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The Economics of the International Stockholding of Wheat

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CONTENTS

TABLES

ILLUSTRATIONS

FOREWORD

In low-income countries the bulk of adjustment to fluctuation in food supplies is made by the poor. The direct price and indirect employment effects of a 10 percent decline in foodgrain supplies reduce foodgrain expenditure by as much as 40 percent in real terms for the lowest 10 percent of the income distribution. In contrast, with the same decline in production the reduction in foodgrain expenditures is only 1 percent in real terms for the top 5 percent of the income distribution. And yet it is the poor who are least able to withstand such privation. The poor spend such a high proportion of their income on food that price increases induced by shortages greatly reduce their capacity to buy foodgrains, whereas the more well-to-do compensate by spending less on other goods and services, thereby further decreasing the income of the poor through reduced employment. Because the food intake of the poor is already so close to the minimum level, supply shortages result in increased malnutrition.

Thus one of the most important actions that can be taken to improve conditions for the poor is to reduce fluctuation in food prices and supplies. IFPRI research has examined various aspects of this problem. IFPRI Research Report 14 notes the deleterious effect on low-income countries of developed countries' efforts to stabilize their food supplies. A forthcoming IFPRI research report will examine trends and fluctuations in the Soviet Union's grain imports. Other IFPRI research compares the burden developing countries face in finding exchange resources to compensate for supply shortfalls deriving from fluctuation in domestic production and that arising from fluctuations in international prices. Fluctuations in world prices of foodgrain imports placed a substantial foreign exchange burden on only a small number of developing countries in the 1965-76 period, whereas the burden on foreign exchange resources stemming from fluctuations in domestic production was heavy for many more countries.

Dan Morrow's research examines in detail the rationale underlying stockholding decisions for wheat, the most important foodgrain from the point of view of international stocks and trade. The report provides not only an understanding of the past behavior of world wheat stockholding but also a basis for anticipating the near future. The following points are of particular importance.

First, there is likely to be substantial stockholding in the world wheat economy even in the absence of new international policies. Although there is certainly room for improvement through measures such as information sharing, limits on export controls, or increased responsiveness of developed-country consumption to world supply fluctuations, the outlook for stockholding is not pessimistic.

Second, commercial stockholding will adjust to changes in the world wheat economy. Thus, if the poor were not so readily squeezed from the market, their increased demand would give rise to increased world price fluctuations and, simultaneously, increased stockholding. Thus, the underlying culprit in the fluctuations in consumption by the poor is more their poverty than the failings of the market per se.

Third, an international program to increase public stocks would at least partly substitute for stocks that would have been held anyway. Although Morrow discusses how to minimize the effect, this suggests that an international stockholding agreement may be an inefficient way to provide greater food security for low-income countries. It should be kept in mind that, as inefficient as they may be, national and international stocks are preferable to no program at all.

The research further substantiates the conclusions drawn from other IFPRI research and reflected in the policy position of the World Food Council of the efficacy of a program to help low-income countries finance food imports in times of domestic supply shortfall. These findings give special relevance to IFPRI's continuing analysis of the scope and workings of an international financial facility to help low-income countries meet large upward fluctuations in their foreign exchange requirements for food

imports; as well as to IFPRI's large program of research on public policies to assist low-income people to increase their food consumption. The combination of strong domestic programs with strong international programs can do much to protect the poor from the privations incident to fluctuation in weather and prices.

John W. Mellor

Washington, D.C.
September 1980

SUMMARY

In low-income countries fluctuations in food supplies impose severe hardships on the poor. Especially since the world food crisis of the early 1970s, considerable attention has been given to various means of using reserve stocks to improve the food security of developing countries. One result of this concern was an attempt to negotiate a new Wheat Trade Convention based on a system of reserve stocks designed to reduce world price variability. After almost two years of meetings conducted jointly by the International Wheat Council and the United Nations Conference on Trade and Development (UNCTAD), these negotiations ended without agreement.

This report seeks to assess the rationale for an international agreement to increase wheat stockholding. To do so, it attempts to explain the behavior of stockholding in the world wheat economy since 1960, to predict that behavior for the near future, and to consider possible benefits from an international agreement to increase stockholding above the predicted level.

As the foundation for this effort, the report first presents the theory of economically optimal stockholding in a market economy without substantial government intervention and surveys the ways in which government policies may induce departures from that pattern of stockholding. Existing literature shows that in an efficient market economy, an economically optimal level of carryover stocks (ending stocks in excess of minimum working stocks) is primarily a function of total supply (production plus stocks carried over from the previous year) in each year. Specifically, no carryover stocks should be held when total supply is approximately equal to trend-level production, and carryover stocks should increase at a rate of 0.6 to 0.8 tons for each ton increase in total supply. In a market economy, this "optimal storage rule" maximizes financial profits from stockholding and would thus be followed by private speculators. Theory also suggests that carryover stocks should be concentrated among exporting countries because their carrying costs are usually lower, but the efficient distribution of carryover stocks among countries will shift continuously depending on production fluctuations and other factors.

However, various government policies can significantly alter the level, location, and welfare consequences of stockholding. A government can directly influence the level of stockholding by subsidizing private stockholding or by operating a public buffer stock. If the acquisition and release prices for a buffer stock are approximately centered around the long-run average price, then it is likely to bring about a net increase in total stockholding only if the price band is rather wide. If the price band is centered above the long-run average price, it will lead to larger total stockholding than would otherwise occur but will involve substantial financial losses. Government trade policies can also have a significant effect on stockholding. Insulation of national prices from world price movements discourages private speculative stockholding within those national markets. The possibility of export controls provides an incentive for stockholding by importers. Those countries that successfully use trade policies to insulate their economies from the world market are relatively indifferent to the price variability in that market. If world price variability induces countries to pursue more protectionist policies, exporting countries would have an interest in increased stockholding to encourage importers to rely more on the world market. In these and other ways, government policies could theoretically bring about departures from the pattern of stockholding that would be expected in a market economy.

By relating this body of theory to observed behavior of stockholding since 1960, the actual pattern of stockholding can be adequately understood as policy-induced departures from the pattern that would be financially profitable in a unified world market. In the 1960s world carryover stocks were well above the level that would be financially profitable because of the cooperative policies of the major exporters to support producer incomes through stockholding, com-

plemented by substantial Soviet stockholding in the mid-1960s. Beginning in 1970/71, the pattern of stockholding shifted as the major exporters relied more on production controls and direct payments to support producer income, as the Soviet Union expanded its livestock sector and relied more on the world market to offset its production shortfalls, and as importers sought to hold stocks due to fears of export controls. As a result, stockholding in the early 1970s was above profitable levels only when supplies were short. Although stock levels increased markedly during the period 1976/77-1978/79, the factors underlying this increase do not indicate a return to the pattern of the 1960s. Instead, for the near future it is predicted that world carryover stocks will be slightly above financially profitable levels in periods of large supply and appreciably above such levels in periods of short supply, although there could be substantial deviations from this pattern as the result of poor information or incorrect expectations about stockholding policies.

The expected financial losses from stockholding above the predicted level might be justified if such stockholding benefited developing countries or if it helped prevent deleterious effects on the evolution of national policies. However, the work of some economists suggests that reduced world price variability would be of substantial value to only a small subset of developing countries. For this limited group, fluctuation in world price rather than fluctuation in domestic production is a major cause of variability in their food import costs and this variability is large relative to their overall capacity to finance imports. Because access to supplies would be fairly well assured by the predicted level of stockholding, it seems that a mechanism to provide financial assistance would be a more efficient means of helping developing countries achieve food security than increased stockholding. Furthermore, although it is plausible that a high degree of price variability in the world market has a harmful effect on the long-run development of national policies by encouraging increased protectionism, by inducing greater insulation of national markets, and by discouraging policies among developing countries to increase consumption among their poorest people, there is no strong empirical evidence for this. Thus it is difficult to construct a compelling case for an agreement to increase world carryover stocks above the predicted level.

However, if an international stockholding agreement is again considered, it should be designed to bring about only a modest increase in stockholding above the level predicted because the benefits are probably limited. It should supplement rather than substitute for stockholding that would take place anyway. A buffer stock with a wide price band and a rather large capacity would be the most feasible way to accomplish this. (The buffer stock needs to be large to offset the inevitable replacement of some stocks that would have been held anyway.) In addition, an agreement should include provisions to ensure consultations about national policies, require exchange of data, restrain policies to insulate domestic markets, and limit the use of production and export controls.

Considering the difficulties of obtaining such an agreement and its limited benefits, international policies to improve food security should give priority to helping developing countries finance needed imports and manage their national working stocks efficiently.

2

THEORY OF STOCKHOLDING IN AN UNRESTRICTED MARKET AND WITH GOVERNMENT INTERVENTIONS

Stockholding of wheat requires the postponement of consumption and the expenditure of resources for storage facilities. An investment in stockholding should be based on the expectation that wheat will be more valuable in a future period. But in any given period how much wheat should be held for future consumption? What constitutes an economically efficient pattern of stockholding in a market economy without substantial government intervention? In answer, a number of economists have developed optimal storage rules derived from simple theoretical models.[1]

Stockholding in a Closed Economy

In a closed (nontrading) economy, the allocation of available supplies between the current period and the next period is optimal when the difference between the current price and the *expected* price for the next period is no greater than the cost of holding a unit of stock for one period (the marginal storage cost plus the interest cost). This is an intertemporal price equilibrium.[2]

Assuming that the demand curve, probability distribution of future harvests, marginal storage costs, and interest rates can be estimated, the carryover stock that is expected to achieve this price equilibrium can be calculated. For given values of these parameters, the optimal carryover stock in any period is a function of the total supply (production of the current year plus stocks carried over from the previous year). This functional relationship is an optimal storage rule. If the rule is followed, expected marginal benefits from stockholding will just equal the expected marginal costs.

An optimal storage rule applies only to carryover stocks, which are those stocks remaining at the end of a crop year minus minimum working stocks—stocks held to tide consumers over the brief period between the end of the statistical crop year and the time when the new crop is actually available for consumption, as well as stocks held for protection against risks associated with the transport and marketing system (such as transport delays) rather than in anticipation of price fluctuations. In theory minimum working stocks are those that would still be held even if the expected difference between next period's and this period's price is less than carrying costs. In this analysis it will be assumed that the minimum level is constant, or, if market volume grows, it is a constant percentage of market volume.

Figure 1 illustrates an optimal storage rule. When total supply is approximately equal to mean production, no carryover stock will be held; that is, ending stocks will equal minimum working stocks. At higher levels of total supply, the optimal carryover stock increases or decreases at a rather smooth rate as total supply increases or decreases. For parameters reasonably associated with a grain economy, this curve is approximately linear and for each ton change in total supply, the optimal carryover stock changes by 0.6 to 0.8 tons.

For the world wheat economy, Bruce

[1]For a detailed explanation of the use of dynamic programing to derive optimal storage rules for grain, see Robert L. Gustafson, *Carryover Stocks for Grains*, Technical Bulletin No. 1178 (Washington, D.C.: U.S. Department of Agriculture, October 1958); Karl Fox, Jati Sengupta, and Erik Thorbecke, *The Theory of Quantitative Economic Policy* (Amsterdam: North-Holland, 1973), Yagil Danin, Daniel Sumner, and D. Gale Johnson, "Determination of Optimal Grain Carryover," Paper No. 74:12, University of Chicago, Office of Agricultural Economic Research, Chicago, Ill., March 1976; and especially Bruce M. Gardner, *Optimal Stockpiling of Grain* (Lexington, Mass.: Lexington Books, 1979).

[2]On the theory of intertemporal price equilibrium, see Takashi Takayama and George Judge, "An Intertemporal Price Equilibrium Model," *Journal of Farm Economics* 46 (May 1964); and Paul A. Samuelson "Intertemporal Price Equilibrium: A Prologue to the Theory of Speculation," in *Collected Scientific Papers*, ed. Joseph Stiglitz (Cambridge, Mass.: MIT Press, 1966); pp. 946-984.

Figure 1—Key properties of an optimal storage rule

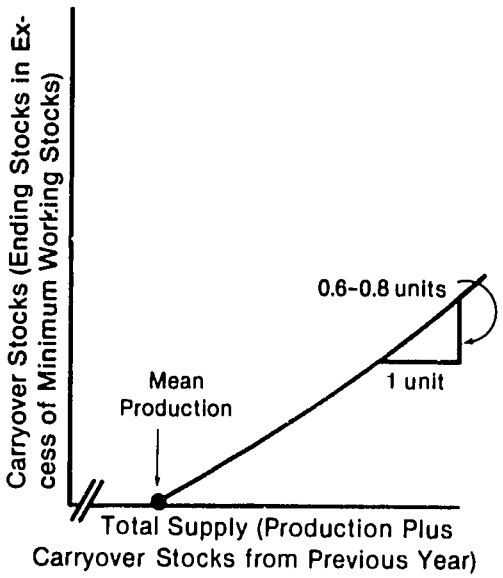
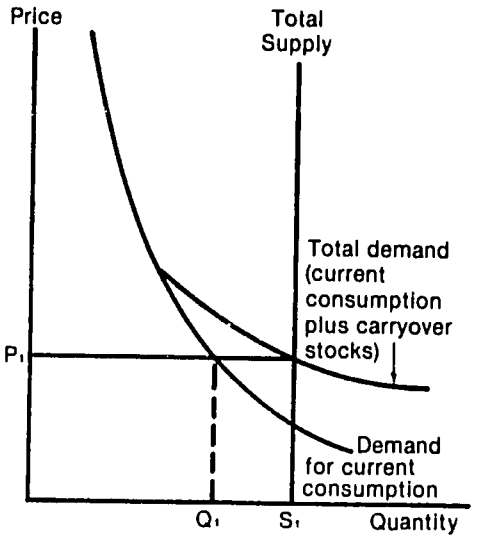


Figure 2—Simultaneous determination of price and carryover stocks



Gardner has estimated an optimal storage rule as if the world were a unified market economy.[3] His results will be used in Chapter 3 as a reference against which to measure the actual behavior of stockholding in the world wheat economy.

