# U.S. GRAIN RESERVES POLICY: OBJECTIVES, COSTS, AND DISTRIBUTION OF BENEFITS

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R-2087-RC
FEBRUARY 1977

Rand
SANTA MONICA, CA. 90406

This research was supported by The Rand Corporation as part of its program of public service.

Published by The Rand Corporation

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# PREFACE

This report was prepared with research funds set aside by The Rand Corporation to support projects for which outside support is inappropriate or unavailable. The present project—an examination of the economic rationale for U.S. Government intervention in private grain storage—provided research findings to the National Commission on Supplies and Shortages. The work builds upon earlier Rand research on grain stockpiling for the White House Council on International Economic Policy.

# SUMMARY

This report examines the economic rationale both for and against U.S. Government intervention in private grain storage, and simulates some of the costs and effects of intervention. The major conclusions of the report are that, in general, a free market provides the optimal level of price stability, and that government intervention in grain storage can be justified only to incorporate nonmarket externalities or to correct noncompetitive behavior by the private market.

Because private storage activity already appears to be highly competitive, there is no need for government intervention to promote competition. Assuming that prices reflect social opportunity costs, profit-motivated storage can be expected to provide the socially optimal level of stocks as protection against uncertainty in grain production and demand. In that case, government intervention for the sole purpose of stabilizing prices would be needless. Distortions in the storage market introduced by domestic agricultural policies and by a possible divergence between social and private discount rates are found to be insufficient justifications for government intervention to increase grain stocks. Stockpiling would not be anti-inflationary, in our view.

To the extent that grain stock policy influences food aid policy and national diplomatic objectives, intervention in the storage market is justified to account for these externalities. We leave for policymakers the task of weighing their evaluations of these externalities against the costs to determine how much intervention is desirable.

Leaving aside the externality benefits, we simulate the costs to world welfare, U.S. welfare, and the U.S. taxpayer of stabilizing grain prices through subsidization of private storage. Although private storage operating without subsidy already eliminates most of the variability in grain prices due to fluctuations in demand and supply, subsidization would further stabilize prices. Among other effects, price stabilization reduces U.S. export earnings, since much of the price variability originates from demand uncertainty abroad.

We discuss the effect of government-held stockpiles on private sector storage and suggest that subsidization of private storage is preferable to government stockpiling as a way to increase overall stock levels. We examine the distribution of benefits between producers and consumers from a government subsidized price stabilization program, and conclude that most benefits go to consumers, particularly foreign consumers and meat-eaters. This welfare analysis ignores the externality benefits and the subsidization and storage costs, which must be accounted for separately. Price stabilization may raise or lower the mean price level; the resulting welfare effects could dominate the other effects of price stabilization.

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# I. INTRODUCTION

The trebling of U.S. grain prices from mid-1972 to mid-1974 has renewed interest in government intervention into private stockpiling. At the 1974 World Food Conference in Rome, representatives from more than 120 nations endorsed a proposal calling for an internationally coordinated system of nationally held grain stocks. Since the Rome Conference, the executive branch of the U.S. Government has debated forms of intervention ranging from subsidization of private storage of grain to government ownership of grain stocks. This report discusses the economic elements in that policy debate, primarily from the U.S. perspective.

We take the activity of the private market for grain storage as a policy baseline, because we believe that government intervention in grain storage can be justified only to (1) correct noncompetitive behavior by the private market, or (2) incorporate nonmarket "externalities."

In Sec. II we examine many arguments for and against government intervention. Intervention to enhance competition in private grain storage appears to be unwarranted. The limited evidence available suggests that this market is already competitive. We classify various types of market externalities, seeking to identify the full range of possible objectives for government intervention in this market. Also, we try to debunk a number of arguments for government intervention which, in our view, are logically incomplete or depend on unwarranted assumptions. Section III analyzes the economic costs and effects of various degrees of government intervention in the grain storage market. We leave it to policymakers to judge the desirable level of government intervention by weighing the economic costs and effects against their own estimates of the value of the externality benefits. Section IV concludes the analysis.

# II. THE CASE FOR AND AGAINST GOVERNMENT INTERVENTION

Both economic and political justifications have been offered for government intervention in the grain storage market. The economic arguments pertain to the promotion of efficiency; they emphasize competitiveness of storage markets, distortions in cash grain markets, and potential differences in public and private discount rates. In discussions with government officials, a number of political arguments emerged for increased grain stockpiling.[1] Proponents of intervention advocated increased grain stocks to stabilize grain prices, to facilitate food aid, to reduce inflation, and to further U.S. diplomatic objectives in the international arena.

## THE COMPETITIVENESS OF PRIVATE STORAGE

The entire grain sector in the United States, including the grain storage market, is generally considered to be among the most competitive of U.S. sectors. Competition in that market requires that the following conditions prevail, as they apparently do:

(1) Many storers supply grain storage, and many traders demand storage space.
(2) The grain storage services of different firms in the industry are substitutable.
(3) There are no barriers to entry or exit from the storage business.
(4) Units operating in the market have access to information about current and expected future grain production, consumption, and stocks.

The distribution of ownership of storage space in the United States indicates that its supply is spread over a large number of firms, and farmers store a large share of U.S. grain stocks on their farms. During the 1967-68 to 1975-76 period, approximately one-third of the wheat stocks, two-thirds of the corn stocks, three-fifths of the barley stocks, two-fifths of the oat stocks, and one-fifth of the sorghum grain and rye stocks carried over at the end of the year were stored on the farm.[2]

Off the farm, as of early 1975, grain storage capacity was nearly 6 billion bushels. We have detailed ownership information, however, only on the 1.1 billion bushels of official terminal and port storage capacity owned by multiple-elevator companies (where official weights and grades are certified). The three largest companies owned 362 million bushels, or 34 percent, of this official capacity; the remaining 68 percent was divided among 46 companies, each of which owned less than 65 million bushels of capacity.[3] The remaining 5 billion bushels of off-farm storage space are in country

[1] Discussions took place in the fall of 1975 with officials of the Council on International Economic Policy, the Council of Economic Advisors, the Departments of Agriculture, State, and Treasury, the Bureau of Management and the Budget, and the Office of the Special Representative for Trade Negotiations.

[2] Commodity Research Bureau, Inc., *Commodity Year Book 1975*, Harry Jiler (ed.), New York, 1975.

[3] *Milling and Grain Directory, 1975*, Sosland Companies, Kansas City, Mo., September 1975, pp. 153-164. The official storage capacity owned by the Bunge Corporation is not indicated.

elevators and official capacity owned by single-elevator companies. Apparently, the share of grain storage capacity owned by the few largest firms is quite modest, by the standards of market concentration used in the industrial organization literature.[4]

This competitiveness is further documented by economic studies regarding cash and futures-price relationships.[5] An analysis of the structure of open interest in corn futures on January 27, 1976 by the Commodity Exchange Authority[6] revealed the presence of 13,024 individual accounts. Of these, 2,002 were trade-associated, held by merchants, warehousemen, processors, feed manufacturers, etc., and 11,022 were held by individuals in a wide range of occupations unrelated to the grain trade. The geographic distribution was worldwide, involving all states of the United States and 25 foreign countries.

In the short run, storage facilities in different locations may not be perfectly substitutable because shipment of grain from one location to another takes time and money. Occasionally, individual elevator companies may be able to influence the price of storage in a particular region, but in the longer run, storage facilities located elsewhere can perform the same function and can be considered homogeneous with the rest.

The possibility of moving grain in or out of bins and elevators facilitates the movement of resources in and out of the storage business. Financing arrangements make grain storage investments particularly liquid. Grain may be purchased for storage on margins of less than 10 percent with loans at prime rates of interest, provided the inventories are offset by short positions in futures markets.[7]

Information regarding current and anticipated supply and demand conditions, stock levels, and government policies is available from the USDA, the individual grain market associations, and private reporting services. The equal access to these principal sources of market information by all buyers and sellers contributes to the competitiveness of the market. The uncertainty of grain demand and supply does not detract from this competitiveness, since all buyers and sellers share equally in this uncertainty.

We interpret the above evidence as showing that the private market for grain storage is competitive. In a competitive market, private storers accumulate stocks until the value of storing one more bushel for sale in a future period, and paying storage costs, would be expected to be less than the value of selling that bushel in the present period. Gustafson's empirical study of U.S. grain stockpiling during the 1901-1950 period demonstrates that private storers in the aggregate held approximately the stock levels generated by the above storage rule.[8]

[4] See George Stigler, *The Organization of Industry*, Irwin, Homewood, Ill., 1968, Chaps. 4, 13.

