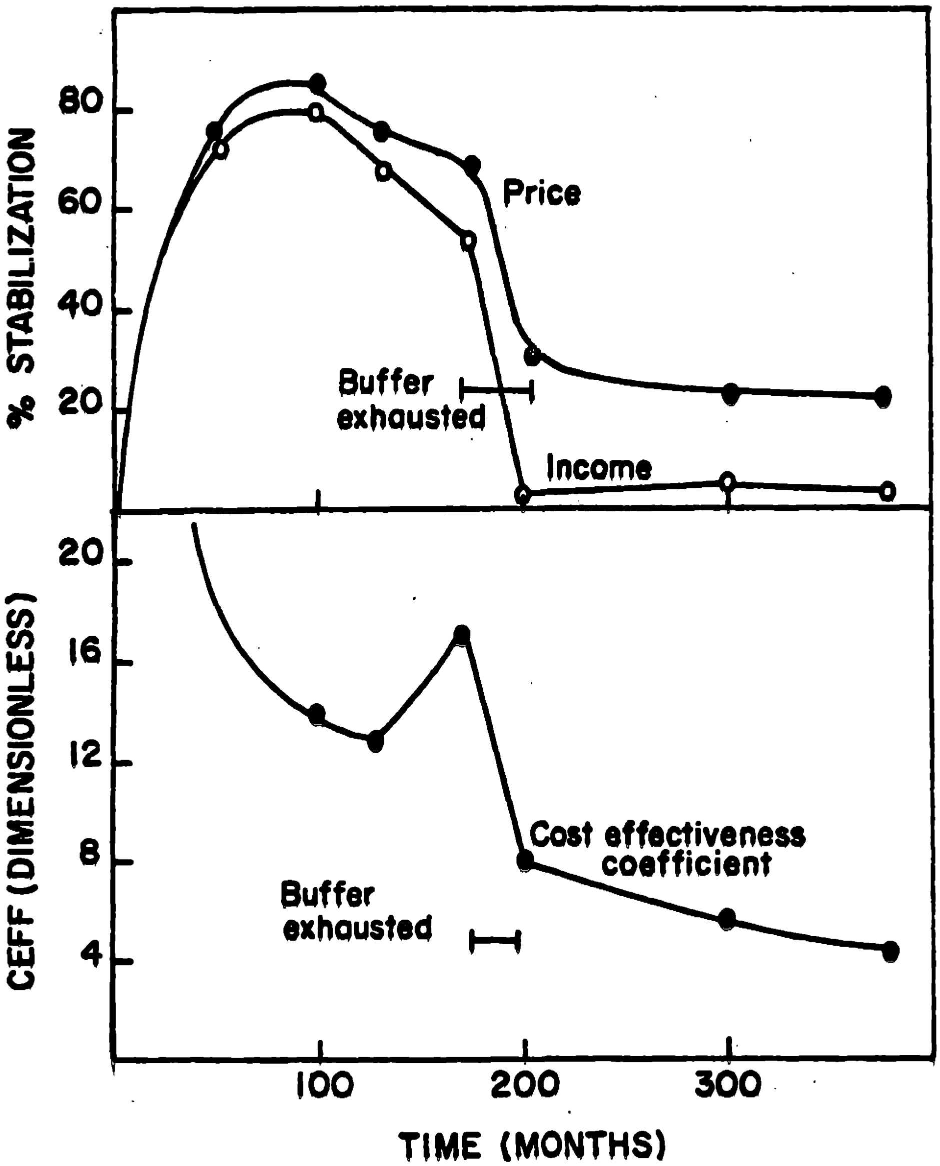


Figure 5-12: Analysis of Run F

(Duplication of Tin Experiment with Scenario Two)

The buffer stock collapses at month 160 with the pegged reference price method. Before month 160, the pegged reference price method works more efficently than Goreux' rule.

After collapse of the buffer stock, the price goes out of control in the pegged price case, while Goreux' rule permits the agency to maintain control until the end of the simulation.

As seen in Figure 5-13, after exhaustion of resources of the stock, Goreux' rule gives better results for price stabilization and cost effectiveness with scenario number two.

Technical issues

Influence of stability measuring rule

It has been discussed in Chapter 3 that the reference price used for computing the deviation of price and therefore measuring stability was of importance. We ran a simulation using different lengths of time to compute the reference price using an exponential smoothing on a period called LENTH. The result shows the influence of choosing consistently the same LENTH in order to be able to compare stability characteristics of models involving different cobweb periods: it is suggested that the smoothing period be not less than one period of the cobweb cycle which equals twenty-seven months in the general commodity model. Beyond this value of LENTH the measure of stability becomes quite constant, as seen in Figure 5-14 and in Table 5-1.

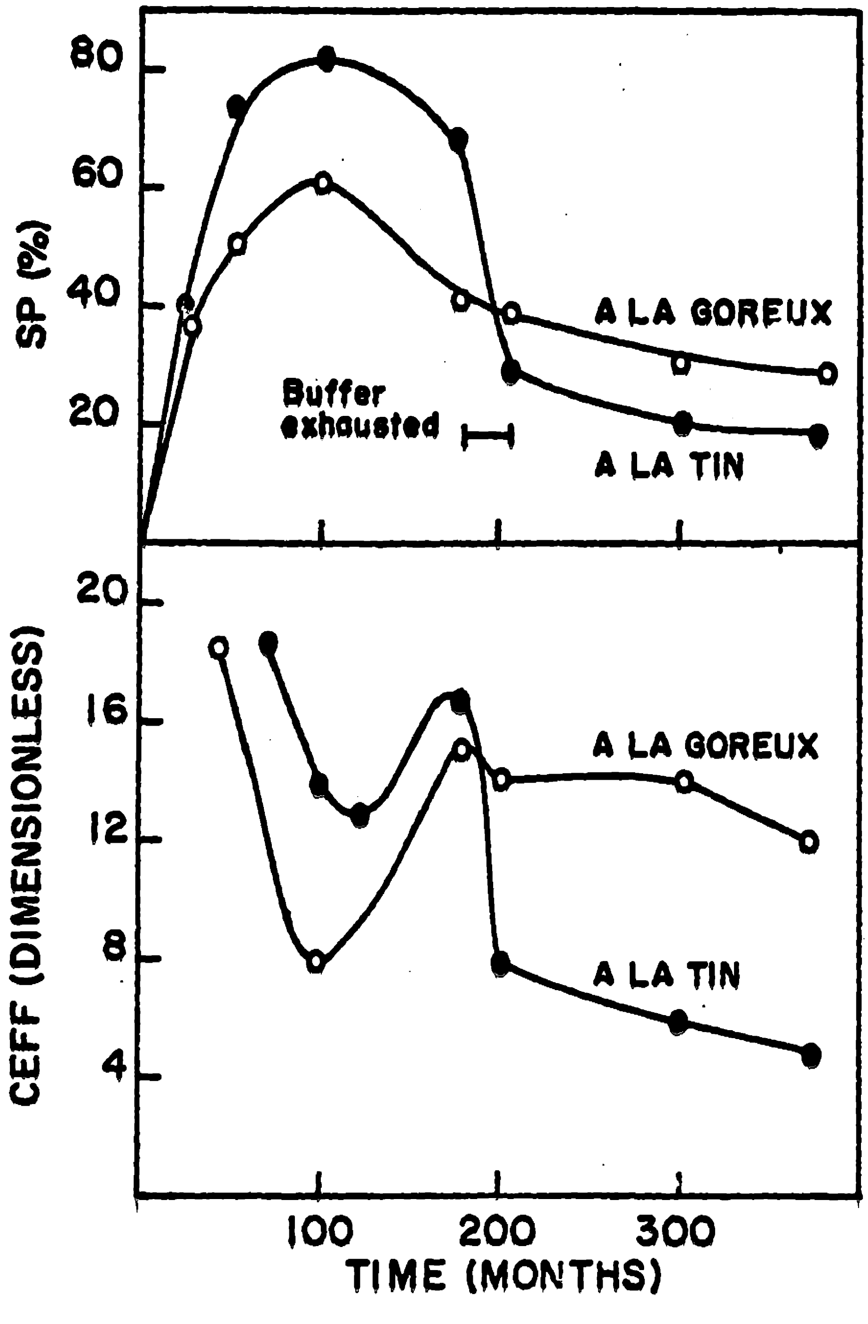


Figure 5-13: Comparison of Goreux' Rule

versus Pegged Reference Price (Scenario Two)

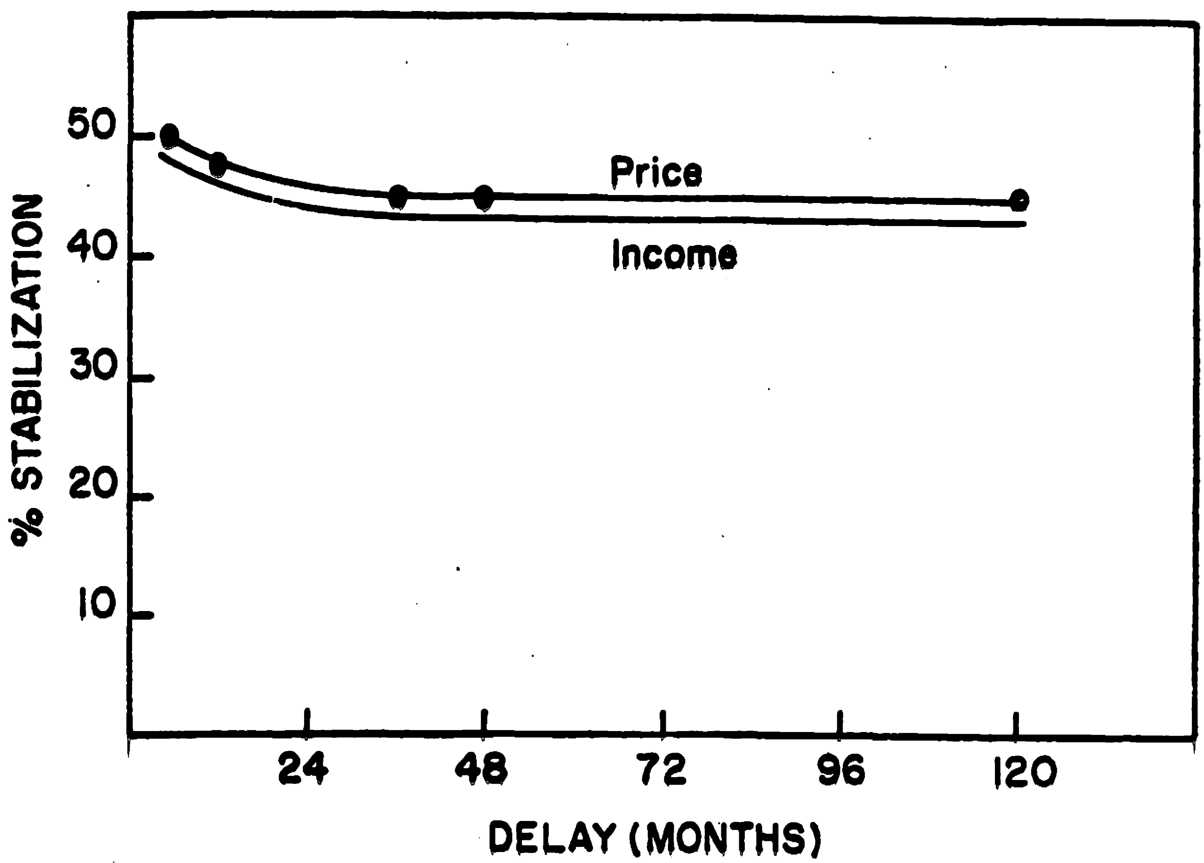


Figure 5-14: Impact of Averaging Period Used for Measuring Stabilization

X*	LENGTH	Cost	Stabilization Measures: Price σ_p \$/unit	Price SP, percent	Income σ_I \$/mo.	Income SI. percent
1	4	431.65	0.233	50.0	137.46	48.0
0	4	-	0.45	-	266.00	-
1	12	431.65	0.372	47.0	219.00	47.0
0	12	-	0.70	-	412.00	-
1	36	431.65	0.429	46.5	252.00	46.5
0	36	-	0.79	-	461.00	-
1	48	431.65	0.44	45.0	257.00	45.0
0	48	-	0.80	-	466.00	-
1	120	431.65	0.46	44.0	267.00	44.0
0	120	-	0.82	-	476.00	-

* X = 1 means stabilizing device is active
X = 0 means that no stabilization device exists

Table 5-1: Impact of averaging period used for measuring stabilization

Modulated intervention within the accepted price range

It may be deemed more efficient to modulate the magnitude of the intervention of the buffer stock with the rate of change of price. In other words, to avoid overshooting in stabilization, the following rule may be proposed (see Table 5-2):

The accepted price range is divided into thirds (see Figure 5-15):

-In the second third, no intervention is made.
-Outside of the range (above PMAX and below PMIN), intervention is mandatory, and performed with standard magnitude,
-Within the ranges 1 (PMAX - PMAX3) and 3 (PMIN - PMIN3) intervention is optional, to be decided upon the following rules:

The criterion for intervention is the concavity of the price curve versus time:

1. If price is within range 1, when the concavity is positive (Case B, Figure 5-15), a stronger intervention is necessary to bring it down.
2. If concavity is negative (Case A, Figure 5-15), a reduced intervention is necessary to avoid overshoots.
3. Similar considerations intervene in range 3, with reversal of sign.

Two simulation runs test those policies. The input is an impulse of 20 per cent for eighteen months.

No significant improvement is introduced by this rule, as seen in Table 5-3. (See also Appendix 12.)

PRICE LEVEL	CASE	ACTION
$P > P\ Max$	-	Full intervention
$P\ Max > P > P\ Max_3$	A	Reduced intervention
	B	Full intervention
$P\ Max_3 > P > P\ Min_3$		No intervention
$P\ Min_3 > P > P\ Min$	C	Reduced intervention
	D	Full intervention
$P > P\ Min_3$	-	Full intervention

Table 5-2: Intervention Magnitude Definition

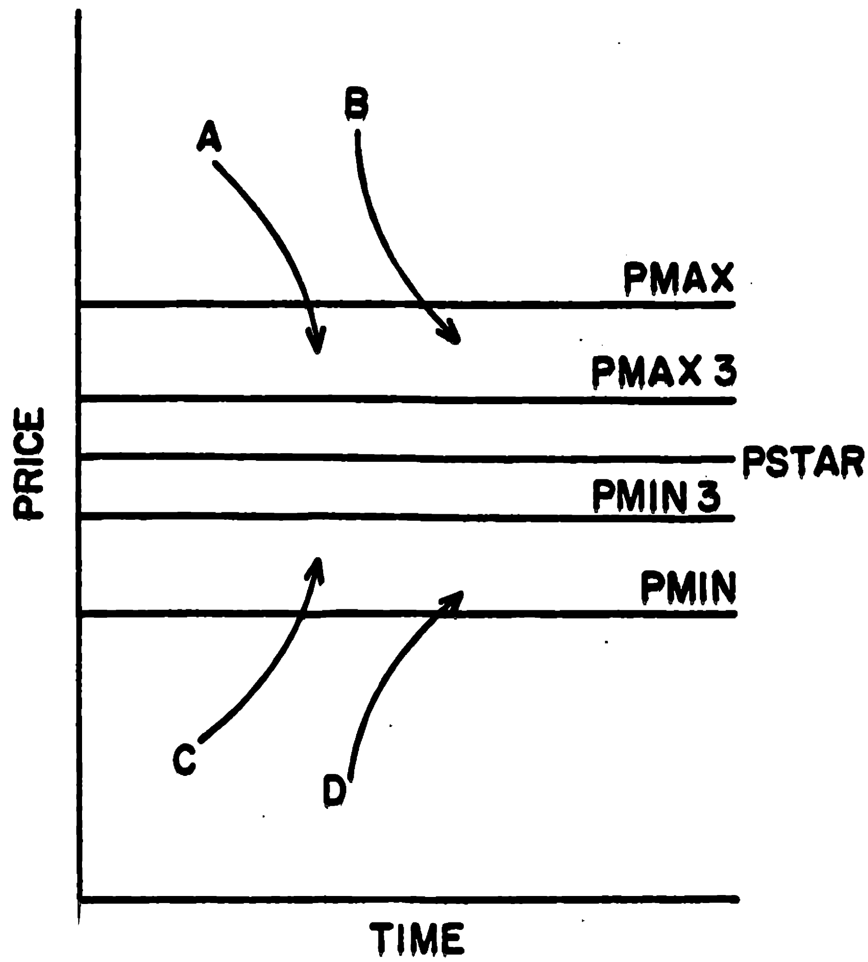


Figure 5-15: Operation of a Modulated Intervention Magnitude

Simulation Conditions	With Modulation P &/unit	I $/mo.	Cost $10^3$$	No Modulation P $/unit	I $/mo.	Cost $10^3$$
DY = 10 RANGE = 3	0.429	252.5	431.65	0.3570	209	427
DY = 1 RANGE = 3	0.654	382	472	0.626	365	472
DY = 20 RANGE = 3	0.387	228	413	0.308	181	411

Table 5-3: Operation of a Modulated Intervention Magnitude

Influence of smoothing period for reference price

As seen in Chapter 3, the reference price must be consistent with trend. Therefore, it should be based on some moving average, and Goreux' rule is chosen here. The question now arises of how long the period on which this moving average is performed should be.

It seems natural to try to make this period higher than the period of the phenomenon one is trying to iron out, but smaller than the period of the phenomena one tries not to affect. (See Forrester, Appendix G, Reference 36.)

For instance, in our model, price variations result from superposition of a random noise influence, with pseudo period of eight months, cobweb induced cycles of twenty-seven months periodicity, and the exogeneous long run has a slight oscillation with a period of fifteen hundred months. Therefore the smoothing delay for price ought to be adapted to those constraints and the stabilization goals. A series of simulations were performed with different time delays for smoothing price (OZ designs the base period, and the moving average is taken on a total of five times OZ) to test the veracity of this statement (see Table 5-4).

But to first make this point clear without being obscured by the complex interactions of the model, we will build an example where these principles are demonstrated. They represent different smoothing periods (OZ) applied to the case of a variable, including a long term exogeneous oscillation of period fifteen hundred months, a cobweb cycle of thirty months and a noise of periodicity of eight months.

As exhibited in Runs 5-H, 5-I, 5-J and 5-K and a period of twenty months will completely iron out the noise, but not affect the thirty months cycle, nor affect the trend. A smoothing period of three months affects very little. A smoothing period of eighty months will iron out the noise and the cobweb components, and not affect the trend.

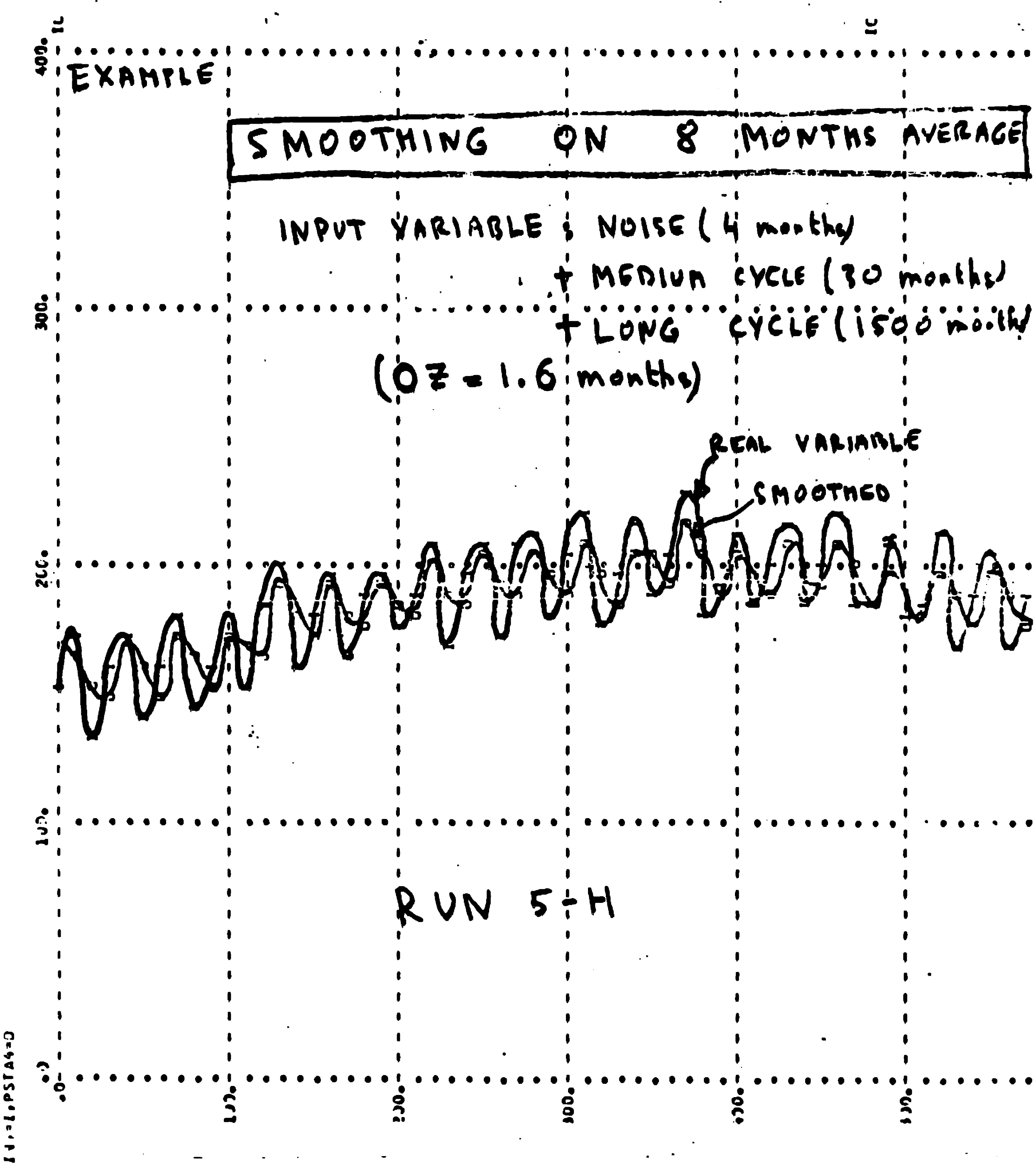
The same principles are applied in the model. As shown in Table 5-4, the same smoothing pattern applies. The effect of increasing this smoothing period increases the stabilization effect (see Table 5-4).