An optimal storage rule involves the simultaneous determination of carryover stocks and price as illustrated in Figure 2. In this figure the demand for carryover stocks as a function of total supply is added to the demand for current consumption. At price P_1 the total supply S_1 is rationed between the demand for current consumption and the demand for carryover stocks. In this way, a given probability distribution of production is uniquely associated through the optimal storage rule with a certain degree of price variability. If the storage rule shifts upward, indicating larger stocks for a given level of total supply, price variability is reduced. Under an optimal storage rule, prices will vary from year to year but will vary less than if no stocks were held. The resulting degree of price variability maximizes welfare.

In a market economy private speculators will collectively follow the optimal storage rule because this maximizes their expected financial profits.[4] Of course, if efficient markets do not exist, stockholding may be larger or smaller than is profitable. And if there are nonfinancial benefits from stockholding, the socially optimal level may be higher than that which is financially profitable. For wheat, an important reason the private market outcome may differ from the socially desired outcome is that extremely poor people do not have sufficient income to create an effective demand in the market. Because high prices lead to severe malnutrition or starvation among poor populations dependent on wheat, and because income transfers are often not feasible, society may wish to achieve greater price stability than the private market would generate. This may justify government intervention in stockholding.

[3]For his dynamic programming model, Gardner assumes the following key parameters: constant price elasticity of demand of -0.13; standard deviation of yields of 4.8 percent of trend; storage costs of $7.35 per ton and a real interest rate of 3 percent. See Gardner, *Optimal Stockpiling*, pp. 94-100.

[4]For proofs see Gustafson, *Carryover Stocks*.

Optimal Stockholding in a Multicountry Economy

The theory of optimal stockholding in a nontrading economy is useful if the world is viewed as a whole. But in a multicountry setting it is also important to consider which countries should hold stocks, how one country's stockholding affects another's, and whether or not coordination of stockholding decisions is necessary. In this discussion it is assumed that efficient markets exist within each country and that unrestricted trade occurs among countries.

Optimal stockholding in a multicountry economy is expected to achieve a price equilibrium not only from year to year but from country to country.[5] Differences between expected price and current price in each country will not exceed carrying costs, and differences between prices in different countries will not exceed transport costs. When this equilibrium prevails, the collective welfare of all—as measured by the sum of expected consumer and producer surplus minus carrying costs and transport costs—will be at a maximum.

Several general observations can be made about an optimal pattern of stockholding. First, as a general rule, carryover stocks are held in countries that have lower carrying costs, which are probably exporting countries because they enjoy lower prices and hence lower interest costs. Rather than holding stocks in addition to minimum working stocks, importing countries rely on opportunities to trade as the means to reduce price fluctuation. In the absence of barriers to trade, those countries that do not hold carryover stocks will nonetheless experience the same degree of price variability as those that do because in each period the prices among countries will differ only by transport costs. In the event of a poor domestic harvest, a country can rely at least partially on the prospect of imports from (or reduced exports to) other countries rather than its own stocks to stabilize domestic consumption and price. Thus, trade allows risk pooling. If trade were entirely prohibited so that each country had to rely on its own stocks, the total stocks for the world as a whole would be higher than otherwise.[6]

Second, if one country fails to realize expected profitable opportunities for stockholding, other countries will take up the opportunities provided that all stockholders have full information about the activities of others. That is, unlike minimum working stocks, carryover stocks in one country substitute for carryover stocks held in another.

Third, the efficient distribution of carryover stocks among countries is a continuously shifting, complex pattern requiring detailed information on production, demand, and relative costs of transport and storage. Because production fluctuates in each country from year to year, the distribution of carryover stocks among countries should change continuously. For example, if world total supply decreases because of a poor harvest in an importing country, the corresponding decrease in world carryover stocks should come disproportionately from the exporting country that can meet the additional import demand at the lowest transportation cost. Or, if world total supply increases due to an excellent harvest in an exporting country, the corresponding increase in world carryover stocks should occur disproportionately in that country. If the world total supply increases due to equally good harvests in all countries, the increase in carryover stocks should come disproportionately from those countries that face the lowest marginal costs for storage in that year. Therefore, to achieve the greatest benefit, distribution of carryover stocks must vary from year to year depending on the distribution of production fluctuations among countries, the distribution of carryover stocks in

[5] See Takashi Takayama and George Judge, *Spatial and Temporal Price and Allocation Models* (Amsterdam: North-Holland, 1971). They propose solution algorithms for relatively simple models of optimal temporal and spatial allocation, but these models do not allow for random fluctuations in future production. For an application of such a model to the world wheat market, see Chan Liu, "Optimal Temporal and Spatial Pricing and Allocation of Wheat in the International Market," (Ph.D. dissertation, University of Illinois, 1975). Gustafson shows that a model to derive an optimal storage rule for many countries given random production quickly becomes too large and expensive to solve (Gustafson, *Carryover Stocks*).

[6] Conversely, if poor harvests in one country are likely to be offset by good harvests elsewhere, the optimal stock level for the world as a whole will be less than the sum of optimal levels for isolated country markets. See Danin, Sumner, and Johnson, *Optimal Grain Carryover*.

the previous year, and the availability of transport and storage facilities.

Finally, to achieve an optimal level of stockholding for the world as a whole and an efficient distribution of those stocks among countries, it is necessary that stockholders have current information or at least correct expectations about the stockholding behavior of others. If stockholding decisions must be made without information about the stockholding undertaken by others, it is likely that the aggregate level of stockholding will be inefficient.

Distribution of Gains and Losses

Under the concept of optimal stockholding in a market economy, the sum of expected consumer and producer surplus (minus carrying costs) will be at a maximum. If for some reason the level of stock deviates from this optimal level, producers will gain and consumers lose or vice versa, depending on the parameters of the particular market. Thus, in microeconomic theory the interests of consumers and producers are divergent with respect to stockholding to reduce price variability. Similarly, in theory the interests of exporting and importing countries as a whole are divergent, but which countries actually gain and which lose depends on the parameters of the market.[7]

Government Interventions

This theory of optimal stockholding could be used to predict the pattern of stockholding that would be pursued by private firms (or profit-maximizing government agencies) in an efficient market without substantial government interventions. But virtually all governments exercise extensive controls over their wheat economies, and government policies can result in substantial departures from the pattern of stockholding predicted for a market economy.

Government Stockholding Policies

Policies to influence the level of stockholding vary according to what the government wishes to accomplish and the means used for reaching that end.

Subsidy to Private Stockholding. Assuming a market exists in which some private speculative stockholding is undertaken, a government can seek to increase the level of stockholding and to reduce price variability by providing a subsidy to private stockholding. By lowering the unit cost of carrying stock, such a policy would increase the level of stock that is expected to be financially profitable and thus shift the stock/supply relationship (the storage rule) upward.[8] The magnitude of the shift would depend on the size of the subsidy.

Stockholding to Maximize Profits. On the other hand, if a government agency buys and sells stocks and attempts to maximize its financial profits, it behaves like any private speculator in the market. Thus, stocks held by the private market would be reduced by one ton for each ton acquired by the agency. Because of this one-for-one displacement of private stocks by government stocks, there would be no net increase in stockholding unless the government agency were to stock more than is financially profitable and thus completely take over stockholding activity.

Using Buffer Stocks to Reduce Price Fluctuations. In an attempt to reduce price variability, a government can operate a stockholding program according to a price band or buffer stock rule. For example, a government agency acquires stocks only at a specified low price and holds these stocks for sale only at a specified higher price. A buffer stock rule is thus not an optimal storage rule and necessarily involves expected financial losses to the government.

As shown by Gardner, when a buffer stock is operated in the presence of private speculative stockholding and with a price

[7] There is substantial literature on the distribution of benefits from price stabilization. For a recent summary see Stephen Turnovsky, "The Distribution of Welfare Gains from Price Stabilization: A Survey of Some Theoretical Issues," in *Stabilizing World Commodity Markets*, ed. Gerald F. Adams and Sonia Klein (Lexington, Mass.: Lexington Books, 1977).

[8] For estimates of the impact of a storage subsidy on the optimal storage rule in the U.S. wheat market, see Emmett B. Keeler, "A Model for Evaluating Grain Reserve Policies," a paper prepared for the RAND Corporation, March 1976; and Gardner, *Optimal Stockpiling*, pp. 147-148.

band centered around the average expected price, the net impact of the buffer stock on total carryover stocks depends primarily on the width of the price band. If the difference between the acquisition and release price is narrow and the capacity of the buffer stock is large, the buffer stock would substantially reduce the opportunity for profitable stockholding and would thus largely replace private speculative stockholding. Because of this substitution of buffer stocks for private stocks, the net increase in stockholding and the reduction in price variability would be quite small. As the price band widens, the buffer stock increasingly supplements private stockholding, and price variability is reduced. However, if the price band becomes too wide, the probability of acquiring or releasing any buffer stock falls and the impact of the buffer stock on price variability declines.

Using Buffer Stocks to Increase Price. If a government wishes to increase prices paid to producers, it can operate a buffer stock with a price band centered above the long-run average price. Under such a rule the average quantity of stock acquired would be large, and expected financial losses would be substantial. If the width of the price band is narrowed to cut these losses by increasing the frequency of sale, private speculative stockholding would be virtually eliminated because the quantity of stock relative to total supply would be larger than would be profitable. This method of increasing price is only effective in the short run because eventually the stocks will be released and the price will fall.

In the longer run, a government must rely on other instruments to increase producer incomes, such as measures to restrict production, direct income payments to farmers, and/or export subsidies that allow producers to receive the higher price prevailing in the domestic market while inducing larger sales to the world market. The rationale for stockholding as an instrument to support producer prices and incomes must rest on the limitations (political, administrative, and budgetary) of these other policy instruments in the short run.

If the government of a major exporting country increases the average world price of wheat through stockholding, its action benefits other exporters. By threatening to shift from stockholding to direct payments or export subsidies to protect its own farmers without benefiting others, that exporting country may induce the other exporters to cooperate in stockholding to raise prices.

Trade Policies

Policies that impose temporary or permanent barriers to trade have important effects on the quantity, location, and welfare consequences of stockholding.

If by erecting trade barriers a country insulates its domestic price from the world price, private firms within that national market cannot speculate freely against price movements in the world market. If domestic prices are held almost completely stable, the incentive for private speculative stockholding within a country is entirely eliminated. Even if a government intervenes only sporadically so that domestic prices fluctuate less than the world price, private speculation is discouraged. If such insulation of national markets were pervasive, stockholding for the world as a whole would be reduced below profitable levels.

On the other hand, the possibility that export limitations may be imposed in times of short supply encourages importers to increase their own stockholding to ensure that they will be able to stabilize their own consumption. This could lead to more stockholding for the world as a whole than would otherwise be rational economically, especially when export controls appear more likely.

Insulation of domestic markets from world price fluctuations can also affect evaluation of the benefits of stockholding.[9]

[9]There is a growing body of literature on this issue. See Richard Just et al., "The Distribution of Welfare Gains from International Price Stabilization Under Distortions," *American Journal of Agricultural Economics* 59 (November 1977): 652-661; Timothy Josling, *Developed-Country Agricultural Policies and Developing-Country Food Supplies: The Case of Wheat*, Research Report 14 (Washington, D.C.: International Food Policy Research Institute, 1980); S. Y. Shei and R. L. Thompson, "The Impact of Trade Restrictions on Price Stability in the World Wheat Market," *American Journal of Agricultural Economics* 59 (November 1977): 628-638; T.J. Grennes, P.R. Johnson, and Marie Thursby, "Insulating Trade Policy Inventories and Grain Price Stability," *American Journal of Agricultural Economics* 60 (February 1978): 132-134; and A.C. Zwart and K.D. Meilke, "The Influence of Domestic Pricing Policies and Buffer Stocks on Price Stability in the World Wheat Industry," *American Journal of Agricultural Economics* 61 (August 1979): 434-447.

Insulated countries with adequate foreign exchange resources may be relatively indifferent to world price fluctuations because these fluctuations are not felt by producers and consumers but are absorbed by the government through fluctuations in its foreign exchange and other accounts. On the other hand, the burden of adjusting consumption to variability in world supply is thereby increased among those countries that do not or cannot insulate themselves.

As more and more countries attempt to protect their domestic markets, the world wheat market becomes more inelastic. Very large price increases can occur in response to even modest decreases in total supply because no country wants to absorb any of that decrease and will expend foreign exchange to avoid it until the foreign exchange transfers required become prohibitive. Of course, for a country to depend on its financial capacity to protect itself, it must have access to exports. If exporting countries employ nonprice rationing to protect their own consumers, even countries with adequate financial resources may not be able to buy sufficient supplies. For this reason all importing countries, even those that are insulated, theoretically benefit from stockholding that limits the probability of export controls.

If high world prices spark fears of export controls, importers may buy for the purpose of holding stocks against even tighter future markets, driving prices higher and increasing the likelihood that exporting countries will in fact apply export controls to protect their own consumers. Importers clearly lose from this self-aggravating, panic-market situation as prices are driven well above the levels necessary to ration the limited supply. Exporters reap windfall gains. But these gains in the short run will be eroded in the long run if a breakdown in a reliable world trade system brings about policies in importing countries to further increase self-sufficiency, thus lessening the long-run demand for exporters' wheat. Therefore, it may be argued that exporters and importers both have an interest in avoiding a panic market. Taking into account the value of carryover stocks in reducing price variability that could lead to a breakdown in the open world trading system, an argument exists for holding more stocks than would be financially profitable.