[5] For example, see Holbrook Working, "Speculation on Hedging Markets," *Food Research Institute Studies*, May 1960; Roger Gray, "Fundamental Price Behavior Characteristics in Commodity Futures," *Futures Trading Seminar*, Vol. III, Mimir, Madison, Wis., 1966, pp. 71-99; Paul H. Cootner, "Speculation and Hedging," *Food Research Institute Studies*, Supp. to Vol. VII, 1967, pp. 65-105; Katherine Dusak, "Futures Trading and Investor Returns: An Investigation of Commodity Market Risk Premiums," *Journal of Political Economy*, Vol. 81(6), December 1973, pp. 1387-1406; and Walter C. Labys and C.W.J. Granger, *Speculation, Hedging and Commodity Price Forecasts*, D. C. Heath, Lexington, Mass., 1970.

[6] Commodity Exchange Authority, "Trading in Corn Futures, September 1966-March 1967," U.S. Department of Agriculture, 1967.

[7] For a discussion of financing arrangement in grain futures markets, see Thomas A. Hieronymus, *Economics of Futures Trading*, Commodity Research Bureau, New York, 1971, pp. 129-135.

[8] Robert L. Gustafson, *Carryover Levels for Grains*, U.S. Department of Agriculture Technical Bulletin No. 1178, Washington, D.C., 1958.

The socially desirable level of stocks equates the marginal social returns to marginal social costs from additional stockpiling. Gustafson and Meade[9] have separately shown that competitive storage markets accumulate socially optimal stocks when spot market prices reflect the social opportunity cost of grain (no distortions in the cash grain market) and when private interest rates reflect the social opportunity cost of capital.

As Gustafson shows, efficient stockpiling of any commodity can be described by a storage rule that specifies the optimal stock in any period ($S_t^{OPT}$) as a function of the commodity's price ($P_t$), the per unit cost of storage (s), a discount rate (r), and some parameters to characterize the uncertainties in demand and supply ($\sigma_s, \sigma_d$):

$$S_t^{OPT} = f(P_t, s, r, \sigma_s, \sigma_d) \quad (1)$$

Price and optimal stock level are uniquely related, so price can be expressed as an implicit function of optimal stock level:

$$P_t^{OPT} = g(S_t, s, r, \sigma_s, \sigma_d) \quad (2)$$

Prices may at times reach very high or low levels and still satisfy the socially optimal conditions of Eq. (2).

The welfare cost of nonoptimal stockpiling is most easily examined in terms of the welfare cost of divergences between $P_t$ and $P_t^{OPT}$. There are analogous costs for both producers and consumers, but we illustrate these costs only for consumers.

Gustafson derived $P_t^{OPT}$ by equating the discounted expected values of marginal units of the commodity in various periods, accounting for storage costs. $P_t^{OPT}$ equals the present value of storing the marginal unit for use in a later period, and so $P_t^{OPT}$ is the "opportunity cost" and the marginal value of the commodity in each period, even when $P_t \neq P_t^{OPT}$. Since $P_t^{OPT}$ is the opportunity cost, $Q_t^{OPT}$ is the efficient consumption level.

In Fig. 1, if the prevailing price is $P_t^1$ (above $P_t^{OPT}$) consumption is too low and a net loss of ABC occurs in consumer surplus. ($P_t^1ABP_t^{OPT}$ of consumer surplus is transferred to producer surplus but has no net welfare effect.) If the prevailing price is $P_t^2$, consumption is too high and a net loss of CEF occurs in consumer surplus.

$P_t^{OPT}$ varies with the business cycle and other sources of disturbance to the economic system. If observed prices swing more widely than $P_t^{OPT}$, there is excessive instability and if they do not swing as much, there is excessive stability. The costs of deviations from the optimal degree of price variation (or of incorrect pricing generally) are the sums of areas like ABC and CEF over time. The benefits of allowing $P_t$ to equal $P_t^{OPT}$ are not benefits from price stabilization, but efficiency gains achieved by assuring that market price and storage quantity do not deviate from the price/stock relationship achieved by an optimal stockpiling rule.

## DISTORTIONS IN THE CASH GRAIN MARKET

Government policy is the primary source of distortions in the spot market for grain. Past price support programs, acreage diversion schemes, export subsidies, and

[9] James E. Meade, "Degrees of Competitive Speculation," *Review of Economic Studies*, Vol. 17, No. 44, 1949-50.

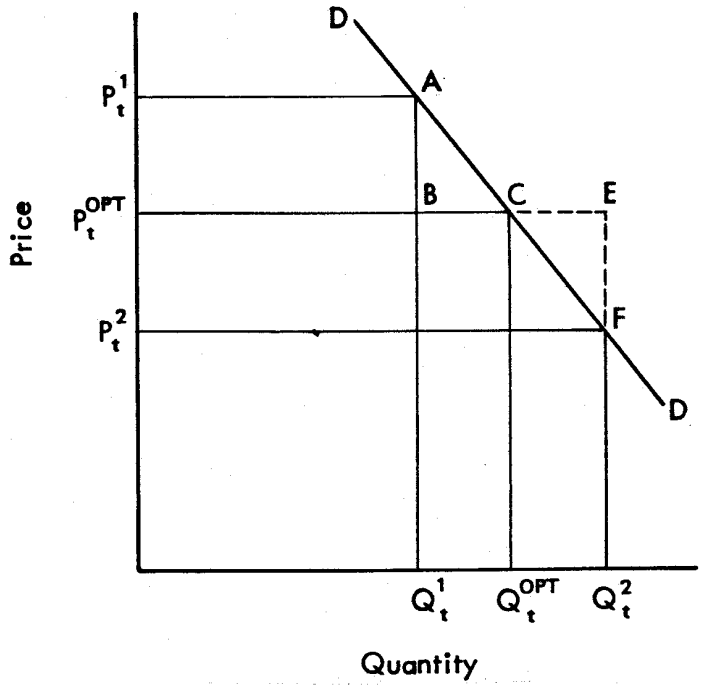


Figure 1

export controls led spot prices to differ from the social opportunity cost of grain production. The presence of such distortions, however, need not justify an offsetting intervention to increase grain stocks.

The most efficient policy is to withdraw the government distortions in the spot market. This policy has been generally followed since the early 1970's. Price support levels are currently well below market prices. Acreage diversion and export subsidization programs were suspended following the 1972 increase in grain prices.

Even if distortions in spot markets return, second-best arguments for offsetting intervention in the storage market depend, as always, on the nature of the distortion. In general, subsidies in the spot market lead to an overaccumulation of grain stocks by private storers.[10] Thus, spot market subsidization justifies an offsetting tax, rather than subsidy, on private storage.

[10] A simple two-period model illustrates this proposition. Suppose that a bountiful harvest precedes a lean harvest, the market prices being $P_B$ and $P_L$, respectively. Let the physical per unit cost of storage be C, and the rate of interest r. Private storage yields the following relationship between the market prices:

$$P_L - P_B = rP_B + C$$

The left-hand side of the equation is the private marginal benefit from storage; the right-hand side is the private marginal cost of storage.

Suppose a specific per unit production subsidy, $S_B$ and $S_L$, were offered during the bountiful and lean periods. The social opportunity cost of grain would be $P_B + S_B$ and $P_L + S_L$ during the bountiful and lean periods, respectively. Socially optimal storage would yield the following relationship:

$$(P_L - P_B) + (S_L - S_B) = (P_B + S_B)r + C,$$

where the left-hand side is the social marginal benefit from storage, and the right-hand side is the social marginal cost of storage.

Marginal private benefit exceeds marginal social benefit by $(S_B - S_L)$ and marginal private cost is below marginal social cost by $rS_B$, so the net subsidy to private storage is $S_B(1 + r) - S_L$. A subsidy in

## DIFFERENTIAL GOVERNMENT AND PRIVATE SECTOR DISCOUNT RATES

Sometimes it is argued that private storers provide suboptimal storage because the private sector discount rate is higher than the social discount rate.[11] This divergence is argued to exist either because the government acts as a trustee for future generations, and, therefore, has an obligation to use a lower discount rate than private storers use, or because the private sector does not diversify risks as well as government can.