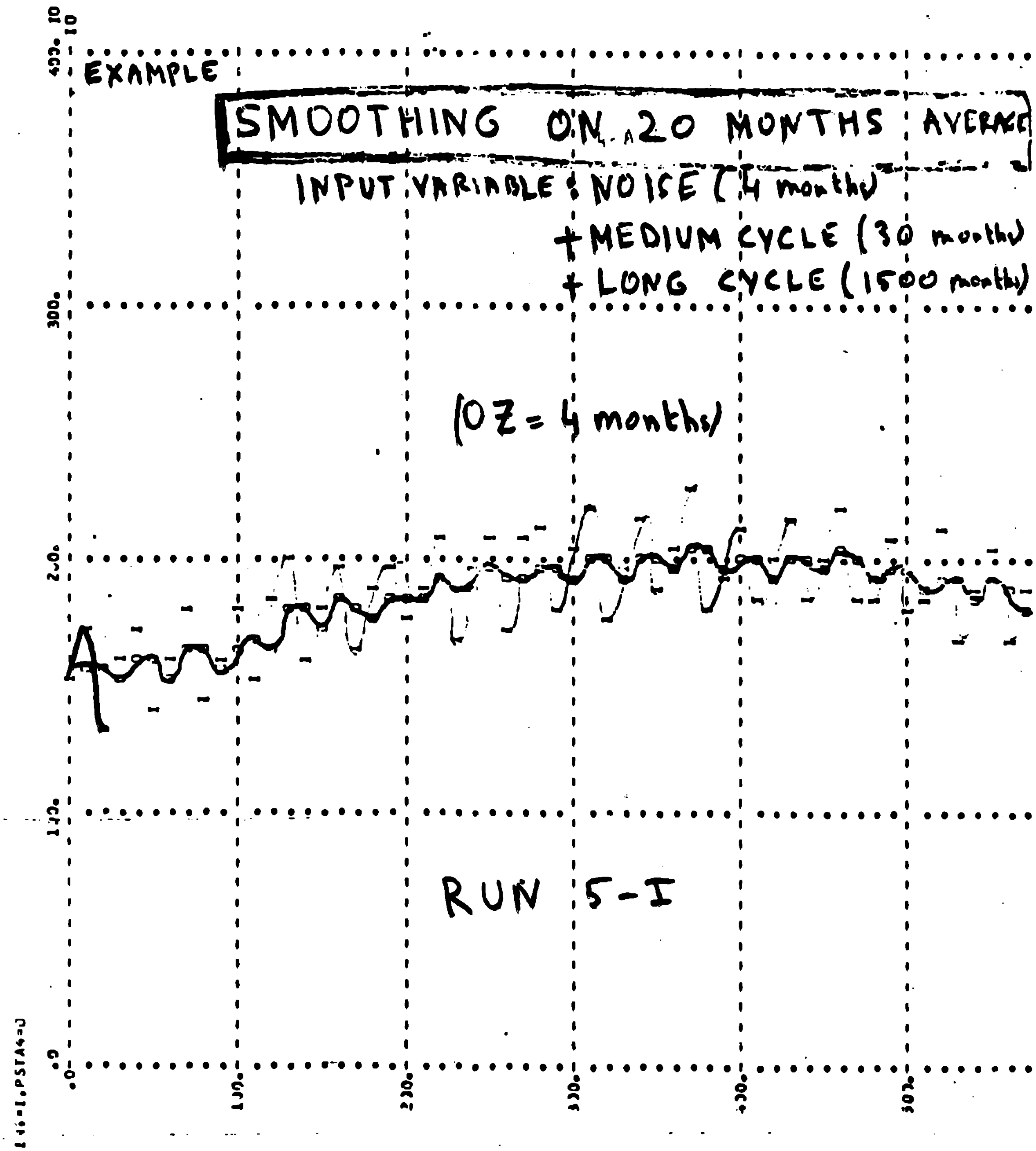
This is due to the fact that when noise is first ironed out, stability is measured as greater, and with a larger smoothing delay, the cobweb cycles can also be ironed out, which increases stability further again. See Runs 5-L, 5-M, 5-N, 5-O and 5-P.

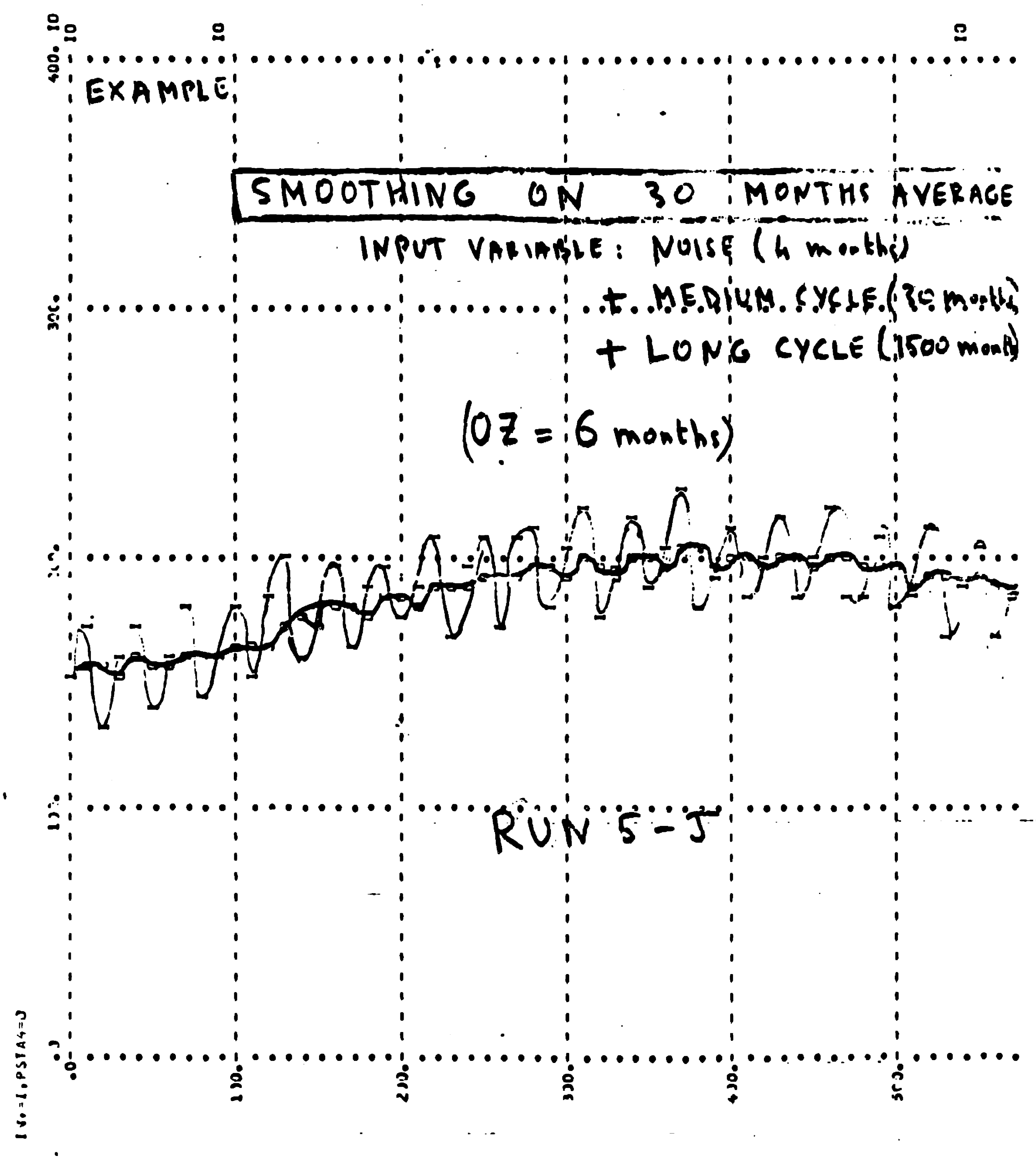
It will also be noted that in the present simulation, cost decreases while the smoothing delay is increasing (see Figure 5-16).

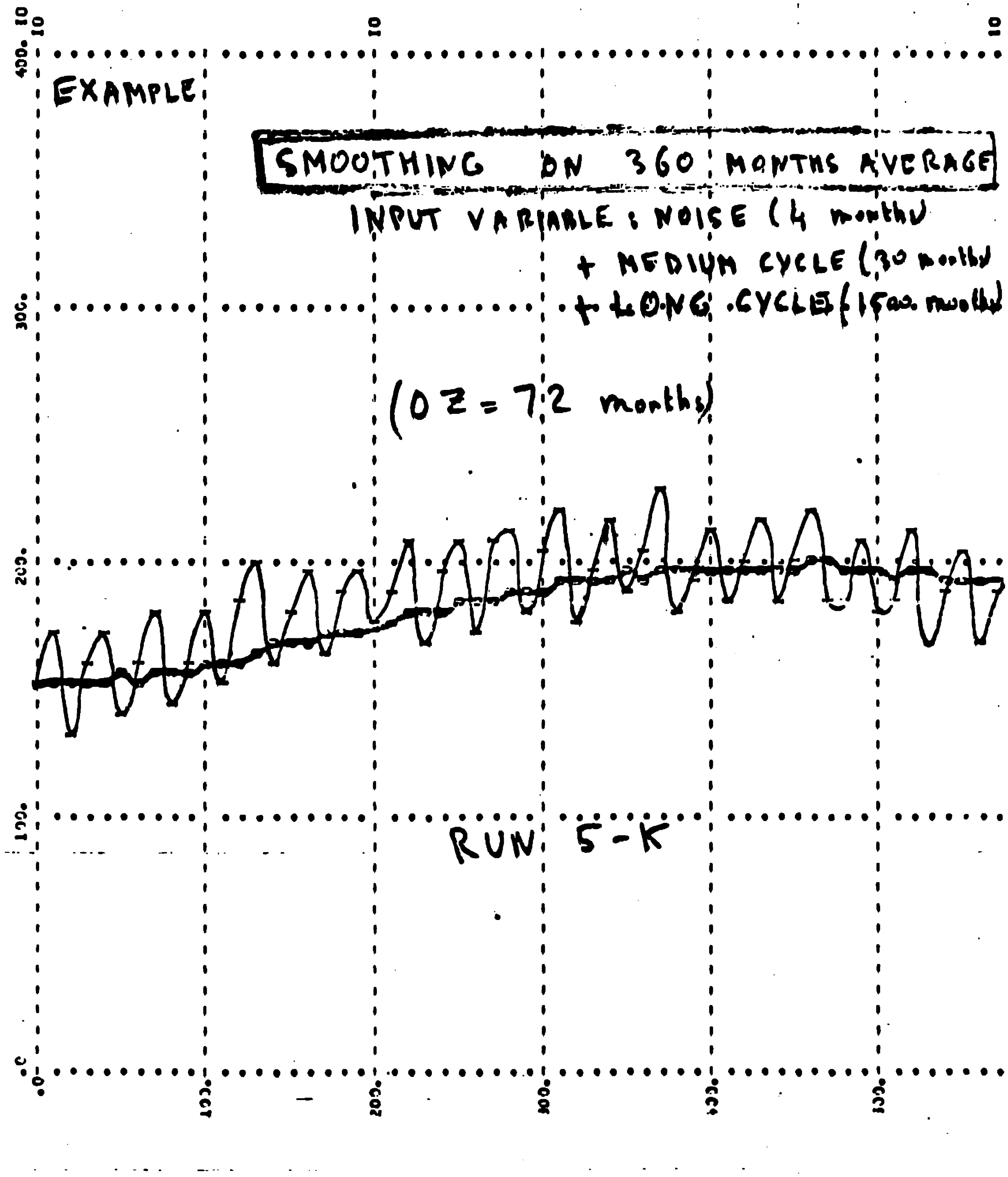
<u>Price range and magnitude of intervention</u>

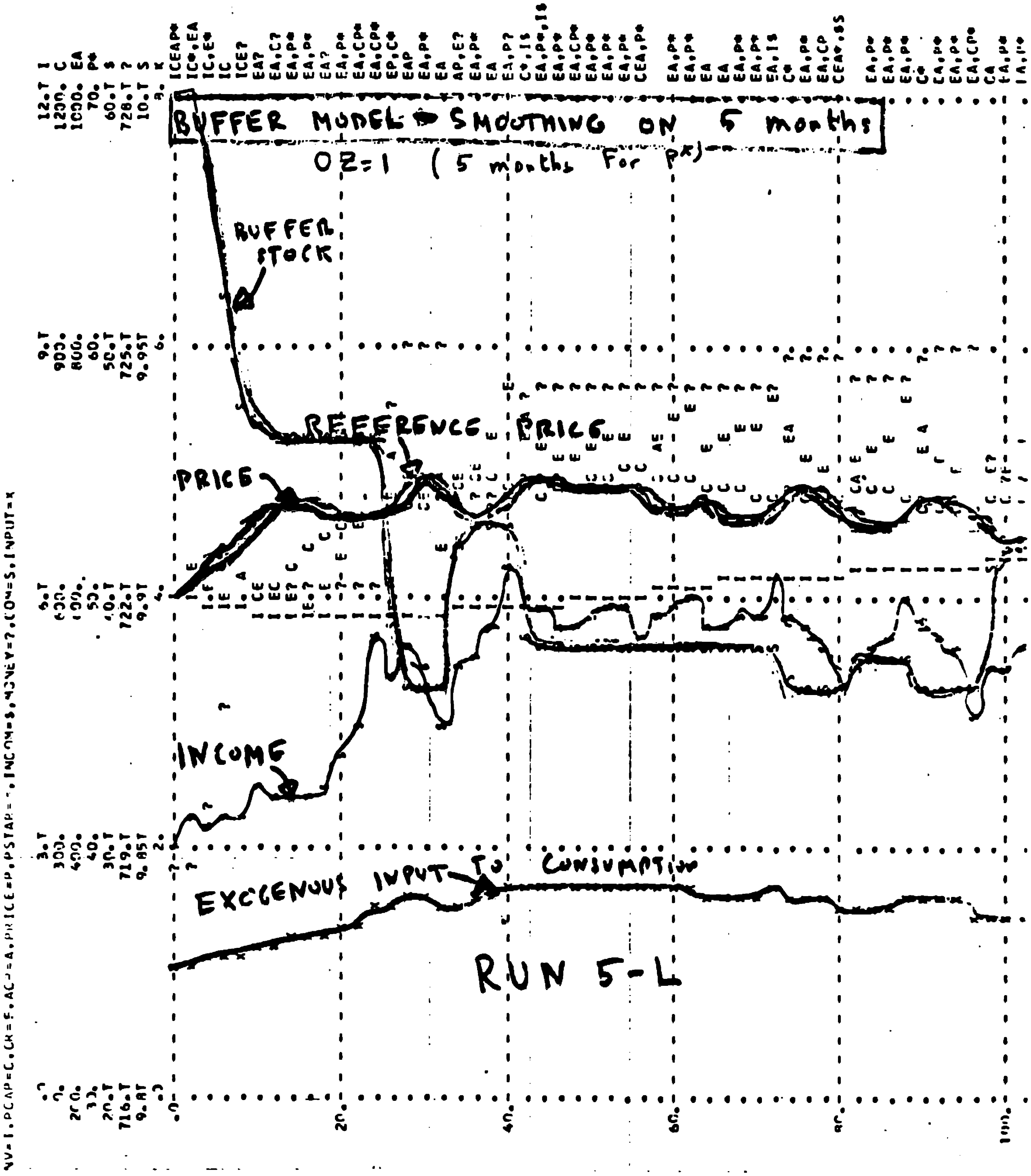
In the working of stabilization through buffer stock, DY, the multiplier for magnitude of intervention, and RANGE (range around reference price for intervention), are certainly of great importance, all other factors unchanged.

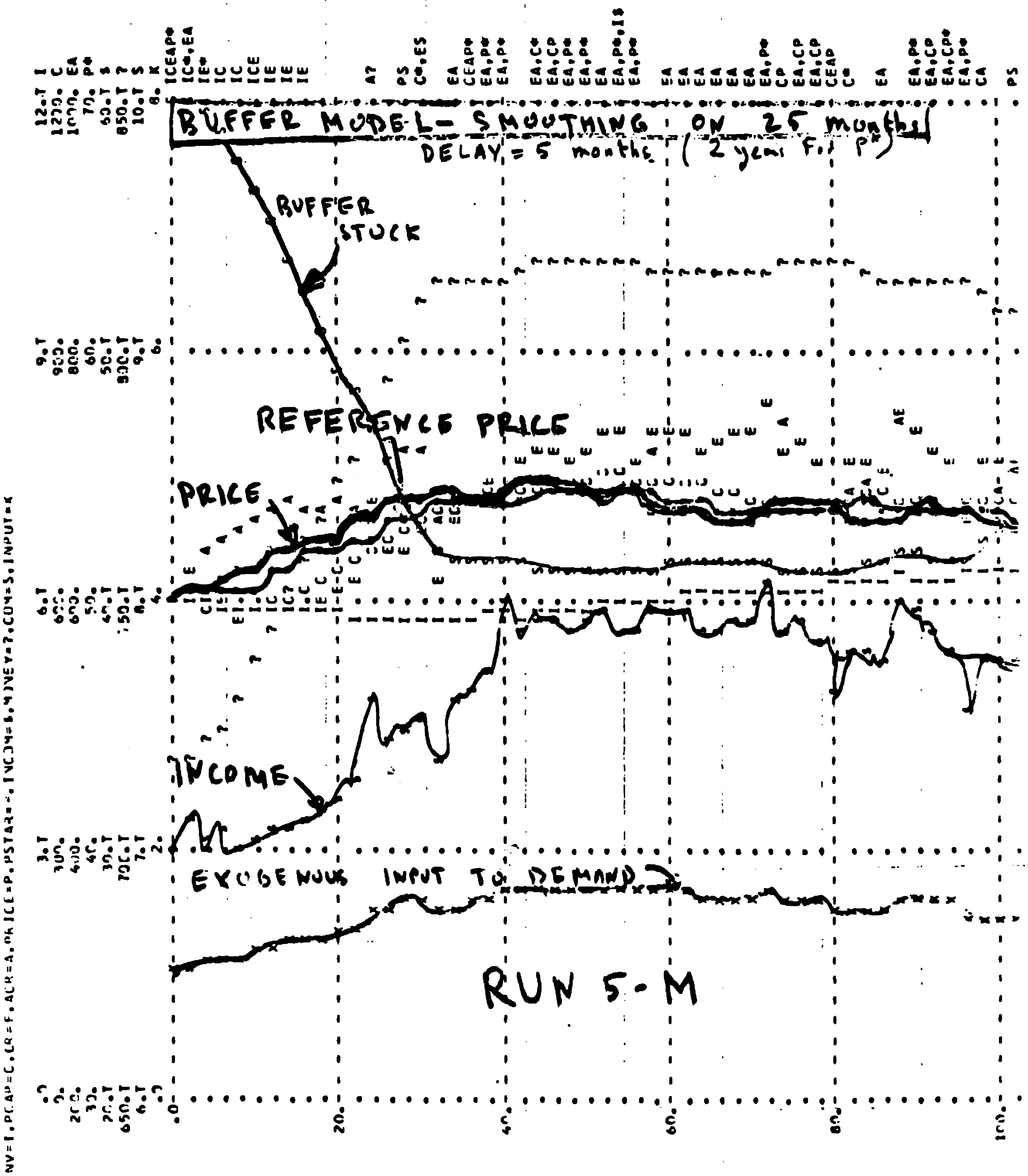

EXAMPLE
SMOOTHING ON 8 MONTHS AVERAGE
INPUT VARIABLE : NOISE (4 months)
+ MEDIUM CYCLE (30 months)
+ LONG CYCLE (1500 months)
(OZ = 1.6 months)
REAL VARIABLE
SMOOTHED
RUN 5-H
400.
300.
200.
100.
0.
100.
200.
300.
400.
500.