Several other points should be considered in connection with government policies. First, if the stockholding policies of a major country suddenly and unexpectedly change, both private firms and other governments may grossly miscalculate the level of stocks they desire to hold. Second, if governments fail to collect or make public data—especially on production and stocks—it can lead to inefficient stockholding decisions for the world as a whole.

3

STOCKHOLDING BEHAVIOR IN THE WORLD WHEAT ECONOMY

This chapter examines the observed patterns of stockholding in the world wheat economy since 1960. It shows that departures from the pattern of financially profitable stockholding for a hypothetical unified world market as estimated by Gardner can be adequately explained by government policies. Basic data on world ending stocks, production, and total supply are presented in Table 1, on world prices in Table 2, and on ending stocks by major countries or regions in Table 3.[10]

To compare the actual stockholding pattern to that estimated by Gardner, it is necessary, first, to calculate world ending stocks and total supply in each year as a percentage of trend-level production because this is the trend-free way in which the optimal storage rule is expressed and, second, to estimate the minimum working stock level for the world as a whole because the optimal storage rule applies only to carryover stocks. The necessary calculations are presented in the Appendix. To make them easier to compare with the current world wheat economy, results are presented not as percentages of trend production in that year but in 1978/79 trend equivalents.

The observed relationship between ending stocks and total supply, together with the financially profitable relationship for a unified world market as estimated by Gardner, are presented in Figure 3.[11] The stocks/supply relationship for the decade of the 1960s, with the exception of 1965/66, is noticeably different from that for the first half of the 1970s. Fitting linear regression lines to these periods separately, the following results are obtained:

for 1960/61-1969/70,

$$\underset{(69.2)}{\text{WOET} = -263.9} + \underset{(0.128)}{0.703}\ \text{WOST},$$

$$R^2 = 0.791, \qquad (3.1)$$

and for 1970/71-1975/76,

$$\underset{(56.7)}{\text{WOET} = -96.8} + \underset{(0.112)}{0.350}\ \text{WOST},$$

$$R^2 = 0.709, \qquad (3.2)$$

where WOET stands for world ending stocks (trend adjusted) in million metric tons, and WOST stands for world total supply (trend adjusted) in million metric tons, and standard errors are shown in parentheses.[12]

[10]The quality of the data on ending stocks, especially for earlier years of the series, is probably rather poor. The U.S. Department of Agriculture data does not include all stocks for the Soviet Union or China but only year-to-year changes in Soviet stocks relative to an arbitrary base; and these world ending stock figures do not represent actual world stock levels at a single point in time but are the summation of stock levels at the end of individual country crop years. These features of the data, however, do not invalidate the interpretations presented. Even if the base level at a point in time is not adequately estimated, the marginal rate of increase in ending stocks is approximately correct assuming that the year-to-year changes in Chinese stocks are not significant, given the relative isolation of China from the rest of the world wheat market for most of this period. Furthermore, these ending stock figures can be compared to minimum working stock estimates based on the same time series because both exclude the actual base level of Soviet and Chinese stocks and exclude the difference between a single point in the calendar year and the sum of ending stocks for different crop years. The latter is a relatively stable proportion of annual utilization.

[11]Because Gardner's estimate is based on the hypothetical concept of a unified world market, his approximation of financially profitable levels of stockholding in the actual world wheat economy is highly theoretical. This interpretation of Gardner's estimated stock/supply relationship is plausible, however, because observed departures from Gardner's estimated relationship move in the directions one would expect the policies of major countries to induce. The relationship estimated by Gardner would shift somewhat if different assumptions about the parameters of the world market or the level of minimum working stocks were used. But the qualitative relationship between the three lines shown in Figure 3 would not change for most alternative assumptions.

[12]Other combinations of years or other functional forms do not provide better statistical results than those shown here. There is a statistically significant difference in the relationship between these two periods.

Table 1—World production, ending stocks, and total supply of wheat from 1960/61 to 1978/79

Year	World Production	World Ending Stocks	World Total Supply[a]	Ending Stocks as Share of Total Supply
		(million metric tons)		(percent)
1960/61	239.4	77.4	313.6	24.7
1961/62	226.4	65.5	303.7	28.9
1962/63	255.3	70.0	320.8	24.0
1963/64	237.4	63.8	307.4	20.8
1964/65	274.5	74.6	338.2	21.9
1965/66	264.1	56.4	338.7	16.7
1966/67	309.0	83.3	354.4	23.5
1967/68	297.0	89.5	380.3	23.5
1968/69	328.3	113.5	417.8	27.2
1969/70	309.7	96.5	423.2	22.8
1970/71	315.5	73.1	412.0	17.7
1971/72	348.8	80.2	421.9	19.0
1972/73	343.2	62.2	423.4	14.7
1973/74	372.5	70.2	434.8	16.1
1974/75	357.2	63.6	427.4	14.9
1975/76	350.1	63.0	413.8	15.2
1976/77	415.1	98.5	478.1	20.6
1977/78	381.3	82.3	479.8	17.2
1978/79	447.8	105.9	530.1	20.0

Source: U.S. Department of Agriculture, Foreign Agricultural Service, "Foreign Production, Supply, and Distribution of Agricultural Commodities Tape," Washington, D.C., 1979, updated for 1978/79.

Note: Ending stocks data are based on an aggregate of different marketing years and do not represent world stocks levels at a fixed point in time. Stocks for the Soviet Union represent year-to-year changes relative to an arbitrary base, and stocks for the People's Republic of China and some Eastern European countries are not included.

[a] Total supply = production + beginning stocks (i.e., ending stocks from the previous year).

Thus, the estimated stocks/supply relationship for the 1960s lies entirely above that estimated by Gardner, whereas the relationship for the early 1970s lies above Gardner's only during periods of relatively low supply. The three observations for the 1976/77-1978/79 period do not fall clearly into either the pattern for the 1960s or that of the early 1970s.

The calculated levels of carryover stocks for seven major countries/regions are presented in Table 4, and these carryover stocks as a percentage of world carryover stocks are shown in Table 5. These seven countries account for about 75 percent of world ending stocks and about 65 percent of world production. It is therefore reasonable to consider the "Rest of the World" as a single region.

Stockholding in the 1960s

Stock levels in the 1960s apparently exceeded the levels that would have been financially profitable because the three major exporters—the United States, Canada, and Australia—used stockholding to support prices and producer incomes. At the beginning of the decade, the United States was by far the largest stockholder (see Tables 3 and 4). As shown in Table 6, most of these stocks were held by the U.S. government as a result of its price support program. Except for the 1964/65 to 1967/68 crop years, the domestic market price was at or below the support price (the loan rate), and the government acquired stocks to hold prices at this level.[13] As expected, the use of

[13] Under the nonrecourse loan program, U.S. producers place their wheat in storage as collateral for a government loan; at the end of the crop year, the producer may either repay the loan and market the wheat or forfeit the stocks to the Commodity Credit Corporation (CCC) of the government. In this way the loan rate per bushel serves as the approximate procurement price for the government. Prior to 1978 stocks acquired by the CCC were sold commercially whenever the market price reached about 115 percent of the loan rate or whenever stocks were going out of condition.

Table 2—Price of wheat in the world market: nominal and real annual averages for marketing years 1960/61 to 1978/79

Year	Nominal[a]	Real[b]
	($/metric ton)	
1960/61	61.0	173.4
1961/62	64.0	181.9
1962/63	64.3	184.8
1963/64	66.1	188.0
1964/65	63.4	178.3
1965/66	62.3	169.4
1966/67	67.3	181.1
1967/68	62.4	166.3
1968/69	63.3	179.9
1969/70	57.8	162.6
1970/71	63.3	160.1
1971/72	61.7	143.2
1972/73	91.8	193.7
1973/74	191.0	333.3
1974/75	179.0	250.2
1975/76	160.6	194.4
1976/77	121.9	146.1
1977/78	118.6	129.9
1978/79	145.0	145.0

[a] These represent a simple average of the following export prices in U.S. dollars for each year: No. 2 Canadian Western Red Spring (CWRS), 13.5 percent protein, f.o.b. St. Lawrence and f.o.b. Vancouver; No. 2 Hard Red Winter (ordinary), f.o.b. Gulf; No. 2 Soft Red Winter, f.o.b. Gulf; No. 2 Dark Northern Spring, 14 percent protein, f.o.b. Lakes; No. 2, Western White, f.o.b. Pacific; Australian Standard White, f.o.b. Eastern Ports. Sources are the International Wheat Council, *World Wheat Statistics*, various issues, and US Department of Agriculture, *Wheat Situation*, various issues. (For a few years, prices for Soft Red Winter and Dark Northern Spring are estimated, based on quotations for different qualities or location.)

[b] In 1978 constant U.S. dollars, adjusted by the index of U.S. dollar unit value of manufactured exports from developed to developing countries (c.i.f. index), which is the deflator used in International Bank for Reconstruction and Development, *Commodity Trade and Price Trends* (Washington, D.C.: IBRD, 1978). The value for 1978 is based on the Import Unit Value Index from the International Monetary Fund, *International Financial Statistics* (Washington, D.C.: IMF, May 1979).

Table 3—Ending stocks for selected major countries, 1960/61 to 1978/79

Year	United States	Canada	Australia	Argentina	Total of Four Major Exporters[a]	European Economic Community[b]	India	Soviet Union	World Total
				(million metric tons)					
1960/61	38.41	16.56	0.99	0.76	56.72	7.48	2.90	3.00	77.36
1961/62	35.98	10.64	0.81	0.24	47.67	7.31	2.80	0.00	65.51
1962/63	32.53	13.26	0.96	0.50	47.25	9.20	3.60	1.00	69.98
1963/64	24.53	12.50	0.88	2.21	40.13	7.20	2.60	4.00	63.76
1964/65	24.98	13.96	0.99	3.34	43.28	6.53	1.90	14.00	74.60
1965/66	17.96	11.43	0.77	0.18	30.34	7.90	3.20	5.00	56.44
1966/67	13.96	15.56	2.52	0.24	32.28	6.43	2.30	32.00	83.28
1967/68	17.15	18.30	1.74	1.01	38.19	6.53	2.30	31.00	89.50
1968/69	24.63	23.18	7.59	0.85	56.25	8.61	3.90	33.00	113.51
1969/70	26.78	27.45	7.54	0.78	62.56	5.11	4.00	14.00	96.47
1970/71	22.37	19.98	3.66	0.68	46.69	5.49	5.00	6.00	73.13
1971/72	26.81	15.89	1.58	0.37	44.65	7.00	7.00	9.00	80.17
1972/73	16.25	9.94	0.56	0.27	27.03	5.82	5.00	11.00	62.23
1973/74	9.25	10.09	1.98	1.03	22.35	7.29	2.80	24.00	70.25
1974/75	11.84	8.04	1.79	0.71	22.38	9.73	2.50	13.00	63.65
1975/76	18.10	8.22	2.78	0.74	29.84	7.53	6.50	2.00	63.04
1976/77	30.26	13.31	2.10	1.40	46.89	7.05	12.00	10.00	98.46
1977/78	32.01	12.10	0.80	0.50	45.40	6.10	10.00	1.00	82.30
1978/79	25.20	15.00	4.50	1.10	45.80	8.80	7.50	19.00	105.90

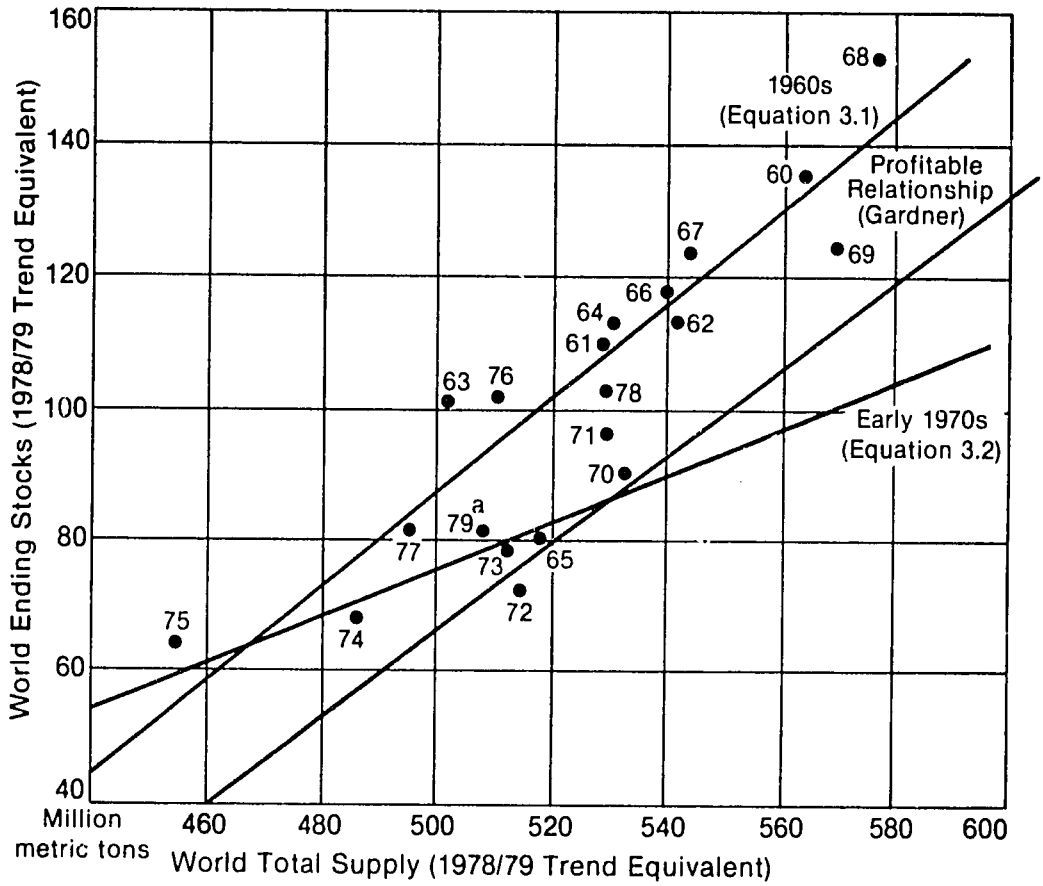
Source: U.S. Department of Agriculture, Foreign Agricultural Service, "Foreign Production, Supply and Distribution of Agricultural Commodities Tape," Washington, D.C., 1979.

