Stockpiling U.S. Agricultural Commodities with Volatile World Markets: The Case of Soybeans

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Abstract

This article examines two alternative U S stockpiling objectives in the context of volatile world markets The first objective is to prevent the U S soybean price from falling below a support price and the second is to bound the U S soybean price by a set of support and release prices A size limit of public soybean stocks is imposed and additional market intervention is not allowed The first objective can be fulfilled more frequently and at less cost than the second Both objectives are fulfilled too infrequently when market volatility increases, unless the distance between the support and release prices is increased

Keywords

Buffer stocks, optimal storage, dynamic programming

The most common rule for operating a public stockpiling program for an agricultural commodity is to buy at a support price and to sell at a higher release price The U S Government has used this stockpiling method for five decades It is widely recognized that maintaining a support price above the average annual free market price is not always feasible unless supplies are sometimes controlled to prevent unacceptable accumulations of public stocks

Economists have recently shown that maintaining a particular set of support and release prices is not always possible, even when the support price is less than the average annual free market price (*9, 10*) [1] That is, public stockpiling cannot indefinitely bound the market price by a set of support and release prices This result, which is less widely recognized, is due to the random influence of weather on the sizes of sequential harvests It is a mathematical certainty that a sequence of random weather outcomes will occasionally result in a sequence of harvests that will, in total, be too large to be consumed at a support price, even if the support price is less than the average market price, and public stocks will rise to unacceptable levels Supply control measures can be used to head off an unacceptable accumulation of public stocks However, this solution may be interpreted as a failure of the stockpiling scheme It is also a mathematical certainty that a sequence of random weather outcomes will occasionally result in a sequence of harvests that will, in total, be too small to prevent depleting public stocks in the attempt to maintain price at the release level There is no comparable method to supply control that will prevent market price from rising above the release price

Although it is not always possible to bound the market price by a set of support and release prices, in most years it is possible to do so without further market intervention The stockpiling objective may be to prevent the market price from falling below the support price rather than to bound it by the support and release prices It is easier to fulfill the objective of only preventing price from falling below the support price Price rising above the release level after the stockpile is depleted does not violate this objective

Most investigations of public stockpiling have ignored the Government's inability to enforce a set of support and release prices Gardner and Salant are noteworthy exceptions (*1, 9*) Salant implies that this problem suggests that stockpiling should not be

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[1] Italicized numbers in parentheses refer to items in the References at the end of this article

attempted However, public stockpiling by use of support and release prices for an agricultural commodity which fulfills the stockpiling objective in most years could well be socially acceptable

One can draw several general conclusions from the research of Gardner and Salant on the probability of enforcing the support and release prices over a planning period The probability of avoiding failure over any given time period (1) will decrease as the market price becomes more variable, (2) will decrease as the level of the stockpile approaches zero or its maximum acceptable level, and (3) can be increased if the Government specifies lower support and higher release prices These general conclusions provide little help to those who formulate public stockpiling policy Information on the probability of fulfilling stockpiling objectives over a given planning period would be much more helpful However, no studies have examined this probability, a significant omission given the prevalence of public stockpiling based on support and release prices

Reliance on volatile foreign agricultural markets for marketing much of U S farm production implies a central concern with commodity stockpiling Stocks can quickly reach unacceptable levels when foreign demand slackens Domestic prices can also move outside the desired price range when the world situation suddenly shifts Therefore, we need to understand the effects of alternative stockpiling proce dures on developing a successful stockpiling policy

This article examines the effects of alternative soy bean support and release prices on the probability of fulfilling the public stockpiling objective over a 10-year period The stockpiling objectives we examine include (1) bounding the market price by support and release prices and (2) preventing the market price from falling below the support price We assume no further market intervention to help fulfill either stockpiling objective We pay particular at tention to the influence of the variability of supply and demand on the probability of fulfilling the stockpiling objective We also examine the public cost of stockpiling

Method

Both Gardner and Salant used dynamic programming in their analyses of public stockpiling (*1, 9*) Rational expectations in private storage is assumed with the dynamic programming method, implying that participants in commodity storage correctly attempt to maximize their returns from storage, given the variability in supply and demand This behavioral assumption is appropriate for investigating the probability of achieving the objective of public stockpiling For example, when the stockpile is low, private storers find it profitable to buy the entire stockpile at the release price and either sell it all immediately at a higher price or sell part of it im mediately at a higher price and store the remainder in anticipation of a higher price next year This speculative attack, described by Salant, increases the probability that the stockpile will be drawn down to zero When the stockpile level gets close to its maximum acceptable level, private storers correctly anticipate the increased probability of the market price falling through the support price floor, and they decrease their level of stocks to avoid losses This speculative attack also increases the probability that the stockpile will reach its maximum acceptable level Private storage immediately increases after the price falls through the support-price floor because speculators can buy stocks at a lower price [2]