The government can best protect the interests of future generations by inducing increased savings and investment throughout society, not merely in a handful of areas such as grain stockpiling. If the government subsidizes investment in stockpiling but not other investments, some investment money will be channeled into grain stockpiling and away from other investments that would pay higher rates of return. If that happens, less wealth will be available in the future than if the most profitable investments were undertaken in each period. On efficiency grounds, future generations will be better served by enforcing a lower discount rate on all investments, rather than only on selected stockpiling.

There is no general agreement as to whether the private or the public sector is better able to diversify risk. First of all, the risks of private investments in grain stockpiles are already diversified through the commodity markets for the various grains and through the stock market, where equity shares of firms owning stockpiles of grain are traded. Second, it is not clear that risks are diversified in the public sector. If policymakers consider government projects on a case-by-case basis, then investment decisions might not sufficiently incorporate the possibility for risk diversification. In sum, this issue being unresolved, we believe the possibility of a divergence between private and social discount rates is not a strong premise on which to base government policy.

## GRAIN STOCKS FOR PRICE STABILITY

The profit incentives that lead to private storage are independent of the underly-

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the spot market reduces the private below the social marginal cost of storage because the subsidy during the bountiful year reduces the amount of financial capital invested per bushel of grain stored. Meanwhile, the difference between the social and private marginal benefit from storage depends upon the nature of the spot market subsidy. If the subsidy is the same in both periods, then social and private marginal benefits are identical, and the net subsidy to private storage is $rS_B$. If the subsidy is higher during the bountiful than the lean harvest, as was the case with previous export subsidization, then $(S_B - S_L)$ is positive. The lower private storage cost and higher private storage benefit lead private storers to overaccumulate grain.

[11] Prominent economists have based their support of government intervention in commodity storage markets on the supposition that government can diversify risks that the private sector cannot. This argument was advanced as early as 1938 by Keynes and as late as 1967 by Houthakker. (See J. M. Keynes, "The Policy of Government Storage of Foodstuffs and Raw Materials," *The Economic Journal*, Vol. 68, September 1938, pp. 449-460, and idem, "The International Control of Raw Materials," *Journal of International Economics*, North-Holland Publishing Co., Amsterdam, Vol. 4, 1974, pp. 299-315; and Hendrik S. Houthakker, *Economic Policy for the Farm Sector*, American Enterprise Institute for Public Policy Research, Washington, D.C., 1967.) But these authors posit rather than analyze this supposition, and they ignore both the private sector opportunities for diversification of storage risks and the limitations of risk diversification by the government. Our discussion in the text agrees with Jimmye Hillman, D. Gale Johnson, and Roger Gray, *Food Reserve Policies for World Food Security: A Consultant Study on Alternative Approaches*, Food and Agriculture Organization, United Nations, ESC:CPS/75/2, January 1975, p. 2, who find "unconvincing" the risk-diversification argument for government intervention.

ing source of price variability. Price fluctuations may be due to unavoidable fluctuations in weather and natural events, changeable buying habits of centrally planned economies, rigidities in world trade that prevent production shortfalls from being dissipated throughout world grain markets, or policy changes by the U.S. Government.[12] But once the instability, uncertainty, or structural shift is reflected in spot and future prices, the actual source of instability is no longer directly relevant for determining desirable stock policies. If trade liberalization or commodity agreements could reduce the instability in U.S. grain markets, then such measures might be pursued. But grain stock policies should be considered on their own merits, taking market fluctuations as given.

As we have indicated, when grain is stored by a competitive private storage market, some price and consumption fluctuations remain. There is a persistent argument that additional redistribution of grain from bountiful to lean years benefits consumers and producers and justifies government intervention to increase price stability beyond the level generated in the private market. If the demand schedule is stable, price stability leads to consumption stability.

This "stability for stability's sake" argument is incomplete, however. Although additional price stabilization beyond the level provided by the private market would be beneficial, any net benefit for consumers and producers taken together must be balanced against the costs of providing that stabilization. As Gustafson has pointed out, private storers balance the marginal private benefits and private costs of price stabilization. Government intervention must be justified on the basis of specific externalities that the free market does not take into account. In the absence of such externalities, the extra stability provided by the government would be expected to cost more in storage costs than it would be worth to society. To argue that additional stability of grain prices would confer benefits is an insufficient justification for government intervention.

Although the analysis of optimal pricing does not distinguish between too much or too little price stability, the government may, in fact, view those situations differently. The taxpayers bear the costs of government-induced excessive price stability; grain consumers and producers directly bear the costs of too little price stability. Because consumers and producers are a more concentrated group than general taxpayers, the government may find it more confortable to err on the side of excessive stability, but that does not make it socially desirable.

## GRAIN STOCKS FOR FOOD AID

Conceptually, food aid and grain stock issues could be settled sequentially. First, the government would determine the desired expenditure for food aid or at least a formula expressing this planned expenditure as a function of supply and demand conditions in the United States and abroad. Next, the administrators of this budget would decide whether to (1) accumulate food reserves when food prices were low, specifically for aid purposes later on; (2) buy food in the spot market only at the times

[12] D. Gale Johnson argues that the trebling of grain prices in world markets between 1972 and 1974 can be attributed largely to trade barriers and price regulation in Europe, the Soviet Union, and other parts of the world, which forced the rest of the world to make the full adjustment to a worldwide poor harvest. See his *World Food Problems and Prospects*, American Enterprise Institute for Public Policy Research, Washington, D.C., June 1975.

and in the quantities needed; (3) purchase call options in the futures market, to buy food later for aid use; or (4) transfer the cash to needy people for their own use in purchasing food or other goods. We will not discuss the merits of food aid, but we can indicate how grain stock policy may influence food aid policy, and vice versa.

To enable the private storage market to account for probable food aid demand, food aid policy should be announced as far ahead of time as possible. (The government could do so by purchasing call options.) Even though intended food aid shipments can be planned only uncertainly on a contingency basis, the private market can be expected to increase its grain stocks according to the probability and size of expected food aid purchases. The additional private storage tends to raise prices in abundant years and diminish them in lean years, thereby diminishing the cost of spot purchasing grain for food aid when the demand arises. Because the private sector can be expected to adjust its storage policies to accommodate the anticipated level and pattern of government food aid purchases, it is not obvious whether food aid can be provided more cheaply through government stockpiles, spot purchases, or forward contracts.

However, it may make political sense to stockpile for aid requirements when prices are low and taxpayers and consumers are least sensitive about cost and diverted food supplies. Essentially, we are arguing that the level of resources devoted to food aid may itself be expanded by government stockpiling, in comparison with spot purchasing or forward contracting, so that food for aid purposes becomes an externality effect of stockpiling. In the past, accumulation of unwanted CCC stocks has resulted in food donations to foreign countries through the PL480 program and to needy people in the United States through school lunch, domestic relief distribution, and other domestic food assistance programs.[13]

## GRAIN RESERVES TO REDUCE INFLATIONARY PRESSURE

Some have argued that fluctuations in grain prices contribute to inflation.[14] It is accepted that grain prices in cash grain markets are highly flexible upward and downward, but it is argued that wages and salaries in many industries are flexible only upward. Fluctuations in grain prices are said to cause intermittent increases in salaries and wages (a "ratchet effect") that contribute to inflation. According to this argument, grain stockpiling that stabilized prices would also reduce inflation.

Even if the ratchet effect were an observable fact, it would not be quantitatively very important. The wholesale value of domestically used wheat and feed grain represents about 2 percent of U.S. disposable personal income. Consequently, each 25-percent increase in wholesale grain prices would raise the cost of living, and therefore wages and salaries, by at most one-half of one percent, according to the above argument, assuming all wages are indexed to the cost of living, while each

[13] Of course, consumers may protest the shipment of government grain stocks during production shortfalls regardless of when the stocks were accumulated. They may prefer that stocks be used domestically to reduce spot market prices.

[14] For example, Roger Gray presents this argument in "Grain Reserves Issues," speech delivered at the 1974 National Agricultural Outlook Conference, Washington, D.C., December 9, 1974.

25-percent decrease in wholesale grain prices would have no effect.[15] The near-trebling of grain prices since 1972 produced a sharp increase in the consumer price index and wages, but we suggest that the presumed downward rigidity in wages relative to grain prices played no role in this scenario.

