STABILIZING THE INTERNATIONAL WHEAT MARKET WITH A U.S. BUFFER STOCK

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INTRODUCTION

Recent world carryover stocks of wheat are 65 percent of their average level during the decade of the 1960's. The precarious nature of this position has been demonstrated by the rapid upward movement of wheat prices in the last few years as world stock levels were depleted. The concern of many has been evidenced by numerous proposals for a world food or grain reserve.

A grain reserve to cope with uncertain and fluctuating production is not a new concept. During the 1960's world carryover stocks of wheat averaged 27 percent of total world production, or 74 million metric tons. The stocks of wheat held by the United States averaged 34 percent of total world stocks or 25 million metric tons. United States wheat carryover stocks are currently 43 percent of their average level during the 1960's, or 10.8 million metric tons. The stocks held by the United States during the late fifties and sixties were accumulated indirectly through the operations of a domestic price support mechanism rather than by a conscious effort for the purpose of smoothing grain production and consumption over time.

In this paper this smoothing purpose of the reserve stock is accomplished by acquiring and releasing grain in response to signals from market prices. The objective of the buffer stock is to reduce the variability of world market price by eliminating extreme upward and downward movements. We examine only a small portion of the total reserve stock question(s). Our focus is on stabilizing the commercial United States wheat market (and consequently the world price) by the use of a U.S. Government controlled buffer stock of wheat. Although this analysis focuses on wheat we believe many of the insights gained can be applied to other grains.

The objectives of this analysis are: (a) to quantify the effect of a U.S. owned and operated buffer stock of wheat on world wheat price variability and other key variables such as income of U.S. producers,

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government cost and export earnings, and (b) to estimate which market participants receive benefits of this buffer stock and who incurs the cost, and (c) to illustrate the impact on wheat price variability of an international reduction of barriers to trade.

The first part of the paper presents an aggregate simulation model of the wheat market. Then the simulator is used to analyze (a) a free or nonbuffered wheat market, (b) a market buffered by a U.S. wheat reserve, and (c) a free market with fewer trade restrictions.

The Wheat Buffer Stock Simulator

The wheat buffer stock simulator contains a supply function incorporating a cobweb production responses, i.e., production this year is a function of last year's wheat price. The simulator also contains both short-run domestic and export demand equations for each year from 1976 to 1982. Both the supply and demand equations contain random disturbance terms. Thus, there is a distribution of supply and demand curves for each of the 7 years and, consequently, a distribution of equilibrium prices.

The simulator is specifically designed to analyze government buffer stock storage rules to reduce variability of market price, see figure 1. Over time the short-run (annual) equilibrium price, P_e, will vary because of random disturbances and shifts in the supply and demand functions. The storage rule examined in this paper consists of a government purchase price (P_L) and government sale price (P_S). If the market drops below P_L, wheat is purchased by the government until the market price is raised to P_L. If the market price exceeds P_S the government sells wheat at the P_S price until either the market is at equilibrium at P_S or until government stocks are exhausted.

In the simulator an iteration consists of selection of random numbers to use in the supply and demand equations. Production, use, market price, government stocks purchases or sales, and other items for year 1 (1976) are computed. The year 1 market price and ending government buffer stock is provided as input to compute year 2 (1977). This process is continued through year 7 (1982). Information from each year is stored for later analysis. The second iteration of the seven years is started with the same set of starting values of 1976 carryin and market price, but a new set of random numbers. The 7-year sequence is repeated 500 times. Results are then summarized for each year and for the 7-year period. Most results reported herein come from the summary of the 7-year period.

Wheat Supply

In the simulator wheat production is defined as:

$$PA_t = 19.15 + 0.066P_{t-1}$$

$$HA_t = 0.91PA_t$$

$$Y_t = 21.6 + 0.4_t + S_t$$

$$Q^s_t = Y_t \cdot HA_t/10.0$$

where

PA_t = area planted in year t expressed in million hectares,
HA_t = area harvested in year t expressed in million hectares,
Y_t = yield in year t expressed in quintals per hectare,
Q^s_t = quantity supplied in year t expressed in million metric tons,
S_t = random normal deviate with $\mu = 0$, $\sigma = 1.35$ quintals per hectare,
t = time, with 1976 = 1, 1977 = 2, ..., 1982 = 7,
P_{t-1} = price of wheat in the previous year expressed in U.S. dollars per metric ton.

Wheat Demand

The short-run wheat demand equations were derived by using linear approximations to constant elasticity demand equations with the following price-quantity points and associated, assumed elasticities. The demand for stocks by private firms is assumed to be constant at pipeline levels.