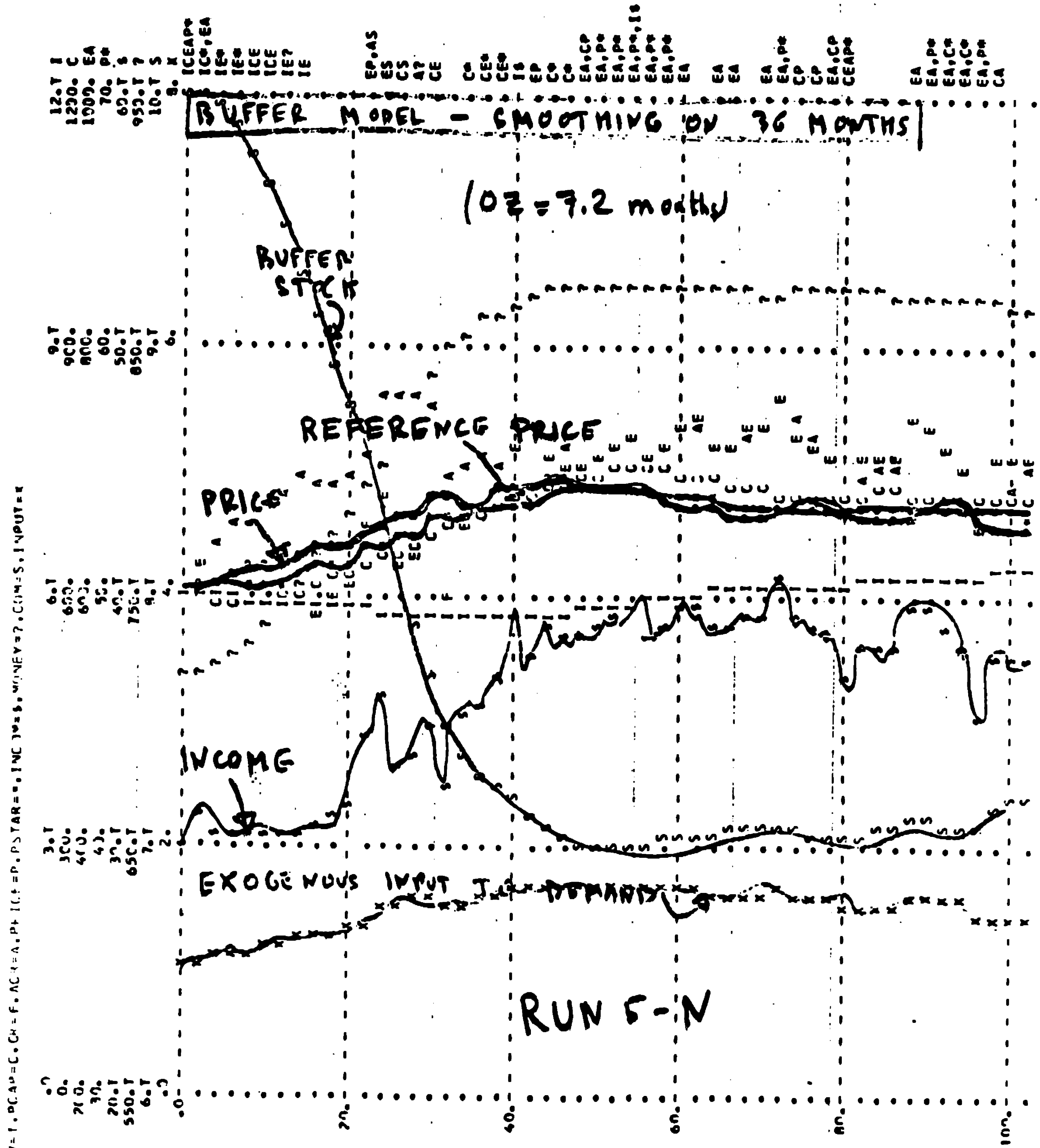

EXAMPLE
SMOOTHING ON 20 MONTHS AVERAGE
INPUT VARIABLE: NOISE (4 months)
+MEDIUM CYCLE (30 months)
+LONG CYCLE (1500 months)
(OZ = 4 months)
RUN 5-I

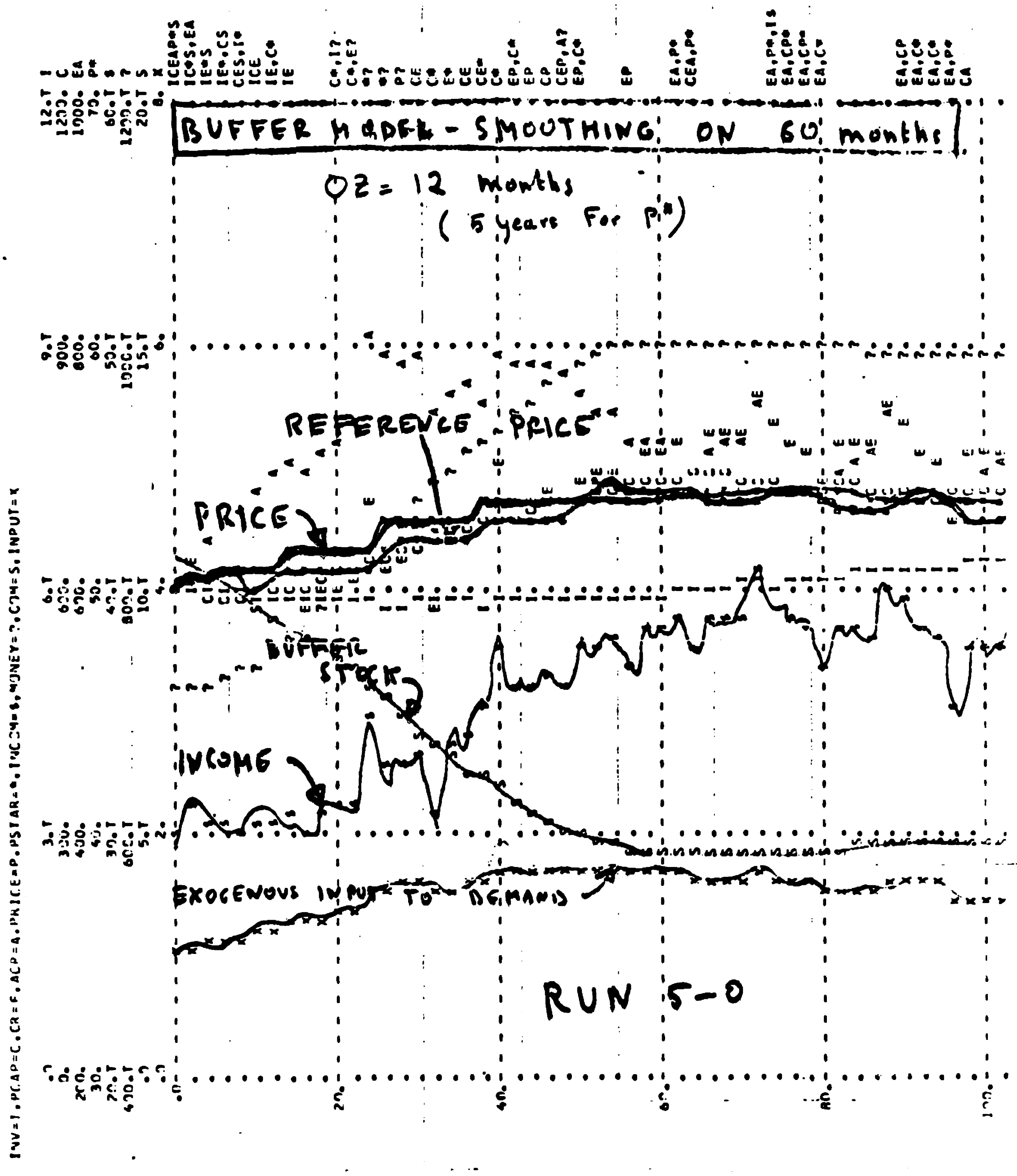

EXAMPLE
SMOOTHING ON 30 MONTHS AVERAGE
INPUT VARIABLE: NOISE (4 months)
+ MEDIUM CYCLE (30 months)
+ LONG CYCLE (1500 months)
(DZ = 6 months)
RUN 5-J

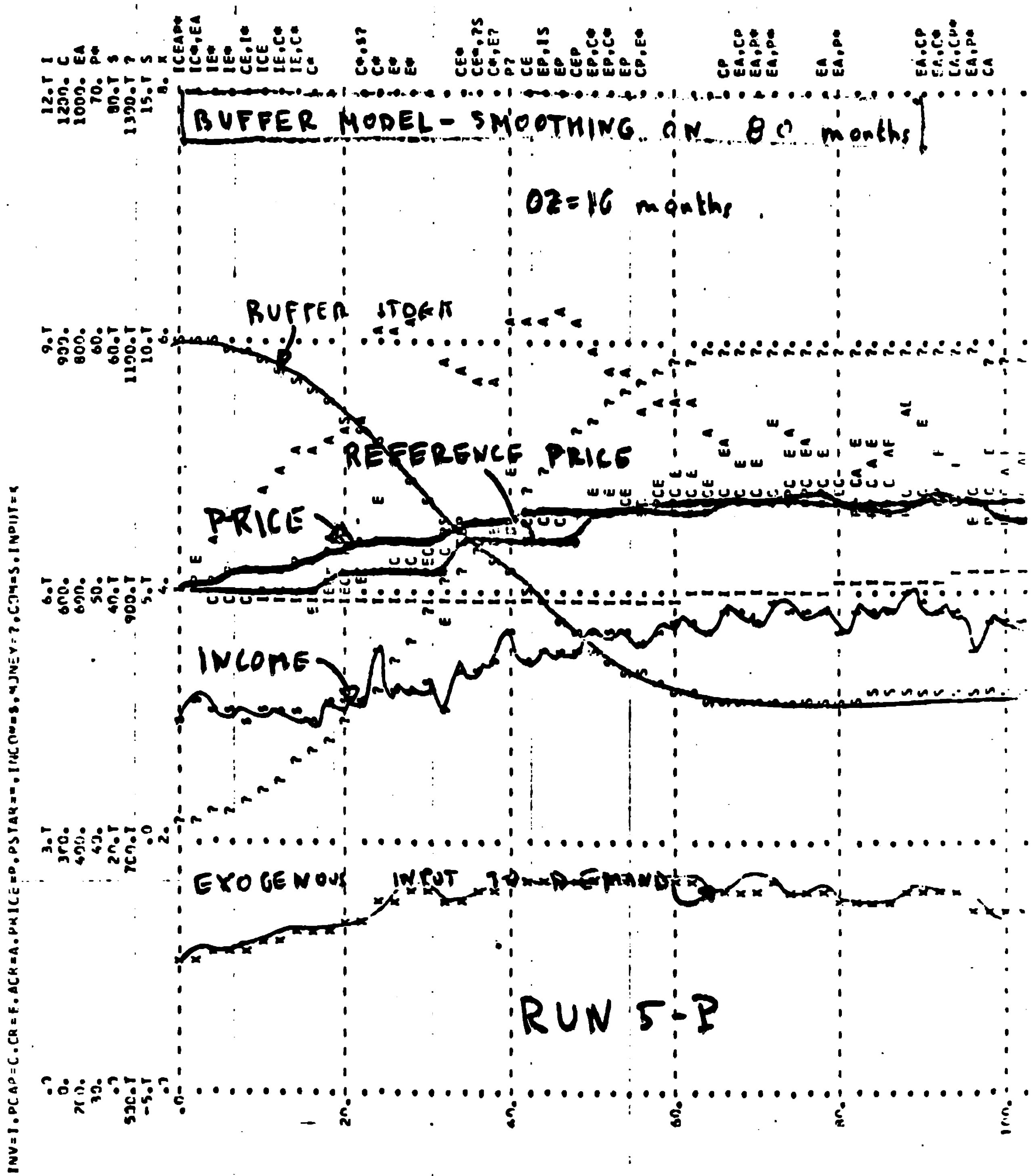

EXAMPLE
SMOOTHING ON 360 MONTHS AVERAGE
INPUT VARIABLE: NOISE (4 months)
+ MEDIUM CYCLE (30 months)
+ LONG CYCLE (1500 months)
(DZ = 72 months)
RUN 5-K
400.
300.
200.
100.
0.
100.
200.
300.
400.
500.


BUFFER MODEL ➔ SMOOTHING ON 5 months
OZ=1 (5 months For P*)
BUFFER STOCK
REFERENCE PRICE
PRICE
INCOME
EXCGENOUS INPUT TO CONSUMPTIW
RUN 5-L


BUFFER MODEL- SMOOTHING ON 25 months
DELAY = 5 months (2 years for P*)
BUFFER STOCK
REFERENCE PRICE
PRICE
INCOME
EXOGENOUS INPUT TO DEMAND
RUN 5-M


BUFFER MODEL - SMOOTHING ON 36 MONTHS
(DZ = 7.2 months)
BUFFER STOCK
REFERENCE PRICE
PRICE
INCOME
EXOGENOUS INPUT TO DEMAND
RUN 5-N
0.
20.
40.
60.
80.
100.


BUFFER MODEL - SMOOTHING ON 60 months
12 Months
(5 years For P*)
REFERENCE PRICE
PRICE
BUFFER STOCK
INCOME
EXOGENOUS INPUT TO DEMAND
RUN 5-0


BUFFER MODEL - SMOOTHING ON 80 months
BUFFER STOCK
REFERENCE PRICE
PRICE
INCOME
EXOGENOUS INPUT TO DEMAND
RUN 5-P

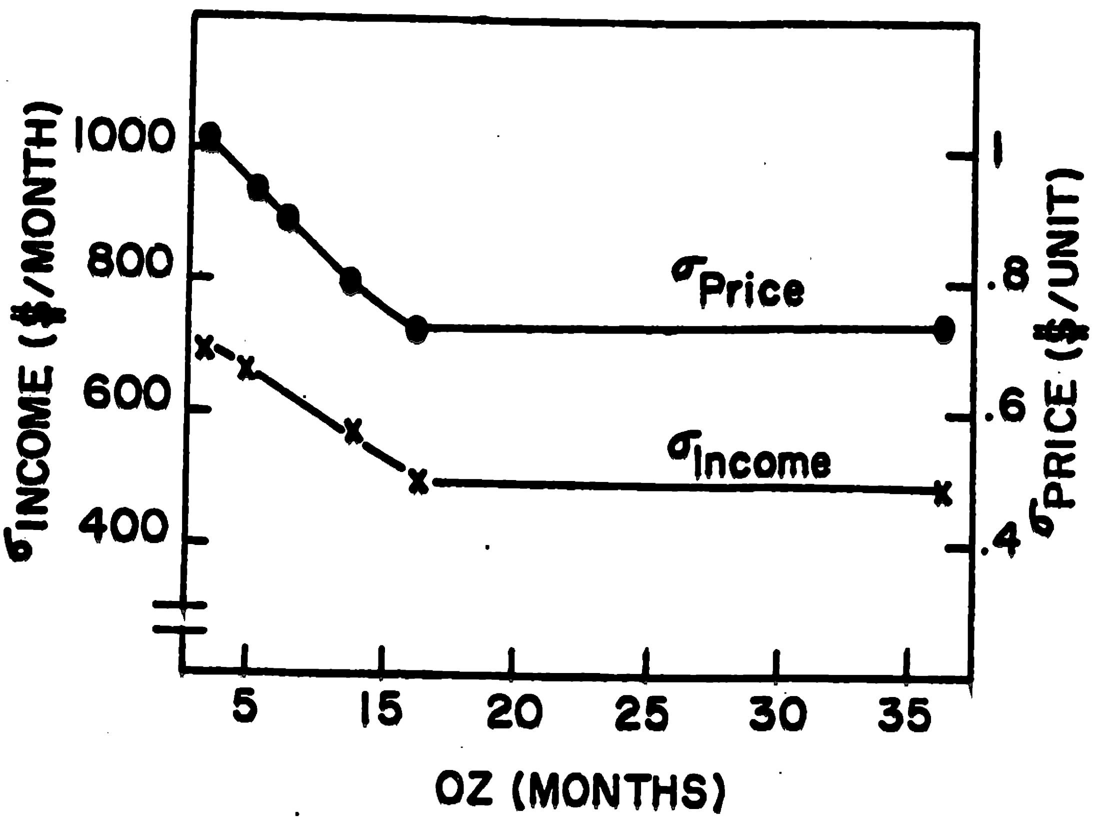


Figure 5-16: Impact of Period Used for Goreux' Formula

OZ mo.	Smoothing Period For P*, mo.	Cost 10^3 \$	σ_P \$/unit	σ_I \$/mo.
1.0	5	509	1.11600	796
5.0	25	340	0.97476	656
7.2	36	234	0.91100	617
12.0	60	0	0.80000	548
16.0	80	-148	0.75700	518
40.0	200	-267	0.74000	508

Table 5-4: Impact of Period Used for Goreux' Formula

To determine the optimal choice of DY and RANGE, it is necessary to proceed iteratively. Tables 5-5, 5-6, and 5-7 show the procedure used. Table 5-5 and Table 5-6 seem to indicate that RANGE should be taken close to 1.5 per cent and DY as large as possible. This is tested in Table 5-7.

Since RANGE equals 1.5 per cent constitutes the optimum coupled with DY as large as possible, this is to be used in determination of stabilizing policy. However, for practical reasons of simulation cost (a higher value of DY means a need for a smaller iterating interval in the simulation), simulations will be based on DY equals twenty.

Concept of desired level of stock

A practical issue for stock management is whether the level of stock ought to simply follow the history of its desired interventions or whether it should not also be based on a desired stock level, towards which it would try to come back after a deviation, due to necessary interventions.

This issue becomes particularly relevant when the level of stock tends to decrease drastically, and it becomes important then to decide whether the intervention should take into account the effect it will have on the buffer stock's own level of stock.

This can be simulated by adding a small module to the buffer stock in order to modulate the magnitude of the intervention to a desired level of stock:

DY = 10

RANGE (per cent)	COST ($$10^3$)	σ_P ($/unit)	σ_I ($/month)
1.1	434	.187	110
0.5	433	.226	131
1.0	432	.270	159
1.5	431	.315	185
2.0	431	.356	210
2.5	438	.354	231
3.0	437	.43	252
5.0	447	.56	325
10.0	467	.74	436
15.0	475	.78	456
20.0	478	.786	459

Table 5-5: Influence of RANGE (DY constant)

RANGE = 1.5%

DY (%)	COST ($10^3)	σ_p ($/unit)	σ_s ($/mo.)
1	473	0.61	356
3	461	0.46	268
5	451	0.39	228
10	431	0.315	185
15	418	0.28	165
20	208	0.2648	154
25	405	0.25	147
30	401	0.242	143
35	359	0.237	133
40	356	0.233	137

Table 5-6: Influence of DY (range constant)

DY	RANGE percent	COST 10^3\$	σ_P \$/unit	σ_I \$/month
10	1.5	431	.315	185
10	2.0	427	.356	209
10	2.5	427	.354	232
15	1.5	416	.282	165
15	2.0	427	.356	209
15	2.5	415	.366	215
20	1.5	408	.26	154
20	2.0	411	.30	181
20	2.5	410	.319	206
25	1.5	405	.75	147

Table 5-7: Selection of the Best Couple (DY,RANGE)

The additional module

1. DCOM.K = (PCENT)(PCAP.K)(12)

DCOM	desired buffer stock level; units
PCENT	multiplier of production capacity; dimensionless
PCAP	productive capacity; units per month
12	one year; months

2. RCOM.K = COM.K/DCOM.K

RCOM	relative buffer; dimensionless
COM	level of buffer stock; units
DCOM	desired buffer stock level; units

3. BRAVO.K = (OSW.K)(MRAVO.K)

BRAVO	modified desired intervention of buffer stock; units per month
OSW	old intervention magnitude multiplier; dimensionless
MRAVO	original desired intervention of buffer stock; units per month

4. OSW.K = CLIP(CURV1.K,CURV2.K,MRAVO.K,0)

OSW	old intervention magnitude multiplier; dimensionless
CURV1	auxiliary 1; dimensionless
CURV2	auxiliary 2; dimensionless
MRAVO	original desired intervention of buffer stock; units per month

5. CURV1.K = TABHL(SOCK1,RCOM.K,0,3,0/25)

SOCK1 = 1/1/1/1/1/1/1/1/1/1/1/1/1 (policy 1)

CURV1 auxiliary 1; dimensionless

SOCK1 auxiliary for CURV1; dimensionless

RCOM ratio of actual to desired stock; dimensionless

6. CURV2.K = TABHL(F1C1,RCOM.K,0,3,0.25)

F1C1 = 1/1/1/1/1/1/1/1/1/1/1/1/1 (policy 1)

CURV2 auxiliary 2; dimensionless

F1C1 auxiliary for CURV2; dimensionless

RCOM ratio of actual to desired stock; dimensionless

As shown in Figures 5-17 and 5-18 there are different policies: Policy 1 is to sell and buy no matter what the level of stock is. Policy 2 is to adapt differentially the intervention multiplier, to buy more when the buffer level is low and less when it is high, and sell more when the buffer level is high and less when it is low. Policy 3 uses the same principle, but a different function.

Several simulations (See Appendix 13) illustrate the compared behaviors of those policies. The input has been chosen with a decreasing trend so that the case when the buffer comes close to exhaustion occurs.