More fundamentally, the forces that cause changes in relative prices, such as the price of labor relative to grain, should not be confused with those that affect the general price level. Although an increase in the price of grain would initially raise the price of grain-intensive goods such as bread and meat, this effect would not automatically spill over to higher prices for all goods and services. The increased cost of grain-intensive goods reduces the resources available to spend on other items, and thus exerts downward pressure on the relative prices for these other goods. By contrast, the general price level rises when people have more money to spend on an unchanged stock of goods and services, or when people have the same amount of money to spend on a smaller quantity. In such a world, nominal wages should be rising. But the ratchet effect requires that wages creep up over time relative to grain prices.

By implication, the ratchet effect assumes that unemployment generated by an initial relative increase in wages does not moderate inflationary wage settlements during subsequent up and down cycles in grain prices. The 1975-76 experience has shown that unemployment does inhibit inflationary wage demands. Market forces in the labor market seem to prevail over the ratchet effect.

## U.S. GRAIN STOCKS TO FURTHER DIPLOMATIC OBJECTIVES

Perhaps U.S. stock policy can be linked to U.S. diplomatic objectives of: (1) liberalizing agricultural trade among the industrialized countries, (2) insulating developing countries from instabilities in world grain markets, or (3) promoting more stable trading relationships with the Soviet Union. In each case the benefits are national in nature and do not enter into private stockpiling decisions. However, if a foreign country is indifferent to U.S. stock policies or hostile to U.S. objectives, diplomatic arguments for increased U.S. stockpiling become less persuasive.

Increased U.S. stocks would stabilize prices, and more stable prices are postulated to promote trade liberalization. Extremely high prices would be less likely, and so would domestic political pressure for U.S. export controls, which arises when prices are abnormally high. If U.S. export supplies were more stable, the European Community (EC), the Japanese, and others might be more willing to relax protection of their domestic agriculture. Reduced protection by the EC would probably lead to smaller export subsidies, and thereby improve the competitiveness of U.S. grain in non-EC markets. Eventually, the reduced trade barriers would lead to an expansion of U.S. grain exports.

[15] This calculation includes both the direct effect of grain prices on the cost of living and first-round indirect effects through meat prices. It ignores decreases in the quantities of grain and meat consumed that would follow from increases in their relative prices, and these adjustments would moderate the calculated change in the cost of living. Also, because not all wages are indexed to the cost of living, the ratchet effect would not operate as perfectly as assumed here.

But this alleged linkage between U.S. grain stocks and trade liberalization ignores an important element of existing trade policies. European and Japanese policies were apparently adopted, not for their direct benefit, but rather to enable domestic farm policy to function. In consequence, an international grain reserves agreement to achieve trade liberalization would require abandonment of some domestic farm income and price support policies in Europe and Japan. Farmers in Europe and Japan are particularly opposed to freer trade, because it would destroy the economic rents generated by their countries' domestic agricultural policies. Analyses in the late 1960s indicated that the EC's Common Agricultural Policy (CAP) was costing European taxpayers and consumers nearly $15 billion annually, much of which was transferred directly to European farmers.[16] Japanese agricultural programs cost taxpayers $2.1 billion in 1968, much of which went to support the price of rice.[17] The higher food cost to consumers should be added to these totals to derive the total contributed by Japanese agricultural programs to Japanese farm income.

Proponents of using U.S. grain stock policy to liberalize world agricultural trade anticipate that present attempts to change the agricultural policies of other countries will succeed even though past attempts failed. In the past, proponents of the CAP and Japanese farm policy supported the large income transfers to the farming sector as the justified cost of providing their consumers with more price stability and supply security than existed in world markets. Moreover, these arguments were advanced even while the United States carried abnormally large stocks and grain prices were generally stable. In sum, the promotion of trade liberalization constitutes an externality of stockholding that might justify some government intervention, but the relation between stockpiling and trade liberalization remains debatable.

Increased price stabilization is postulated to benefit developing countries, but the argument for "stability for stability's sake" is no more justified here than elsewhere. Of course, developing countries would benefit from additional stockpiling paid for by other countries.

Increased economic development is sometimes alleged to follow from increased stability. More stable prices reduce uncertainties about the level of expenditures for grain imports, and thereby enhance the ability of developing countries to finance development projects. However, MacBean was unable to detect any effect of trade uncertainties on economic development.[18] During periods of abnormally high import prices, developing countries appear to adjust without major consequences for development plans by drawing down foreign reserves or by delaying capital acquisition until import prices return to normal levels.

It might be argued that increased U.S. grain stockpiling promotes détente by creating a more stable supply source for Soviet grain imports. Agriculture is a major problem area for the Soviet economy. Instability results from the use of lands that

[16] J. P. Krauer and B. Bernston estimated this cost at $14.4 billion in 1966-67; see their "Cost of the Common Agricultural Policy to the European Community," *Foreign Agricultural Trade of the United States*, U.S. Department of Agriculture, Washington, D.C., 1969, cited in D. Gale Johnson, *World Agriculture in Disarray*, The Macmillan Company, New York, 1973, p. 47. Dennis Bergman et al. estimated the cost at $12 to $14 billion in 1967-68; see "A Future for European Agriculture," Atlantic Paper 4, Atlantic Institute, Paris, 1960, also cited in Johnson, *World Agriculture in Disarray*, p. 49.

[17] Johnson, *World Agriculture in Disarray*, p. 50.

[18] Alasdair MacBean, *Export Instability and Economic Development*, Harvard University Press, Cambridge, Mass., 1966.

are vulnerable to wide climatic variations, and from technological problems of planting and harvesting. However, the Soviets have shown limited interest in securing more stable grain supplies. The recent Soviet agreement to import minimum quantities of U.S. grain each year through 1980 may not alter the pattern of Soviet imports greatly from what they would have been otherwise.

Apparently, the United States cannot easily use grain stockpiling to achieve international diplomatic and political objectives. Nonetheless, any value for negotiation to be gained by stockpiling is a market externality that would justify increasing U.S. grain stocks above the level stored by the private market.

# III. THE COSTS AND EFFECTS OF INCREASED GRAIN STOCKPILING

The above discussion suggests that the primary benefits of government intervention in private sector grain stockpiling would come from the promotion of food aid and diplomatic externalities. Because the values of these externalities are difficult to quantify, they will be omitted from the following analysis. But it may be possible to quantify the cost of promoting price stability and, indirectly, the externalities, leaving to policymakers the task of weighing costs against their subjective evaluation of the externality benefits. Unfortunately, resource constraints have prevented us from providing reliable estimates of these costs, but we are able to illustrate here the types of calculations that are needed and have not yet been performed. Moreover, we have confidence in the qualitative implication of the results.

In particular, we examine the costs to world welfare, U.S. welfare, and the U.S. taxpayer of stabilizing grain price fluctuations by use of alternative amounts of government subsidization of private storage. The simulations are based on a very simple, and therefore not entirely reliable, model of the projected 1979 U.S. and world markets for wheat. The model does incorporate the best available estimates of projected supply and demand conditions, however, and is therefore more reliable than many other models used to simulate grain stock policy. Future research should be directed toward improving our estimates of the "cost of stability," using more sophisticated simulation models.

A second tractable subject relevant to grain stock policy concerns what we call the "offset rate," the fraction of a bushel by which the private market reduces its stockholdings for every bushel held by government, supposing for the moment that price stabilization is to be achieved using a government stockpile rather than subsidies to private storage. After policymakers decide how much price stability to promote and determine the total (government plus private) grain stocks required to achieve that degree of stability, they must determine the level of government stocks that induce the desired total grain stocks. Again, the existing economics literature does not answer this question directly, nor do we provide empirical estimates. We comment, however, on various factors that affect the offset rate and present some quantitative results based on simulation of alternative policy options. We discuss and recommend the option of subsidizing the private sector to hold increased stocks, by which government can increase total stocks without displacing any private stocks.

A third subject considered below is the distribution of the benefits of stockpiling subsidies between grain producers and consumers. This distribution will affect political support for and resistance to government stock policy, both domestically and internationally. If costs of a grain stockpile are to be shared internationally, the distribution of stockpiling benefits among exporting and importing countries may provide a basis for distributing the cost burden.