Demand	Quantity	Price	Elasticity
	Million metric tons	Dollars/ metric ton	
Food	14.56	$129.	- .1
Feed	5.44	$129.	- .35
Seed	2.18	$129.	0.0
Export	29.94	$129.	-1.0

The equations for the linear approximations are summed horizontally to yield the following total demand equation for U.S. wheat.[1/] See figure 2.

$$Q^D_t = 57.7 - .089P_t + R \qquad \$165 < P$$

$$Q^D_t = 88.3 - .274P_t + R \qquad 92 < P < 165$$

$$Q^D_t = 148.0 - .924P_t + R \qquad P < 92$$

1/ To conserve space only the total demand equation is presented in this paper.

where

Q_t^D = total quantity of U.S. wheat demanded in year t expressed in million metric tons,

P_t = price of wheat in year t expressed in U.S. dollars per metric ton,

R = random normal deviate with $\mu = 0$, $\sigma = 8$ million metric tons.

A Free Market Simulation

The wheat simulator is first run without a buffer stock program. The only linkage between one year and the next is the lagged price in the supply equations (the 1975 price used is $138 per ton). Results from the free market simulation are used (a) to make some qualitative judgments about the validity of the model and (b) to serve as a base for comparing results from the buffer stock simulations. Results are shown in column 2 of table 1.

Mean values of the 3500 observations (500 iterations over 7 years) appear reasonable relative to historical data for the 1972-74 period. Production is up 28 percent over the 1972-74 period but about the same as in 1975. Domestic use and exports over the simulated period also are reasonably higher. Wheat price averages about the same as over the historical period.

Variability is slightly less over the simulated period than over the 1960-74 period for annual harvested area, production and quantity exported. Relative to the historical period when wheat price changed little except for the large increase toward the end, the simulated price variability for 1976 to 1982 may be too small given the free market assumption. If so, then the price stabilizing impact of a buffer stock is understated in the results. The distribution of simulated annual wheat price, shown in the top of figure 3, is skewed due to the shape of the total demand curve.

Buffer Stock Simulation

A second run of the simulator is made assuming a U.S. buffer stock program is used to modify wheat price fluctuations, following the concept shown in figure 1. The flow chart in figure 4 shows the sequence of operations followed by the simulator.

In order to define a stock management price rule, two issues need to be resolved; (a) what should be the difference between the stock purchase and sale prices, and (b) at what level should the prices be set? With small differences, there would be a greater frequency of purchases and sales by the stock manager, and greater constraint of the market price. If the purchase and sale prices are not set in the proper relation to the long-run trend of the equilibrium price, stocks will either accumulate to unacceptable levels, or tend to be exhausted.

In this analysis the release price ($140/ton) is set at 156 percent of the purchase price ($90/ton). This price differential allows a $50 range over which there would be no intervention in the market by the stock management agency. These particular price levels were selected so that the expected value of the buffer stock at the end of the 7-year sequence would be the same as the starting value. The assumption is made that the desired initial stock level is already accumulated.

In this simulation the average buffer stock level of 15 million tons was chosen. Research results by Steele reported in "World Food Security and Grain Stocks" [4] indicate that 95 percent of the time a buffer stock of 24 million metric tons would cover the world's potential single year shortfalls. However, his analysis assumes no price adjustment (i.e., the entire shortfall would be made up by releasing grain from the buffer stock). Allowing the price mechanism to work until the upper bound price is reached before releasing grain, reduces the necessary size of the buffer stock. Given the supply and demand equations assumed in this paper, a shortfall of approximately 9 million tons on average would be absorbed by the market before grain would be released from the buffer stock. Given a shortfall of 24 million tons, 9 million tons would be made up through price adjustment and the remainder, 15, would be covered by releasing grain from the buffer stock. This assumes the entire shortfall is translated into a horizontal shift in the export demand equation.

Simulation results suggest that a buffer stock program can effect major reduction in world wheat price variation (table 1) in terms of both reduced coefficient of variation and percent of observations above $140 (see figure 3).

The storage and interest cost of carrying an average of 15 million tons of buffer stocks averages $217 million, but when purchase costs are added and receipts from stock sales are subtracted, the average annual U.S. Treasury outlay for the buffer stock program is only $126 million. Treasury outlay varies over a wide range, however. In one year out of 5 the buffer stock agency's sales would more than cover costs, but in 1 year out of 12, the net Treasury outlay would exceed $1 billion (figure 5). Even though the buffer stock averages 15 million tons, the chance of being out of buffer stocks in any given year is 7 percent (although the chance of price exceeding the release price is only 5 percent) and the chance of the stock exceeding 30 million tons is also 7 percent (figure 6). Thus a 95 percent safety margin can be achieved both with a buffer stock of 15 million tons and some price variability of a stock of 24 million tons and minimal price variability.