1. Before month 140

At month 120 (see Table 5-8), Policy 1 is much more effective

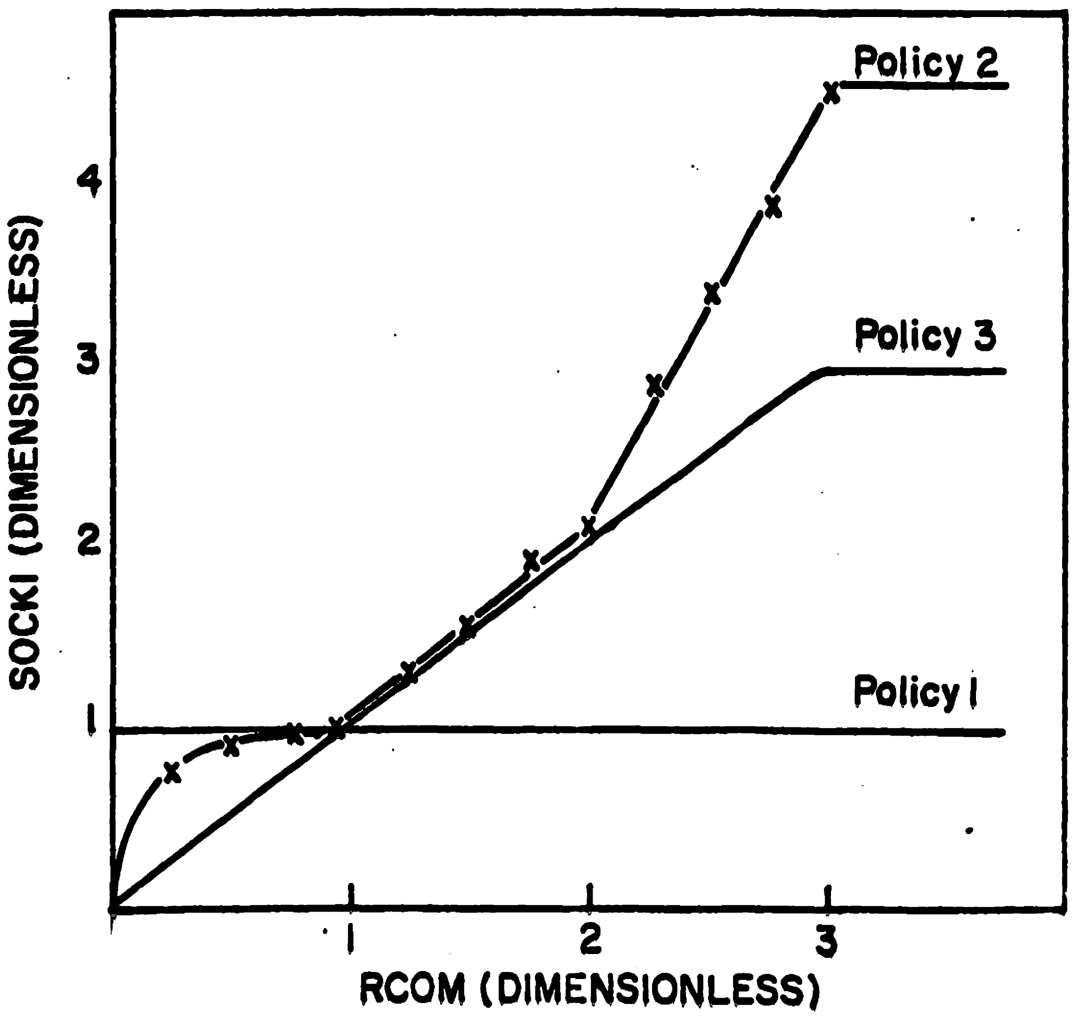


Figure 5-17: Purchasing Rules for Desired Stock Level

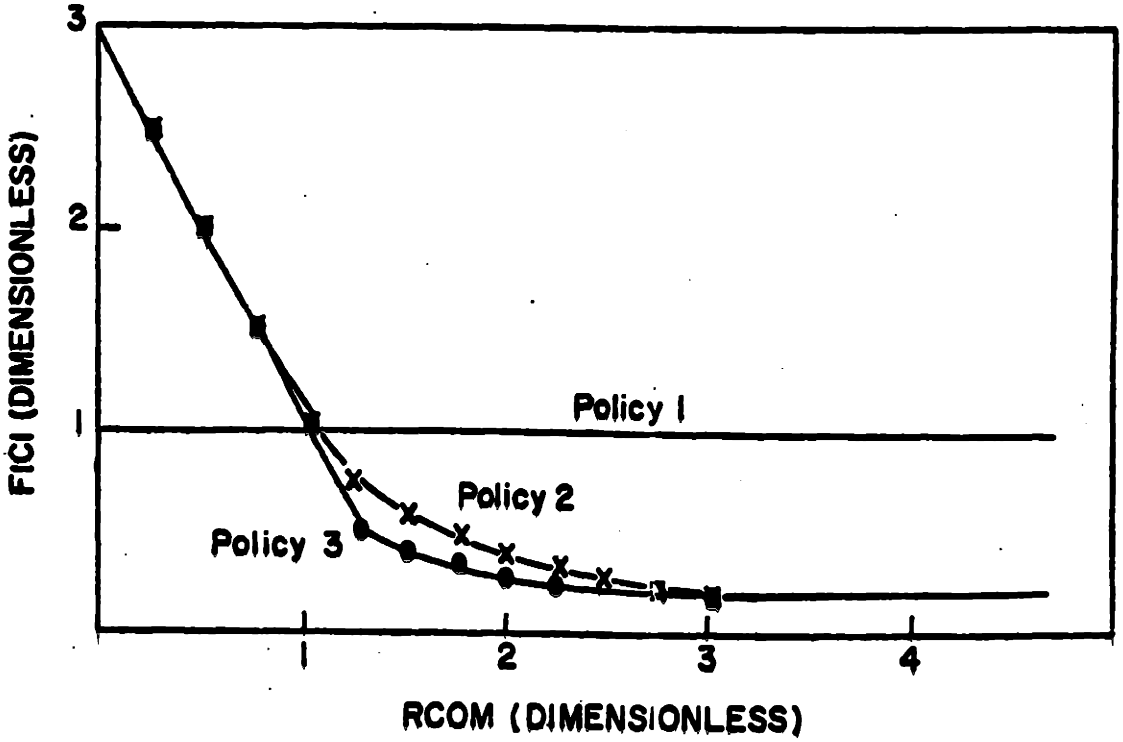


Figure 5-18: Selling Rules for Desired Level of Stocks

	Cost	Stability Measure				
		Price		Income		
	Cost 10^3\$/mo.	σ_P \$/unit	SP percent	σ_I \$/mo.	SI percent	CEFF
Reference Simulation	0	2.23	-	846	-	-
Policy 1	287	0.51	77.0%	33	72%	27
Policy 2	115.73	1.17	47.5%	482	43%	41
Policy 3	105	1.10	50.0%	451	47%	47.5

Table 5-8: Influence of Desired Stock Level Before Exhaustion of Stock (Time 120)

than Policies 2 or 3 in terms of price stabilization; 77 per cent for Policy 1 versus 50 per cent for Policy 2, and 47.5 per cent for Policy 3.

As for income stabilization, 72 per cent for Policy 1 versus 43 per cent (Policy 2) and 47 per cent (Policy 3).

However, cost effectiveness is higher for Policy 3 (47.5) than for Policy 2 (41) or Policy 1 (27).

Without knowledge of the utility function of the agency, it is difficult to decide which one is better; if we are in a range where cost is of little importance with respect to stabilization, then Policy 1 is superior. If cost is a factor of importance, Policy 3 is far better.

2. After month 140

The simulations show that if the case happens of buffer stock collapse, the differences between outcomes of the various policies become much smaller:

Policy 1 is still the best in terms of pure price stabilization, but the gap with the other two policies is narrower: 40 per cent versus 33 per cent and 32.5 per cent.

Policy 3 is still the best choice in terms of cost effectiveness: 27 per cent versus 24 per cent and 18.7 per cent. (See Table 5-9.)

	Cost	Price		Income		CEFF
		σ_P	SP	σ_I	SI	
	10^3\$/mo.	\$/unit	percent	\$/mo.	percent	
Reference Simulation	0	1.488	-	832	-	-
Policy 1	213	0.890	40.0%	693	18.5%	18.7
Policy 2	135	1.040	32.5%	69	16.5%	24
Policy 3	122	0.998	33.0%	685	17.0%	27

(Stability Measure spans the Price and Income column groups.)

Table 5-9: Influence of Desired Stock Level After Exhaustion of Stock (Time 372)

These simulations demonstrate that if the concept of desired stock level is used, the outcome will be better in terms of cost-effectiveness of price stabilization than with a simpler buffer stock policy.

Cost effectiveness analysis

Analysis of the previous issues has defined the best rules for intervention: setting of reference price, buffer stock management, and measure of effectiveness. It is possible to define what would be the cost effectiveness of a buffer stock policy; from the preceding subsections it appears that the modulation of intervention magnitude is the factor that can be affected to modify effectiveness most. We therefore perform a simulation using the five years rule defined by Goreux, a range of 1.5 per cent, a DY of twenty, a desired stock level, a simple intervention rule without concavity influences, and we measure it along a thirty-six month moving average. We modify the magnitude of intervention as a function of stock level. The result is a relationship between cost of operations and level of price stabilization obtained.

As could be expected, this curve is increasing, slowly at the beginning and eventually very steeply, as the maximum level of stabilization cannot be greater than a bounded limit, here 47 per cent (see Figures 5-19 and Table 5-10). A similar curve is derived for income stabilization; the limit for income stabilization is 26 per cent (see Figure 19a).

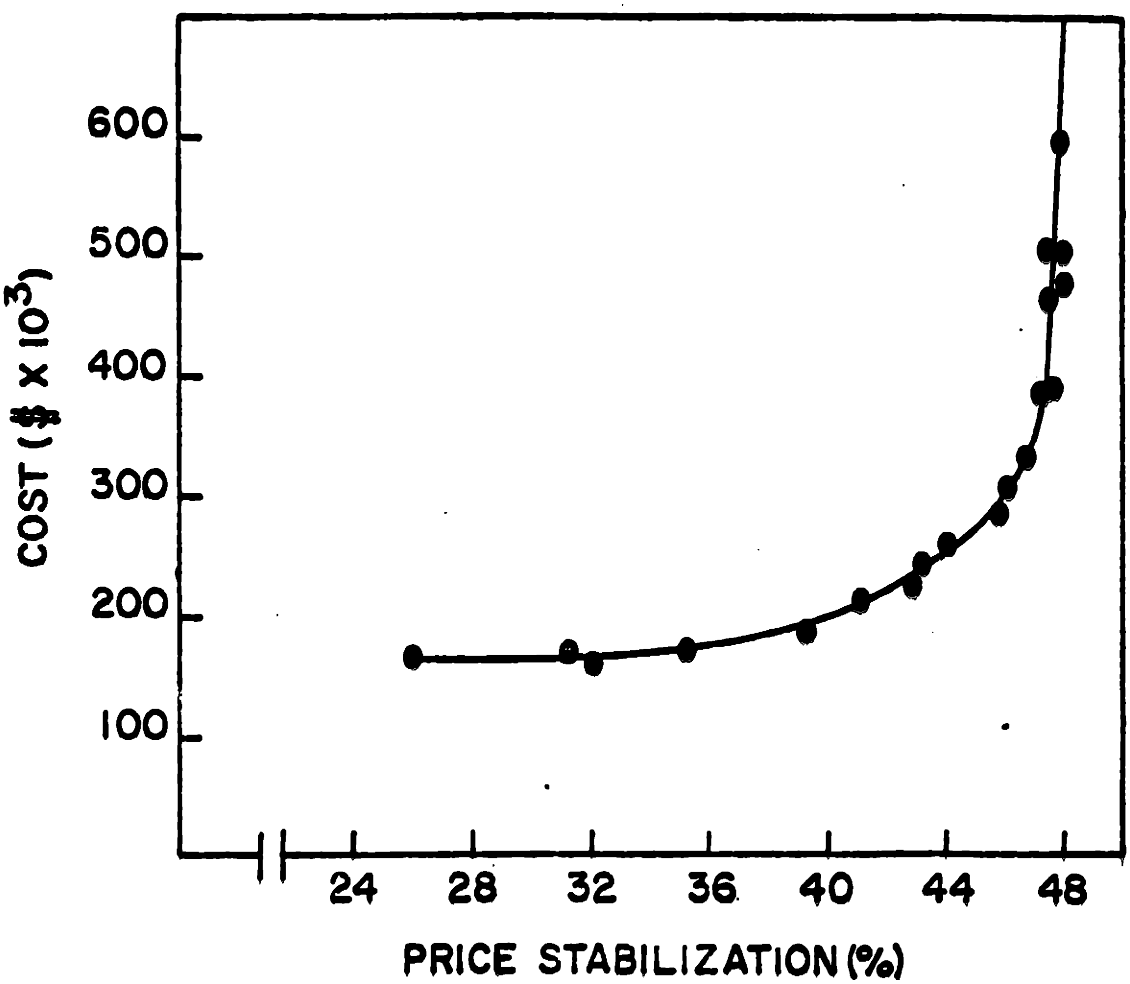


Figure 5-19: Price Stabilization Cost-Effectiveness

Table 5-10: Cost effectiveness

COST ($\$10^3$)	σ_P (\$/unit)	σ_I (\$/mo.)	SP (%)	SI (%)
0	1.488	833	0	0
166.63	1.1038	722	25.8	13.3
167.72	1.0798	715	30.8	14.2
157.57	1.0068	697	32.2	16.6
163.40	0.9457	688	35.4	17.4
184.66	0.89832	678	38.7	18.6
213.35	0.86779	670	41.0	19.5
226.65	0.85553	665	42.4	20.0
234.33	0.85212	663	42.5	20.4
242.97	0.8449	660	43.3	20.8
259.72	0.82944	653	44.0	21.6
288.86	0.80952	642	45.5	23.0
312.34	0.8008	635	46.0	23.8
335.09	0.79512	631	46.5	24.3
396.76	0.78828	623	46.7	25.1
467.77	0.78632	691	46.9	25.7
435.23	0.78544	618	47.0	25.8
560.16	0.78482	618	47.0	25.8

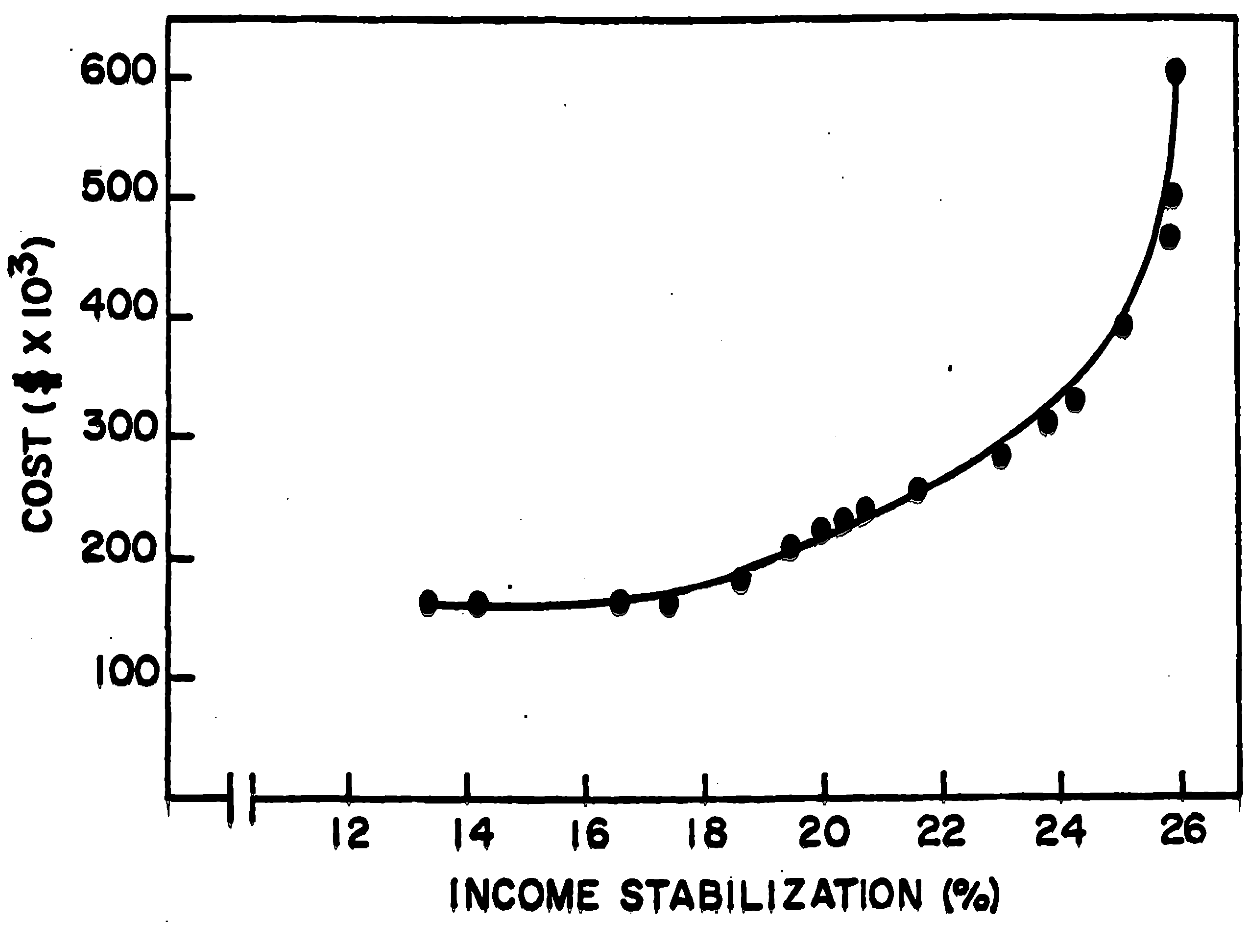


Figure 5-19a: Cost Effectiveness of Stability Policies

Conclusion

The issue of stabilization through buffer stocks has been thoroughly explored, and all theoretical and empirical issues discussed. A simulation model that represents the world market for a commodity, subject to a regulating buffer stock agency, has been proposed, and validated on the example of the tin experiment.

From exploration of technical and structural issues, it appears that the best operation scheme can be identified through simulation.

The managers of the stock, however, are free to modulate the amplitude of intervention as a function of their available stocks, and of any other consideration. This leads to define different levels of stabilization that can be obtained at different total cost levels. The curve derived in Chapter 5, however, is only part of the answer: it has been derived for a given set of exogeneous inputs to consumption sequenced in time; in other words, a scenario. Therefore, this curve represents, for the buffer stock we defined, the relationship between cost for an expected level of stabilization: this level of stabilization is relative to the scenario simulated. To this history in a real case, should be attached a level of probability obtained by the Delphi method; similar simulations should then be performed with different possible scenarios, each attached to a level of probability. Then the combining of all those curves weighted according to the assigned probabilities would give the relationship between expected cost of operation and expected resulting stability.

The shape of the final curve will be similar to the basic shape illustrated in Figure 5-19. The combining through weighting of an infinity of similarly shaped curves will neither affect this shape nor, more specifically, the final steep rise. This could then be used to define the policy of the regulating agency for the period considered.

All this could be simply adapted to the case of a real world commodity; it would involve definition of parameters for the world market module, for the reference price getting module and the buffer intervention module. All simulations performed in this study could then be rerun to bring the final output: the cost effectiveness curve.

The End.

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APPENDIX 1

COMMODITY MARKETS

Commodities classification

The United Nations study[2] proposed a classification of commodities:

a. Commodities produced exclusively in developing countries, without near substitutes in consumption (e.g., coffee, tea, tungsten, etc.)

b. Commodities produced in developing countries only, with industrial substitutes (e.g., rubber, diamonds, etc.)

c. Commodities from developing countries, with near substitutes in primary products of developing countries (e.g., groundnuts, copra, versus butter, oil, etc.)

d. Commodities from developing countries also produced in industrial countries (e.g., zinc, iron, petroleum, sugar, wheat, etc.)

Commodity markets

For some commodities, markets are only regional, and distribution on a large scale only incidental, because of production-transport cost relationships. For this category (e.g., highly perishable commodities such as milk, or heavy low-cost commodities such as clay) no world market exists. Prices may vary widely among different regional markets.

For the other commodities, a world market exists in which the relationship price-production has a strong influence. The more or less uniform price in this market has an influence on production decisions in the whole world.

However, in some cases, producers sell the bulk of their output on insulated domestic markets, and export only marginal amounts, on what may be called a "residual market."[2] The price realized on such a residual market is largely "fortuitous:"[2] it does not reflect the costs of production, but rather the imbalances between supply and demand on the main national markets.

Such a situation also occurs in the case when most of the transactions on a long run committment basis (e.g., mercury, Chapter 4).

Other commodities, such as the "tropical products," are virtually all exported (e.g., rubber, cocoa, wool, tin, etc.)

APPENDIX 2

OPEN-LOOP ANALYSIS FOR BUFFER STOCK OPERATION

Preliminary considerations

-Around the equilibrium point, for an "action time," LT.

-The symbol Δ denotes deviation from equilibrium value, and the index 0 denotes equilibrium:

e.g. $\Delta INV = INV - INV_0$

-The equilibrium is taken for P = 50.

Derivation from consideration of the equation of the model

1. $\Delta CR = -CBUF$
2. $\Delta INV = -(LT)(\Delta CR)$
3. $\Delta COV = \Delta INV / CR$
4. $\Delta ROCV = \Delta COV / DCOV_0$
5. $\Delta PRICE = (PRICE) \dfrac{\Delta RCOV}{RCOV} \left(-\dfrac{9}{5}\right)$

(elasticity of PTAB around P = 50)

If we close the loop, we want a gain of 0 overall (i.e., bring back PRICE to its original value after a deviation).

Multiplying all equations together:

$$\Delta PRICE = \frac{\frac{9}{5}(LT)(PRICE)}{(CR)(DCOV_0)(RCOV)} \; CBUF$$

Assuming RCOV close to 1 (small deviation),

$$\Delta PRICE = \frac{9}{50} \; LT \; \frac{PRICE}{CR} \; CBUF$$

Therefore CBUF to apply to correct Δ is:

$$CBUF = \frac{50}{9LT} \; CR \; \frac{\Delta PRICE}{PRICE}$$

Notes

1. $$\begin{aligned} \Delta PRICE &= PRICE - PRICE_0 \\ &= (PRICE - PSTAR) - (PRICE_0 - PSTAR) \\ &= PRICE - PSTAR \end{aligned}$$

if we assume $PRICE_0 = PSTAR$, meaning that we want to come back to PSTAR rather than to $PRICE_0$

2. LT measures the time delay grossly expected (open-loop analysis is only for gains and does not account for delays of induced changes besides LT) to restore complete equilibrium for price by applying constantly this intervention.

We define $DY = \frac{50}{9LT}$ (dimensionless)

if we want LT = 1 month, DY = 5.5

2 weeks, DY = 11

1 week, DY = 22

4 days, DY = 40

APPENDIX 3

OPEN-LOOP ANALYSIS FOR QUOTA INTERVENTION RULE

Notations

Same as in APPENDIX 2.