## THE PRICE OF STABILITY

Existing studies do not examine the cost of grain price stability. Rather, they examine "the desirable size of stock," approaching the subject in either of two ways. The "mechanical" approach determines the level of grain stocks required to reduce, to a specified level, the probability that unusually large production shortfalls will cause grain supply and consumption to drop below arbitrarily chosen levels. The appropriate size of carryover stocks is simply that size required to achieve the government's presumed goals. This approach has been used by Sharples and Walker; Steele; the FAO; Bailey, Kutish, and Rojko; Tweeten, Kalbfleisch, and Lu; Reutlinger; Simaika; and Miller.[19]

The "economic" approach determines the level of carryover grain stocks that equates the marginal expected benefit of storing the last ton of grain to the marginal expected cost. Ideally, this approach would incorporate externality benefits and costs, as well as those reflected in market demand and supply curves. When only the market related benefits and costs are incorporated, the economic approach models profit-maximizing private storage and predicts the carryover stock levels held by the private sector. Gustafson pioneered this approach to grain stockpiling issues. More recently, this approach has been used by Danin, Sumner, and Johnson. Their results are also summarized by Hillman, Johnson, and Gray in a study done for the FAO.[20]

## THE MODEL

Our simulation model combines the mechanical and economic approaches. We simulate the behavior of private storers operating under alternative, mechanically chosen, government storage subsidies.[21] The objective is to examine the costs and effects of increasing the level of stocks beyond profit-maximizing levels.

Profit-maximizing storage depends in a complex way on current price and the expected future behavior of the market. There is no closed-form solution for the profit-maximizing stock level, and we require a simple model of the market to

[19] Jerry A. Sharples and Rodney Walker, "Analysis of Wheat Loan Rates and Target Prices Using a Wheat Reserve Stocks Simulation Model," unpublished paper, U.S. Department of Agriculture and Purdue University, May 1975; W. Scott Steele, "The Grain Reserve Issue," Economic Research Service, U.S. Department of Agriculture, 1974 (unpublished), cited in United Nations Food Conference, *The World Food Situation and Prospects to 1985*, Foreign Agricultural Economic Report No. 98, Washington, D.C., rev. March 1975; Food and Agriculture Organization of the United Nations, *World Food Security: Evaluation of World Cereals Stock Situation*, CL:64/27, October 1974; W. R. Bailey, F. A. Kutish, and A. S. Rojko, *Grain Stocks Issues and Alternatives*, Agricultural Economic Research Report, U.S. Department of Agriculture, Washington, D.C., February 1974; Luther Tweeten, Dale Kalbfleisch, and Y. C. Lu, *An Economic Analysis of Carryover Policies for the United States Wheat Industry*, Technical Bulletin T-132, Oklahoma State University, Stillwater, Okla., October 1971; Shlomo Reutlinger, "A Simulation Model for Evaluating Buffer Stock Programs," *Symposium on Food Grain Marketing in Asia*, Asian Productivity Organization, Tokyo, December 7-11, 1970, pp. 115-122; J. B. Simaika, *Probability of Success of a 'Stock and Allocation' Policy*, Food and Agriculture Organization, United Nations, ESS/MSC/74-1, September 1974; G. L. Miller, "Ways of Balancing the Costs and Benefits of National (or Regional) Stocks, Assuming Either Full or Partial Insurance Against Crop Failure and Other Contingencies," Food and Agriculture Organization, United Nations, ESC:CPS/75/6, Rome, February 1975.

[20] Yigal Danin, Daniel Sumner, and D. Gale Johnson, "Determination of Optimal Grain Carryovers," Paper No. 74:12, Office of Agricultural Economic Research, University of Chicago, March 1975; Hillman, Johnson, and Gray.

[21] This simulation is more fully developed and described in Emmett Keeler, "Simulated Costs and Effects of Alternative Wheat Stock Policies," The Rand Corporation (forthcoming).

compute it numerically. Since profit-maximizing behavior is one component of subsidized storage policies, they cannot be examined analytically either.

Any modeling effort must decide which real-world complications are critical and which are less relevant. We have chosen to concentrate on the interactions between the private market and government policy, which we consider most important. Despite the simplifications, we believe our qualitative results are plausible and should afford a sounder basis for policy than other results we have seen.

Recent USDA estimates of the parameters of market supply and demand schedules are contained in the Sharples and Walker model of the U.S. wheat market, and we likewise base our analysis on these schedules.[22] The model includes U.S. domestic supply and demand schedules and an export demand schedule:

$$Z_t = 1561 + 191P_{t-1} + F_t;\ F = N(0,73^2) \tag{3}$$

$$H_t = 1140 - 83.3P_t \tag{4}$$

$$X_t = 1620 - 161.7P_t + R_t;\ R = N(0,300^2) \tag{5}$$

$Z_t$ is domestic wheat production in year t. It equals planned production, which depends on last year's price, $P_{t-1}$, and a random variation, $F_t$ (due, e.g., to weather). The cobweb expectations generator is a first-order approximation to more complex distributed lag generators. Domestic demand, $H_t$, and export demand, $X_t$, are both linear functions of current price, but export demand also includes some random variation, $R_t$, largely attributable to production uncertainties abroad. A nonstochastic domestic demand schedule is employed because the stochastic element in this schedule is relatively small. All parameters are in millions of bushels. $R_t$ generates most of the market variability in the model. Over the 1962-73 period, the standard deviation of U.S. wheat exports about their mean trend was 6.1 million tons (225 million bushels); following Sharples and Walker, however, we chose a standard deviation of 8.2 million tons (300 million bushels) for analysis because exports are expected to be more variable over the 1975-81 period. The sensitivity of our results to this variability will be examined later. The Sharples-Walker model incorporates a trend factor, but to simplify, we have taken their supply and demand schedules for the 1979 market and assumed these conditions prevail indefinitely.

Let $C_t$ be the carryover of wheat stocks from year t to t+1. Assume that the government does not engage in stockpiling, so $C_t$ is held entirely by the private sector. Let $D_t$ be total usage in year t and $S_t$ be supply in year t. Then,

$$S_t = Z_t + C_{t-1} \tag{6}$$

$$D_t = H_t + X_t = S_t - C_t \tag{7}$$

Substituting Eqs. (3), (4), and (5), and solving for $P_t$, we obtain

$$P_t = (2760 + R_t - D_t)/245 \tag{8}$$

Each simulation begins with a zero wheat stock.

Our primary interest is in the costs and effects of alternative storage subsidies. The cost of storing x bushels of wheat from year t−1 to year t is the sum of assumed

[22] Other aspects of the Sharples-Walker model involve misleading simplifications of the real world. Most crucial is the model's neglect of private storage.

physical storage costs of $0.15 per bushel plus an assumed opportunity cost on invested capital equal to 8 percent.[23]

An "optimal" storage rule allocates current supply between current consumption and storage so as to equate the marginal value of current consumption to the expected marginal value of additional supply next period, accounting for storage costs and discounting.

$$P_t = E(P_{t+1})/(1 + s) \quad (9)$$

where s is the cost of storing a bushel for one year, including both physical and opportunity costs. But the marginal value (i.e., price) of next period's supply, $P_{t+1}$, depends on next period's storage, which in turn depends on supply and storage in all future periods. Gustafson used dynamic programming methods (simulations of Eqs. (8) and (9) over time) to find the optimal storage rule. He then observed that, given our assumptions, the free market achieves this solution.

We adapt this approach by varying the per bushel cost of storage, summarized in s, to simulate the consequences of alternative storage subsidies. In evaluating alternative storage subsidies, two different measures of social welfare are used. Welfare is assumed to be the area under the domestic and/or foreign wheat demand curves, less the value of resources going into wheat production and storage.[24] One altruistic measure is total world welfare (that portion of domestic plus foreign welfare related to wheat). The other measure is more narrowly national, the sum of domestic welfare and export sales revenue. Presumably the true measure is somewhere between these extremes; we probably value the consumption benefits in Bangladesh at a substantial fraction of domestic benefits, but we may only be concerned with export revenues from the USSR or OPEC. Also calculated is the taxpayer cost of alternative policy options. This cost measure is not an indicator of social cost, since it neglects net benefits in the private sector. Nonetheless, it may be of interest.

The simulation experiments yielded benefits and costs in each period, which were then discounted to the present to give aggregate measures of welfare. Estimates were derived from 100 different hypothetical 50-year histories. The average of the 5000 years of simulated experience for each welfare measure were calculated, as were mean annual values for export sales, physical storage costs, and the level of carryover stocks. The variance of fluctuations in wheat prices was also calculated. This is our measure of price instability and the target of policy.