Note: Ending stocks data are based on an aggregate of different marketing years and do not represent world stocks levels at a fixed point in time. Stocks for the Soviet Union represent year-to-year changes relative to an arbitrary base, and stocks for the People's Republic of China and some Eastern European countries are not included.

[a] Includes the United States, Canada, Australia, and Argentina.

[b] The European Economic Community is regarded as a single country.

Figure 3—Observed stocks/supply relationship since 1960 compared to the financially profitable relationship for a unified world market



Note: Years refer to crop years; that is 60 refers to 1960/61.
[a]1979 is based on preliminary estimates.

a narrow price band centered above the average price caused government stocks to displace private stocks. Private stocks increased to more than 5-8 million tons[14] only when government stocks began to fall in 1964/65.[15] Even in those years when the market price was above the support price and the majority of stocks were privately held, government programs assured a price floor and thus stimulated private stockholding.

At the beginning of the decade, Canada was the other major stockholder. Between 1960/61 and 1965/66 the United States and Canada together accounted for an average of 79 percent of world carryover stocks (excluding the Soviet Union). From 1956 to 1965 the United States and Canada apparently cooperated in holding larger-than-profitable

[14]"Tons" denotes metric tons for the purposes of this report.

[15]For an analysis of the relationship between government and private stocks in the United States during this period, see Anne Peck, "Implications of Private Storage of Grains for Buffer Stock Schemes to Stabilize Prices" in *Food Research Institute Studies* 26 (1978): 125-140.

Table 4—Carryover stocks for major countries and the world, 1960/61 to 1978/79

Year	United States	Canada	Australia	Argentina	Four Major Exporters[a]	European Economic Community[b]	India	Soviet Union	Rest of World[c]	World	World Excluding Soviet Union
					(million metric tons)						
1960/61	32.38	10.23	0.57	0.40	43.58	3.40	1.66	3.00	0.51	52.15	49.15
1961/62	29.75	4.21	0.37	−0.12	34.22	3.13	1.50	0.00	0.72	39.56	39.56
1962/63	26.10	6.72	0.51	0.14	33.47	4.92	2.23	1.00	1.65	43.27	42.27
1963/64	17.69	5.85	0.42	1.84	26.01	2.81	1.16	4.00	2.28	36.26	32.26
1964/65	18.13	7.20	0.52	2.96	28.81	2.04	0.39	14.00	1.04	46.28	32.28
1965/66	10.88	4.55	0.29	−0.21	15.53	3.32	1.62	5.00	1.83	27.29	22.29
1966/67	6.66	8.56	2.02	−0.14	17.10	1.73	0.64	32.00	1.78	53.25	21.25
1967/68	9.60	11.19	1.23	0.62	22.64	1.72	0.56	31.00	2.66	58.57	27.57
1968/69	16.84	15.94	7.07	0.46	40.31	3.68	2.07	33.00	2.60	81.66	48.66
1969/70	18.74	20.10	7.01	0.38	46.22	0.06	2.08	14.00	1.30	63.66	49.66
1970/71	14.07	12.49	3.12	0.27	29.95	0.33	2.98	6.00	0.07	39.34	33.34
1971/72	18.24	8.27	1.02	−0.04	27.50	1.72	4.88	9.00	2.26	45.36	36.36
1972/73	7.40	2.20	−0.01	−0.14	9.45	0.41	2.78	11.00	2.72	26.35	15.35
1973/74	0.12	2.21	1.39	0.61	4.33	1.75	0.46	24.00	2.74	33.28	9.28
1974/75	2.41	0.03	1.18	0.29	3.91	4.06	0.05	13.00	4.53	25.55	12.55
1975/76	8.36	0.08	2.15	0.32	10.91	1.73	3.93	2.00	5.21	23.78	21.78
1976/77	20.21	5.02	1.46	0.97	27.48	1.11	9.39	10.00	10.11	58.00	48.00
1977/78	21.63	3.68	0.14	0.07	25.50	0.02	7.16	1.00	6.90	40.59	39.59
1978/79	14.49	6.44	3.82	0.66	25.41	2.57	4.52	19.00	11.40	62.90	43.90

Source: Derived from data in Tables 3 and 15.

[a] The United States, Canada, Australia, and Argentina are included in this column.

[b] The European Economic Community is regarded as a single country.

[c] This column includes the world minus the United States, Canada, Australia, Argentina, the Soviet Union, the European Economic Community, and India.

Table 5—Carryover stocks for major countries as a percentage of world carryover stocks, 1960/61 to 1978/79

Year	Four Major Exporters[a]	Five Major Exporters[b]	India	Rest of World[c]	Soviet Union
			Including Soviet Union		
1960/61	83.6	90.1	3.2	1.0	5.7
1961/62	86.5	94.4	3.8	1.8	0.0
1962/63	77.3	88.7	5.2	3.8	2.3
1963/64	71.7	79.5	3.2	6.3	11.0
1964/65	62.2	66.6	0.8	2.2	30.4
1965/66	56.9	69.0	5.9	6.7	18.4
1966/67	32.1	35.4	1.2	3.4	60.0
1967/68	38.6	41.6	0.9	4.5	53.0
1968/69	49.4	53.9	2.5	3.2	42.4
1969/70	72.6	72.7	3.3	2.0	22.2
1970/71	76.2	77.0	7.6	0.2	15.2
1971/72	60.6	64.4	10.8	5.0	19.8
1972/73	35.8	37.4	10.5	10.3	41.8
1973/74	13.0	18.3	1.4	8.2	72.1
1974/75	15.3	31.2	0.2	17.7	50.9
1975/76	45.9	53.1	16.5	27.9	2.5
1976/77	47.4	49.3	16.0	17.4	17.3
1977/78	62.8	62.9	17.6	17.0	2.5
1978/79	40.4	44.5	7.2	18.1	30.2
			Excluding Soviet Union		
1960/61	88.7	95.6	3.4	1.0	
1961/62	86.5	94.4	3.8	1.8	
1962/63	79.2	90.8	5.3	3.9	
1963/64	80.6	89.3	3.6	7.0	
1964/65	89.2	95.6	1.2	3.2	
1965/66	69.7	84.5	7.2	8.2	
1966/67	80.5	88.6	3.0	8.4	
1967/68	82.1	88.3	2.0	9.6	
1968/69	82.8	90.4	4.2	5.3	
1969/70	93.1	93.2	4.2	2.6	
1970/71	89.9	90.8	8.9	0.2	
1971/72	75.6	80.4	13.4	6.2	
1972/73	61.5	64.2	18.1	17.7	
1973/74	46.7	65.5	5.0	29.5	
1974/75	31.1	63.5	0.4	36.1	
1975/76	50.1	58.0	18.0	23.9	
1976/77	57.2	59.6	19.4	21.1	
1977/78	64.4	64.5	18.1	17.4	
1978/79	57.9	63.7	10.3	26.0	

Source: Derived from data in Table 3.

[a] These include the United States, Canada, Australia, and Argentina.

[b] These include the United States, Canada, Australia, Argentina, and the European Economic Community (which is regarded as a single country).

[c] This column includes the world minus the United States, Canada, Australia, Argentina, the European Economic Community, the Soviet Union, and India.

Table 6—U.S. wheat stocks, 1958/59 to 1977/78

Crop Year	Support Price[a]	Market Price[b]	Ending Stocks[c]		
			Private	Government	Total
	($/bushels)	($/bushels)		(million bushels)	
1958/59	1.82	1.73	284	1,084	1,368
1959/60	1.81	1.76	186	1,198	1,384
1960/61	1.78	1.74	278	1,225	1,503
1961/62	1.79	1.83	346	1,074	1,420
1962/63	2.00	2.04	168	1,102	1,270
1963/64	1.82	1.85	194	800	994
1964/65	1.30	1.37	286	635	921
1965/66	1.25	1.35	361	299	660
1966/67	1.25	1.63	391	122	513
1967/68	1.25	1.39	530	100	630
1968/69	1.25	1.24	764	140	904
1969/70	1.25	1.24	705	277	982
1970/71	1.25	1.33	470	353	823
1971/72	1.25	1.34	628	355	983
1972/73	1.25	1.76	591	6	597
1973/74	1.25	3.95	339	1	340
1974/75	1.37	4.09	435	0	435
1975/76	1.37	3.56	665	0	665
1976/77	2.25	2.73	1,112	0	1,112
1977/78	2.25	2.33	1,131	46	1,177

Sources: U.S. Department of Agriculture, *Wheat Situation*, various issues. Also see Bruce Gardner, *Optimal Stockpiling of Grain* (Lexington, Mass.: Lexington Books, 1979).

[a] This is the loan rate.

[b] This is the average price received by farmers.

[c] These are the ending stocks for the year ending June 1.

stocks in order to set the world price and to stabilize their market shares.[16]

Over the course of the decade, two related trends were apparent. First, the United States shifted increasingly from stockholding to other instruments to support producer incomes. Following the Agricultural Act of 1964, the U.S. loan rate was sharply reduced in an effort to decrease government stockholding. To support farm incomes, the acreage control program (which had been used throughout the 1950s) was strengthened and a system of direct payments to producers (which included domestic and export certificate payments and acreage diversion payments) was initiated.[17] As a result of these policy changes, the export price in the world market decreased almost 20 percent between June 1964 and June 1965. Alex McCalla notes that this "price war" marked a significant change in the cooperative relationship between the United States and Canada.[18] The new U.S. policies, together with a surge in world import demand due largely to production shortfalls in the Soviet Union in 1965 and South Asia in 1965 and 1966, caused world ending stocks to fall to their lowest level of the decade in 1965/66. In that year the observed stocks/supply relationship fell sharply below the line of equation (3.1), as shown in Figure 3.

Second, in a directly related development, stockholding by Canada and Australia increased relative to U.S. stockholding and

[16] See Alex F. McCalla, "A Duopoly Model of World Wheat Pricing," *Journal of Farm Economics* 48 (August 1966): 711-727. McCalla argues that the Canadian Wheat Board was the price leader, and the United States, which could control its commercial export price through its export subsidy program, was the price follower.

[17] For an account of U.S. wheat policies, see Willard W. Cochrane and Mary E. Ryan, *American Farm Policy, 1948-1973* (Minneapolis: University of Minnesota Press, 1976), and Don F. Hadwiger, *Federal Wheat Commodity Programs* (Ames, Iowa: Iowa State University, 1970).

[18] McCalla, "A Duopoly Model."

in absolute terms during the remainder of the decade. From a low point of 4.6 million tons in 1965/66, Canadian carryover stocks grew continuously to 20.1 million tons at the end of 1969/70. At that point Canada's carryover stocks were larger than those of the United States and equalled more than twice its annual export volume. Australia, which had held virtually no carryover stocks previously, began to hold stocks in 1966/67. In the last two years of the decade, Australia accounted for almost 20 percent of the carryover stocks held by the three major exporters. It has been argued that this was the direct result of a policy shift in which Australia sought to cooperate with the United States and Canada in a triopoly.[19]. Especially after the price war of 1968/69 brought about the collapse of the International Grains Arrangement of 1967, Australia accepted willingly a share of responsibility for holding back stocks to support the world price.

It is especially interesting to note that after 1965/66 when the U.S. policy shift caused a temporary breakdown in cooperation among the major exporters, the Soviet Union substantially increased its stocks. Thus, except for 1965/66, when the Soviets had a major production shortfall, the close relationship between ending stocks and total supply for the world as a whole was maintained. From 1966/67 through 1968/69 the Soviet Union was an important net exporter and therefore may have had an interest in supporting the world price, but when the three major exporters resumed holding large stocks, Soviet stocks were significantly reduced.

Thus, stockholding behavior in the 1960s appears to have followed the theoretical propositions outlined in Chapter 2. A strong relationship between world ending stocks and total supply was maintained, but stockholding was larger than the financially profitable level because exporters used stockholding to increase the average price. In the latter half of the decade, when the largest exporter threatened to rely increasingly on other policy instruments to support its farm prices, the other major exporters were compelled to cooperate in stockholding. To a great extent stockholding that one country did not undertake was assumed by others so that the stable stocks/supply relationship was preserved, except in the year immediately following a significant policy shift by a major country. As a result of this stockholding pattern, world price was quite stable, with minor fluctuations immediately following the major policy shift of 1965/66 (see Table 2).

Stockholding in the Early 1970s

By 1970/71 the relationship between world ending stocks and total supply had clearly shifted downward. The increased price variability from 1970/71 to 1975/76 was not merely the result of extraordinary harvest fluctuations. Instead, new policies brought about a shift in the usual stocks/supply relationship. As shown in Figure 3, stockholding during this period appeared to be larger than profitable when supply was small but smaller than profitable when supply was large. A substantial share of carryover stocks was held by importers. There were three primary reasons for this new pattern of stockholding.