Derivations

1. $\Delta INV = (\Delta CUF)(INR)$
2. $\Delta PR = \Delta INR$
3. $\Delta INV = (LT)(\Delta PR)$
4. $\Delta COV = \Delta INV/ECR_0$
5. $\Delta RCOV = \Delta COV/DCOV_0$
6. $\Delta PRICE = (PRICE)(\Delta RCOV)(\frac{-9}{5})/RCOV_0$

Then

$$\Delta PRICE = \frac{(PRICE\ (\frac{-9}{5})\ (\Delta CUF)(INRO)(LT)}{(RCOV_0)(ECR_0)(DCOV_0)}$$

$$\Delta PRICE = (PRICE)(\Delta CUF)\ \frac{(\frac{-9}{5})(600)(LT)}{(1)(600)(10)}$$

$$= \frac{-9LT}{50}(\Delta CUF)(PRICE)$$

To compensate a change of PRICE, we must apply:

$$\Delta CUF = \frac{-50}{9LT}\ \frac{\Delta PRICE}{PRICE}$$

$$\Delta CUF = + \frac{50}{9LT} \frac{\Delta PRICE}{PRICE}$$

For LT = two weeks,

$$\Delta CUF = 2.5 \frac{\Delta PRICE}{PRICE}$$

APPENDIX 4

COMMENTS ON FIGURE 3-2

T_b is the period of the exogeneous input (business cycle of 8.35 years, for example)

T_c is the period of the cobweb induced cycle

T_n is the period of the random noise factor.

Stabilization of either of those deviations from the trend will be attempted if the period of the phenomenon to iron out is small enough, so that reserves accumulated will not be excessive.

For example, if $T_c < T_b$ as in the Figure, we can attempt to smooth both random disturbances (T_n) and cobweb cycles (T_c), and not T_b, since this would involve too large a stock accumulation for four years, i.e., half a cycle (e.g., hog).

If, however, $T_c > T_b$ (e.g., cocoa), only the random disturbances (T_n) should be smoothed out, to avoid an excessive investment in stocks.

APPENDIX 5

COMMENTS ON FIGURE 4-5

The effect of demand for stocks is an internal transfer of ownership among the inventory holders class. With Meadows' hypothesis, this involves in effect no change in the model (the gain of the loop inventory-demand for stocks-inventory is zero).

APPENDIX 6

TABLES IN MERCURY MODEL

(See Figures 4-8, 4-9, and 4-10)

Price-coverage relationship

PRICE.K = TABHL(PTAB,RCOV.K,0,5.994,0.333)

PTAB = 1000/450/280/253/210/195/170/150/130/120/105/90/80/70/
60/50/40/30/20

PRICE price per unit; dollars per flask

PTAB price table; dollars per flask

RCOV relative coverage; dimensionless

Desired capacity

DPCAP.K = TABHL(CATAB,EP.K,100,1600,100)

CATAB = 12000/16500/2200/26000/30000/32000/33500/34500/35000/
35400/35750/36050/36550/36750/36950

DPCAP desired production capacity; flasks per month

CATAB desired capacity table; flasks per month

EP expected price by producers; dollars per unit

Expected consumption

EPCC.K = TABHL(COTAB,PRICE.K,100,1600,100)

COTAB = 21000/17200/15000/14000/13000/12000/11200/10600/10200/
9900/9750/9525/9325/9150/9000/8500

EPCC expected consumption; units per flask

COTAB expected consumption table; units per flask

PRICE price per unit; dollars per unit

APPENDIX 7

COMMENTS ON FIGURES 4-9 AND 4-10

Figure 4-9

The relationship is derived as follows:

a. Elasticity is assumed constant and equal to 0.53 (Reference37).

b. The equation of the curve is therefore

$$Q = Q_0 \left(\frac{P}{P_0}\right)^{0.53}$$

c. We use the fact that for 1961, we know one point on this curve:

$P = 210$ dollars per flask

$Q = 17000$ flasks per month

Figure 4-10

The relationship is derived as follows:

a. Elasticity is assumed constant and equal to -0.29 (Reference 37).

b. The equation of the curve is therefore

$$Q = Q_0 \left(\frac{P}{P_0}\right)^{-2.9}$$

c. We use the fact that for 1961, we know one point on this curve:

P = 210 dollars per flask

Q = 17000 flasks per month

APPENDIX 8

COMMENTS ON FIGURE 4-2

For a marginal change in inventory level (one unit), the decrease of benefits derived from safety is measured by A'B' - AB; referring to the marginal cost curves. This is measured also by CD = A'B' - AB.

Because we are dealing with marginal changes, CD is also measuring the difference of slopes of tangents to the marginal cost curves at the equilibrium point.

(The equilibrium point is defined by maximum benefits from inventory holding.)

The price asked for by inventory holders to give up one unit at the margin has to compensate the benefit foregone:

Price asked for = benefits foregone

PRICE = CD

We assume that the functions involved are continuous, so that the derivatives are the same on either side of the equilibrium point, so that

PRICE = marginal revenue = marginal cost of inventory carrying

APPENDIX 9

MEADOWS MODEL

```
*       GENERAL DYNAMIC COBWEB MODEL
NOTE    INITIAL CONDITIONS SET TO EQUILIBRIUM
L       INV.K=INV.J+(DT)(PR.JK-CR.JK)
N       INV=INVN
C       INVN=6000
A       COV.K=INV.K/ECR.K
A       RCOV.K=COV.K/DCOV
C       DCOV=10
A       PRICE.K=TABLE(PTAB,RCOV.K,0,1.998,.333)
T       PTAB=100/94/80/50/20/10/0
L       EP.K=EP.J+(DT)(PRICE.J-EP.J)/EPAD
N       EP=EPN
C       EPN=50
C       EPAD=3
A       DPCAP.K=TABLE(CATAB,EP.K,0,100,20)
T       CATAB=0/40/200/1000/1200/1280
R       CTIR.KL=(DPCAP.K-PCAP.K-CBT.K)/CTID
C       CTID=3
L       CBT.K=CBT.J+(DT)(CTIR.JK-CTCR.JK)
N       CBT=(CTID(DPCAP-PCAP))/(1+CTID)
R       CTCR.KL=DELAY3(CTIR.JK,CTD)
C       CTD=4
L       PCAP.K=PCAP.J+(DT)(CTCR.JK-CDR.JK)
N       PCAP=PCAPN
C       PCAPN=600
R       CDR.KL=PCAP.K/ALPC
C       ALPC=200
R       INR.KL=(PCAP.K)(CUF.K)
A       CUF.K=TABHL(CUTAB,RDAC.K,0,1.998,.333)
A       RDAC.K=DPCAP.K/PCAP.K
T       CUTAB=1/1/1/1/1/1/1
R       PR.KL=DELAY3(INR.JK,PD)*PUF.K
C       PD=6
A       PUF.K=TABLE(PUTAB,RDAC.K,0,1.998,.333)
T       PUTAB=1/1/1/1/1/1/1
A       EPCC.K=TABLE(COTAB,PRICE.K,0,100,20)
T       COTAB=7/6.5/5/1/.3/0
L       PCCR.K=PCCR.J+(DT)(EPCC.J-PCCR.J)/CRAD
N       PCCR=PCCRN
C       PCCRN=3
C       CRAD=3
R       CR.KL=(POP)(PCCR.K)(INPUT.K)
C       POP=200
L       ECR.K=ECR.J+(DT)(CR.JK-ECR.J)/ECAD
N       ECR=ECRN
C       ECRN=600
C       ECAD=100
NOTE    EQUATIONS TO GENERATE EXOGENOUS
NOTE    INPUT TO CONSUMPTION
A       INPUT.K=1+STEP.K+NOISE.K
A       STEP.K=STEP(SH,ST1)+STEP(-SH,ST2)
C       SH=0
C       ST1=5
C       ST2=10
A       NOISE.K=NM*SAMPLE(NORMRN(0,NSD),SI,0)
C       NM=0
C       NSD=.5
C       SI=8
NOTE    CONTROL CARDS
SPEC    DT=.2/LENGTH=60/PRTPER=0/
A       PLTPER.K=STEP(PP,PIT)
C       PP=3
C       PIT=0
PLOT    INV=I(0,12000)/PCAP=C(0,1200)/PRICE=P(0,100)/CR=E(0,1000)
```

INV	INVENTORY OF COMMODITY	(UNITS)
INVN	INITIAL VALUE OF INVENTORY	(UNITS)
COV	INVENTORY COVERAGE	(MONTHS)
RCOV	RELATIVE INVENTORY COVERAGE	(DIMENSNLESS)
DCOV	DESIRED INVENTORY COVERAGE	(MONTHS)
PRICE	COMMODITY PRICE	(DOLLARS/UNIT)
PTAB	PRICE TABLE	(DOLLARS/UNIT)
EP	PRICE EXPECTED BY PRODUCERS	(DOLLARS/UNIT)
EPN	INITIAL VALUE OF EX. PRICE	(DOLLARS/UNIT)
EPAD	EX. PRICE ADJUSTMENT DELAY	(MONTHS)
DPCAP	DESIRED PRODUCTION CAPACITY	(UNITS/MONTH)
CATAB	CAPACITY TABLE	(UNITS/MONTH)
PCAP	PRODUCTION CAPACITY	(UNITS/MONTH)
CDR	CAPACTIY DEPRECIATION RATE	(UNITS/MO/MO)
ALPC	AVERAGE LIFE OF PROD. CAP.	(MONTHS)
PCAPN	INITIAL VALUE OF PROD. CAP.	(UNITS/MONTH)
INR	COMMODITY INITIATION RATE	(UNITS/MONTH)
PR	COMMODITY PRODUCTION RATE	(UNITS/MONTH)
PD	PRODUCTION DELAY	(MONTHS)
EPPC	EQUI. PER CAPITA CONSUMPTION	(UNITS/MAN-MO)
COTAB	CONSUMPTION TABLE	(UNITS/MAN-MO)
CR	CONSUMPTION RATE	(UNITS/MONTH)
POP	POPULATION OF CONSUMERS	(MEN)
ECR	EXPECTED CONSUMPTION RATE	(UNITS/MONTH)
ECRN	IN. VALUE OF EX. CON. RATE	(UNITS/MONTH)
ECAD	EX. CON. RATE ADJ. DELAY	(MONTHS)
PCCR	PER CAPITA CONSUMPTION REQS.	(UNITS/MONTH)
PCCRN	INITIAL VALUE OF PCCR	(UNITS/MONTH)
CRAD	CONSUMPTION REQS. ADJ. DELAY	(MONTHS)
CTIR	CAP TRANSFER INITIATION RATE	(UNITS/MO/MO)
CTID	CAP TRANSFER IN. DELAY	(MONTHS)
CBT	CAPACITY BEING TRANSFERRED	(UNITS/MONTH)
CBTN	INITIAL VALUE OF CBT	(UNITS/MONTH)
CTCR	CAP TRANSFER COMPLETION RATE	(UNITS/MO/MO)
CTD	CAPACITY TRANSFER DELAY	(MONTHS)
CUF	CAPACITY UTILIZATION FACTOR	(DIMENSNLESS)
RDAC	RATIO OF DES. TO ACT. CAP.	(DIMENSNLESS)
CUTAB	CAPACITY UTILIZATION TABLE	(DIMENSNLESS)
PUF	PRODUCTION UTIL. FACTOR	(DIMENSNLESS)
PUTAB	PRODUCTION UTILIZATION TABLE	(DIMENSNLESS)
INPUT	EXOGENOUS INPUT TO CONSUMP.	(DIMENSNLESS)

APPENDIX 10

MERCURY MODEL

```
L      INV.K=INV.J+(DT)(PR.JK-CR.JK)
N      INV=INVN
C INVN=136000
A      COV.K=INV.K/ECR.K
A       RCOV.K=COV.K/DCOV
C DCOV=5.93
A PRICE.K=TABHL(PTAB,RCOV.K,0,5.994,0.333)
T PTAB=1000/450/280/253/210/195/170/150/130/120/105/90/80/70/60/50/40/
X1 30/20
L      EP.K=EP.J+(DT)(PRICE.J-EP.J)/EPAD
N      EP=EPN
C EPN=210
C EPAD=72
L      ECR.K=ECR.J+(DT)(CR.JK-ECR.J)/ECAD
N      ECR=ECRN
C ECRN=17000
C ECAD=6     BECAUSE EQUALS DCOV
A      DPCAP.K=TABHL(CATAB,EP.K,100,1600,100)
T CATAB=12000/16500/22000/26000/30000/32000/33500/34500/35000/
X1 35400/35750/36050/36300/36550/36750/36950
R      CTIR.KL=(DPCAP.K-PCAP.K-CBT.K)/CTID
C CTID=12
L      CBT.K=CBT.J+(DT)(CTIR.JK-CTCR.JK)
N       CBT=DPCAP-PCAP
R      CTCR.KL=DELAY3(CTIR.JK,CTD)
C CTD=12
L      PCAP.K=PCAP.J+(DT)(CTCR.JK-COR.JK)
N PCAP=17000
R      COR.KL=PCAP.K/ALPC
C      ALPC=1200    MONTHS EPUISER UNE MINE
R      INR.KL=(PCAP.K)(CUF.K)
A      CUF.K=TABHL(CUTAB,RDAC.K,0,1.998,.333)
A      RDAC.K=DPCAP.K/PCAP.K
T      CUTAB=1/1/1/1/1/1/1
R      PR.KL=DELAY3(INR.JK,PD)
C PD=1
A  EPCC.K=TABHL(COTAB,PRICE.K,100,1600,100)
T COTAB=21000/17200/15000/14000/13000/12000/11200/10600/10200/
X1 9900/9750/9525/9325/9150/9000/8900
L      PCCR.K=PCCR.J+(DT)(EPCC.J-PCCR.J)/CRAD
N    PCCR=PCCRN
C PCCRN=17000
C CRAD=24
R CR.KL=(PCCR.K)(INPUT.K)
NOTE   INPUT TO CONSUMPTION
A      INPUT.K=1+STEP.K+NOISE.K+STEP1.K
A  STEP1.K=0
A      STEP.K=STEP(SH,ST1)+STEP(-SH,ST2)


C SH=0.2
C      ST1=50
C      ST2=68
A      NOISE.K=NM*SAMPLE(NORMRN(0,NSD),SI,0)
C NM=0
C      NSD=.5
C SI=3
NOTE   CONTROL CARDS
SPEC DT=0.2/LENGTH=800/PRTPER=12/
A      PLTPER.K=STEP(PP,PIT)
C PP=10
C      PIT=0
PLOT INV=I/PCAP=C/PRICE=P/CR=E/RCOV=?/PR=*/
RUN 1
```

APPENDIX 11

TIN MODEL

```
N TINCM=
A INCOM.K=(PRICE.K)(ACR.K)-(PRICE.K)(JAN.K)
L TINCM.K=TINCM.J+(DT)(RVNU.JK-0)
R RVNU.KL=(INCOM.K)/(ZY.K)
NOTE
C DLT=0.1
A DLT3.K=(3)(DLT)
NOTE      CONTER OF ITERATIONS
R IRAT.KL=3/(DLT3.K)
L CNTER.K=CNTER.J+(DT)(IRAT.JK-ORAT.JK)
N CNTER=1
R ORAT.KL=PULSE(ACTER.K,12,12)
A ACTER.K=(3)(CNTER.K)/(DLT3.K)
NOTE
NOTE      PRICE FORECAST MODULE
NOTE                          CUMULATIVE AND AVERAGE CURRENT PRICE
NOTE SMOOTHING ON ONE MONTH
L P1M.K=P1M.J+(DT)(PRICE.J-P1M.J)/1
N P1M=PRICE
NOTE
R IRATA.KL=(3)(PRICE.K)/(DLT3.K)
L CUMLP.K=CUMLP.J+(DT)(IRATA.JK-ORATA.JK)
N CUMLP=PRICE
R ORATA.KL=PULSE(APULS.K,12,12)
A APULS.K=(3)(CUMLP.K)/(DLT3.K)
A XX.K=MAX(1,CNTER.K)
A AVPRX.K=CUMLP.K/XX.K
R IRATB.KL=PULSE(APT.K,12,12)
A APT.K=(3)(AVPRX.K)/(DLT3.K)
NOTE                         PAST PRICE INFORMATION
L AVPM1.K=AVPM1.J+(DT)(IRATB.JK-ORATB.JK)
N AVPM1=PRICE
R ORATB.KL=PULSE(APTM1.K,12,12)
A APTM1.K=(3)(AVPM1.K)/(DLT3.K)
L AVPM2.K=AVPM2.J+(DT)(ORATB.JK-ORATC.JK)
N AVPM2=PRICE
A APTM2.K=(3)(AVPM2.K)/(DLT3.K)
R ORATC.KL=PULSE(APTM2.K,12,12)
NOTE      MODULE FOR STABILITY DEFINITION
L AVPM3.K=AVPM3.J+(DT)(ORATC.JK-ORATD.JK)
L AVPM4.K=AVPM4.J+(DT)(ORATD.JK-ORATE.JK)
N AVPM3=PRICE
N AVPM4=PRICE
A APTM3.K=(3)(AVPM3.K)/(DLT3.K)
A APTM4.K=(3)(AVPM4.K)/(DLT3.K)
R ORATD.KL=PULSE(APTM3.K,12,12)
R ORATE.KL=PULSE(APTM4.K,12,12)
A RSTAR.K=((5)(QSTAR.K)+AVPM3.K+AVPM4.K)/7.
NOTE
NOTE
NOTE                        PRICE FORECASTING
NOTE
NOTE
A PP1.K=(ALFA)(PFCST.K)+(BETA)(AVPM1.K)
A PP2.K=(ALFA)(PP1.K)+(BETA)(PFCST.K)
C ALFA=0.7
C BETA=0.3
```

```
NOTE
NOTE     LINK TO BUFFER STOCK OPERATION **
A PECST.K=(ALFA)(AVPRX.K)+(BETA)(AVPM1.K)
NOTE **  CHANGES
A OSTAR.K=(0.2)(AVPM2.K+AVPM1.K+PECST.K+PP1.K+PP2.K)
A RSTAR.K=(OO)(OSTAR.K)+(1.-OO)(USTAR.K)
C OO=1
A USTAR.K=50+(BENE.K)(AJUST)
C AJUST=1
L BENE.K=BENE.J+(DT)(R.JK-RO.JK)
R R.KL=PULSE(ANFIN.K,36,36)
NOTE **** RSG READJUSTED EVERY 3 YEARS AFTERWARDS ********
A COMP.K=(0.15)(COMN)
A MD.K=COM.K-COMP.K
N BENE=0
A ENFIN.K=(RSTAR.K-50)/DLT
R RO.KL=PULSE(BENO.K,36,36)
A BENO.K=BENE.K/DLT
A ANFIN.K=CLIP(0,ENFIN.K,MD.K,0)
NOTE
NOTE
NOTE
NOTE
NOTE ******************************************************************************
NOTE
NOTE
NOTE
NOTE  ***** MODULE OF BUFFER STOCK OPERATIONS *****
NOTE
C X=1               **** 1 MEANS THAT BUFFER IS ACTIVE***
NOTE
NOTE     **** TRIGERRING MECHANISM  ********
A PMIN.K=PSTAR.K*0.985
A PMAX.K=PSTAR.K*1.015
A S1.K=PRICE.K-PMAX.K
A S2.K=PRICE.K-PMIN.K
A T1.K=CLIP(PSTAR.K,PMIN.K,S2.K,0)
A TRIGR.K=CLIP(PMAX.K,T1.K,S1.K,0)
A JE.K=(S1.K)(S2.K)
NOTE
L COM.K=COM.J+(DT)(0-CBUF.JK)
N COM=COMN
C COMN=1000
L MONEY.K=MONEY.J+(DT)(0-SPENT.JK)
N MONEY=(PRICE)(PCAP)(24)  0
NOTE ****** REKA IS INTRODUCED TO MAKE  SURE THAT THE BUFFER OPERATION
NOTE IS RESPECTING THE LIMITS OF EXISTING INVENTORIES IN THE WORLSD**********.
A BINV.K=(3)(INV.K)
A REKA.K=ACR.K-PR.JK-(BINV.K)/(DLT3.K)
A SRAVO.K=CLIP(DRAVO.K,REKA.K,DRAVO.K,REKA.K)
A BRAVO.K=MIN(SRAVO.K,ACR1.K)
A ACR1.K=(0.75)(ACR.K)
A DRAVO.K=CLIP(CRAVO.K,0,JE.K,0)
A CRAVO.K=(X)(DY)(CR.JK)(PRICE.K-TRIGR.K)/(PRICE.K)
N CRAVO=0
C DY=1              **** MAGNITUDE OF INTERVENTION  *****
NOTE *THIS SECTION TO ASSURE THAT OUTFLOWS IN MONEY OR MATERIAL DO NOT EXCEED
```

```
NOTE        THE PHYSICAL RESERVES OF THE  BUFFER *
R  CBUF.KL=CLIP(CBU1.K,CBU2.K,BRAVO.K,0)
A  CBU1.K=CLIP(0,BRAVO.K,0,COM.K)
A  CBU2.K=CLIP(BRAVO.K,-A2.K,MONEY.K,-A1.K)
A  A2.K=MONEY.K/PPICE.K
A  A1.K=(BRAVO.K)(PRICE.K)(DLT)
A  PPICE.K=(3)(DLT)(MAX(PRICE.K,1))
R  SPENT.KL=CLIP(SPEN1.K,SPEN2.K,BRAVO.K,0)
A  SPEN1.K=CLIP(0,-ADOLB.K,0,COM.K)
A  SPEN2.K=CLIP(-ADOLB.K,MONEY.K,MONEY.K,-A1.K)
A  ADOLB.K=(BRAVO.K)(PRICE.K)
NOTE     ***** LINK TO WORLD MARKET MODULE *****
R  CR.KL=ACR.K-JAN.K
A  JAN.K=CLIP(CBU1.K,CBU2.K,BRAVO.K,0)
NOTE
NOTE
NOTE
NOTE  ****************************************************
NOTE
NOTE
NOTE    ***** MODULE FOR WORLD MARKET *****
NOTE
L  INV.K=INV.J+(DT)(PR.JK-CR.JK)
N  INV=INVN
C  INVN=6000
A  COV.K=INV.K/FCR.K
A  RCOV.K=COV.K/DCOV
C  DCOV=10
A  PRICE.K=TABLE(PTAB,RCOV.K,0,1.998,.333)
T  PTAB=100/94/80/50/20/10/0
L  EP.K=EP.J+(DT)(PRICE.J-EP.J)/EPAD
N  EP=EPN
C  EPN=50
C  EPAD=3
A  DPCAP.K=TABLE(CATAB,EP.K,0,100,20)
T  CATAB=0/400/200/1000/1200/1280
R  CTIR.KL=(DPCAP.K-PCAP.K-CBT.K)/CTID
C  CTID=3
L  CBT.K=CBT.J+(DT)(CTIR.JK-CTCR.JK)
N  CBT=(CTID(DPCAP-PCAP))/(1+CTID)
R  CTCR.KL=DELAY3(CTIR.JK,CTD)
C  CTD=4
L  PCAP.K=PCAP.J+(DT)(CTCR.JK-CDR.JK)
N  PCAP=PCAPN
C  PCAPN=600
R  CDR.KL=PCAP.K/ALPC
C  ALPC=200
R  INR.KL=(PCAP.K)(CUF.K)
A  ZUF.K=TABHL(CUTAB,RDAC.K,0,2.997,.333)
A  RDAC.K=DPCAP.K/PCAP.K
T  CUTAB=1/1/1/1/1/1/1/1/1/1
R  PR.KL=DELAY3(INR.JK,PD)*PUF.K
C  PD=6
A  PUF.K=TABHL(PUTAB,RDAC.K,0,2.997,.333)
T  PUTAB=1/1/1/1/1/1/1/1/1/1
A  EPCC.K=TABLE(COTAB,PRICE.K,0,100,20)
T  COTAB=7/6.5/5/1/.3/0
L  PCCR.K=PCCR.J+(DT)(EPCC.J-PCCR.J)/CRAD
```

```
C PCCRN=3
C CRAD=3
A ACF.K=(POP)(PCCR.K)(INPUT.K)
C POP=2
L FCR.K=FCR.J+(DT)(CR.JK-ECR.J)/FCAD
N FCR=FCRN
C FCRN=6
C FCAD=1
NOTE         MODULE FOR QUOTAS
A CUF.K=(LANDA.K)(ZUF.K)(QUOTA)+(1-QUOTA)(ZUF.K)
C QUOTA=          MEANS NO QUOTAS
L LANDA.K=LANDA.J+(DT)(IANDA.JK-DANDA.JK)
N LANDA=1
A XANDA.K=CLIP(1.AN.K.+S2.K.0)
A AN.K=MAX( .5.BN.K)
A BN.K=1+(V)(PRICE.K-TRIGR.K)/(PRICE.K)
C V=2.5
R DANDA.KL=PULSE(LAND1.K.3.3)
A LAND1.K=LANDA.K/DLT
R IANDA.KL=PULSE(XAND1.K.3.3)
A XAND1.K=XANDA.K/DLT
NOTE
NOTE    COST OF OPERATION MODULE
A LO.K=(PRICE.K)(COM.K)(  B  )+CLIP1.K
A CLIP1.K=CLIP(SPEN1.K.SPEN2.K.BPAVO.K.0)
NOTE SELL SPENT -
A YX.K=1.  8
A YY.K=(TIME.K)(LOGN(YX.K))
A ZY.K=EXP(YY.K)
L COST.K=COST.J+(DT)(BANK.JK-0)
N COST=0
A ABANK.K=(LO.K)/(ZY.K)
R BANK.KL=SWITCH(0.ABANK.K.X)
NOTE    MEASURES OF STABILITY MODULE
L TIME.K=TIME.J+(DT)(T.JK-0)
N TIME=0
R T.KL=1
L COTER.K=COTER.J+(DT)(ITER.JK-0)
N COTER=1
R ITER.KL=(3)/(DLT3.K)
L PITY.K=PITY.J+(DT)(IPY.JK-0)
N PITY=0
R IPY.KL=(AP.K)(AP.K)
A AP.K=PIM.K-SSTAR.K
A OPITY.K=(PITY.K)/(COTER.K)
A PSTAB.K=SQRT(OPITY.K)
L SSTAR.K=SSTAR.J+(DT)(PRICE.J-SSTAR.J)/LENTH
N SSTAR=PRICE
C LENTH=36
L IITY.K=IITY.J+(DT)(IIITY.JK-0)
N IITY=0
R IIITY.KL=(AB.K)(AB.K)
A AB.K=(AP.K)(CR.JK)
A OIITY.K=(IITY.K)/(COTER.K)
A ISTAB.K=SQRT(OIITY.K)
NOTE EQUATIONS TO GENERARE EXOGENEOUS
NOTE INPUT TO CONSUMPTION
```

```
A INPUT.K=(1+STEP.K)(NOISE.K)
C H=.01
C D=0.023
A STEP.K=RAMP(-H,0)+RAMP(H,72)+STEP(0.2,72)+RAMP(Q,90)
A NOISE.K=(NM.K)(SAMPLE(NORMRN(0,NSD),SI,0))+1
A NM.K=STEP(0,1,0)+STEP(0,1,1 )
C NSD=.6
C SI=9
NOTE CONTROL CARDS
SPEC DT=.1/LENGTH=372
C PRTPER=12
A PLTPER.K=STEP(PP,PIT)
C PP=3
C PIT=0
NOTE
NOTE
PLOT INV=I( ,12 )/PCAP=C( ,12 )/CR=E,ACR=A/PRICE=P(3 ,7 )/
X1 PSTAR= (3 ,7 )/INCOM=1/MONEY=2/COM=S/INPUT=X
PLOT MONEY=$/COM=S/PSTAR= /CRUF=U/SPENT=X/BRAVO=7/COST=J
PRINT 1)PITY/2)IITY/3)COST/4)PRICE/5)COM/6)INCOM/7)TINCM/8)PSTAR
PRINT 9)LANDA/10)CUF/11)INPUT/12)ANFIN/13)PSTAB/14)ISTAB
NOTE INTERVENTION RULE A LA GORFUX ****************
RUN 1
```