Table 1 presents simulation results for a number of alternative policies. Simulation 1 is our base case of private sector storage operating without a subsidy. The actual welfare values are not shown since they depend on the shape of the demand curve at extremely high prices, about which little is known. The standard errors and the other lines of the table depend only on differences in welfare for demand variations in the normal range of prices and are thus more reliable. The standard errors in parentheses are the errors of the averages, so the annual standard errors are 70 ($= \sqrt{5000}$) times as large.

[23] The 8 percent interest rate follows the Sharples-Walker assumptions. Preferably, the selected interest rate would reflect the riskiness of grain stock investments.

[24] The demand curves used here are not income-compensated, as they should be. However, the error involved is small, since wheat consumption represents a small portion of income and the demand for wheat is highly income-inelastic.

Table 1

The Cost of Stabilizing U.S. Wheat and the Effect of Reducing the Variability of U.S. Wheat Export Demand: Expected Annual Values for Alternative Policies from an Exemplary Simulation

| Simulated Policy | Variance of Market Price (Dollars per bushel) | Average Carryover (Million bushels) | Costs, Welfare, and Export Sales (in $ million) | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Physical Storage Costs[a] | Subsidy Costs[b] | Domestic Consumer Welfare | Export Sales | National Welfare[c] | World Welfare[d] |
| 1. Reference case | | | | | | | | |
| Private sector storage with export s.d. = 300[e] (standard error in parenthesis) | 0.52<br>(0.01) | 171<br>(2) | 24<br>(0.3) | 0 | —<br>(3) | —<br>(20) | —<br>(18) | —<br>(52) |
| | | Divergence from Reference Case | | | | | | |
| 2. Storage subsidies | | | | | | | | |
| a. $0.15/bushel (standard error of difference in parenthesis) | 0.37 | +71<br>(3) | +10<br>(0.5) | +34<br>(0.5) | +3<br>(1) | -3<br>(2) | -10<br>(2) | -2<br>(2) |
| b. $0.30/bushel | 0.19 | +289 | +36 | +120 | +2 | -5 | -38 | -31 |
| 3. Reduced fluctuation in export demand | | | | | | | | |
| Export s.d. = 225[e] | 0.37 | -63 | -9 | 0 | +8 | -60 | -44 | (f) |
| Export s.d. = 100[e] | 0.16 | -136 | -19 | 0 | +25 | -136 | -92 | (f) |
| | | | | | Divergence from Reference Case | | | |
| 4. No storage | 4.08 | 0 | 0 | 0 | -136 | -416 | -528 | -408 |
| 5. Perfect price stability in an idealized world | 0 | 0 | 0 | 0 | +35 | -150 | -91 | +36 |

[a]Excludes the opportunity cost of capital invested in stored grain.

[b]Assumes working stocks are not subsidized.

[c]National welfare is the sum of domestic welfare from consuming U.S. wheat, plus export sales revenue less physical and opportunity costs of storage.

[d]World welfare is the sum of domestic and foreign welfare from consuming U.S. wheat, less physical and opportunity costs of storage.

[e]The standard deviation of export demand in millions of bushels.

[f]World welfare depends on how export variability is reduced.

Simulations 2a and 2b reveal our model's estimates of the price of stability for the wheat market. Two sets of estimates result from the alternative social welfare measures described above. Subsidization appears to produce modest reduction in price variability at modest net social cost. To reduce the variance of wheat prices from \$0.52 to \$0.37 per bushel (standard deviation from \$0.72 to \$0.61), world welfare declines by \$2 million. National welfare declines by more, \$10 million, because the nationalistic definition of welfare does not value the foreign gains from price stabilization. To further reduce the price variance to \$0.19 per bushel (standard deviation to \$0.44), world welfare declines by another \$29 million, while national welfare declines by another \$28 million.

The table shows that the subsidy programs require larger transfer of resources among the private and public sectors. To reduce the price variance from \$0.52 to \$0.37 per bushel, the government can expect to incur budgetary costs of \$34 million per year. To further reduce the price variance to \$0.19 per bushel, the government can expect to incur an additional budgetary cost of \$86 million per year. These budgetary costs represent income transfers from taxpayers to private storers.

The subsidy programs also entail a transfer of resources within the private sector. The first subsidy program requires that \$10 million of private resources be transferred from nonstorage to physical storage activity. An additional amount, not shown in the table, of roughly the same magnitude is transferred to cover the opportunity cost of the additional capital invested in grain. The second subsidy program requires an additional transfer of \$26 million to cover the incremental physical storage activity and a transfer of roughly this same size to cover the additional opportunity cost.

Such subsidization policies have other effects that are worth noting. Because the 15 cents per bushel subsidy fully covers the physical costs of storage, private storers spend only the opportunity cost of capital invested in stored grain. The 30 cents per bushel storage cost almost fully compensates both physical and opportunity costs of storage. A storage subsidy exceeding physical and opportunity storage costs would eventually lead to enormous accumulation of stocks.[25]

Subsidizing private storage, and thereby stabilizing price fluctuations, tends to reduce the value of export sales in our model. The reason is that price fluctuations are largely due to fluctuations in export demand, so prices are higher when export quantities are greater. Reducing price fluctuations through storage subsidies reduces prices in years when exports are greatest and increases prices when exports are least, with the result that the value of export sales is decreased. Theoretically, to the extent that the United States monopolizes the world's grain storage industry, it could increase domestic welfare at the expense of grain-importing countries' welfare by reducing the amount of U.S. grain storage, thus increasing price variability. However, grain-importing countries would then have an incentive to construct additional storage facilities and take over the reduced U.S. storage role.

Domestic consumer welfare rises when small storage subsidies are applied and price fluctuations reduced. But since storage subsidies increase the rate of initial stock buildup, subsidies bid up the price of wheat while the initial stockpile is being accumulated. Consequently, the 15 cents per bushel subsidy benefits consumers by

[25] In Table 1, subsidy costs are less than average carryover times the storage subsidy because subsidy costs are a discounted average whereas carryover is an undiscounted average.

$3 million per year; but a subsidy of 30 cents per bushel produces faster and greater stock accumulation, which raises market prices, with the result that the net benefit to consumers is reduced to $2 million per year.

To test the sensitivity of the results to the assumed standard deviation of export demand, we simulated private storage activity, first assuming export demand fluctuations have a standard deviation of 225 million bushels, its historical level between 1962 and 1973, and then assuming an export demand standard deviation of 100 million bushels, as might be produced by trade liberalization or minimum purchase trade agreements coupled with an increase in foreign storage activity. The results are shown in simulation 3 of Table 1. Reducing the standard deviation of export demand fluctuations by 25 percent to 225 million bushels, and by 67 percent to 100 million bushels, stabilizes grain prices about the same degree as storage subsidies of 15 and 30 cents per bushel. However, price stability resulting from stabilization of export fluctuations benefits domestic consumers more than does price stability resulting from storage subsidies, because the former does not involve a stockpile buildup and an accompanying temporary increase in prices.

Simulations 4 and 5 show the results from extreme assumptions on storage. In simulation 4, storage is assumed to be impossible, and in simulation 5, storage is free and transfers can be made forward and backward in time. In such a world, fluctuations in supply, demand, and price do not exist. A comparison with simulation 1 shows that private sector storage, even without subsidy, dampens most of the price fluctuations that would exist in a world without storage. Private storage reduces the variance of price fluctuations from $4.08 per bushel to $0.52 per bushel. Over 90 percent of world welfare lost to fluctuation is retrieved (408 out of 408 + 36 million dollars). Although domestic and consumer welfare and world welfare go up with perfect price stability, national welfare goes down. This is because export demand variation increases U.S. export revenues.

Three distinct types of error are involved in each estimate given in Table 1. First, there is variation due to the 5000 simulated years being individually lucky or unlucky. This variation is given by the standard deviation shown below simulation 1. Only the variation of export demand seems to make much difference and only for export sales and national and world welfare. Second, there are interaction effects of history and policy. For example, storage subsidies appear more beneficial when initial good years are followed by bad years than when initial bad years are followed by good years. This error was estimated only for simulation 2a and is shown below the 2a results in the table. The standard error of estimate applies to the difference between figures for private storage without subsidy and with a subsidy of 15 cents per bushel. While world welfare differs considerably with different histories, these differences affect plans fairly equally in the range we examined.