First, the major exporters increasingly relied on production controls to limit the accumulation of stocks. Ending stocks and total supply reached their highest levels of the decade in 1968/69, and world wheat prices reached their lowest real level. Just as the high cost of operating a buffer stock to increase the average price had apparently become intolerable to the United States in 1964, it became intolerable to the major exporters collectively. In response, the exporters moved to cut back production. In 1969/70 the United States, having removed its direct acreage limitation programs in 1967/68 and 1968/69, initiated an even larger program of acreage diversion (see Table 7). At the same time, through its unprecedented Operation LIFT (Lower Inventories for Tomorrow) program, Canada cut its wheat acreage by half.[20] As shown in Table 8, Australia and Argentina also reduced

[19] Chris M. Alaouze, A. S. Watson, and N. H. Sturgess, "Oligopoly Pricing in the World Wheat Market," *American Journal of Agricultural Economics* 60 (May 1978): 173-185.

[20] For a brief description of Operation LIFT, see International Wheat Council, *Review of the World Wheat Situation* (London: International Wheat Council, 1970/71).

Table 7—Area diverted and harvested and diversion payments made under U.S. wheat production control programs, 1960/61 to 1976/77

Crop Year	Area Diverted on Farms Participating	Diversion Payments	Area Harvested
	(million hectares)	($ million)	(million hectares)
1960/61	0.0	0.0	20.9
1961/62	0.0	0.0	21.0
1962/63	4.3	285.5[a]	20.9
1963/64	2.9	163.4	17.7
1964/65	2.1	32.7	18.4
1965/66	2.9	36.9	20.2
1966/67	3.3	26.1	20.1
1967/68	0.0	0.0	20.1
1968/69	0.0	0.0	23.6
1969/70	4.5	71.6	22.2
1970/71	6.4	62.5	19.1
1971/72	5.5[b]	0.0	17.6
1972/73	8.1	132.0	19.3
1973/74	3.0	103.0	19.1
1974/75	0.0	. . .	21.8
1975/76	0.0	. . .	26.5
1976/77	0.0	. . .	28.2

Source: National Association of Wheat Growers, *Wheat Facts 1978* (Washington, D.C.: National Association of Wheat Growers, 1978).

[a] During these years there were no marketing certificate payments in addition to diversion payments.

[b] This is the required set-aside.

Table 8—Wheat area harvested by Canada, Australia, and Argentina, 1960/61 to 1977/78

Crop Year	Canada	Australia	Argentina
		(million hectares)	
1960/61	9.93	5.44	3.62
1961/62	10.24	5.96	4.42
1962/63	10.65	6.66	3.74
1963/64	11.16	6.67	5.68
1964/65	12.01	7.25	6.14
1965/66	11.45	7.09	4.60
1966/67	12.01	8.43	5.21
1967/68	12.19	9.08	5.81
1968/69	11.91	10.85	5.84
1969/70	10.10	9.49	5.19
1970/71	5.05	6.48	3.70
1971/72	7.85	7.14	4.31
1972/73	8.64	7.60	4.96
1973/74	9.57	8.95	3.96
1974/75	8.93	8.31	4.23
1975/76	9.48	8.60	5.30
1976/77	11.25	9.00	6.40
1977/78	10.11	10.00	3.90

Source: U.S. Department of Agriculture, Foreign Agricultural Service, "Foreign Production, Supply, and Distribution of Agricultural Commodities Tape," Washington, D.C., 1979.

acreage substantially between 1968/69 and 1970/71. In total, wheat area harvested among the four major exporters was reduced from 52.2 million hectares in 1968/69 to 34.3 million hectares in 1970/71. For the world as a whole, area harvested fell from 224 million hectares in 1968/69 to 207 million hectares in 1970/71.

The exporters, as part of the effort to reduce stocks, did not increase prices as supply decreased. The real price of wheat in 1970/71 and 1971/72 was lower than would have been expected for the level of ending stocks based on the stocks/price relationship prevailing in the 1960s (see Figure 4).[21] As the exporters apparently intended, world consumption grew rapidly from 287 million tons in 1967/68 to 342 million tons in 1971/72, and world ending stocks were reduced.[22]

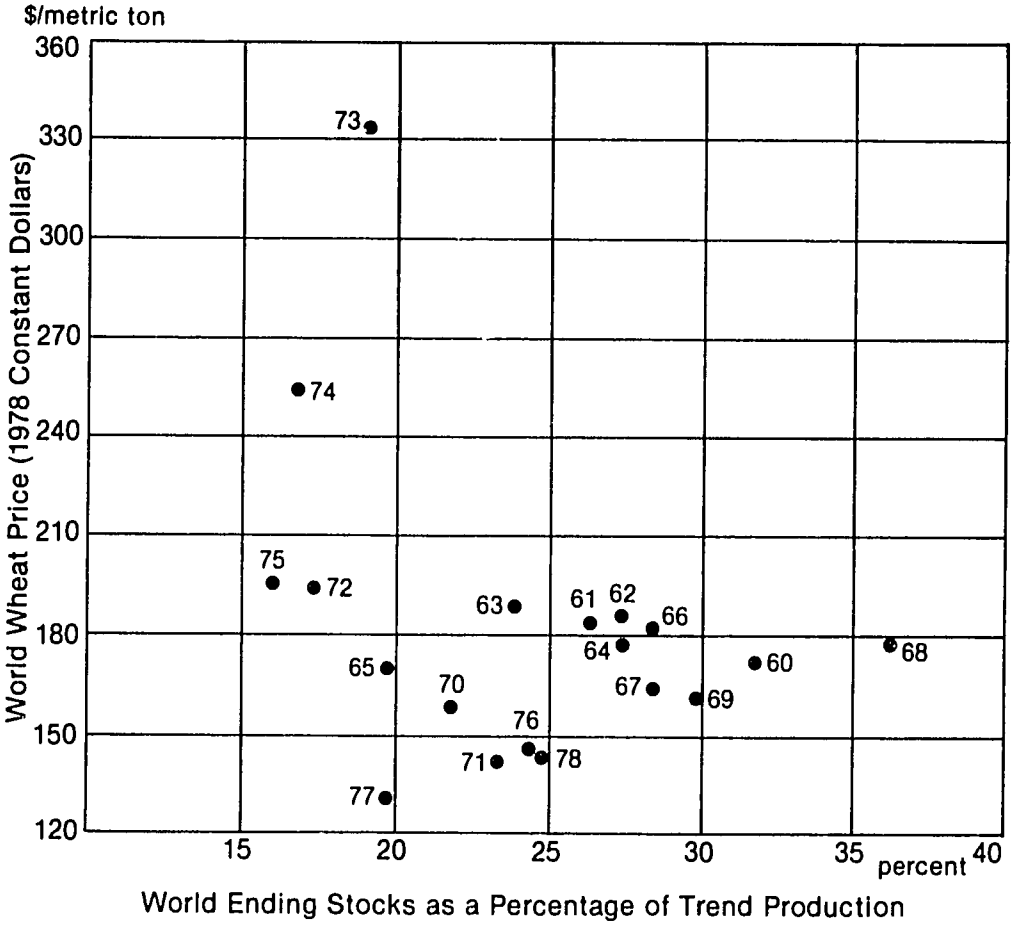
Second, in 1972/73 the Soviet Union made an unanticipated decision to import rather than to reduce consumption or stocks following a major domestic production shortfall. In that year Soviet wheat production was down 12.8 million tons from the previous year (see Table 8). In 1963/64 and 1965/66 the Soviets had relied on a combination of imports, consumption cutbacks, and stock depletion to compensate for shortfalls. But in 1972/73 they chose to import 15.6 million tons (and cut exports by 4.5 million tons), which allowed them to maintain consumption levels and even add slightly to stocks.

The Soviet decision was based on a desire to maintain the program of livestock

[21] The downward shift in the observed stocks/supply relationship is confirmed by the corresponding shift in the observed stocks/price relationship.

[22] See Dale E. Hathaway, "Food Prices and Inflation," *Brookings Papers on Economic Activity*, No. 1 (Washington, D.C.: Brookings Institution, 1974) p. 95; and World Food Council, *World Food Security for the 1980s: Report by the Executive Director* (WFC/1979/5), April 1979: 12. They have also observed that the shift in world stockholding behavior that led to the high and unstable prices of the 1972-75 period actually began in 1969/70.

Figure 4—Observed relationship between real world wheat prices and ending stocks as a percentage of trend production



production started in the mid-1960s.[23] Between 1966/67 and 1972/73 Soviet use of wheat for feed increased from 16.2 million tons to 41.3 million tons, whereas total consumption increased from 72.2 to 98.3 million tons. This expanded use for feed reduced Soviet ending stocks from an estimated 33 million tons in 1968/69 to 6 million tons in 1970/71.

Together, the efforts of exporters to reduce their stocks and the Soviet decision to maintain consumption growth cut world carryover stocks from 81.7 million tons in 1968/69 to 26.3 million tons in 1972/73 (Table 4). By 1972/73 world stockholding had fallen below the estimated profitable level. Prices began to rise and increased sharply in 1973/74 when virtually all commodity prices skyrocketed.[24]

Third, from 1973/74 to 1975/76 the

[23]For a detailed account of the Soviet grain economy, see D. Gale Johnson, "The Soviet Livestock Sector: Problems and Prospects," Paper No. 74:1, University of Chicago, Office of Agricultural Economic Research, Chicago, Ill., March 1974; and D. Gale Johnson, *The Soviet Impact on World Grain Trade* (London: British-North America Committee, May 1977).

[24]See Richard N. Cooper and Robert Z. Lawrence, *The 1972-75 Commodity Boom*, Paper No. 235, Yale University, Economic Growth Center, New Haven, Conn., 1976.

desire to protect national economies in the face of an unreliable world market apparently led to aggregate stockholding above the financially profitable level for an open world market. When wheat export prices reached their peak in 1973/74, only the Soviet Union had substantial carryover stocks (72 percent of the world total). Presumably the Soviet Union did not export these stocks and profit from the high prices because it was unwilling to be dependent on the world market in the next year. In 1974/75 the importers and the European Economic Community actually added to carryover stocks so that 85 percent of the world carryover stocks were held by the Soviet Union, European Economic Community, and the Rest of the World. Such behavior—acquiring stocks in a year of record prices—was almost certainly motivated by fear that opportunities for trade would collapse.[25] In fact, Canada, Australia, the European Economic Community, and Argentina actually pursued policies that directly or indirectly protected their domestic consumers and limited their exports, resulting in several million tons of carryover stocks.[26] Thus, the fears of importers were not entirely irrational.

In 1975/76 the Soviet Union suffered its worst production shortfall of the period observed (Table 9), and it again turned to the world market for compensating imports. But, unlike 1972/73 when the United States was eager to reduce its stock levels, the U.S. government intervened. A moratorium was declared in July 1975 on further sales to the Soviets and was lifted only after the U.S./U.S.S.R. bilateral agreement to stabilize the volume of grain trade was concluded in October.[27] Thus, Soviet imports were held

Table 9—Wheat economy of the Soviet Union, 1960/61 to 1978/79

Year	Area Harvested	Beginning Stocks	Production	Imports	Exports	Feed Grain Use	Total Domestic Utilization
	(million hectares)			(million metric tons)			
1960/61	60.40	2.00	64.30	0.58	5.02	9.68	58.86
1961/62	55.00	3.00	66.48	0.24	5.34	13.00	64.39
1962/63	67.40	0.00	70.78	0.24	5.74	8.20	64.28
1963/64	64.60	1.00	49.69	9.75	2.66	2.67	53.78
1964/65	67.90	4.00	74.40	2.22	2.20	9.20	64.42
1965/66	70.20	14.00	59.69	8.55	2.63	20.42	74.60
1966/67	70.00	5.00	100.50	3.08	4.39	16.23	72.20
1967/78	67.00	2.00	77.42	1.51	5.29	20.31	74.63
1968/69	67.23	32.00	93.34	0.22	5.83	27.10	85.78
1969/70	65.40	33.00	79.92	1.15	6.44	33.50	93.62
1970/71	65.20	14.00	99.73	0.48	7.20	38.64	101.02
1971/72	64.03	6.00	98.76	3.52	5.83	36.38	93.46
1972/73	58.50	9.00	85.99	15.59	1.30	41.34	98.28
1973/74	63.15	11.00	109.78	4.51	5.00	30.50	96.29
1974/75	59.70	24.00	83.91	2.50	4.00	33.68	93.41
1975/76	52.00	13.00	66.22	10.10	0.50	29.79	86.82
1976/77	59.96	2.00	96.88	4.60	1.00	27.98	92.48
1977/78	62.00	10.00	92.16	6.86	1.00	41.71	107.02
1978/79	62.80	1.00	120.80	5.14	1.50	46.53	106.47

Source: U.S. Department of Agriculture, Foreign Agricultural Service, "Foreign Production, Supply, and Distribution of Agricultural Commodities Tape," Washington, D.C., 1979, updated for 1978/79.

[25]This point is made by Alexander Sarris and Lance Taylor in "Cereal Stocks, Food Aid, and Food Security for the Poor," *World Development* 4 (December 1976): 967-976.

[26]Canada and Australia maintained their domestic price to millers at well below the export prices offered by the Boards; the European Economic Community imposed an export tax; and Argentina briefly embargoed exports. See Grennes, Johnson, and Thursby, "Insulating Trade Policies."

[27]The agreement specified that during each of the next five years the Soviet Union would import at least 6 million tons of wheat and coarse grains from the United States and would consult with the U.S. government if it wished to import more than 8 million tons.

substantially below the level of 1972/73, and, despite the record low for world total supply, U.S. carryover stocks for 1975/76 increased to 8.4 million tons. In that year the United States, India, and the Rest of the World. held 74 percent of world carryover stocks.