Who Gains and Who Loses from Price Stability?

The buffer stock solution shows that the average price of wheat falls in the U.S. with increased buffer stock, but the average quantity produced changes very little. Thus as a result of reduced price variability, U.S. producers lose gross sales while domestic and foreign buyers benefit by paying less. Comparing the free market results to the buffer stock simulation, producers under the latter situation would have $447 million less in mean value of gross wheat sales (table 2), with one-fourth of the loss due to lower quantity. The $230 million reduction to domestic consumers is virtually all due to lower price. For foreign consumers half the reduction is due to smaller quantity and half due to lower price.

Removing Trade Restrictions

Tweeten [2] estimates that the price elasticity of demand for U.S. exports would increase in absolute value if trade restrictions were reduced around the world. We tested the impact on the free market results of raising the elasticity from -1.0 (assumed for all the runs reported in this paper) to -5.0 in the simulator. We found the effect of the higher elasticity on price variability was approximately the same as the results reported in table 1 with a buffer stock of 15 million tons. This demonstrates that successful negotiations to reduce trade barriers (thus increasing price elasticity of demand) can act as a substitute for a portion of the buffer stock. An elasticity of -5 does not seem too realistic, however this elasticity was chosen merely to illustrate the sensitivity of the model result to changes in the export demand elasticity.

Conclusions

A U.S.-owned buffer stock could greatly reduce U.S. and world wheat price variability. The cost, if run efficiently, could average under $300 million per year but in a few years cost could exceed $1 billion.

Major beneficiaries of reduced price variability would be U.S. consumers and foreign buyers. If the buffer stock management rules were stated as law, rather than left to administrative discretion, uncertainty would be reduced and producers and consumers could operate more efficiently. State monopoly traders, however, could also optimize within the U.S. buffer stock rules. Their actions might tend to reduce the price stabilization implied by the results of this study.

For the price rules to efficiently operate, a method would need to be developed to adjust the buffer stock price bounds over time as the long-run equilibrium price changed. One way would be to make the price adjustment a function of the size of the buffer stock such that as the stock grows beyond acceptable limits, price bounds are lowered according to a specified schedule, and vice versa.

Finally, negotiations to reduce trade restrictions and increase the price elasticity of demand for U.S. exports, can also increase price stabilization and reduce the size of buffer stock needed to achieve a given level of stabilization.

Table 1. Mean values, measures of dispersion and frequencies of selected items using the wheat market simulator, 1976-1982 average, and using historical data.

Item	Unit	Historical data	Simulations[1/] FM[2/]	Simulations[1/] S = 15[3/]
		(1972-74)		
Mean value of:				
Harvested area	mil. ha.	22.5	25.6	25.2
Production	mil. ton	45.8	58.4	57.4
Domestic use	do.	20.1	22.8	22.8
Exports	do.	30.6	35.6	34.6
Price	dol./ton	119[4/]	123[5/]	115[5/]
Storage and interest charge[6/]	mil. dol.	--	--	217
Net U.S. Treasury outlay[7/]	do.	--	--	126
Measure of dispersion of:		(1960-74)		
Harvested area	Coef. of var.	.11	.10	.06
Production (quantity)	do.	.14	.13	.08
Exports (quantity)	do.	.25	.19	.19
Price	do.	.48	.42	.21
Value of production	do.	--	.37	.20
Value of exports	do.	--	.40	.35
Frequency of:				
Stock agency purchases	Percent	--	--	24
Stock agency sales	do.	--	--	26
No stock agency action	do.	--	--	50
Zero buffer stocks	do.	--	--	7
Price exceeding $140/ton	do.		27	5

1/ Each item is calculated from 3500 observations (500 per year for 7 years).

2/ Free market simulation.

3/ Assumes a buffer stock of 15 mil. metric tons, on the average, over the 7-year period and purchase and release prices of $90 and $140 per metric ton, respectively.

4/ In 1972-74 dollars.

5/ In 1975 dollars.

6/ Storage cost of $7.33 per ton and interest charge of 8 percent.

7/ Storage and interest charges plus purchases minus sales.