The dynamic programming algorithm written for this study extends an algorithm formulated by Ippolito (*5*) Ippolito's algorithm solves for the optimal or rational level of private storage and for the rational level of production, given the current level of private storage Producers and private storers correctly attempt to maximize their rate of return based on expectations of supply and demand The extended algorithm includes public stockpiling with the possibility of failing to enforce the support and release prices Failure occurs both when public stocks are low and are subsequently eliminated by a speculative attack and when stocks reach a maximum level Stockpile sales are not possible when the stockpile level is zero Stockpile purchases are also not possible when the stockpile is at its maximum level

Our analysis is the first dynamic programming analysis of commodity storage that includes rational production simultaneously with private storage and

[2]The dynamic programming method includes both speculative and physical storage activities in the determination of the optimal or expected profit-maximizing levels of private carryover An individual involved in private carryover, that is, in carrying a commodity from one harvest to the next, may be involved in physical storage or price speculation, or both

with a public stockpiling program which can fail to enforce support and release prices Both Gardner and Salant specified production as a random variable with a stationary mean [3] The rational production decisions influence the probability of failing to achieve the stockpiling objective As the public stockpile is drawn down, the expected price rises, reflecting the increased probability that the market price will break through the release-price ceiling Producers increase their intended or expected production because of the higher expected market price, and thereby reduce the probability of the public stockpile being drawn down to zero Conversely, as the public stockpile approaches its maximum acceptable level, the expected market price decreases, reflecting the increased probability that the market price will break through the support price floor, and causes producers to reduce their intended production This response reduces the probability that the stockpile will accumulate to its maximum acceptable level Both production responses reduce the frequency of speculative attacks by private storers [4]

The rational production response to the level of private carryover also decreases the probability that the stockpile will fail The level of rational production decreases (increases) in response to a larger (smaller) private carryover from the previous year These production responses reduce the amount of stockpile purchases and sales, thereby lowering the probability that the stockpile will fail to enforce the support and release prices over the planning period

The expected production level at planting is found in the dynamic programming algorithm by solving equation (1) given the levels of private and public stocks Thus, farmer expectations at planting become

$$E(GOVSL_{m,n\,t}) + C_{n,t-1} + E(PROD_{m,n,t}) = E(GOVPU_{m,n,t}) + E(C_{m,n\,t}) + E(D_{m,n,t}) \quad (1)$$

[3]The price expectations in production and in private storage are consistent when both are based on rational expectations Because a producer may also be involved in private storage, this means that an individual's price expectations are consistent in both activities However, an individual's price expectations in production are inconsistent with those in private storage when production is specified as a random variable and private storage is based upon rational expectations

[4]The dynamic programming method allows the effects of the stockpile to be built into the price expectations and thereby into the responses of storers and producers This method avoids the common problem of analyzing the effects of changing a "policy" parameter in an econometric model without considering the effects of the policy change on the underlying economic behavior (*6*)

$m = 1, 2, \ldots, M$

$n = 1, 2, \ldots, N$

where

t = current year,

n = index for alternative levels of private carryin,

m = index for alternative levels of the public carryin (stockpile level),

$E(GOVSL_{m,n,t})$ = expected stockpile sales,

$C_{n,t-1}$ = private carryin (private carryover from the previous year),

$E(PROD_{m,n\,t})$ = expected production $= \gamma + \delta\, E\,(P_{m,n,t})$,

$E(P_{m,n,t})$ = expected price,

$E(GOVPU_{m,n,t})$ = expected stockpile purchases,

$E(C_{m,n,t})$ = expected private carryover, and

$E(D_{m,n,t})$ = expected current year demand $= \alpha - \beta\, E(P_{m,n,t})$

Both the levels of private carryin and the public stockpile are independent variables in the determination of the expected production level The producers' expected production level, which is found by the dynamic programming algorithm, is the rational level because it equates total expected supply and demand Other expected production levels result in either excess expected supply or demand The level of the public stockpile may restrict the quantity of stockpile purchases and/or sales and may thereby influence the level of the rational producer response