In summary, the low stock levels of 1972/73 and the policies that brought them about caused a panic market and the emergence of a fundamentally new stockholding behavior. Stockholding from 1973/74 to 1975/76 was above the profitable level not as the result of efforts to support producer prices as in the 1960s but because countries, especially importers, sought to secure their own supplies for the next year and to reduce their dependence on an unreliable world market. This is especially clear in the behavior of India and the Rest of the World. As shown in Table 10, the average carryover stocks for these regions increased sharply after 1971/72, especially after 1974/75. Table 11 shows that ending stocks as a percentage of trend utilization also increased for most regions in the Rest of the World. However, because of the inadequacy of data for many countries, the increase in stockholding by the regions of North Africa/Middle East, other South Asian countries, and Southeast Asia is probably overstated. For some countries in these regions, the U.S. Department of Agriculture (USDA) did not report any ending stocks in the 1960s, whereas reported stocks were fairly large in the 1970s. Therefore, the tables may reflect an increase in availability of stock data as well as an actual increase in stockholding.

Because of this new behavior, world stock levels never fell to estimated minimum working stock levels during this period. In each year from 1972/73 to 1975/76, one or more countries held ending stocks substantially above their lowest historical level (as a percentage of trend market volume). Thus, the world as a whole had a cushion of stocks that could have been used if countries had been willing to place confidence in the world market. Instead, lowest observed ending stocks for the world (about 17 percent of trend production) were substantially greater than the sum of lowest observed ending stocks for individual countries (10 percent).

It should be noted that the period 1970/71 to 1975/76 does not provide direct evidence that stockholding would have been smaller than profitable if supplies were large. World

Table 10—Average carryover stocks before and after 1971/72 for selected countries/regions

Region	Before 1971/72[a]		After 1971/72	
	Share[b]	Absolute	Share[b]	Absolute
	(percent)	(million metric tons)	(percent)	(million metric tons)
Four major exporters[c]	83.8	30.71	52.9	15.47
Five major exporters[d]	91.1	33.18	62.4	16.92
India	4.3	1.53	12.9	4.10
Rest of world	4.7	1.49	24.7	6.36

Source: Derived from U.S. Department of Agriculture, Foreign Agricultural Service, "Foreign Production, Supply, and Distribution of Agricultural Commodities Tape," Washington, D.C., 1979.

Note: "Before" includes the years 1960/61 to 1970/71; "after" the years 1972/73 to 1978/79. The absolute value represents an average of these years.

[a] 1971/72 is excluded because it was a transitional year.

[b] The Soviet Union is excluded.

[c] This includes the United States, Canada, Australia, and Argentina.

[d] This row includes the above and the European Economic Community.

Table 11—Ending stocks as a percentage of trend utilization for selected countries/regions

Region	Average Before 1971/72	Average After 1971/72
	(percent)	(percent)
Other western Europe[a]	28.2	36.5
Japan	20.8	23.4
Eastern Europe	5.8	3.2
North Africa/ Middle East	8.4	19.7
Other South Asia[b]	7.9	10.6
Southeast Asia	3.1	7.2
Brazil	14.6	6.8
Mexico	11.0	7.9
India	17.7	22.7

Source: Derived from U.S. Department of Agriculture, Foreign Agricultural Service, "Foreign Production, Supply, and Distribution of Agricultural Commodities Tape," Washington, D.C., 1979.

Note: "Before" includes the years 1960/61 to 1970/71; "after" the years 1972/73 to 1978/79.

[a] The European Economic Community is excluded.

[b] India is excluded.

stockholding fell below the profitable level as estimated by Gardner only in 1972/73, but in that year the outcome was affected by the unanticipated shift in import policy by the Soviet Union. However, it seems likely that without government stockholding to support prices in periods of large supply, stock levels would have fallen because private stockholders could not have expected to make a profit due to insulation of national markets. Table 12 illustrates the extent to which the major countries insulated their domestic prices from world prices in these years. Although it appears that the United Kingdom, Canada, and the United States allowed their domestic wholesale prices to rise by the same order of magnitude as the world export price, there was in each case actual or potential government intervention in the domestic price movement that discouraged private stockholding. The increase for the United Kingdom reflects entry into the European Economic Community, not a market price movement; the increase for Canada masks the extensive control of the Canadian Wheat Board over export quantities and domestic milling prices; and the increase for the United States does not indicate the considerable uncertainty among private firms about whether the government would impose export controls.[28]

Thus stockholding behavior in the early 1970s appears to confirm several theoretical propositions suggested in Chapter 2. In the absence of exporter stockholding to increase average prices, world carryover stocks would fall below profitable levels if supplies were large because insulation of national markets would discourage private stockholding. But carryover stocks would exceed profitable levels if supplies were short because fear of export controls would induce importers to hold more stocks.

Stockholding from 1976/77 to 1978/79

The world wheat harvests in 1976/77 and 1978/79 were exceptionally large (Table 1), and world ending stocks increased significantly. For these three years the world stocks/supply relationship appears closer to the relationship estimated for the 1960s

Table 12—Domestic wholesale prices for wheat in selected countries, 1970/71 to 1973/74

Country	1970/71	1971/72	1972/73	1973/74	Amount Change (1970/71 -1973/74)
		(U.S.$/metric ton)			(percent)
World export price[a]	63.3	61.7	91.8	191.0	302
U.S.	69.8	61.0	81.9	167.9	241
Canada	63.1	61.5	97.6	201.9	320
Australia	65.4	65.4	70.5	84.1	129
European Economic Community (6)	105.2	105.8	121.1	145.6	138
U.K.	64.2	58.1	86.3	143.5	224
Japan	97.6	102.0	111.6	140.3	144
India	125.0	124.0	128.0	107.0	86
Mexico	120.0	105.0	129.0	164.0	137
Turkey	94.0	75.0	89.0	109.0	116
Pakistan	109.0	108.0	66.0	63.0	58

Sources: Food and Agriculture Organization of the United Nations, *Agricultural Protection and Stabilization Policies: A Framework of Measurement in the Context of Agricultural Adjustment* (C 75/UM/2), October 1975; and Food and Agriculture Organization of the United Nations, *Production Yearbook* (Rome: FAO, various issues).

[a] This is defined in Table 2.

[28] In October 1974 after placing in temporary abeyance certain contracts for exports of large quantities, the United States instituted a system of export reporting that required prior approval of export sales by USDA. The system of prior approval was ended in March 1975. In July 1975 USDA imposed a moratorium on grain sales to the Soviet Union. For more detail see International Wheat Council, *Review of the World Wheat Situation*, various issues.

than that estimated for the early 1970s, but there were essential differences. Three factors explain the increased stockholding during this period.

First, there was a substantial increase in private stockholding in the United States stimulated by limits on export controls[29] and by the new U.S. Farmer-Owned Reserve (FOR) program which began in April 1977. Between 1975/76 and 1976/77 U.S. ending stocks increased from 18.1 to 30.3 million tons (Table 3), and none of this quantity was owned by the government. At the end of 1977/78 only about 1.3 million tons out of 32.0 million tons was owned by the government. The FOR program provided a subsidy to private stockholding for a limited quantity within a limited price range. In brief, for up to 11.2 million tons of wheat (and larger quantities of feedgrains), the FOR program paid storage costs provided that the market price was below approximately $148/ton (based on the average f.o.b. prices) and paid interest costs provided that the market price was below approximately $180/ton.[30] More than half of U.S. carryover stocks during 1977/78-1978/79 benefited from this subsidy.

The U.S. government indicated that a principal rationale behind this program was to ensure that the United States would be regarded as a reliable supplier to importing countries. The "Statement of the President on Inflation" of April 15, 1977 said, "This reserve will also help promote export sales of agricultural commodities by showing that we can meet supply commitments even when we have poor crop yields." This indicates an emphasis by U.S. policymakers on market development and a belief that world price variability reduces the long-term growth of world import demand by inducing importers to increase efforts toward self-sufficiency.

Second, some importers continued to hold substantial carryover stocks acquired during the 1972/73-1975/76 period despite the increase in exporter stocks. As shown in Table 5, the average share of the world's carryover stocks held by India and the Rest of the World from 1976/77 to 1978/79 was an unprecedented 35 percent. Such costly stockholding was apparently motivated by continuing fears that access to supplies in the world market was unreliable.[31]

And third, during 1978/79 harvests were so large that both Australia and Canada lacked the transport and port facilities to export as much wheat as they would have liked.[32] Ending stocks were certainly larger than they would otherwise have chosen, especially in Australia.

Considering these factors, the pattern for the 1976/77-1978/79 period does not indicate a return to the stocks/supply relationship of the 1960s. Instead, it appears that the increase in stockholding reflected special circumstances, not a propensity to hold carryover stocks well above profitable levels during periods of large supply. Part of the stockholding by Canada and Australia was entirely unwanted. If importers begin to feel restored confidence in the world market, they will probably draw down their stocks. And finally, although programs such as the FOR do lead to stockholding above the profitable level, this program provided a subsidy for only a fraction of the world's ending stocks (about 10 percent in 1978/79) and thus could not bring about a significant upward shift in the world's stock/supply relationship.[33]

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[29]The Export Administration Act of 1975 defined strict conditions under which the Secretary of Agriculture could impose limits on the export of agricultural commodities. The Food and Agriculture Act of 1977 also required that if any limits were imposed loan rates must be increased to 90 percent of parity, more than twice current levels.

[30]See U.S. Department of Agriculture, *Commodity Program Provisions Under the Food and Agriculture Act of 1977*, AER No. 389 (Washington, D.C.: USDA, October 1977) for details of the FOR program.

[31]India's stock buildup was brought about by imports that India may have committed itself to in 1975, not domestic production in excess of consumption, although domestic price supports contributed to the situation. In any case, India chose not to export these stocks. See J. S. Sarma, "India—A Drive Towards Self-Sufficiency in Food Grains," *American Journal of Agricultural Economics* 60 (December 1978): 859-864.

[32]See International Wheat Council, *Wheat Market Report*, various issues.

[33]It is difficult to estimate how large U.S. ending stocks would have been without the FOR program, but it appears that the net increase brought about by the FOR was only a fraction of the quantity placed under the program. While the quantity under FOR increased from almost zero to about 10 million tons from the end of 1976/77 to the end of 1977/78, total ending stocks increased from 30.26 million tons to 32.01 million tons. Total supply in excess of exports increased from 50.65 to 55.17 million tons, and average price fell from $100.3 per ton to $85.6 per ton, indicating that an increase in private speculative stockholding would have taken place anyway. The U.S. *(continued)*

Pattern of Stockholding for the Near Future

Based on the evolution of policies, five factors suggest that the world's stock/supply relationship in the near future will be as follows: if supplies are large, stocks will be at or just slightly above the profitable level because private stockholding in the United States will be stimulated by government programs such as FOR; if supplies are small, stocks will be above the financially profitable level as importers seek to protect themselves by accumulating stocks. However, in individual years policy shifts or incorrect expectations about the behavior of major countries could lead to substantial deviations from this predicted pattern.

First, speculative stockholding in exporting countries, especially in the private U.S. market, will probably take advantage of most of the opportunities for profitable stockholding. For the United States this prediction is based on the recognition that: the futures market and information systems in the United States are well developed and will bring about a convergence of expectations about near-term price movements; instruments for risk sharing will allow speculators to take large stock positions; the U.S. government loan program provides a market floor price and thereby reduces the risk of stockholding; and the United States will likely continue its present policies favoring an open market.[34] However, if supplies are short, the fear that the government might impose export controls could suppress private stockholding below the profitable level.

Second, to the extent that importers fear administrative limitations on exports in years of tight supply, they will probably continue to undertake stockholding that they would not otherwise consider economical. However, importers will be motivated to undertake such stockholding primarily in periods of reduced world supply, thereby raising total stocks above profitable levels in such periods. As world total supply increases, the importing countries' incentive to stock will decrease.

Third, the major exporters will no longer need to rely on stockholding to support farm incomes because the real price of wheat will probably not decline and because in any case it is current U.S. policy to use production controls as necessary to prevent unwanted stock accumulation.

Throughout the 1950s and 1960s the real price of wheat declined gradually (as shown for the 1960s in Table 2). But recent projections indicate that for the next decade or so real wheat prices will probably increase somewhat. Based on a detailed model of the world's grain-oilseed-livestock economy, a USDA report predicts that real wheat prices in 1985 will be 9-52 percent above the average for 1969/70 to 1971/72.[35] The World Bank commodity price projections indicate that in 1985 the real wheat price will be about 12 percent above the average of those three years and will remain at that level through 1990. Similarly, a recent Iowa State University study concludes that real wheat prices will be 8.7 percent higher in 1985 than in 1969/70 to 1971/72 and 35 percent higher by the year 2000.[36]

A primary factor in this projected increase is the continuing rapid growth in demand in the developing countries and, to a lesser extent, the centrally planned economies. Studies by the World Bank, the Food and Agriculture Organization of the United Nations (FAO), the International Food Policy

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(footnote 33 continued)

government also stimulated private stockholding through other programs during this period. First, the nonrecourse loan program ensured a price floor in the market, which reduced the downside risk of speculators. Second, the U.S. government provided over $500 million in loans at below-market interest rates for the construction of on-farm storage facilities.

[34] Johnson calculates that the profitable level of stockholding in the United States for all grains at the end of 1977/78 was 67 million tons compared to an actual ending stock level of 74 million tons. He attributes this private stockholding in excess of the profitable level to the reduction in risk caused by the government price support program. D. Gale Johnson, "Estimating Appropriate Levels of Grain Reserves for the United States: A Research Report," Paper No. 77-26, University of Chicago, Office of Agricultural Economic Research, Chicago, Ill., November 1977.

[35] U.S. Department of Agriculture, Economics and Statistics Cooperative Service, *Alternative Futures for World Food in 1985*, vol. I, *World GOL Model Analytical Report*, Foreign Agriculture Economic Report No. 146 (Washington, D.C.: USDA, 1978).

[36] Don Mitchell and Earl Heady, *U.S. Export Farm Employment and Income Simulated Under Alternative Export Demands*, CARD Report No. 81 (Ames, Iowa: Iowa State University, no date).