APPENDIX 12

MODULATED INTERVENTION MAGNITUDE: RESULTS OF SIMULATION

TIME E+00	PITY E+00	IITY E+03	COST E+03	PRICE E+00	COM E+03	INCOM E+03	TINCM E+03	PSTAR E+00	LANDA E+00	CUF E+00	INPUT E+00	ANFIN E+00	PSTAR E+00	ISTAR E+00
0.	.00000	.000	.00	49.910	10.000	29.946	.0	49.910	0.	1.0000	1.0000	0.	.00000	.00
12.	.00211	.740	45.78	49.741	[illegible]	29.233	34[illegible].3	49.935	0.	1.0000	.9736	0.	.04591	27.20
24.	.00681	2.331	97.11	49.593	[illegible]	33.973	661.1	49.851	0.	1.0000	1.1263	0.	.08244	48.28
36.	.05275	17.290	119.32	49.359	9.626	28.483	918.4	50.157	0.	1.0000	.9712	0.	.22968	131.49
48.	.07214	24.301	139.30	51.317	9.534	29.850	1181.7	50.513	0.	1.0000	1.0591	0.	.26860	155.99
60.	.08206	27.739	171.15	49.730	9.527	30.389	1414.9	50.633	0.	1.0000	.9992	0.	.28646	166.55
71.99	.09209	32.101	201.72	49.433	9.708	32.021	1627.2	50.130	0.	1.0000	1.0369	0.	.30642	179.17
83.99	.10053	34.255	222.21	49.512	9.547	27.996	1815.4	50.092	0.	1.0000	.9588	0.	.31706	185.16
95.99	.10638	36.344	243.25	51.069	9.475	25.978	1991.4	50.309	0.	1.0000	.9042	0.	.32616	190.64
107.99	.11405	39.043	268.46	51.018	9.703	30.136	2147.4	50.195	0.	1.0000	1.0158	0.	.33771	197.59
119.99	.11745	40.189	297.41	50.242	9.699	31.426	2299.0	50.146	0.	1.0000	1.0702	0.	.34272	200.47
131.99	.12252	41.975	305.74	49.519	9.760	29.960	2421.5	50.478	0.	1.0000	.9712	0.	.35003	204.88
143.99	.12709	43.665	322.32	50.171	9.820	28.049	2542.0	50.321	0.	1.0000	.9216	0.	.35649	208.96
155.99	.13407	46.307	328.05	51.711	9.263	29.327	2649.6	50.093	0.	1.0000	1.2111	0.	.36739	215.19
167.99	.15067	51.543	333.10	51.590	8.759	28.593	2748.5	50.740	0.	1.0000	1.0759	0.	.38816	227.03
179.98	.15266	52.311	347.57	49.875	9.074	31.562	2942.5	51.004	0.	1.0000	.9767	0.	.39071	228.72
191.98	.15517	53.657	358.58	51.131	9.160	28.549	2926.5	50.559	0.	1.0000	.9676	0.	.39518	231.64
203.98	.15527	54.373	368.05	49.255	9.200	29.354	2997.8	50.118	0.	1.0000	.9413	0.	.39783	233.18
215.98	.16233	55.819	375.31	50.875	9.092	27.243	3064.3	50.027	0.	1.0000	.9531	0.	.40287	236.26
227.98	.16390	56.360	381.26	51.259	8.913	30.011	3124.2	50.107	0.	1.0000	1.1119	0.	.40485	237.40
239.99	.14743	57.565	387.20	50.329	8.820	28.573	3179.9	50.493	0.	1.0000	.9806	0.	.40918	239.93
251.98	.14560	58.391	394.01	51.294	8.934	30.829	3231.7	50.455	0.	1.0000	1.0457	0.	.41183	241.64
263.97	.17184	59.154	399.54	49.842	8.931	31.730	3276.7	50.324	0.	1.0000	1.0571	0.	.41453	243.22
275.95	.17322	59.449	404.54	50.701	8.918	30.225	3319.5	50.528	0.	1.0000	1.0509	0.	.41619	244.23
287.93	.17430	60.048	409.72	49.715	9.040	30.228	3357.6	50.551	0.	1.0000	.9841	0.	.41749	245.05
299.91	.17589	60.618	413.45	51.288	8.944	29.663	3392.4	50.295	0.	1.0000	1.0688	0.	.41940	246.21
311.9	.17514	61.679	416.91	51.895	8.863	30.191	3423.7	50.588	0.	1.0000	1.0751	0.	.42313	248.35
323.88	.18015	62.083	420.83	49.632	9.002	30.680	3452.8	50.659	0.	1.0000	.9588	0.	.42438	249.17
335.86	.18250	63.039	423.90	51.20[illegible]	8.980	29.653	3479.2	50.396	0.	1.0000	1.0418	0.	.42732	251.02
347.86	.18316	63.195	426.74	49.632	9.979	29.641	350[illegible]	50.259	0.	1.0000	.9932	0.	.42797	251.39
359.83	.18433	63.620	429.29	50.998	8.969	29.737	3523.7	50.334	0.	1.0000	1.0312	0.	.42934	252.23
371.91	.18473	63.756	431.65	49.540	8.972	29.731	3542.7	50.329	0.	1.0000	.9879	0.	.42981	252.50

1- DY=10 ; RANGE = 3% ; STEP IMPULSE + NOISE

TIME	PITY	IITY	COST	PRICE	CJM	INCJM	TINCP	PSTAR	LANDA	CUF	INPUT	ANFIN	PSTAB	ISTAB
E+0	E+0	E+3	E+3	E+0	E+0	E+3	E+3	E+0	E+0	E+0	E+0	E+00	E+00	E+00
.0	.00000	.000	.00	49.910	10.000	29.946	.0	49.910	0.	1.0000	1.0000	0.	.00000	.00
12.	.00211	.740	45.78	49.741	10.000	29.23[illegible]	340.3	49.935	0.	1.0000	.9735	0.	.04591	27.20
24.	.00577	2.331	37.11	49.534	10.000	33.473	641.1	49.851	0.	1.0000	1.1063	0.	.08243	49.28
36.	.03933	12.042	116.39	49.558	9.559	28.660	917.8	50.102	0.	1.0000	.9712	0.	.19825	113.76
48.	.05123	17.217	134.49	51.072	9.411	29.621	1178.6	50.438	0.	1.0000	1.0581	0.	.22647	131.21
60.	.06115	20.656	166.06	49.346	9.478	30.391	1412.8	50.622	0.	1.0000	.9982	0.	.24726	143.72
71.99	.06634	22.734	200.26	49.692	9.723	32.313	1626.5	50.311	0.	1.0000	1.0369	0.	.25873	150.98
83.99	.07365	24.043	222.27	49.589	9.608	28.791	1816.0	50.174	0.	1.0000	.9589	0.	.26590	155.06
95.99	.07510	25.507	241.91	50.865	9.491	25.674	1991.5	50.207	0.	1.0000	.9642	0.	.27404	160.02
107.99	.08112	27.356	267.17	50.754	9.737	29.831	2147.1	50.151	0.	1.0000	1.0158	0.	.28306	165.40
119.99	.08225	28.037	285.67	50.201	9.634	31.412	2238.8	50.147	0.	1.0000	1.0702	0.	.28644	167.35
131.99	.08555	29.236	303.15	49.723	9.735	29.558	2421.1	50.449	0.	1.0000	.9712	0.	.29259	170.99
143.99	.08803	30.163	320.52	49.979	9.311	27.919	2541.3	50.342	0.	1.0000	.9216	0.	.29678	173.67
155.99	.09428	32.265	325.98	51.531	9.290	29.393	2649.6	50.128	0.	1.0000	1.2111	0.	.30705	179.63
167.99	.10331	36.110	333.11	51.369	8.058	28.644	2748.0	50.064	0.	1.0000	1.0759	0.	.32528	190.34
179.98	.10576	36.475	344.29	50.049	8.951	31.414	2841.7	50.940	0.	1.0000	.9767	0.	.32674	190.98
191.98	.10856	37.164	355.01	50.848	9.031	28.824	2925.5	50.583	0.	1.0000	.9876	0.	.32946	192.78
203.98	.11024	37.744	365.13	49.513	9.134	29.371	2997.5	50.146	0.	1.0000	.9413	0.	.33202	194.28
215.98	.11251	38.585	372.24	50.559	9.014	27.205	3064.0	50.025	0.	1.0000	.9531	0.	.33557	196.43
227.98	.11388	39.023	377.85	51.045	8.824	29.914	3123.5	50.275	0.	1.0000	1.1119	0.	.33746	197.53
239.98	.11553	39.323	383.21	50.534	8.553	29.265	3179.0	50.443	0.	1.0000	.9806	0.	.34136	199.81
251.98	.11758	40.318	390.31	51.031	8.317	30.931	3230.6	50.502	0.	1.0000	1.0457	0.	.34289	200.79
263.97	.11879	40.742	395.91	49.873	8.839	31.635	3270.0	50.364	0.	1.0000	1.0571	0.	.34466	201.85
275.97	.11998	41.131	400.54	50.849	8.792	30.110	3318.7	50.568	0.	1.0000	1.0509	0.	.34623	202.81
287.93	.12058	41.387	406.13	49.918	8.961	30.390	3356.9	50.571	0.	1.0000	.9841	0.	.34724	203.44
299.91	.12194	41.881	409.81	51.090	8.883	29.785	3391.7	50.325	0.	1.0000	1.0688	0.	.34920	204.65
311.9	.12378	42.535	412.75	51.019	8.732	30.449	3423.0	50.459	0.	1.0000	1.0751	0.	.35162	206.17
323.92	.12433	42.712	416.69	49.815	8.356	30.653	3452.0	50.041	0.	1.0000	.9588	0.	.35261	206.67
335.96	.12578	43.252	420.01	51.015	8.311	29.911	3478.4	50.476	0.	1.0000	1.0418	0.	.35456	207.97
347.94	.12515	43.379	422.93	49.771	8.911	29.773	3531.4	50.292	0.	1.0000	.9932	0.	.35513	208.23
359.93	.12584	43.526	425.26	50.832	8.857	25.779	3523.0	50.296	0.	1.0000	1.0312	0.	.35615	208.97
371.91	.12711	43.719	427.62	49.762	8.851	29.606	3542.1	50.219	0.	1.0000	.9879	0.	.35652	209.09

2- REFERENCE FOR 1 - SAME INPUTS - NO MODULATION OF INTERVENTION

FIRE	PIIY	IITY	COST	PRICE	[illegible]CSA	INCOM	TINCP	ESTAF	LANCA	CUF	INPUT	ANFIN	PSTAB	ISTAB
E+03	E+0[illegible]	E+03	E+03	E+[illegible]	E+03	E+03	E+03	E+0[illegible]	E+[illegible]	E+[illegible]	E+[illegible]	E+03	E+0[illegible]	E+00
[illegible]	[illegible]	[illegible]	[illegible]	49.91[illegible]	10.0[illegible]	29.940	[illegible]	49.91[illegible]	[illegible]	1.0[illegible]	1.0[illegible]	[illegible]	.0[illegible]	.00
12.	.0[illegible]211	.74	45.78	49.741	10.0[illegible]	29.23	54[illegible].3	49.935	[illegible]	1.0[illegible]	.9730	[illegible]	.04591	27.20
24.	.0[illegible]631	2.33	37.11	49.593	1[illegible]	3[illegible].473	641.1	49.651	[illegible]	1.0[illegible]	1.1 53	[illegible]	.08244	46.28
36.	.14644	47.[illegible]8	121.49	48.086	9.[illegible]	28.473	92[illegible].9	5[illegible].361	[illegible]	1.0[illegible]	.9712	[illegible]	.35267	216.99
48.	.18539	52.24	150.98	51.32[illegible]	9.929	29.94	1191.1	5[illegible].710	[illegible]	1.0[illegible]	1.0531	[illegible]	.43173	249.49
[illegible]	.19554	65.4	183.92	49.422	9.943	29.945	1422.5	5[illegible].661	[illegible]	1.0[illegible]	.9992	[illegible]	.44219	255.73
[illegible].99	.21773	73.63	217.9[illegible]	49.56[illegible]	9.974	32.5[illegible]2	1634.5	5[illegible].[illegible]55	[illegible]	1.0[illegible]	1.1369	[illegible]	.46661	271.34
[illegible].99	.23952	3[illegible].47	241.07	49.310	9.912	27.62[illegible]	1822.[illegible]	5[illegible].113	[illegible]	1.0[illegible]	.9598	[illegible]	.44941	283.68
[illegible].99	.24921	83.95	264.97	5[illegible].917	9.[illegible]	25.9[illegible]6	2[illegible]2	5[illegible].424	[illegible]	1.0[illegible]	.9[illegible]42	[illegible]	.49921	289.75
1[illegible].99	.273[illegible]	92.51	287.31	51.38[illegible]	9.930	[illegible].349	2155.6	5[illegible].76	[illegible]	1.0[illegible]	1.0158	[illegible]	.52252	3[illegible]4.15
[illegible].99	.25[illegible]5	95.72	3[illegible].45	5[illegible].[illegible]1	9.944	3[illegible].952	2294.6	5[illegible].[illegible]48	[illegible]	1.0[illegible]	1.0 7 2	[illegible]	.53252	3[illegible]9.39
[illegible].99	.23[illegible]	97.79	324.60	48.576	9.977	29.033	2425.6	5[illegible].455	[illegible]	1.0[illegible]	.9712	[illegible]	.53745	312.72
[illegible].97	.29713	1[illegible].98	34[illegible].33	5[illegible].569	9.595	27.593	2540.2	5[illegible].275	[illegible]	1.0[illegible]	.9210	[illegible]	.545[illegible]7	317.74
[illegible].97	.32733	111.[illegible]5	353.12	54.[illegible]43	9.551	29.3[illegible]	2657.5	51.[illegible]59	[illegible]	1.0[illegible]	1.2111	[illegible]	.5721[illegible]	333.24
[illegible].97	.35443	115.44	365.15	5[illegible].01[illegible]	9.312	3[illegible].173	2758.5	51.235	[illegible]	1.0[illegible]	1.1759	[illegible]	.59536	345.69
1[illegible].93	.36312	124.35	377.65	40.935	9.369	31.[illegible]61	2854.[illegible]	5[illegible].936	[illegible]	1.0[illegible]	.9767	[illegible]	.6[illegible]1	352.64
1[illegible].93	.37359	127.12	39[illegible].[illegible]7	51.384	9.77[illegible]	27.459	2936.6	5[illegible].224	[illegible]	1.0[illegible]	.9076	[illegible]	.61139	354.54
2[illegible].93	.37415	128.65	4[illegible].[illegible]9	48.345	9.725	29.551	3[illegible]7.[illegible]	5[illegible].[illegible]86	[illegible]	1.0[illegible]	.9413	[illegible]	.61497	352.69
[illegible].99	.387[illegible]	131.39	418.7[illegible]	51.3[illegible]5	9.687	26.071	3[illegible]75.2	5[illegible].[illegible]56	[illegible]	1.0[illegible]	.9531	[illegible]	.62217	363.16
2[illegible].98	.39[illegible]72	133.15	416.48	52.575	9.461	3[illegible].624	3135.2	5[illegible].222	[illegible]	1.0[illegible]	1.1119	[illegible]	.62537	364.89
23[illegible].99	.39[illegible]	135.[illegible]	423.33	5[illegible].[illegible]42	9.829	29.172	31[illegible].7	5[illegible].5[illegible]	[illegible]	1.0[illegible]	.9[illegible]6	[illegible]	.63[illegible]4	366.3[illegible]
2[illegible].93	.4[illegible]59	137.77	43[illegible].68	51.764	9.632	3[illegible].763	3242.9	5[illegible].39[illegible]	[illegible]	1.0[illegible]	1.0457	[illegible]	.63529	371.17
[illegible].97	.4[illegible]740	139.[illegible]3	435.73	40.770	9.847	31.447	3257.2	5[illegible].244	[illegible]	1.0[illegible]	1.0571	[illegible]	.63832	372.96
2[illegible].95	.4[illegible].39	137.33	442.31	5[illegible].[illegible]3	9.347	3[illegible].409	33[illegible]	5[illegible].545	[illegible]	1.0[illegible]	1.0599	[illegible]	.63[illegible]8	373.27
2[illegible].93	.41[illegible]41	14[illegible].13	447.49	49.582	9.653	3[illegible].324	33[illegible].1	5[illegible].4[illegible]	[illegible]	1.0[illegible]	.9641	[illegible]	.64[illegible]9	374.34
[illegible].91	.41234	14[illegible].79	45[illegible]	52.150	9.832	2[illegible].650	34[illegible].2	5[illegible].292	[illegible]	1.0[illegible]	1.0666	[illegible]	.64214	375.22
[illegible]	.41573	142.22	456.13	5[illegible].458	9.337	3[illegible].65[illegible]	3434.3	5[illegible].691	[illegible]	1.0[illegible]	1.0751	[illegible]	.64555	377.12
[illegible].89	.41687	143.[illegible]2	46[illegible].[illegible]3	48.001	9.482	3[illegible].118	3403.4	5[illegible].[illegible]2[illegible]	[illegible]	1.0[illegible]	.9586	[illegible]	.64720	379.17
[illegible].85	.42472	145.[illegible]	45[illegible].3	51.471	9.353	28.855	3499.6	5[illegible].337	[illegible]	1.0[illegible]	1.0418	[illegible]	.65171	36[illegible].92
[illegible].34	.42[illegible]	14[illegible].4[illegible]	40[illegible].4[illegible]	4[illegible].37[illegible]	9.634	2[illegible].405	[illegible].4	5[illegible].277	[illegible]	1.0[illegible]	.9932	[illegible]	.65261	381.42
[illegible].33	.42773	146.17	459.22	51.114	9.820	29.0[illegible]7	3534.3	5[illegible].329	[illegible]	1.0[illegible]	1.0312	[illegible]	.654[illegible]5	382.32
[illegible].91	.42332	146.35	471.3	4[illegible].444	9.827	2[illegible].531	3553.2	5[illegible].313	[illegible]	1.0[illegible]	.9879	[illegible]	.65446	382.56