Finally, there is error due to various simplifications and misspecifications of the model. First, we simulate only one type of storage subsidy scheme, although other storage schemes could be designed to stabilize prices at a lesser cost to government (see below). Second, we assume that 1979 supply and demand conditions prevail indefinitely, neglecting supply and demand trends. Third, we assume constant physical storage charges, whereas in actuality they vary with supply and demand conditions in the storage industry. Fourth, we attribute the annual price fluctuations to random fluctuations in supply and export demand schedules, whereas these fluctuations may be somewhat predictable. Finally, we ignore any effect of price stabiliza-

tion on trade liberalization, as discussed in Sec. II, and thereby the export demand schedule.

## THE EFFECT OF GOVERNMENT STOCKS ON PRIVATE STOCKHOLDING

We do not have a reliable estimate of the effect of government stockholding on private stock levels, because only since 1972 have U.S. Government grain stocks been low enough to permit profitable arbitraging of grain between bountiful and lean harvest years by the private sector. More years may be required before we learn how private storers respond to renewed opportunities for profitable storage.

Theoretically, the extent to which government stock policy reduces private sector stockpiling depends on whether the government subsidizes the private sector to increase its grain stockholding or buys and sells grain on government account. If the government buys and sells grain on its own account, the effect of government stocks on private sector stockpiling would depend on the amount of government stockpiling, and the rules for stock management.

Two types of rules are generally proposed. The government might act to maximize profits or it might buy and sell at certain preselected fixed prices. Government stockholding managed for profit would mimic private speculators but incorporate externalities into its accounting by an implicit tax or subsidy on stockholdings. In this case, as Gustafson showed, buying and selling decisions are based purely on the comparison of this year's price with the price expected next year. The effect of such rules on the market would be dramatic and easy to analyze. If the government were implicitly subsidizing its stocks, private speculators could not compete and would be driven out of the market. Total stocks would be governmental stocks; stabilization results for the wheat market hypothesized above would be as in the subsidy policies in Table 1. If the government were implicitly taxing its own stocks, it could not compete with the private stockholding market, and there would be no government stockholding.

Under price band rules, the government acts only when prices threaten to fall outside of a certain band. The government buys enough to support a floor price, and sells whatever stocks it has so long as the price is above a ceiling price. The ceiling cannot be enforced if the stockpile runs out. Because the price bands alter the price expected next year, they alter the incentives for private stockholding. In evaluating price band policies, the combination of public actions and private market effects must be considered together. For example, before private response is included in the model, a simple and relatively harmless floor policy that buys whenever price falls below $2.10 and sells whenever price is above $2.10 has an average carryover of 128 million bushels, 43 million less than optimal, a variance of price of $0.79, and a loss of world welfare of $21 million. When profit-maximizing private response to this policy is added to the simulation, total average carryover is just 8 million more than optimal, and price variation and welfare are essentially unchanged from free market values. Raising the floor to $2.40 gives average government stockholdings of 181 million bushels and average private stockholdings of 38 million bushels, and raising the floor price to $2.70 eliminates private stockholding, with government stockholding averaging 336 million bushels.

Simulations of a variety of price band policies showed them to be less efficient than subsidized profit-maximizing behavior in achieving extra stability. There are several reasons for this. Price band policies with moderate band width usually result in inefficiently large storage. While the private market can compensate for some government actions, it cannot hold negative stocks. For example, if the government price band is centered at the mean, the average stockpile in this model becomes infinite.[26] Centering the band above the mean only exacerbates the problem. If the purchase price is very low, average government stocks are small, and efficiency losses and stability benefits are minor. In every case, however, the price band policy itself degrades the information contained in the market price, which no longer reflects the marginal return to carryover. Finally, if the government policy is supposed to supplant private stockholding, any gap between buying and selling price is inefficient. Optimal price and carryover stock level uniquely determine each other and buying and selling prices are identical.

## GOVERNMENT SUBSIDIES OF PRIVATE STOCKHOLDING

If the government subsidizes private sector grain stockpiling rather than owning grain stocks on government account, private sector stockpiling will be increased, rather than reduced, by government intervention. Private grain storers will choose to store additional grain, and this will provide increased stabilization of grain consumption levels and prices. By adjusting the subsidy, government can adjust the level of total grain stocks and the level of price stabilization, as illustrated previously.

Storage costs consist of investment costs for constructing new storage facilities and storage carrying costs. Carrying costs include depreciation on facilities, maintenance, administration, loan amortization, forgone interest on capital tied up on stored grain, loading and unloading costs of rotating stocks through storage, and the cost of grain deterioration and loss. The U.S. Government could raise stock levels and increase price stability by subsidizing any of these private storage costs.

The costs and price stabilization effects of a storage subsidy would depend on the type of subsidy used. For example, increased stabilization would come from a storage subsidy in abundant harvest years coupled with a storage tax in lean harvest years. The relative costs and effects of alternative storage subsidy schemes should be investigated in future research.

McKinnon and Houthakker have suggested that the U.S. Government buy and sell grain futures contracts so as to partially stabilize future prices, allowing market forces to stabilize cash grain prices in response.[27] Such a scheme would encourage private storage while the government is building up a long position in grain futures when futures prices are relatively low, and would discourage private storage while the government is liquidating a long position in grain futures when future prices are

[26] There is an asymmetry in the accumulation and release of government stocks at the floor and ceiling prices. Government sometimes runs out of stocks and does not sell grain when market price reaches the ceiling, whereas it always buys grain when market price falls to the floor. As a result, government stocks would accumulate indefinitely when floor and ceiling prices were centered at the expected market price, assuming the underlying supply and demand fluctuations are symmetrically distributed.

[27] Ronald I. McKinnon, "Futures Market, Buffer Stocks, and Income Stability for Primary Producers," *Journal of Political Economy*, Vol. 75, No. 6, December 1967, pp. 855-860; and Houthakker, pp. 51-60.

relatively high. These authors elaborate on how such a scheme could be implemented.[28]

The choice between government ownership and subsidization of grain stocks might affect the achievement of the objectives of grain stock policy. For political reasons, government ownership of stocks might represent a more visible government commitment to price stabilization than would subsidization of private storage, and a more visible commitment might placate domestic and international political forces favoring stabilization of grain prices or other results of larger stocks. An increase in food aid shipments might result from government ownership of stocks more readily than it would from increased stockholding by the private sector.

However, more government resources may be required to achieve a desired degree of stability by using a government-owned stockpile than by subsidizing private storers. First, government might have to take over much of the storage function of the private sector before it raised total stock levels significantly. Second, flexible and timely private market control of stock accumulation and release would likely be more efficient than the government in stabilizing prices.

## THE WELFARE EFFECTS OF INCREASED GRAIN STOCKPILING

The distribution of benefits between grain producers and consumers resulting from additional grain stockpiles beyond free market levels is of interest even though, as discussed above, these benefits will be less than the increased storage costs. The issue is important because the storage costs of an internationally coordinated stockpiling system might be allocated among grain-importing countries and grain-exporting countries according to their shares of the storage benefits.

The welfare effects of price stabilization have been analyzed in the economics literature by Waugh, Oi, Massell, Turnovsky, Samuelson, and others.[29] The analyses by Waugh, Oi, and Massell are applicable here. Waugh demonstrated that consumers lose from stabilization of price fluctuations that are caused by shifts in the supply schedule, while Oi demonstrated that producers lose from stabilization of price fluctuations caused by shifts in the demand schedule. These analyses used consumer and producer surplus accounting and assumed zero storage costs and a zero discount rate.[30] In such models, profit-motivated storage would automatically eliminate all price fluctuations, but private storage is not incorporated in these models.

[28] The Commodity Credit Corporation's offer to purchase grain from farmers at the loan rate amounts to giving them a "put option" to sell grain at that price. Traders, millers, exporters, and others could be obliged on a compulsory basis to hold a specified additional stock amount or proportion of their turnover to meet national stock objectives. The Swiss have such a system, and the Japanese were considering one in 1975.

[29] F. V. Waugh, "Consumer Aspects of Price Instability," *Econometrica*, Vol. 34, No. 4, 1966; Walter Y. Oi, "The Desirability of Price Instability Under Perfect Competition," *Econometrica*, Vol. 29, No. 1, January 1961, pp. 58-64; Benton Massell, "Price Stabilization and Welfare," *Quarterly Journal of Economics*, Vol. 83, No. 2, May 1969, pp. 284-298; Stephen J. Turnovsky, "Price Expectations and the Welfare Gains from Price Stabilization," *American Journal of Agricultural Economics*, Vol. 56, No. 4, November 1974, pp. 706-716; Paul Samuelson, "The Consumer Does Benefit from Feasible Price Stability," *Quarterly Journal of Economics*, Vol. 86, No. 3, August 1972, pp. 476-493.