One can calculate the anticipated or expected values of the variables in equation (1) by taking their expectations in equation (2) over the possible outcomes, after harvest, for the supply minus demand random terms Thus, private storage expectations at harvest become

$$C_{n,t-1} + E(PROD_{m,n,t}) + W_i$$

$$= -GOVSL_{h,t} + GOVPU_{j,t} + C_{k,t} + \alpha - \beta P_{i,t} \quad (2)$$

Given n and m

$$i = 1, 2, \quad , I$$

where

$C_{n,t-1}$ = private carryin,

$PROD_t$ = $E(PROD_{m,n,t}) + v = \gamma + \delta E(P_{m,n,t}) + v$ = production outcome,

v = random term in supply equation,

$D_{i,t} = \alpha - \beta P_{i,t} + u$ = demand outcome,[5]

u = random term in demand equation,

$P_{i,t}$ = current year price,

W_i = midpoint of an interval on the probability distribution of the supply random term minus the demand random term ($v - u$),

i = index for the levels of W_i,

$Pr(W_i)$ = probability of W_i occurring,

$GOVSL_{h,t}$ = stockpile sales,

h = index for the levels of stockpile sales,

$GOVPU_{j,t}$ = stockpile purchases,

j = index for the levels of stockpile purchases,

$C_{k,t}$ = private carryover, and

k = index for the levels of private carryover

Details on solving equations (1) and (2) without public stockpiling are provided in (*8*).[6]

[5]The random term in the demand equation, u, appears as a component of W_i on the left side of equation 2 The remainder of the demand equation appears on the right side of equation 2

[6]The above notation is consistent with that in our earlier article to which the interested reader can refer to see how the algorithm solves equations (1) and (2)

Including public stockpiling involves the additional computation of adding to or subtracting from the public stockpile whenever necessary and possible to prevent the market price from falling below the support price and from rising above the release price In addition, with public stockpiling included, equation (1) must be solved for each combination of private and public stocks because both influence the level of price and thereby influence demand and supply expectations We used 30 levels of private stocks and 30 levels of public stocks, or a total of 900 combinations (n, m = 1, , 30) Omitting public stockpiling would mean that equation (1) would be solved 30 rather than 900 times [7] Ippolito's method of finding the rational production response allows the computations to be kept at an acceptable level (*5, 8*) Using the traditional dynamic programming approach and including 30 levels of production in addition to 30 levels of public and of private stocks would most likely require a prohibitive computational load The traditional approach would consider $30 \times 30 \times 30$, or 27,000 combinations rather than 900 This example demonstrates the curse of dimensionality in dynamic programming

We used the dynamic programming solutions for each of the 900 combinations of private carryin and public stock levels in simulating 500 replications of the soybean market over a 10-year planning period The simulation procedure involves specifying initial levels of private carryin and public stocks and then calculating a value of W_i from randomly drawn values for u and v The level of stockpile sales and purchases and of private carryover associated with the random value for W_i are taken from the dynamic programing results in equation (2) The rational production response, given the levels of private carryin and public stocks, is also taken from the dynamic programming results We calculated values for the current year's price, demand, production, and stockpile revenues and costs using the randomly drawn values for u and v and the dynamic programming results Using the stockpile sales or purchases, we then calculated an updated level of the stockpile which may be zero or its maximum acceptable level

[7]In an earlier dynamic programming analysis of public stock piling, we assumed that public stocks would always be available and that accumulation to large stock levels would not be a problem (*3*) This assumption meant that the market price could always be bounded by the support and release prices It also meant that the level of public stocks did not influence demand and supply expectations In the context of this discussion, this implies that only 30 solutions are required rather than 900 solutions

This updated stockpile level and the level of private carryover provide the initial conditions for the following year

Preparations for Analysis

If the stockpiling objective is to prevent the market price from falling below the support price and from rising above the release price, then it may be desirable to make the frequencies of running out of and accumulating public stocks to an unacceptable level approximately equal However, this task is difficult Setting the support and release prices equidistant from the annual average price is a simple specification But, with private carryover involved, this specification makes running out of public stocks more frequent than accumulating them to an unacceptable level

The private carryover resulting from a large current-year harvest and/or small current year demand reduces the quantity of stockpile purchases required to maintain the market price at the support level However, part or all of this private carryover is frequently sold at a price less than the release price and, hence, may not be available when needed to help maintain the market price at the release level This private storage behavior implies that one must make the release price easier to defend by setting it at a greater distance from the average annual price than the support price so as to prevent drawing down public stocks to zero more frequently than accumulating them to an unacceptable level How much farther cannot be determined analytically However, one can experiment with several levels of the release price relative to a particular support price in our dynamic programming algorithm to make the frequency of the two methods of stockpile failure nearly equal