3- DY=1 ; RANGE = 3% ; STEP IMPULSE + NOISE

TIME	PITY	IITY	CUST	PRICE	CUA	INCOM	TINCM	PSTAR	LANDA	CUF	INPUT	ANFIN	PSTAB	ISTAB
E+00	E+00	E+03	E+03	E+00	E+03	E+03	E+03	E+00	E+00	E+00	E+00	E+00	E+00	E+00
.0	.00000	.00	.00	49.910	10.000	29.946	.0	49.910	0.	1.0000	1.0000	0.	.00000	.00
12.	.00211	.74	43.78	49.744	10.000	29.230	340.3	49.935	0.	1.0000	.9736	0.	.04591	27.20
24.	.00680	2.33	87.11	49.553	10.000	33.573	641.1	49.851	0.	1.0000	1.0163	0.	.09244	49.28
36.	.13315	44.75	121.24	49.602	9.375	28.583	920.9	50.349	0.	1.0000	.9712	0.	.37289	211.55
48.	.17293	57.55	156.25	51.247	9.914	30.029	1193.5	50.706	0.	1.0000	1.0581	0.	.41592	239.89
60.	.18155	63.49	184.23	49.326	9.533	29.931	1422.5	50.662	0.	1.0000	.9582	0.	.42587	245.94
71.99	.20364	67.52	217.79	49.567	9.993	32.392	1534.6	50.069	0.	1.0000	1.0369	0.	.44793	260.04
83.99	.21869	73.35	241.69	49.358	9.912	27.867	1822.4	50.117	0.	1.0000	.9589	0.	.46765	270.82
95.99	.22652	76.28	264.92	50.891	9.935	25.959	2000.3	50.439	0.	1.0000	.9042	0.	.47636	276.19
107.99	.24875	84.13	287.56	51.552	9.566	30.254	2155.9	50.064	0.	1.0000	1.0158	0.	.49375	290.06
119.99	.25714	85.33	305.42	50.359	9.743	30.596	2295.2	50.049	0.	1.0000	1.0762	0.	.50739	294.67
131.99	.26272	88.81	324.59	48.706	9.975	29.889	2427.0	50.448	0.	1.0000	.9712	0.	.51256	298.01
143.99	.27001	91.63	341.01	50.508	10.003	27.666	2546.5	50.265	0.	1.0000	.9216	0.	.51962	302.66
155.99	.27735	101.41	353.14	53.097	9.335	29.051	2650.0	50.394	0.	1.0000	1.2111	0.	.54713	318.45
167.99	.32523	109.71	365.97	50.645	9.793	30.135	2756.6	51.224	0.	1.0000	1.0759	0.	.57116	331.22
179.99	.33363	114.16	379.89	48.970	9.572	31.141	2854.2	50.561	0.	1.0000	.9767	0.	.58020	337.88
191.98	.34365	110.79	391.29	51.306	9.921	27.529	2936.9	50.332	0.	1.0000	.9876	0.	.56621	341.61
203.98	.34743	117.99	400.49	48.673	9.551	29.514	3037.4	50.185	0.	1.0000	.9413	0.	.58943	343.49
215.98	.35401	120.70	409.04	51.177	9.914	26.554	3175.4	50.099	0.	1.0000	.9531	0.	.59574	347.42
227.98	.35334	121.33	416.70	52.533	9.858	30.712	3135.6	50.215	0.	1.0000	1.1119	0.	.59862	349.15
239.98	.36532	124.25	424.00	50.085	9.542	29.034	3191.1	50.578	0.	1.0000	.9616	0.	.60442	352.49
251.98	.37335	126.19	431.09	51.608	9.394	30.728	3243.2	50.413	0.	1.0000	1.0457	0.	.60956	355.23
263.97	.37340	127.13	437.09	49.831	9.872	31.441	3297.6	50.293	0.	1.0000	1.0571	0.	.61106	356.64
275.95	.37427	127.51	442.06	50.620	9.860	30.445	3330.5	50.532	0.	1.0000	1.0579	0.	.61178	357.08
287.93	.37624	126.23	447.94	49.656	9.913	30.364	3368.5	50.477	0.	1.0000	.9841	0.	.61339	358.10
299.91	.37758	128.05	452.38	52.067	9.801	29.049	3403.5	50.295	0.	1.0000	1.0608	0.	.61469	358.95
311.9	.38237	130.18	456.51	50.536	9.656	30.567	3434.7	50.076	0.	1.0000	1.0751	0.	.61811	360.83
323.88	.38398	130.39	460.51	48.722	9.922	30.262	3453.4	50.634	0.	1.0000	.9588	0.	.61966	361.79
335.86	.38422	132.76	463.01	51.415	9.375	28.948	3490.2	50.344	0.	1.0000	1.0418	0.	.62367	364.39
347.84	.39118	133.19	466.35	49.490	9.879	29.966	3512.3	50.275	0.	1.0000	.9932	0.	.62465	364.82
359.83	.39109	133.64	469.75	51.014	9.594	29.653	3534.7	50.326	0.	1.0000	1.0312	0.	.62565	365.57
371.81	.39213	133.78	472.35	49.540	9.809	29.597	3553.5	50.317	0.	1.0000	.9879	0.	.62618	365.76

4- DY = 1; RANGE = 3% ; REFERENCE FOR 3 ; SAME INPUTS;
NO MODULATION OF INTERVENTION

TIME	PITY	IITY	COST	PRICE	C[illegible]	INCOM	TINV	PSTAR	LANDA	CUF	INPUT	ANFIN	PSTAR	ISTAR
E+0[illegible]	E+0[illegible]	E+03	E+0[illegible]	E+0[illegible]	E+03	E+03	E+03	E+0[illegible]	E+0[illegible]	E+0[illegible]	E+0[illegible]	E+0[illegible]	E+0[illegible]	E+0[illegible]
0.	[illegible]	[illegible]	[illegible]	49.91[illegible]	1.[illegible]	29.945	[illegible]	49.91[illegible]	0.	1.[illegible]	1.[illegible]	0.	[illegible]	[illegible]
12.	.1[illegible]211	.7[illegible]	45.75	49.741	1.[illegible]	29.25[illegible]	34[illegible].3	49.935	0.	1.[illegible]	.9735	0.	.[illegible]4591	27.2[illegible]
24.	[illegible]	25.331	67.11	49.595	1.[illegible]	33.573	641.1	49.651	0.	1.[illegible]	1.1163	0.	.[illegible]8244	48.28
36.	.[illegible]3323	12.32[illegible]	1[illegible].49	49.546	9.552	26.314	917.5	5[illegible].1[illegible]	0.	1.[illegible]	.9712	0.	.15736	113.67
48.	.[illegible]5537	13.[illegible]	134.3[illegible]	51.246	9.418	29.717	1179.1	5[illegible].448	0.	1.[illegible]	1.[illegible]581	0.	.23456	136.4[illegible]
60.	.[illegible]6315	22.5[illegible]9	165.93	49.784	9.475	37.329	1412.4	5[illegible].615	0.	1.[illegible]	.9982	0.	.25641	149.36
71.99	.[illegible]75[illegible]	25.555	197.16	49.457	9.025	32.[illegible]11	1625.[illegible]	5[illegible].218	0.	1.[illegible]	1.[illegible]369	0.	.275[illegible]7	161.14
83.99	.[illegible]81[illegible]4	27.755	217.41	49.597	9.46[illegible]	26.862	1815.5	5[illegible].[illegible]98	0.	1.[illegible]	.9588	0.	.28468	166.59
95.99	.[illegible]8646	27.657	237.56	51.[illegible]54	9.374	25.919	1989.2	5[illegible].2[illegible]7	0.	1.[illegible]	.9642	0.	.29495	172.21
107.99	.[illegible]9256	31.715	2[illegible]3.29	5[illegible].[illegible]70	9.623	3[illegible].171	2145.[illegible]	5[illegible].191	0.	1.[illegible]	1.[illegible]156	0.	.3[illegible]391	175.[illegible]9
119.99	.[illegible]9531	32.712	282.14	5[illegible].2[illegible]6	9.522	31.526	2257.1	5[illegible].10[illegible]	0.	1.[illegible]	1.[illegible]7[illegible]2	0.	.3[illegible]672	18[illegible].97
131.99	.11[illegible]16	34.[illegible]10	[illegible].31	49.621	9.601	29.869	2419.0	5[illegible].482	0.	1.[illegible]	.9712	0.	.31646	185.52
143.99	.1[illegible]430	35.[illegible]55	316.91	5[illegible].[illegible]96	[illegible].749	28.186	2[illegible]4[illegible].1	5[illegible].528	0.	1.[illegible]	.9216	0.	.323[illegible]5	189.64
155.99	.1[illegible]586	37.335	321.35	51.282	9.115	29.1[illegible]6	2[illegible]4[illegible].1	5[illegible].[illegible]19	0.	1.[illegible]	1.2111	0.	.33145	194.51
167.99	.12131	[illegible]1.375	322.32	51.914	[illegible].354	28.374	2744.7	5[illegible].520	0.	1.[illegible]	1.[illegible]759	0.	.34[illegible]	2[illegible]3.24
1[illegible]7[illegible].98	.1218[illegible]	41.358	334.61	49.9[illegible]5	[illegible].537	31.1[illegible]5	2857.3	5[illegible].829	0.	1.[illegible]	.9757	0.	.34895	2[illegible]4.59
1[illegible]1.98	.124[illegible]5	42.[illegible]34	344.47	51.1[illegible]3	[illegible].[illegible]9	28.5[illegible]7	29[illegible]1.[illegible]	5[illegible].525	0.	1.[illegible]	.9876	0.	.353[illegible]8	2[illegible]7.21
2[illegible].90	.12[illegible]	4[illegible].[illegible]	[illegible].86	49.325	8.[illegible]	29.375	2[illegible]2.4	5[illegible].139	0.	1.[illegible]	.9413	0.	.35576	2[illegible].78
21[illegible].98	.13[illegible]12	44.[illegible]50	36[illegible].5[illegible]	5[illegible].527	8.334	27.219	[illegible]9.3	5[illegible].[illegible]19	0.	1.[illegible]	.9531	0.	.3[illegible]72	211.79
[illegible]27.95	.13131	4[illegible].257	365.75	51.[illegible]47	[illegible].325	29.971	311[illegible].[illegible]	5[illegible].[illegible]76	0.	1.[illegible]	1.1119	0.	.36237	212.74
2[illegible].93	.1[illegible]439	4[illegible].311	371.[illegible]3	5[illegible].429	8.239	28.4[illegible]	3174.3	5[illegible].469	0.	1.[illegible]	.9[illegible]6	0.	.36059	215.2[illegible]
25[illegible].93	.135[illegible]5	4[illegible].341	377.52	51.243	8.334	31.2[illegible]5	3225.5	5[illegible].470	0.	1.[illegible]	1.[illegible]457	0.	.36666	216.[illegible]6
25[illegible].87	.13915	47.[illegible]52	382.69	49.853	8.355	31.[illegible]3	3271.[illegible]	5[illegible].329	0.	1.[illegible]	1.[illegible]571	0.	.37169	218.32
27[illegible].85	.13555	49.2[illegible]1	387.32	5[illegible].739	8.315	3[illegible].146	3313.9	5[illegible].524	0.	1.[illegible]	1.[illegible]5[illegible]9	0.	.37371	219.55
2[illegible]7.93	.14[illegible]55	4[illegible].535	392.31	49.761	8.4[illegible]	3[illegible].275	3351.[illegible]	5[illegible].57[illegible]	0.	1.[illegible]	.9841	0.	.37492	22[illegible].31
2[illegible].91	.14[illegible]1[illegible]	4[illegible].116	395.72	51.170	8.333	29.731	33[illegible].7	5[illegible].290	0.	1.[illegible]	1.[illegible]6[illegible]	0.	.377[illegible]6	221.52
[illegible]11.9	.145[illegible]2	5[illegible].[illegible]79	3[illegible].75	51.[illegible]39	8.240	3[illegible].185	341[illegible].1	5[illegible].553	0.	1.[illegible]	1.[illegible]751	0.	.38[illegible]52	223.76
3[illegible].93	.14387	[illegible].359	4[illegible].52	49.70[illegible]	8.390	3[illegible].723	3447.1	5[illegible].574	0.	1.[illegible]	.9548	0.	.38193	224.5[illegible]
335.86	.14[illegible]	[illegible].192	4[illegible]5.53	51.2[illegible]	8.415	2[illegible].824	3473.5	5[illegible].44[illegible]	0.	1.[illegible]	1.[illegible]419	0.	.38472	225.26
347.34	.14[illegible]	[illegible].376	4[illegible].19	49.[illegible]7[illegible]	8.414	2[illegible].67[illegible]	349[illegible].4	5[illegible].275	0.	1.[illegible]	.9932	0.	.38543	226.66
35[illegible].03	.14364	[illegible].758	41[illegible].54	51.[illegible]8	8.4[illegible]1	29.732	3516.1	5[illegible].327	0.	1.[illegible]	1.[illegible]312	0.	.38684	227.53
[illegible]71.91	.15[illegible]30	[illegible].711	412.79	49.550	8.4[illegible]6	29.753	35[illegible]7.1	5[illegible].[illegible]27	0.	1.[illegible]	.9879	0.	.38738	227.84

5 — DY = 20; RANGE = 3%; INPUT = STEP IMPULSE + NOISE;

TIME E+00	PITY E-03	IITY E+03	COST E+03	PRICE E+00	COM E+03	INCOM E+03	TINCOM E+03	PSTAF E+00	LANDA E+00	CUF E+00	INPUF E+00	ANFIN E+00	PSTAB E+00	ISTAB E+00
.0	.0	.0	.0	49.91[illegible]	[illegible]	29.946	.0	49.91[illegible]	0.	1.0000	1.0000	0.	.00000	.00
12.	2.139	.740	45.78	49.741	[illegible]	24.[illegible]	540.3	49.935	0.	[illegible]	.9736	0.	.04591	27.29
24.	6.733	2.33[illegible]	87.11	49.535	[illegible]	33.573	641.1	49.851	0.	[illegible]	1.1063	0.	.08242	49.27
36.	26.365	6.117	103.11	49.774	9.484	28.518	917.2	50.246	0.	[illegible]	.9712	0.	.10275	93.90
48.	35.372	11.498	127.71	50.950	9.20[illegible]	29.429	1175.3	50.351	0.	[illegible]	1.0581	0.	.18789	109.09
60.	46.737	15.878	159.19	50.[illegible]1	9.327	30.299	1479.4	50.592	0.	[illegible]	.9982	0.	.21619	125.01
71.99	52.49[illegible]	17.204	194.63	49.784	9.524	32.413	1623.9	50.369	0.	[illegible]	1.0359	0.	.22470	131.39
83.99	53.51[illegible]	18.322	217.39	49.677	9.543	28.438	1814.2	50.229	0.	[illegible]	.9588	0.	.23154	135.36
95.99	57.418	19.560	236.91	50.[illegible]	9.426	25.659	1989.7	50.271	0.	[illegible]	.9042	0.	.23962	140.23
107.99	51.337	23.319	262.72	50.772	9.371	29.666	2145.5	50.166	0.	[illegible]	1.0158	0.	.24706	144.63
119.99	62.334	21.453	281.33	50.213	9.556	31.527	2247.5	50.155	0.	[illegible]	1.0732	0.	.25027	145.49
131.99	65.358	22.994	298.47	49.837	9.553	29.892	2419.8	50.[illegible]3	0.	[illegible]	.9712	0.	.25610	149.98
143.99	67.352	23.240	315.91	49.936	9.775	27.687	2539.6	50.345	0.	[illegible]	.9216	0.	.26010	152.47
155.99	71.593	24.315	321.57	51.1[illegible]2	9.212	25.236	2640.6	50.[illegible]8	0.	[illegible]	1.2111	0.	.26758	156.86
167.93	73.150	25.339	326.94	51.106	8.336	28.[illegible]6	274[illegible]	50.469	0.	[illegible]	1.0759	0.	.27964	163.73
179.98	78.089	27.763	333.[illegible]8	50.192	8.[illegible]4	31.[illegible]2	2837.4	50.760	0.	[illegible]	.9767	0.	.28[illegible]7	164.51
191.98	83.[illegible]51	27.5[illegible]1	343.79	5[illegible].333	8.513	29.[illegible]41	292[illegible]	50.552	0.	[illegible]	.9876	0.	.29293	165.93
203.98	81.515	23.[illegible]8	352.93	49.598	8.675	29.354	2993.1	50.17[illegible]	0.	[illegible]	.9413	0.	.28551	167.36
215.98	83.441	23.69[illegible]	359.49	50.594	8.342	27.143	[illegible]	50.[illegible]18	0.	[illegible]	.9531	0.	.20380	169.38
227.95	84.227	23.992	364.44	50.[illegible]2	9.299	29.725	3118.7	50.[illegible]	0.	[illegible]	1.1119	0.	.29039	170.27
239.96	86.525	25.701	369.[illegible]	50.763	8.[illegible]4	28.117	3174.5	50.404	0.	[illegible]	.9506	0.	.29432	172.57
251.93	87.253	30.327	375.82	50.923	6.275	31.[illegible]27	3225.6	50.5[illegible]3	0.	[illegible]	1.0457	0.	.29545	173.28
263.37	84.243	30.301	381.15	49.874	8.[illegible]7	31.542	3271.2	50.377	0.	[illegible]	1.0571	0.	.29705	174.24
275.35	89.314	30.744	385.46	50.909	6.245	30.[illegible]92	3313.9	50.498	0.	[illegible]	1.0519	0.	.29865	175.34
287.35	85.633	30.953	390.71	49.99[illegible]	8.[illegible]	30.435	335[illegible]	50.563	0.	[illegible]	.9841	0.	.29981	175.93
299.91	91.[illegible]92	31.392	394.33	50.981	6.373	29.90[illegible]	338[illegible].9	50.347	0.	[illegible]	1.0668	0.	.30162	177.18
311.9	92.512	31.877	395.88	50.399	8.154	3[illegible].574	3418.2	50.471	0.	[illegible]	1.0751	0.	.30416	178.54
323.88	92.332	32.121	40[illegible].60	49.558	9.321	30.054	3447.2	50.538	0.	[illegible]	.9569	0.	.30489	178.94
335.36	93.731	32.426	40[illegible]	51.0[illegible]	8.[illegible]	30.[illegible]95	3473.7	50.531	0.	[illegible]	1.0418	0.	.30658	180.07
347.34	94.464	32.590	406.00	49.893	8.429	29.[illegible]9	3470.7	50.313	0.	[illegible]	.9932	0.	.30735	180.53
359.33	95.[illegible]0	32.799	408.91	50.[illegible]5	6.377	29.715	3518.3	50.279	0.	[illegible]	1.0312	0.	.30831	181.11
371.31	95.323	32.309	411.14	49.703	6.385	29.742	3537.3	50.311	0.	[illegible]	.9679	0.	.31071	181.35