Table 2. Average value of production and use, free market simulation and buffer stock simulation, 1976-1982 annual average.

Item	Free market	Buffer stock	Difference
	--------Million dollars---------		
Production	6998	6551	-447
Domestic use	2728	2498	-230
Exports	4270	4053	-217

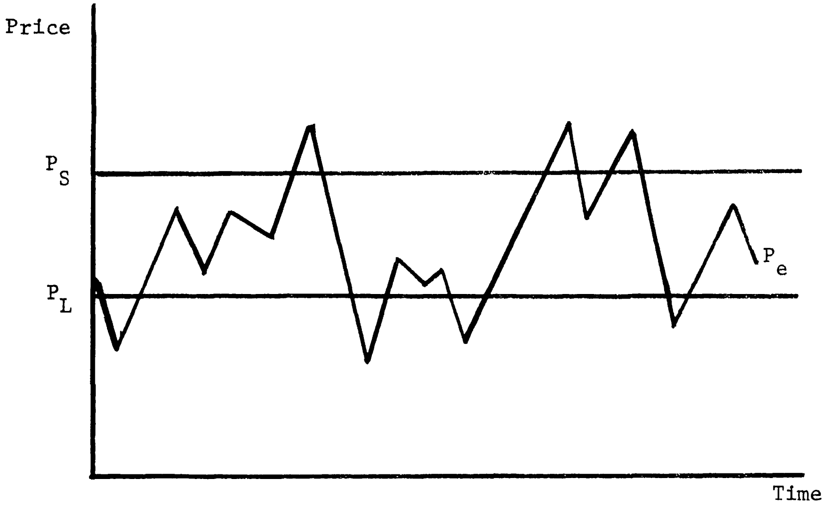


Figure 1. Equilibrium price over time.

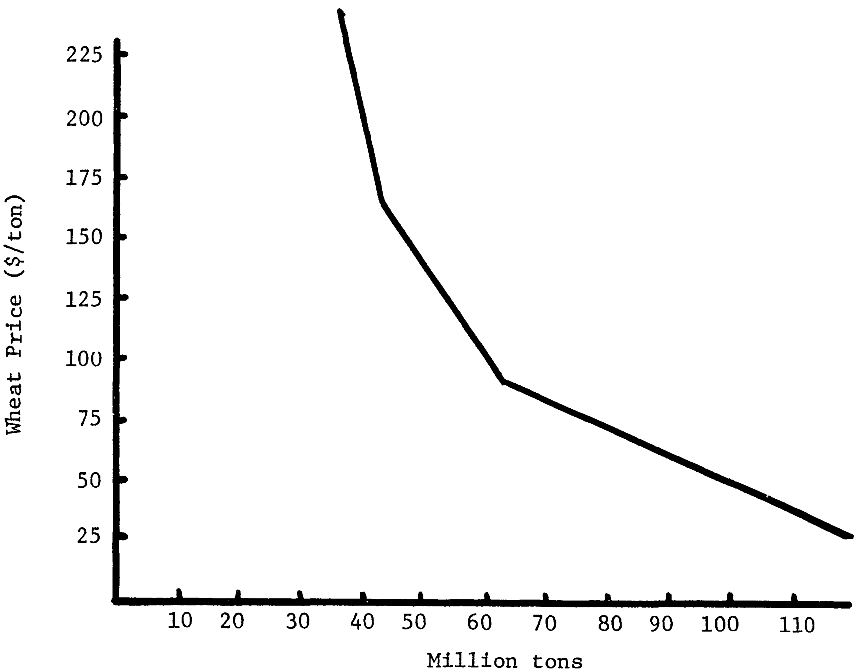
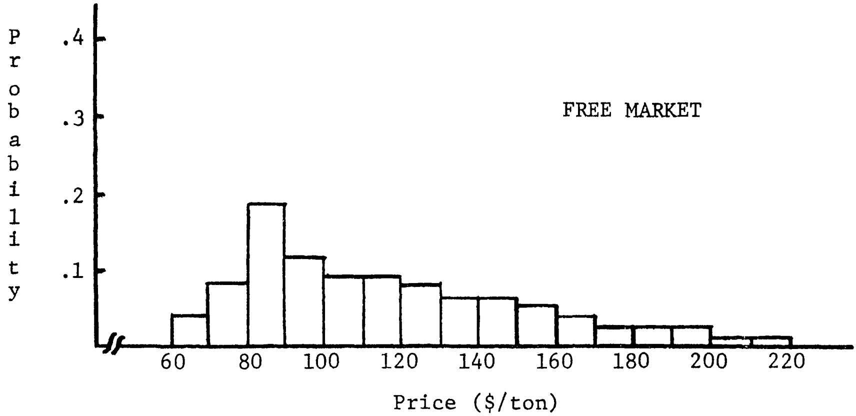


Figure 2. Aggregate demand for U.S. wheat.