If the stockpiling objective is to prevent severely depressed market prices, particularly after harvest, then specifying the support and release prices equidistant from the mean price may be adequate Running out of public stocks would occur more frequently than would accumulating them to an unacceptable level However, running out of public stocks is not a stockpiling failure with this objective, accumulating them to an unacceptable level is

Soybean supply and demand elasticity estimates were derived from Gordon (2) Both elasticity estimates were 0 5 We converted these elasticity estimates to slope parameters by using a market equilibrium level of 2 268 billion bushels, the 1979 U S production of soybeans (table 1) Because the slope parameters measure the response to price in 1972 dollars, the prices in the analysis are also in 1972 dollars

Table 1—Parameters used in dynamic programming algorithm and in computer simulations with the dynamic programming results

Item	Equation	
Supply equation[1]	Prod	$= \gamma + \delta E(p) + v$
	γ	= 1,134
	δ	= 298 4
	Standard deviation of v	= 245
Demand equation[1]	D	$= \alpha - \beta p + u$
	α	= 3402
	β	= 298 4
	Standard deviation of u	= 173 0
	Standard deviation of u′	= 377 5
"State of the world"[2] W = v − u	Standard deviation of W	= v − u = 300
W′ = v − u′	Standard deviation of W′	= v − u′ = 450
Annual storage charges	$0 30 per bushel	
Interest rate for discounting from next year to current year	10	

[1]Parameters in the supply and demand equations represent millions of bushels
[2]The standard deviations of the random error terms u′ and w′ represent increases of 118 percent and 50 percent above their estimated historical levels

The estimates of the standard deviation of the random supply and demand terms were also taken from Gordon (2) The higher standard deviation of $W'_1(v - u')$ used in the analysis represents a 50-percent increase in overall market variability and is assumed to be due solely to increased demand variability This assumption is consistent with O'Brien's view of the possibility of another doubling of export demand variabilities in the eighties (7)

The error terms u and v are assumed to be independent and normally distributed, consequently, W_1 is also normally distributed To make W_1 operational

in the dynamic programming algorithm, we truncated at plus and minus 2 5 standard deviations and calculated probabilities for intervals of equal width over the truncated distribution We used 60 intervals when W_1 was set at a standard deviation of 300 million bushels and 90 intervals when W_1 was set at a standard deviation of 450 million bushels The midpoints of the intervals were used for the values of W_1 in the dynamic programming algorithm and the computer simulations

We made private carryover and the public stockpile operational in the dynamic programming algorithm by specifying them as discrete variables Each was given 30 levels from zero to 725 million bushels in increments of 25 million bushels These levels correspond with m, n = 1, 2, , 30 in equations (1) and (2)

This specification of the stockpile makes the stockpile purchases and sales discrete with the same 25-million-bushel increments The maximum level of stockpile purchases and sales depends on the level of the stockpile

The Analysis

The analysis examines the effects of setting the support price at one standard deviation below mean price and the release price at several alternative levels above mean price It also examines the effects of a 50-percent increase in overall market variability and the effects of the initial public stockpile level (table 2)

Computer simulation based on the results from a version of the dynamic algorithm that omits public stockpiling (Ippolito's algorithm) estimated the mean and standard deviation of the market price to be $3 79 and $0 76 per bushel, respectively, when demand variability was set at the historical level (case 1) Initially, the release and support prices were set at $4 55 and $3 03 per bushel, $3 79 ± 0 76, and were used in the public stockpiling version of the dynamic programming algorithm We used these results along with a beginning level of private carryin and public stocks set at 375 million

Table 2—Public stockpiling outcomes for selected combinations of support and release prices, market variability, and beginning stockpile levels

Case	σ_w[1]	Support price[2]	Release price[2]	Beginning stockpile	Probability of failing to enforce		Average annual price[4]	Average annual stockpile returns[5]
					Support price[3]	Release price[3]		
	Million bushels	*Dollars/bushel*		*Million bushels*			*Dollars/bushel*	*Million dollars*
1	*300*	*0*	*∞*	—	—	—	3 79	—
							(76)	
2	300	3 03	4 55	375	0 05	0 30	3 74	−115
		(1)	(1)		(27)	(150)	(63)	(405)
3	300	3 03	4 69	375	06	22	3 75	−144
		(1)	(1 25)		(28)	(111)	(65)	(376)
4	300	3 03	4 93	375	13	07	3 77	−226
		(1)	(1 50)		(64)	(35)	(67)	(335)
5	300	3 03	4 55	200	01	48	3 78	−56
		(1)	(1)		(5)	(240)	(67)	(316)
6	450	3 03	4 69	375	34	46	3 76	−121
		(0 75)	(0 84)		(171)	(231)	(82)	(639)
7	450	0	∞	—	—	—	3 79	—
							(1 01)	
8	450	2 77	5 07	375	05	34	3 76	−77
		(1)	(1 25)		(26)	(172)	(89)	(431)