Research Institute, and USDA all indicate that because of rapid population and income growth grain import demand by developing countries is likely to at least double by 1985 compared to the early 1970s.[37]

If these price projections should prove accurate, the problem of maintaining producer income in the major exporting countries will be much less difficult than it was during the 1950s and 1960s. The question of using policy interventions to raise average price levels may not arise.

There is, of course, considerable uncertainty about any price projections. But even if real wheat prices should fall below politically acceptable levels, the United States—and perhaps other major exporters—will almost certainly choose production controls, direct income payments, and perhaps export subsidies to support producer income rather than unwanted stock accumulation. The United States' shift away from the high support prices and large stockholding, which began in the 1960s, continued in the 1970s. Under the Agriculture and Consumer Protection Act of 1973, the United States added a policy instrument for direct deficiency payments to supplement producer income when the market price was below a target price. The current Food and Agriculture Act of 1977 maintains authority for production controls (both "set asides" and direct diversion payments) and deficiency payments.[38] The nonrecourse loan program is no longer the primary means used to protect producer income. The 1977 legislation (Title IV, Section 401) states that the loan rate should be lowered as necessary to ensure that U.S. wheat remains competitively priced in export markets. This avoids the situation in which the domestic market price rests at the loan rate, the government acquires stocks, and exports receive a direct subsidy. In implementing the 1977 legislation, the United States imposed production controls on the 1978/79 and 1979/80 wheat crops. To be eligible for deficiency payments, producers had to set aside 20 acres to soil-conserving uses for each 100 acres planted in wheat. USDA explicitly stated that its objective was to limit U.S. ending stocks of wheat to 7.5 percent of world utilization.[39] In contrast, U.S. ending stocks in 1960/61 reached 16.2 percent of world utilization and from 1960/61 to 1964/65 averaged 12.8 percent. For 1977/78 and 1978/79 world ending stocks were 21.4 percent and 25.7 percent of world utilization (see Table 1). In contrast, ending stocks averaged 29.0 percent during the 1960s and reached 36.9 percent in 1968/69. Thus, it seems clear that the United States hopes to avoid the large stock accumulation of the 1960s and, unless the real price trend is unexpectedly adverse, has the policy instruments to achieve this.

The desire among exporters to avoid extensive stockholding to support prices is also demonstrated by the price/stocks relationship from 1976/77 to 1978/79. As shown in Figure 4, real prices in those years were as low or lower than in 1970/71 and 1971/72 when exporters were attempting to reduce their stock levels. They were considerably lower than in the 1960s when stockholding was used to support prices. These price patterns are another indication that stockholding behavior from 1976/77 to 1978/79 does not reflect a return to the pattern of the 1960s.

Because exporters have switched to other means of supporting producer prices and incomes, they will no longer hold larger stocks than would be profitable in a market economy unless they can identify other benefits from such additional stockholding.

If extreme world price variability stimulates increased efforts toward self-sufficiency among importers, exporters would gain in the long run from reduced variability, and this could justify increased stockholding by exporters. But such gains would be a collective good:[40] all exporters would benefit

[37]For summaries and comparisons of these studies, see International Bank for Reconstruction and Development, *Developing Country Foodgrain Projections to 1985*, World Bank Staff Working Paper No. 247 (Washington, D.C.: IBRD, November 1976); and U.S. Department of Agriculture, *World GOL Model*

[38]U.S. Congress, *Conference Report on Food and Agriculture Act of 1977*, Report No. 95-418, 95th Cong., 1st sess., 1977.

[39]See U.S. Government, *Federal Register*, December 1, 1978, p. 56252. It should be noted that the U.S. government chose a level of production control that would lead to the desired level of ending stocks assuming trend yields. However, the actual ending stocks would likely be above or below the desired level depending on actual yields, as well as on actual participation by producers in the government programs.

[40]On the theory of the provision of collective goods, see Mancur Olson, *The Logic of Collective Action* (Cambridge, Mass.: Harvard University Press, 1965).

regardless of how much they contributed. Thus, no exporting country would undertake individually as much stockholding as would be worthwhile collectively.[41]

A fourth factor affecting future stockholding stems from this consideration. The United States is likely to continue its FOR program to subsidize private stockholding. This program is expressly motivated by recognition of the potential gains from being a reliable supplier, but it is rather limited in size and will probably not bring about a significant increase in world stockholding.

Fifth and finally, the earlier point about the importance of correct information must be considered in projecting for the future. Lack of information or incorrect expectations about the policies of major market participants could lead to inefficient decisionmaking by others. For instance, if there is inadequate information about potential Soviet imports—either because data on the Soviet grain economy and its stock levels is not available or because the Soviet Union or the United States (under the bilateral agreement) make unpredictable administrative decisions—there could be substantial departures from the relatively stable stockholding pattern that otherwise should prevail.

The observed stock level for 1979/80 is consistent with the prediction that future stockholding will be above financially profitable levels but lower than the level of the 1960s. Based on May 1980 estimates, world production in 1979/80 fell to 419.6 million tons, world total supply to 525.5 million tons, and world ending stocks to 86.8 million tons. In 1978/79 trend equivalents, the observed ending stocks and total supply for 1978/79 were 81.2 and 508.4 million tons, respectively. On Figure 3 this new point lies slightly above the estimated relationship for the early 1970s but well below that for the 1960s. This supports the argument that the high stock levels for the years 1976/77 through 1978/79 do not indicate a return to the pattern of the 1960s.

[41] This explains the seemingly contradictory statements by the U.S. government. On the one hand, Secretary of Agriculture Bob Bergland promotes the FOR program as a means for the United States to be a reliable supplier and stimulate import demand; on the other hand, he protests that the United States will not become the "world's granary" and that other countries must also undertake stockholding.

4

IMPLICATIONS FOR A NEW INTERNATIONAL AGREEMENT

The pattern of stockholding predicted for the near future has both positive and negative features. On the positive side, there will probably be significant stockholding even without a new international agreement. Indeed, the pattern predicted indicates that the average level of stockholding will be higher than in the early 1970s, and thus there will be less price variability and less risk of high import prices to developing countries. Moreover, the pattern will be efficient in the sense that a substantial portion of world carryover stocks will respond to world supply and price levels. That is, given adequate information, carryover stocks held by exporters for commercial purposes will adjust efficiently to changing world market conditions. Finally, the holding of some carryover stocks by importing countries, especially during periods of short supply, will reduce the concentration of stocks in North America where transport constraints or administrative controls over exports may occur.

On the negative side, however, these carryover stocks held by importers may incur higher carrying costs than stocks held by exporters. More importantly, unanticipated policy shifts and incorrect information about stockholding behavior of major countries could continue to cause substantial departures from an efficient stockholding pattern.

On balance, the positive aspects seem to outweigh the negative ones. Reducing the risks of concentration of stocks in only a few countries probably justifies higher carrying costs incurred by importers. And, even if major governments fail to cooperate, participants in the world market can probably obtain reasonably good information about the wheat economies in those countries. Of course, increased efforts to exchange data and information about policies would improve the efficiency of stockholding decisions for the world as a whole.

Possible Benefits from Increased Stockholding

Despite this relatively encouraging assessment, the question remains whether there would be net benefits from a new policy to increase stockholding of wheat to reduce world price variability—that is, to bring about an upward shift in the stocks/supply relationship. If the predicted pattern is correct, in most years the world would achieve at least a level of stockholding that is financially profitable to the stockholders themselves. Additional stockholding would incur financial losses. Would these be justified by resulting social benefits?

Social benefits from increased stockholding could arise from two sources. First, increased stockholding might provide benefits to developing countries as a whole and especially to the poorest people within those countries. If so, the financial cost of increased stockholding could be borne by the developed countries as a means of international aid. Second, increased stockholding and reduced price variability may have beneficial effects on the long-run development of the world wheat economy. For example, they might encourage a more efficient trade regime. Although external to the calculations of private stockholders or even individual countries, these collective benefits could justify the financial cost of additional stockholding. However, it is extremely difficult to assess the magnitude and distribution of these possible gains.[42]

[42] It may also be argued that, as another benefit, price stability tends to encourage production by reducing producers' risks. However, it is assumed here that most countries pursue national policies to insulate farmer income from world price variability. Therefore, it is most relevant to consider the effect of world price variability on national policies rather than on farmers directly.

Benefits to Developing Countries

An increase in world carryover stocks could conceivably benefit developing countries by decreasing fluctuations in actual domestic food consumption and/or by decreasing the variability of food import costs.[43] This would decrease the frequency with which poorer groups face acute malnutrition and reduce the risk that food imports could be made only by cutting back on the import of capital goods.

Alberto Valdés and Panos Konandreas have studied the contribution of fluctuations in world wheat price to the variability of food import costs for developing countries from 1965 to 1976 and also the extent to which fluctuations in food import costs strained their foreign exchange resources.[44] They show that there was considerable diversity among developing countries. For many countries fluctuations in their own production, not fluctuations in the world price, were the major source of variability of food import costs. For such countries the cost of imports would vary greatly regardless of the stability of the world price. In these cases adequate financial capacity to vary import expenditures—rather than stability of world price—is necessary to stabilize domestic prices and consumption. They also show that the effect of fluctuations in food import costs on the overall balance of payments varies greatly among countries (see Table 13). For some countries, such as Libya, Nigeria, Colombia, and Guatemala, even the maximum observed foodgrain import costs were less than 5 percent of total export revenue. For others, such as Bangladesh, India, and Sri Lanka, the maximum cost exceeded 40 percent of revenues. In summary, their work indicates that reduced world wheat price variability would have

Table 13—Ratio of food imports to total export revenue for selected countries, 1965-76

Country	Mean	Maximum
	(percent)	
Asia		
Bangladesh[a]	88.4	119.4
India[b]	22.4	44.5
Indonesia	9.5	19.9
Korea, Republic of	13.5	21.4
Philippines	4.9	9.1
Sri Lanka	27.2	49.2
North Africa/Middle East		
Algeria[c]	6.0	9.3
Egypt[d]	14.0	27.0
Jordan[d]	10.6	15.4
Libya[d]	1.4	2.3
Morocco	7.0	13.4
Syria[d]	5.7	18.4
SubSaharan Africa		
Ghana[d]	3.7	5.4
Nigeria[d]	1.9	2.5
Senegal[b]	12.2	17.8
Tanzania[d]	5.5	22.2
Upper Volta[e]	7.4	13.0
Zaire[c]	3.1	6.9
Latin America		
Brazil	3.9	8.5
Chile	5.3	13.9
Colombia	2.8	4.9
Guatemala	2.4	3.3
Mexico	0.4	9.3
Peru	6.6	10.5

Source: Alberto Valdés and Panos Konandreas, "Assessing Food Security in Developing Countries," in *Food Security in Developing Countries*, ed. Alberto Valdés (Boulder, Col.: Westview Press, forthcoming).

[a] The time period of analysis is 1973-76.

[b] The time period of analysis is 1965-75.

[c] The time period of analysis is 1966-76.

[d] The time period of analysis is 1967-76.

[e] The time period of analysis is 1968-75.

[43] Assuming the average price of imports is not changed, the average import costs to developing countries would not be changed by increased stockholding. The change in the expected value of social surplus in developing countries cannot be established confidently but is likely to be small. The extensive theoretical literature as summarized by Turnovsky indicates that the distribution of gains and losses depends on actual market parameters (Turnovsky, "Distribution of Welfare Gains"). Sarris' model is the most comprehensive effort to estimate these parameters, but his results are based largely on the assumption that demand functions have constant elasticity. (Alexander H. Sarris, "The Economics of International Grain Reserves" [Ph.D. dissertation, Massachusetts Institute of Technology, 1976]). He also notes that for countries that partly or completely insulate domestic prices from world market fluctuations, changes in world price variability affect the import bill or export revenues but not consumer or producer surplus. Gardner also suggests that changes in expected social surplus from increased price variability are small in absolute terms (Gardner, *Optimal Stockpiling*, pp. 85-88).

[44] Alberto Valdés and Panos Konandreas, "Assessing Food Insecurity in Developing Countries" in *Food Security for Developing Countries*, ed. Alberto Valdés (Boulder, Col.: Westview Press, forthcoming).

substantially reduced risks for only a subset of developing importing countries for which world price variability rather than domestic production variability is a major source of fluctuation of food import costs and the fluctuation of food import costs is large relative to the capacity to finance imports. This has been—and will probably continue to be—a rather limited number of countries. Among the 24 countries for which Valdés and Konandreas report results, there were only 3 (Sri Lanka, Egypt, and Senegal) for which price fluctuations accounted for more than 25 percent of food import cost variability and the maximum ratio of food import costs to total export revenue exceeded 15 percent. This suggests that specific measures to improve the financial capacity of developing countries to import would be a more viable means to enhance food security than a policy to reduce world wheat price variability because such assistance could be targeted to those countries that require it any given year.

This financial capacity would be useful only if developing countries have access to supplies in the world market. Neither international guarantees against export controls, which are very weak, nor quantitative commitments for food aid under the Food Aid Convention, which amount to only a fraction of developing country imports, are adequate to assure such access. However, if the prediction about future stockholding is true, there is a high probability that access to commercial markets will remain open. Thus strengthening the capacity of developing countries to finance imports could indeed help redistribute world supplies to the most needy countries.[45]

Thus an international agreement designed to increase world carryover stocks above predicted levels and reduce world wheat price variability would be of positive but limited value to developing countries as a whole. To improve food security, international aid priorities should probably be directed to providing financial assistance to those developing countries that need help to finance imports in particular years.

An improved capacity to hold intraseasonal and working stocks may also be important to food security for many developing countries. Unlike world carryover stocks, these stocks would not be accumulated and released in response to world price fluctuations. They are held partly to compensate for inadequacies in national transport and information systems, and their efficient level is independent of the level of world carryover stocks.