[30] To the extent that risk averseness is present, consumer and producer surplus analysis understates stabilization benefits. Also, since price fluctuations in one market can have nonnegligible effects on real income and demand in other markets if expenditures in the first market are large enough, the welfare analysis in the first market should use general rather than partial equilibrium demand schedules.

Massell integrated the Waugh and Oi analyses and showed that the net welfare gain, assuming prices are perfectly stabilized, is $(\alpha + \beta/2)\sigma_{pp}$, where $\alpha$ and $-\beta$ are the price slopes of linear supply and demand functions and $\sigma_{pp}$ is the prestabilization variance of prices. Thus, aggregate net welfare gains from price stabilization are proportional to the price responsiveness of the supply and demand schedules and the degree of price variance stabilized.[31] The benefit accruing to consumers is

$$\frac{(2\alpha + \beta)\sigma_{vv} - \beta\sigma_{uu}}{2(\alpha + \beta)^2}$$

and the benefit accruing to producers is

$$\frac{(\alpha + 2\beta)\sigma_{uu} - \alpha\sigma_{vv}}{2(\alpha + \beta)^2}$$

where $\sigma_{uu}$ is the variance of the random element u in a supply function of the form $S = \alpha p + u$, and $\sigma_{vv}$ is the variance of the random element v in a demand function of the form $D = -\beta p + v$. The greater $\sigma_{uu}$ relative to $\sigma_{vv}$, the larger the benefit going to producers and the smaller the benefit going to consumers, and vice versa.[32] When only the supply schedule or only the demand schedule fluctuates ($\sigma_{vv} = 0$ or $\sigma_{uu} = 0$), consumers or producers, respectively, lose from price stabilization. But the net benefit is always positive (ignoring storage costs), so conceptually the gainers can compensate the loser and leave everyone better off.

If profit-motivated storage were introduced into this model and storers knew the long-run expected price, then prices would stabilize perfectly, since storage costs are zero, including the opportunity cost of stored grain. For policy purposes, we are interested in the welfare effects of marginal price stabilization introduced by the government when storage costs are positive and when private storers already provide profit-maximizing storage, a situation different from the one above. Within the context of the Massell model, the aggregate net benefit to consumers and producers remains ($\alpha$ P $\beta/2)\Delta\sigma_{pp}$, where $\Delta\sigma_{pp}$ is the reduction in price variance caused by stabilization policy. But storage costs and the costs of government storage subsidies are not taken into account by this formula, and must be considered separately.

Price stabilization creates the largest net increase in consumer and producer welfare (per unit of price variance eliminated) in markets where supply and demand are relatively responsive to price changes. In the cases of both food grains (wheat and rice) and feed grains (coarse grains), short-run supply schedules are inelastic. Short-run schedules are relevant since variation in short-run prices is the concern, long-run supply being influenced by long-run expected price, which does not vary much. But the demand for feed grains is probably more elastic than that for food grains because livestock grazing substitutes for grain feeding, meat products can be substituted for by other foods, and meat has a relatively high income elasticity, whereas food grains have no good substitute and their demand is income-elastic.

If, as assumed above for the U.S. wheat market, price fluctuations are caused

[31] Turnovsky extended the analysis to cover the generation of price expectations that determine production decisions. This contrasts with Massell's model, in which supply depends on current price. But Turnovsky and Massell come to the same central conclusion, that price stabilization leads to a net increase in aggregate consumer plus producer welfare, even though either producers or consumers might lose from price stabilization depending on the source of instability.

[32] See Massell, pp. 292-293.

primarily by fluctuations in the export demand schedule, and to a lesser extent by production fluctuations, but not by fluctuations in the domestic demand schedule, then price stabilization will mostly benefit foreign consumers, to a lesser (possibly negative) extent domestic producers, and will leave domestic consumers worse off. This comparatively large gain accruing to foreign consumers accords with the earlier simulation results. But that welfare analysis is not identical to the analysis here because the simulations incorporate effects caused by the initial buildup of stocks and the consequent increase in average price, a subject to which we turn next.

## A SHIFT IN THE MEAN PRICE LEVEL

The analyses by Gray[33] and Hillman, Johnson, and Gray maintain that stabilization would reduce the average level of grain prices. The fall of average price follows from their assumption that the demand schedule is more inelastic at higher price levels than at lower price levels.[34] This assumption is based on observations of two arc elasticities of the demand schedule for corn futures, observed four years apart. Comparing December futures prices on the Chicago futures market for corn with changes in the prevailing estimate of the year's corn crop, the authors found that the arc elasticity of the demand schedule was −0.55 in 1970 at an average futures price of $1.40 per bushel, while it was −0.23 in 1974 at an average futures price of $3.00 per bushel.

In our opinion, this evidence is not a sufficient basis for estimating demand elasticities. In 1970 the U.S. Government held 543 million bushels of corn under loan or owned by the CCC at the close of the marketing year on September 30, and the total U.S. carryover stock was 1005 million bushels, whereas in 1974 the Government held only 8 million bushels and the total carryover stock was only 483 million bushels.[35] The lower stock level alone may explain why futures prices were more sensitive to crop forecasts in 1974 than they were in 1970.[36] The use of crop forecasts as a proxy for the supply of grain in a future period may also be open to question.

The Sharples-Walker simulations explore the consequence of a grain price stabilization policy that raises the average level of grain prices. They examine the price stabilization effects of raising the price band governing stock accumulation and release and thus raising the average grain price, leaving consumers worse off and benefiting producers. We found that for the policies simulation by Sharples and Walker, the increase in average prices leads to larger welfare effects than does the stabilization of prices.

This stabilization of grain prices may be associated with a change in the average

[33] "Grain Reserves Issues."

[34] Their analysis neglects the effect of reducing the variance in prices on consumer and producer welfare, assuming risk aversion.

[35] Commodity Research Bureau, Inc., p. 125.

[36] This explanation is supported by a regression analysis by Bruce Gardner, "Price Response of Grain and Livestock Futures to Crop Production Estimates," personal memorandum to A. Greenspan and P. MacAvoy, September 29, 1975. He examines the interaction between stock levels and 14 arc elasticities on the demand schedule for corn futures over the period 1960 to 1975, similar to the arc elasticities calculated by Gray and by Hillman, Johnson, and Gray, and estimates that on average the demand elasticity was −0.53 when stock levels were at about one billion bushels and −0.30 when stock levels were at about 300 million bushels. The change in stock levels between 1970 and 1974 would almost entirely account for the change in demand elasticities observed by Gray and by Hillman, Johnson, and Gray.

level of prices to the benefit or detriment of consumers and producers. In the long run, this could be expected to affect the quantity of resources devoted to grain production, which would in turn lead to a full or partial offsetting change in the initial increase or decrease in average grain prices. Given that long-run supply elasticities are generally believed to be high in agriculture, stabilization programs would probably have little effect on the average level of prices. In the short run, stockpile buildup and release have important effects on the mean price of grain and hence on transfers between present and future producers and consumers.

# IV. CONCLUSION

Since the grain storage market appears to be competitive and efficient, government intervention to raise stock levels and stabilize prices must be based on externalities. These are difficult to evaluate, but relate to diplomatic, trade, and food aid objectives. The importance of the link between stocks and these objectives is a major unresolved issue in this report.

Supposing that government intervention is to be pursued, our simulations show that storage subsidies are more efficient than price band policies in achieving extra price stability. Moreover, subsidies eliminate the problem of private offsets of government stocks. Table 1 above indicates the estimated budgetary and social costs of alternative subsidies, and the redistribution of income among storers, taxpayers, producers, exporters, and domestic and foreign consumers. Subsidies are found to reduce export revenues.

If the government bears the costs of price stabilization, the aggregate net producer and consumer surplus benefits are found to be proportional to the reduction in price variance and to the sum of supply and demand price responsiveness. On this basis, price stabilization would produce greater net benefit, per unit of price variance eliminated, in feed grain markets than in food grain markets. Benefits accrue largely to supply or demand elements that are the source of the price instability. For the simulation model employed here, foreign wheat consumers and to a lesser extent domestic wheat producers would be the primary beneficiaries of stabilization policy. However, the expected net benefit, excluding externalities, would not be as large as the incremental storage costs. In the short run, various stabilization programs may cause expected grain prices to rise or fall, and these price changes can have more effect on welfare than the reduction of price variation.

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