6_ REFERENCE FOR 5 - SAFE, BUT WITHOUT MODULATION OF INTERVENTION

TIME E+00	PITY E+00	IITY E+06	COST E+00	PRICE E+00	COM E+00	INCOM E+03	TINCM E+03	PSTAR E+00	LANDA E+00	CUF E+00	INPUT E+00	ANFIN E+00	PSTAB E+00	ISTAR E+00
.0	.0	.0	0.	49.910	3600.0	29.946	.0	49.910	1.0000	1.0000	1.0000	0.	.0000	.00
12.	10.9	3.6	0.	47.521	3600.0	27.383	326.6	49.559	.9444	1.0000	.8568	0.	.2998	172.47
24.	70.1	21.6	0.	46.535	3600.0	28.763	597.1	48.413	.9125	1.0000	.8408	0.	.5392	299.47
36.	96.3	28.1	0.	44.517	3600.0	19.579	824.0	47.980	1.0000	1.0000	.6216	0.	.5166	278.79
48.	372.9	101.5	0.	43.894	3600.0	20.813	1011.7	46.426	.8493	1.0000	.5502	0.	.8805	459.43
60.	433.1	112.5	0.	43.603	3600.0	14.187	1150.0	44.774	1.0000	1.0000	.3993	0.	.8490	432.41
71.99	1125.3	175.6	0.	29.360	3600.0	15.976	1232.9	41.853	.5000	1.0000	.4977	0.	1.2494	493.49
83.99	2125.2	330.3	0.	56.114	3600.0	10.863	1350.2	42.614	1.0000	1.0000	.4602	0.	1.5898	626.77
95.99	2622.6	369.2	0.	38.513	3600.0	19.572	1432.7	45.669	.6958	1.0000	.5588	0.	1.6521	619.91
107.99	3320.8	623.6	0.	63.599	3600.0	31.044	1578.5	45.916	1.0000	1.0000	.9223	0.	1.7529	759.59
119.99	5978.8	860.3	0.	47.731	3600.0	28.556	1666.8	50.035	1.0000	1.0000	1.3345	0.	2.2314	844.45
131.99	6002.8	875.6	0.	49.421	3600.0	42.076	1836.8	53.503	.7899	1.0000	1.3630	0.	2.1319	814.21
143.99	6252.3	983.3	0.	55.700	3600.0	30.837	1989.6	53.948	1.0000	1.0000	1.4520	0.	2.0832	824.14
155.99	6394.9	1054.6	0.	57.858	3600.0	38.503	2129.3	53.972	1.0000	1.0000	2.0424	0.	2.0242	622.01
167.99	6533.6	1125.9	0.	56.040	3600.0	52.589	2265.0	55.251	1.0000	1.0000	2.6194	0.	1.9717	818.48
179.98	6709.6	1230.9	0.	55.865	3600.0	49.454	2401.4	56.225	.9977	1.0000	2.4311	0.	1.9304	824.79
191.98	6798.3	1293.6	0.	58.110	3600.0	45.659	2534.5	57.227	1.0000	1.0000	2.7558	0.	1.8814	820.70
203.98	6837.6	1320.5	0.	56.577	3600.0	51.480	2653.0	57.494	.9786	1.0000	2.7378	0.	1.8305	804.45
215.98	6904.8	1368.9	0.	58.807	3600.0	46.003	2767.4	57.822	1.0000	1.0000	3.0607	0.	1.7877	795.99
227.96	7025.6	1478.9	0.	66.096	3600.0	57.732	2879.8	58.801	1.0000	1.0000	4.4717	0.	1.7552	805.30
239.98	7260.4	1637.0	0.	60.411	3600.0	48.522	2978.8	60.126	.9910	1.0000	3.7769	0.	1.7391	825.81
251.98	7278.4	1653.3	0.	61.158	3600.0	57.121	3074.6	60.340	1.0000	1.0000	4.5899	0.	1.6993	809.91
263.97	7300.1	1671.5	0.	60.133	3600.0	62.531	3159.9	60.004	1.0000	1.0000	4.9937	0.	1.6628	795.65
275.95	7402.3	1764.1	0.	62.415	3600.0	59.215	3244.3	60.855	1.0000	1.0000	5.2417	0.	1.6376	799.43
287.93	7428.9	1788.3	0.	60.938	3600.0	60.624	3318.3	61.572	.9283	1.0000	4.8731	0.	1.6060	787.94
299.91	7471.2	1836.3	0.	67.476	3600.0	69.178	3391.4	61.819	1.0000	1.0000	6.0399	0.	1.5780	782.33
311.9	7790.7	2131.7	0.	66.247	3600.0	66.112	3459.1	63.744	1.0000	1.0000	6.4238	0.	1.5801	826.53
323.88	7867.2	2206.1	0.	60.329	3600.0	57.695	3518.9	65.338	.9591	1.0000	5.3785	0.	1.5582	825.12
335.86	8037.8	2385.1	0.	69.034	3600.0	65.266	3579.1	65.307	1.0000	1.0000	6.6496	0.	1.5466	842.50
347.84	8107.0	2442.4	0.	65.552	3600.0	67.116	3629.3	65.229	1.0000	1.0000	6.3255	0.	1.5763	837.73
359.83	8189.2	2530.4	0.	68.819	3600.0	68.692	3679.5	66.175	1.0000	1.0000	7.1067	0.	1.5082	838.34
371.81	8240.6	2580.9	0.	66.589	3600.0	68.334	3723.5	67.056	1.0000	1.0000	6.7958	0.	1.4883	832.92

WITH DESIRED LEVEL OF STOCK

Reference Run

TIME	PITY	IITY	COST	PRICE	COM	INCOM	TINCM	PSTAR	LANDA	CUF	INPUI	ANPIN	PSIAM	ISIAM
E+00	E+00	E+06	E+03	E+00	F+03	E+03	E+03	E+00	E+00	E+00	E+00	E+00	E+00	F+00
.0	.0	.0	.00	49.910	3.600	29.945	.0	49.910	1.0000	1.0000	1.0000	.00	.00000	.00
12.	2.0	.7	26.59	49.188	3.819	28.684	334.9	49.749	.9921	1.0000	.8568	.00	.12795	75.49
24.	11.3	3.7	74.19	48.540	4.556	30.836	672.1	49.277	.9833	1.0000	.8408	.00	.21630	123.54
36.	24.3	7.5	110.94	47.819	5.088	25.417	868.4	48.672	.9769	1.0000	.6216	.00	.25934	143.72
48.	53.7	15.4	166.89	47.103	6.202	23.403	1078.8	47.949	.9776	1.0000	.5502	.00	.33402	179.11
60.	100.5	26.5	233.25	45.856	7.761	21.692	1253.6	47.029	.9590	1.0000	.3993	.00	.40898	209.99
71.99	183.4	43.3	314.13	44.395	9.990	27.554	1395.6	45.836	.9425	1.0000	.4977	.00	.50433	245.07
83.99	234.9	52.1	340.62	44.495	10.130	17.402	1513.1	44.913	.9936	1.0000	.4602	.00	.52853	248.91
95.99	253.1	55.7	352.42	45.725	9.696	14.451	1615.8	44.666	1.0000	1.0000	.5588	.00	.51831	240.47
107.99	260.7	56.1	337.81	47.150	8.095	19.266	1713.0	45.277	1.0000	1.0000	.9223	.00	.49117	227.79
119.99	310.6	65.4	287.60	48.708	4.893	27.941	1815.1	46.765	1.0000	1.0000	1.3345	.00	.50858	233.43
131.99	445.2	98.9	221.60	50.394	1.090	27.108	1927.9	48.851	1.0000	1.0000	1.3630	.00	.58060	273.62
143.99	969.2	272.6	202.61	54.465	-.001	25.975	2058.7	51.879	1.0000	1.0000	1.4520	.72	.82018	435.01
155.99	1140.5	359.4	202.62	58.200	-.011	42.955	2197.8	54.029	1.0000	1.0000	2.0424	21.32	.85486	479.90
167.99	1367.0	479.7	202.65	56.288	-.008	51.552	2334.7	55.136	1.0000	1.0000	2.6194	35.66	.90188	534.28
179.98	1596.9	616.9	203.48	55.998	.053	46.749	2470.6	56.261	1.0000	1.0000	2.4311	53.32	.94174	585.34
191.98	1707.2	694.8	202.74	57.821	-.005	45.021	2603.2	57.293	1.0000	1.0000	2.7558	65.76	.94281	601.44
203.98	1761.5	732.5	204.31	57.084	.130	48.886	2722.4	57.548	.9897	1.0000	2.7378	68.84	.92910	599.15
215.98	1836.4	786.2	202.84	58.152	-.008	44.874	2835.8	57.849	1.0000	1.0000	3.0607	75.60	.92195	603.24
227.98	1953.9	894.5	202.87	66.218	-.007	58.412	2948.4	58.745	1.0000	1.0000	4.4717	84.15	.92562	624.39
239.98	2213.5	1071.6	208.45	59.578	.585	49.846	3047.3	60.172	.9895	1.0000	3.7769	.00	.96025	668.15
251.98	2225.0	1082.2	219.54	60.097	1.761	57.137	3144.1	60.616	.9983	1.0000	4.5899	.00	.93956	655.26
263.97	2230.7	1087.3	222.55	59.668	1.978	63.934	3210.6	60.129	.9977	1.0000	4.9937	.00	.91915	641.78
275.95	2249.0	1103.6	217.37	60.765	1.097	57.558	3311.2	60.072	1.0000	1.0000	5.2417	.00	.90263	632.36
287.93	2261.5	1114.7	216.52	60.140	.890	58.249	3384.3	60.461	.9991	1.0000	4.8731	.00	.88608	622.10
299.91	2275.1	1127.5	212.81	61.839	.172	59.443	3452.8	60.802	1.0000	1.0000	6.0399	105.03	.87080	613.03
311.9	2650.6	1484.4	211.74	66.864	-.016	63.248	3522.8	63.011	1.0000	1.0000	6.4238	122.09	.92167	689.73
323.88	2770.1	1596.2	213.83	64.320	.406	65.318	3583.9	65.195	.9830	1.0000	5.3785	138.94	.92461	701.97
335.86	2822.0	1650.4	215.36	66.344	.648	66.939	3642.2	65.731	1.0000	1.0000	6.6496	.00	.91642	700.82
347.84	2856.6	1684.7	215.59	65.671	.641	66.574	3694.0	65.552	1.0000	1.0000	6.3255	.00	.90598	695.74
359.83	2888.8	1718.1	213.46	66.617	.051	67.575	3742.4	65.852	1.0000	1.0000	7.1067	159.26	.89576	690.82
371.81	2955.2	1786.7	213.27	66.718	.000	67.026	3787.1	66.633	1.0000	1.0000	6.7958	163.01	.89128	693.03

WITH DESIRED LEVEL OF STOCK

Policy 1

TIME E+00	PITY E+00	IITY E+06	COST E+03	PRICE E+00	CCM E+00	INCOM E+03	TINCM E+03	PSTAR E+00	LANDA E+00	CUF E+00	INPUT E+00	ANFIN E+00	PSTAB E+00	ISTAR E+00
.0	.0	.0	.00	49.910	3600.0	29.946	.0	49.910	1.0000	1.0000	1.0000	.00	.0000	.00
12.	2.0	.7	26.47	49.164	3816.3	28.652	334.8	49.747	.9916	1.0000	.8568	.00	.1295	76.37
24.	12.9	4.2	72.47	48.351	4519.1	30.659	621.0	49.242	.9777	1.0000	.8408	.00	.2316	131.88
36.	29.1	-8.8	105.72	47.424	4967.1	24.953	865.0	48.569	.9650	1.0000	.6216	.00	.2839	156.34
48.	75.9	21.2	152.69	46.331	5853.5	22.442	1070.0	47.651	.9580	1.0000	.5502	.00	.3973	209.88
60.	178.6	43.0	199.95	43.603	6879.7	19.130	1231.4	46.242	.8986	1.0000	.3993	.00	.5452	267.55
71.99	471.9	90.4	246.69	40.563	8089.3	23.927	1348.8	43.901	.8219	1.0000	.4977	.00	.8091	354.18
83.99	556.2	102.3	231.58	43.036	6713.9	11.496	1439.1	42.500	1.0000	1.0000	.4602	.00	.8133	348.92
95.99	581.0	104.9	203.90	42.981	4822.7	20.698	1515.4	42.614	1.0000	1.0000	.5588	.00	.7776	330.48
107.99	584.7	105.6	154.01	46.336	1943.3	24.837	1596.1	43.538	1.0000	1.0000	.9223	.00	.7355	312.54
119.99	1639.9	279.2	115.73	59.174	15.1	20.425	1705.6	47.749	1.0000	1.0000	1.3345	-38.82	1.1686	482.20
131.99	2200.4	396.5	122.20	51.888	361.4	39.421	1837.1	52.384	.9931	1.0000	1.3630	-3.06	1.2908	547.92
143.99	2348.6	482.5	133.48	54.562	904.7	33.309	2000.4	53.984	1.0000	1.0000	1.4520	.00	1.2768	578.73
155.99	2466.9	540.3	127.17	55.663	430.8	39.782	2139.7	53.868	1.0000	1.0000	2.0424	26.36	1.2572	588.64
167.99	2649.6	634.9	121.47	56.316	54.8	51.739	2272.6	54.751	1.0000	1.0000	2.6194	46.28	1.2556	614.43
179.98	2868.1	761.8	121.79	55.973	81.0	46.610	2407.7	56.284	.9981	1.0000	2.4311	55.73	1.2621	650.45
191.98	2966.1	831.4	121.65	58.105	62.2	45.339	2540.8	57.337	1.0000	1.0000	2.7558	63.46	1.2427	657.93
203.98	3017.6	867.0	123.59	57.127	221.9	48.806	2660.1	57.576	.9964	1.0000	2.7378	68.90	1.2161	651.83
215.98	3079.2	911.0	122.06	58.877	70.1	45.061	2773.8	57.833	1.0000	1.0000	3.0607	75.68	1.1936	649.37
227.98	3192.0	1012.4	121.67	65.531	25.1	57.477	2885.2	58.702	1.0000	1.0000	4.4717	83.94	1.1831	666.27
239.98	3418.4	1169.3	127.22	59.584	614.6	49.742	2984.2	60.089	.9962	1.0000	3.7769	.00	1.1933	697.94
251.98	3433.6	1183.3	140.90	60.098	2074.5	57.240	3081.2	60.597	.9977	1.0000	4.5899	.00	1.1672	685.17
263.97	3439.2	1188.3	145.06	59.707	2408.7	64.030	3168.1	60.180	.9981	1.0000	4.9937	.00	1.1413	670.86
275.95	3459.2	1206.3	140.85	60.894	1619.0	57.793	3249.1	60.153	1.0000	1.0000	5.2417	.00	1.1195	661.05
287.93	3473.2	1218.7	140.67	60.147	1464.3	58.088	3322.2	60.549	.9994	1.0000	4.8731	.00	1.0981	650.46
299.91	3488.6	1233.4	137.81	62.497	837.7	60.990	3391.3	60.910	1.0000	1.0000	6.0399	.00	1.0783	641.17
311.9	3685.3	1431.0	133.28	67.701	17.2	66.263	3459.8	62.546	1.0000	1.0000	6.4238	118.95	1.0868	677.21
323.88	3875.1	1605.5	135.15	64.091	393.0	64.428	3520.4	64.701	.9928	1.0000	5.3785	135.70	1.0936	703.91
335.86	3936.3	1669.7	137.02	66.455	703.9	67.217	3578.9	65.685	1.0000	1.0000	6.6496	.00	1.0823	704.91
347.84	3973.0	1706.0	137.28	65.664	698.1	66.666	3630.7	65.689	1.0000	1.0000	6.3255	.00	1.0685	700.15
359.83	4020.3	1755.6	135.93	67.464	300.8	68.968	3679.6	65.984	1.0000	1.0000	7.1067	158.72	1.0567	698.32
371.81	4075.3	1812.2	135.62	66.712	198.0	68.036	3724.0	66.707	1.0000	1.0000	6.7958	164.40	1.0466	697.95

WITH DESIRED LEVEL OF STOCK

Policy 2

TIME	PITY	IITY	COST	PRICE	COM	INC	TINCM	PSTAR	LANDA	CUF	INPUT	ANFIN	PSTAR	ISTAR
F+00	E+00	E+06	E+03	E+00	F+00	E+03	E+03	E+00	E+00	E+00	F+00	E+00	E+00	F+00
.0	.0	.0	.00	49.910	3800.0	29.946	.0	49.910	1.0000	1.0000	1.0000	.00	.0000	.00
12.	2.1	.7	26.33	49.134	3813.3	28.611	334.6	49.745	.9910	1.0000	.8568	.00	.1313	77.39
24.	15.6	5.0	70.14	48.117	4469.6	30.487	619.5	49.192	.9692	1.0000	.8408	.00	.2545	144.35
36.	34.7	10.4	99.74	47.089	4830.0	24.561	861.3	48.455	.9560	1.0000	.6216	.00	.3098	169.69
48.	91.6	25.2	140.91	46.056	5570.4	21.923	1063.0	47.451	.9546	1.0000	.5502	.00	.4364	228.82
60.	203.9	48.1	181.56	43.347	6414.5	18.552	1220.0	45.970	.8986	1.0000	.3993	.00	.5825	282.91
71.99	483.3	91.2	223.98	40.541	7498.8	23.559	1334.8	43.694	.8343	1.0000	.4977	.00	.8188	355.66
83.99	558.5	101.4	206.48	43.066	6079.6	12.253	1424.0	42.443	1.0000	1.0000	.4602	.00	.8150	347.34
95.99	575.3	103.0	179.37	43.726	4279.4	10.937	1501.7	42.722	1.0000	1.0000	.5588	.00	.7738	327.38
107.99	582.0	104.0	132.61	46.944	1628.1	20.893	1584.8	43.855	1.0000	1.0000	.9223	.00	.7338	310.27
119.99	1481.2	244.1	104.92	53.867	274.2	25.425	1692.9	48.050	1.0000	1.0000	1.3345	-36.64	1.1106	450.87
131.99	1859.1	366.6	108.43	51.907	452.3	37.751	1835.2	52.362	.9938	1.0000	1.3630	-2.77	1.1864	526.83
143.99	2019.1	452.1	113.34	54.777	656.9	32.966	1992.5	53.840	1.0000	1.0000	1.4520	.00	1.1838	560.21
155.99	2171.3	527.7	110.51	56.746	423.4	38.858	2132.2	53.984	1.0000	1.0000	2.0424	27.98	1.1795	581.47
167.99	2351.0	619.9	108.65	56.058	274.4	52.407	2266.3	54.933	1.0000	1.0000	2.6194	47.04	1.1827	607.31
179.98	2549.4	738.9	108.31	55.974	241.7	46.411	2402.4	56.294	1.0000	1.0000	2.4311	55.37	1.1899	640.59
191.98	2647.2	807.8	108.25	58.115	214.3	45.276	2535.0	57.280	1.0000	1.0000	2.7558	63.81	1.1740	648.53
203.98	2697.5	842.7	110.64	57.118	392.9	48.868	2654.3	57.564	.9968	1.0000	2.7378	69.30	1.1498	642.63
215.98	2759.6	887.5	109.59	58.889	267.4	45.133	2768.1	57.844	1.0000	1.0000	3.0607	75.48	1.1302	640.91
227.98	2870.1	984.3	109.03	65.143	188.5	56.499	2879.2	58.700	1.0000	1.0009	4.4717	83.81	1.1218	654.97
239.98	3068.7	1122.1	113.42	59.500	645.1	49.496	2978.0	59.984	.9969	1.0000	3.7769	.00	1.1307	683.72
251.98	3082.4	1134.6	124.65	59.949	1827.7	56.880	3074.5	60.417	.9992	1.0000	4.5899	.00	1.1059	670.94
243.97	3088.9	1140.4	127.68	59.622	2040.9	64.109	3161.0	60.048	.9991	1.0000	4.9937	.00	1.0816	657.19
275.95	3123.8	1171.7	123.96	61.410	1358.9	58.411	3242.7	60.260	1.0000	1.0000	5.2417	.00	1.0638	651.51
287.93	3148.6	1193.7	125.02	60.430	1409.9	58.191	3316.5	60.899	.9986	1.0000	4.8731	.00	1.0455	643.77
299.91	3171.8	1216.7	123.45	63.937	1012.0	62.418	3386.7	61.309	1.0000	1.0000	6.0399	.00	1.0282	636.80
311.9	3358.5	1397.1	119.46	66.217	260.0	65.632	3454.1	62.816	1.0000	1.0000	6.4238	121.46	1.0375	669.13
323.88	3498.1	1531.3	120.98	64.109	552.5	64.335	3515.4	64.718	.9970	1.0000	5.3785	.00	1.0390	687.44
335.86	3561.5	1597.4	122.87	66.654	855.3	67.223	3573.9	65.614	1.0000	1.0000	6.6496	.00	1.0295	689.48
347.84	3597.2	1632.3	123.19	65.648	850.4	66.750	3625.6	65.663	1.0000	1.0000	6.3255	.00	1.0167	684.84
359.83	3654.4	1692.4	122.37	67.754	568.3	68.753	3674.8	66.076	1.0000	1.0000	7.1067	.00	1.0075	685.64
371.81	3708.3	1747.5	122.36	66.647	516.6	67.992	3719.1	66.823	1.0000	1.0000	6.7958	164.96	.9984	685.38

WITH DESIRED LEVEL OF STOCK

Policy 3