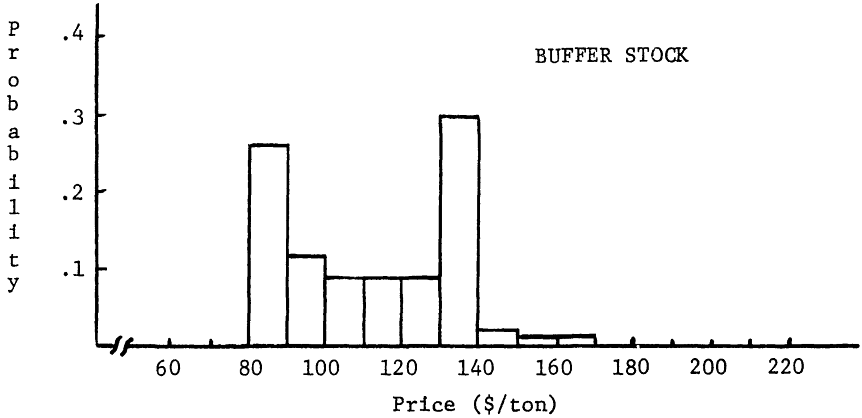
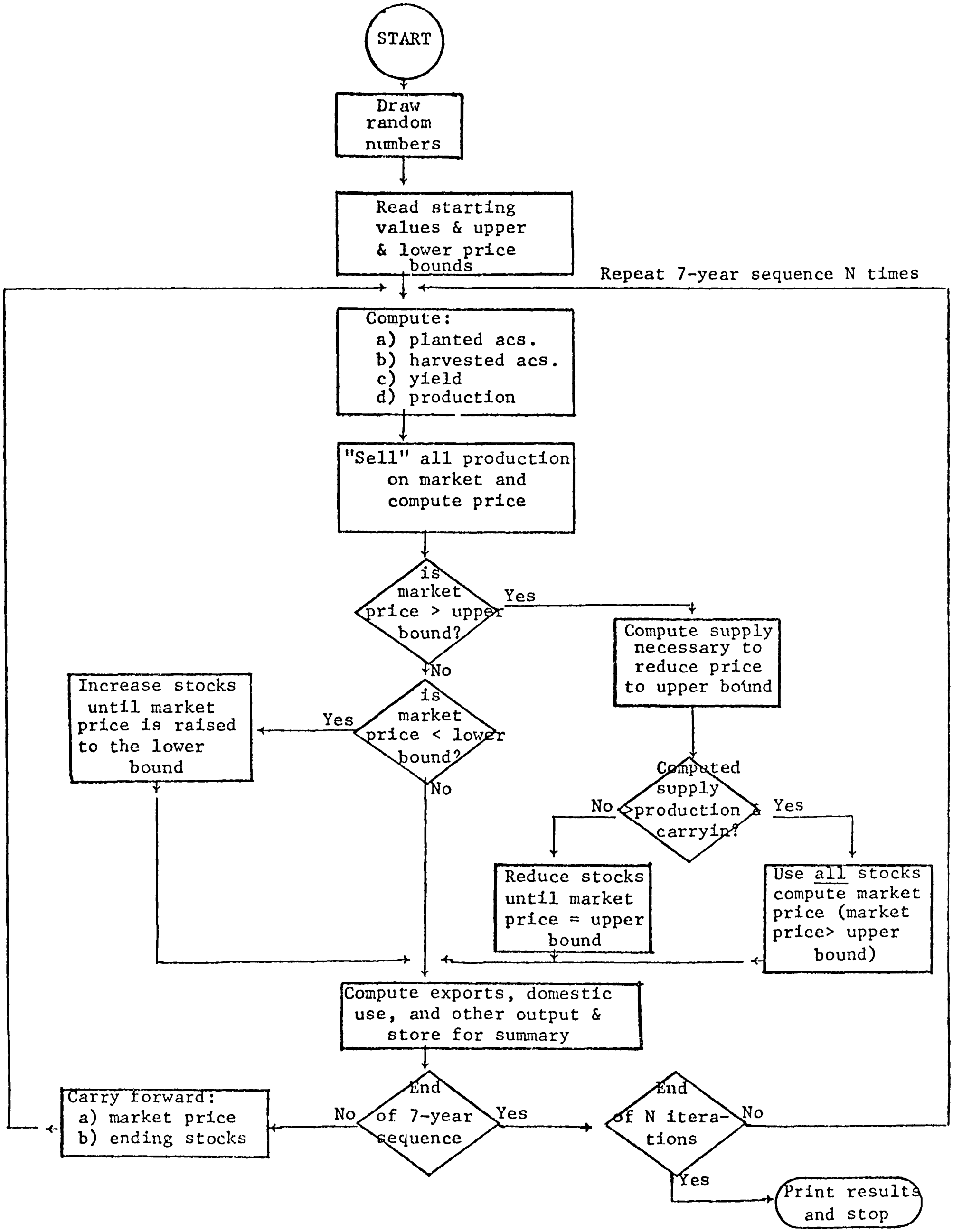