Beneficial Effects on Evolution of National Policies

A high degree of price variability in the world market probably has a deleterious effect on the evolution of national policies. Three plausible examples follow. First, world price variability could have a "ratchet effect" on effective rates of protection. High prices may induce increased levels of protection among both importing and exporting countries, whereas low prices may not induce corresponding decreases. Thus in time world price variability could lead to more trade barriers and increased departures from trade based on comparative advantage. Second, world price variability may drive countries to insulate their domestic prices more fully from world price fluctuations, stabilizing domestic prices but destabilizing traded quantities. Because such insulation only increases world price variability, this is a self-aggravating process in which the world market and those few national markets that are not insulated must bear an increasing burden of adjustment to supply fluctuations. The world market thus becomes less reliable. Third, world price variability and the attendant insecurity of import supplies may compel developing countries to avoid policies to improve the consumption levels of the poor for fear that these levels could not be sustained in a year when world supplies are short.

Unfortunately, the last three decades do not provide much opportunity for empirical

[45] Availability of supplies to the most needy countries also would be improved by a greater willingness among developed countries to share the burden of reduced consumption during world shortages. Because the demand for wheat for human consumption is so inelastic in developed countries, the largest potential for cutbacks lies in the use of wheat for livestock feed, especially in the United States, the European Economic Community, and the Soviet Union. The extent to which the insulation of developed countries from the world wheat market imposes a burden on developing countries is analyzed by Tim Josling in *Developed-Country Agricultural Policies*

tests of the impact of world price variability on national policies. Prices were unstable only during the first part of the 1970s, and for many countries there were important intervening circumstances at that time. Therefore, empirical evidence is likely to be inconclusive. For example, to test the hypothesis that world price variability has a ratchet effect on rates of protection as reflected in part by national support prices, the relationship between changes in the national support prices for 30 countries and changes in the world wheat price from 1963 to 1977 was examined.[46] If a ratchet effect existed, there would have been a sharp increase in support prices in response to the increases in the world wheat price in 1973/74 and 1974/75 that were not matched by a decrease in response to the decline in the world wheat price in 1975/76 and 1976/77. Although such a pattern was clearly observed in nominal support prices, the pattern of real prices varied considerably among countries. In most cases the rapid inflation of the mid-1970s eroded the value of the increased nominal support prices. It is plausible that there would have been a more noticeable ratchet effect if the surge in inflation, which was due only partly to grain prices, had not been as pronounced, but as it was the statistical evidence is weak.

Nevertheless, the potential welfare consequences of such effects on the evolution of national policies and hence on world market structure could be important. For example, if world price variability has a ratchet effect on the support prices among importing countries or in other ways induces those countries to increase their efforts to reduce long-run import requirements, the growth of the export market would be retarded. In this way world price variability could significantly reduce long-run export revenues for the producers in the exporting countries. It can be readily shown that even a modest decline in the rate of growth of import demand would cause losses to exporting countries far in excess of the direct losses from reduced world price variability as estimated by some researchers.[47] Thus, if world price variability tends to discourage growth of import demand, exporting countries would benefit from a policy to reduce price variability through increased international stockholding.

In view of the complexity of the issue and the lack of statistical evidence, however, it is unlikely that a consensus on the magnitude or distribution of benefits to the world wheat economy can be achieved.

Implications for an Agreement

On balance there would probably be net social benefits from an international agreement designed to bring about increased stockholding of wheat and reduced world price variability, but unless empirical evidence is developed to define the extent of the gains, it is not likely that such an agreement can be attained.

However, if negotiation of a stockholding agreement is again attempted, its objective should be a modest, rather than substantial, upward shift in the stocks/supply relationship. An increase in stockholding above the level that would otherwise prevail should be modest because the net social benefits are uncertain and probably limited. For the following reasons, the appropriate means for accomplishing this should be a buffer stock with a wide price band and a relatively large total capacity.

Although the objective should be to bring about an upward shift in the stocks/supply relationship for the world as a whole, it would not be feasible to do so by placing all stockholding under the international agreement. As discussed in Chapter 2, the marginal adjustments required to maintain an efficient level of total stocks and an efficient distribution of that total among countries in response to the distribution of production fluctuations and storage capacities are far too complex and competitive to be managed by a single international agency under a set of rules. Instead the international

[46] For details, see Daniel Morrow, "The Economics of International Stockholding of Wheat" (Ph.D. dissertation, Harvard University, 1980).

[47] Sarris estimated that a 32 percent reduction in price variability would reduce annual average earnings of the major exporting countries by $41.8 million. Under conservative assumptions, a one-time increase of 1 percent in the average domestic support price among importing countries would cause annual average losses of over $200 million (Sarris, "Grain Reserves"). Also see Morrow, "International Stockholding."

agreement must be conceived as a marginal element of cooperation—intended to capture collective benefits—superimposed on the independent and often competitive stockholding undertaken for private or national benefit. That other stockholding will encompass commercial stocks, including private speculative stockholding, held primarily in exporting countries on a profit-seeking basis. It may also include stocks held in importing countries such as India that are managed primarily in response to fluctuations in national production, not world price. These independent stockholding decisions should be relied on to make the necessary marginal adjustments because the international agreement itself would necessarily be too crude an instrument to oversee all of them. But a buffer stock intended to place only a portion of carryover stocks under the management of price band rules would be a feasible mechanism for an international agreement.

To ensure that the buffer stock brings about a net increase in world stockholding, the range between the accumulation and release prices must be rather wide, and the maximum buffer stock obligation must be sufficiently large to compensate for the fact that not all of the stock held under the agreement would actually be additional to what would otherwise be held.[48] These two criteria reflect the general principle that the rules for the international agreement must be different from the rules for managing stocks that countries are likely to pursue independently. If they are not different, countries could participate in the international agreement without behaving differently than they otherwise would. Thus, the world wheat economy—the pattern of stockholding and price variability—would not change. As noted in Chapter 2, a wide price band for the buffer stock is necessary to bring about an upward shift in total stockholding. Because the stocks under the international agreement would nonetheless partly displace stocks that would otherwise be held, the total buffer stock obligation should be somewhat large even though its net contribution to world stockholding would be rather modest.

In addition an international agreement should include other measures. It has been shown that uncertainty about policies of major countries, failure to provide data about stocks or other key aspects of the wheat economy, insulation of national markets, and the use of production and export controls have contributed significantly to increased price variability and inefficient stockholding decisions. Thus an agreement should include provisions to ensure consultations about national policies, require exchange of data, restrain policies to insulate national markets (especially during periods of world market stress), and limit the use of production and export controls.

Finally, given the difficulty in negotiating an international agreement on stockholding and the modest contribution that any such agreement could make to helping developing countries stabilize their food consumption, it is important to pursue other means to provide necessary assistance. International aid programs should be designed to improve the capacity of developing countries both to finance imports and to manage their own stocks efficiently.

[48] D. Gale Johnson has called attention to this issue: "Most discussions of international grain reserve schemes ignore the extent to which the reserves so held or controlled simply substitute for reserves that would otherwise have been held. Thus, if an agreement were reached that a group of countries would agree to create a reserve of a given size, say 50 million tons, the increase in world grain reserves would only be a fraction of this. American and Canadian experience indicates that governmentally held reserves replace most privately held stocks. Stocks held pursuant to an international agreement would substitute quite directly for stocks held by at least some governments. Consequently, the size of reserves that resulted from an international agreement might add relatively little to world grain stocks until the amount of such reserves became very large." (D. Gale Johnson, "Limitations of Grain Reserves in the Quest for Stable Prices," *World Economy*, June 1978, pp. 289-299.)

APPENDIX

METHODOLOGY USED TO ADJUST DATA FOR THE GROWTH TREND AND TO CALCULATE MINIMUM WORKING STOCK LEVELS

Adjustment of Data on Ending Stocks and Total Supply

Because of the growth trend in production and consumption of wheat, ending stocks must grow in any year in absolute terms in order to remain a constant percentage of production or consumption. To describe an optimal storage rule in a way that can be applied to any year, Gardner and others have calculated carryover stocks and total supply as a percentage of mean production in that year. To provide a description of the historical stocks/supply relationship that is not distorted by trend growth and to allow comparison of this historical relationship to that estimated by Gardner, the actual data is adjusted as follows. Beginning stocks and production in each year are calculated as a fraction of trend production (logarithmic) in that year. Total supply as a fraction of trend production in that year is then the sum of the fractions for beginning stocks and production. Ending stocks as a fraction of trend production are equal to beginning stocks as a fraction of trend production from the previous year. To facilitate comparison with the current world wheat economy, these results for ending stocks and total supply as a fraction of trend production in each year are then expressed in 1978/79 equivalents; that is, each fraction is multiplied by the absolute figure for 1978/79 trend production (420.5 metric tons). These adjusted data are shown in Table 14 below and Figure 3.

Calculation of Minimum Working Stocks

To make Gardner's estimates for optimal stockholding in a unified world market comparable to the trend-adjusted data in Figure 3, it is also necessary to estimate minimum working stocks for the world as a whole in 1978/79. For this purpose, it is assumed that the minimum working stocks for the world as a whole is the sum of minimum working stocks in each major country or region. It is further assumed that at some time since 1960/61 each major country/region has reached its minimum working stock levels. Therefore, consistent with the definition of minimum working stocks in Chapter 2, the minimum working stock level as a percentage of market volume (production for exporters and utilization for importers) is estimated to be equal to the lowest observed level of ending stocks as a percentage of market volume for each major country/region. Table 3 in the main text shows ending stocks of wheat for seven major countries and the world as a whole

Table 14—World production, ending stocks, and total supply of wheat adjusted to 1978/79 trend equivalent, 1960/61 to 1978/79

Year	World Production	World Ending Stocks	World Total Supply
	(million metric tons)		
1960/61	430.5	134.7	564.0
1961/62	394.1	110.4	528.8
1962/63	430.1	114.1	540.5
1963/64	387.2	100.7	501.3
1964/65	433.3	114.0	534.0
1965/66	403.6	83.5	517.6
1966/67	457.0	119.2	540.4
1967/68	425.2	124.0	544.4
1968/69	454.8	152.2	578.8
1969/70	415.3	125.2	567.6
1970/71	409.5	91.9	534.8
1971/72	438.2	97.5	530.1
1972/73	417.4	75.2	514.9
1973/74	438.5	80.0	511.7
1974/75	406.9	70.2	487.0
1975/76	386.1	67.3	456.3
1976/77	443.0	101 7	510.4
1977/78	394.0	82.3	495.7
1978/79	447.8	102.7	530.1

Source: Derived from U.S. Department of Agriculture, Foreign Agricultural Service, "Foreign Production, Supply, and Distribution of Agricultural Commodities Tape," Washington, D.C., 1979.

since 1960/61. Based on the assumptions and procedure just described, Table 15 shows the estimated minimum working stocks for those countries, for the Rest of the World as an aggregate, and for the world as a whole.

The considerable differences among countries can be attributed to several factors. Most importantly, the difference between the end of the statistical crop year (when ending stocks are estimated) and the time at which wheat from the new crop is in position for export or processing in major consuming areas will vary among countries. For example, Canada's statistical crop year ends on July 31, whereas harvests occur in August and September; the new wheat crop cannot reach export position until some time thereafter. Thus, Canada's ending stocks on July 31 must include stocks to be consumed and exported for the two months or so until the new crop is available. But for other major countries, the gap between the end of the statistical crop year and the availability of new crop wheat is shorter. Thus, their ending stock figures include a higher percentage of interseasonal, in contrast to intraseasonal, stocks. Other differences in minimum working stock levels among countries result from differences in reporting systems and data availability. For example, some countries may have incomplete data on on-farm stocks. Finally, some differences would be expected among different marketing systems. For instance, in those countries that experience consistent interruptions in the transportation network, millers may prefer to hold larger working stocks.

Based on the estimate from Table 15 that world minimum working stocks equalled 43 million tons in 1978/79, Gardner's estimate of ending stocks as a function of total supply in a unified world market can be written approximately as follows: WOET = −267.5 + 0.67 WOST. As a basis of comparison, Gardner's results for the case of no supply elasticity and no external costs were used, and perfect rather than approximate linearity was assumed.

Table 15—Estimated minimum working stocks, 1960/61 to 1978/79

Country	Lowest Observed Percentage of Trend Volume[a]	1978/79 Trend Volume	Minimum Working Stocks for 1978/79
		(million metric tons)	(million metric tons)
United States	19.5 (1973/74)	54.9	10.71
Canada	46.0 (1974/75)	18.6	8.56
Australia	5.5 (1972/73)[b]	12.3	0.68
Argentina	6.0 (1978/79)[c]	7.3	0.44
European Economic Community	14.0 (1977/78)[d]	44.5	6.23
India	9.0 (1974/75)	33.1	2.98
Soviet Union[e]	0.0	. . .	0.00
Rest of the world[f]	6.9 (1970/71)	194.2	13.40
Total			43.00

Source: Derived from data in Table 3.

[a] Each of these figures is the lowest observed value for ending stocks as a percentage of logarithmic trend of production for exporters or utilization for importers (1960/61 to 1978/79).

[b] The figure of 5.38 percent was rounded upward because ending stocks in 1972/73 were 8.6 percent of Australia's current production.

[c] Several times before 1973/74, Argentina's minimum working stocks fell below 6.0 percent, but early Argentine data on stocks is poor. For 1977/78 and 1978/79, the figures were 6.9 percent and 6.8 percent respectively.

[d] Based on trend production.

[e] Because reported ending stocks were zero in 1961/62 and 1.0 million metric tons in 1977/78, it is assumed that reported data are in fact in excess of minimum working stocks.

[f] For this purpose, the world minus the seven countries listed above is treated as a unit.

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