Figure 3. Distribution of annual wheat price, 3500 observations, 1976-1982.

Figure 4. Flow Chart of Wheat Stocks Management Simulation Model (Price Bounds Example).



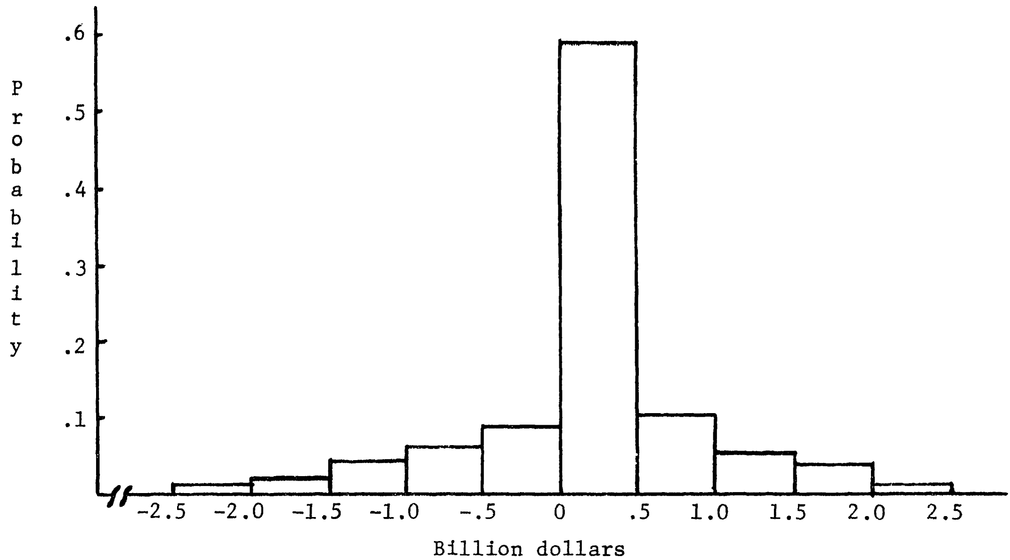


Figure 5. Distribution of annual net U.S. Treasury outlay, buffer stock solution, 3500 observations, 1976-1982 (includes interest and storage cost plus sales minus purchases).

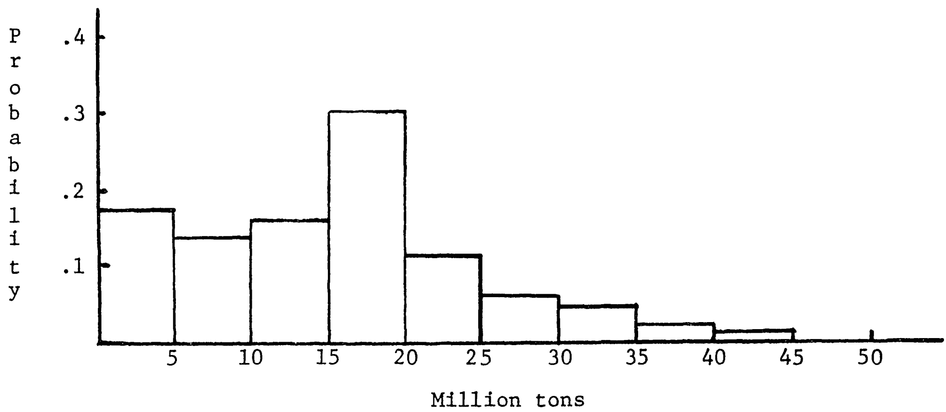


Figure 6. Distribution of size of buffer stock, buffer stock solution, 3500 observations, 1976-1982.

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