— = Not applicable ∞ = Infinity
[1] Standard deviation of the difference between the supply equation and demand equation error terms
[2] Numbers in parentheses are the distances from the estimated free market average price in terms of standard deviation
[3] Numbers in parentheses are the number of failures in 500 replications
[4] Numbers in parentheses are the standard deviations of annual price
[5] Numbers in parentheses are the standard deviations of the annual stockpile returns

bushels to simulate 500 replications of the soybean market over a 10-year period (case 2)

The simulation procedure estimated that the probability of not being able to enforce the release price as a result of drawing the public stockpile down to zero over the 10-year period was 0 3 The corresponding probability for not being able to enforce the support price as a result of accumulating public stocks to the maximum level was 0 05 This result is consistent with the earlier contention that public stocks will be drawn down to zero more frequently than will accumulating them to an unacceptable level when the support and release prices are equidistant from the mean price

The probability of running out of public stocks and of not being able to enforce the release price for a given year increased annually over the 10-year period Toward the end of the period, this probability was large relative to the probability of not being able to enforce the release price over the entire 10-year period For example, the probability of not being able to enforce the release price in year 5 was 0 10 For year 10, this probability was 0 22 The reason for the rise is the tendency of failures to follow failures With no public stocks available at the end of year t, the probability of not being able to enforce the release price in year t + 1 is greatly increased That failures tend to follow failures was made more evident when we reduced beginning public stocks from 375 to 200 million bushels (case 5) With fewer public stocks available, the rate of not enforcing the release price was increased in the early years For year 10, the probability of failing to enforce the release price had risen to 0 36

Although depleting public stocks was more frequent than was accumulating them to the maximum level of 725 million bushels, the stockpile losses averaged $115 million annually (case 2) However, the standard deviation of the annual amounts earned and lost by the stockpile was $405 million, or nearly four times the absolute value of the average annual amount lost The high variability of the annual losses relative to their average level indicates that the stock pile at times earned considerable profits and was a risky venture

The reason for the stockpile losing money on average is that the operating rule of buying at the support price and selling at the release price is a suboptimal rule for making a positive rate of return from storage (*1*) The optimal storage rule varies the amount of carryover according to the level of the current price and of next year's expected price Gustafson showed that the optimal storage rule corresponds to the profit maximizing carryovers in a competitive market (*4*)

Although the stockpile frequently failed to enforce the release price, the standard deviation of market price was reduced to $0 63 per bushel (case 2), a 17-percent decrease from case 1 which had no public stockpiling

If the stockpiling objective is only to prevent the market price from falling below the support price, then specifying the release and support prices at plus and minus one standard deviation from the mean price may be judged favorably With this objective, the probability of the stockpile failing over the 10-year period is 0 05 when the beginning stockpile level is 375 million bushels (case 2) With a beginning stockpile level of 200 million bushels, this probability drops to 0 01 (case 5) because a larger accumulation of public stocks is required to reach the maximum level A release price less than $4 55 per bushel could reduce the probability of accumulating stocks to the maximum level because public stocks would be sold more frequently However, private carryover would be reduced as a result of the smaller distance between the release and support prices, thus requiring larger stockpile purchases and consequently a more expensive stockpile

A better balance between the rates of running out of public stocks and accumulating them to the maximum level is desirable, if the stockpiling objective also includes protecting consumers from high prices We used release price levels of 1 50 and then 1 25 standard deviations above mean price with the support price remaining at 1 0 standard deviation below mean price in an attempt to get a more balanced stockpile

The release price of $4 93 per bushel, or 1 5 standard deviations above the mean price, unbalanced the stockpile in the other direction (case 4) The probability of failing to enforce the release price over the 10-year period is 0 07 The corresponding probability of failing to enforce the support price is 0 13 Furthermore, the average cost of the stockpile compared with case 2 increased from $115 million

to $226 million annually The increased costs were due to the tendency to accumulate more stocks

The release price of $4 69 per bushel, or 1 25 standard deviations above mean price, also tended to draw down stocks (case 3) With this release price, the probability of depleting public stocks and not being able to enforce the release price over the 10-year period was 0 22 The probability of accumulating public stocks to the maximum level and not being able to enforce the support price was 0 06

This experiment with different levels of the release price demonstrates the difficulty of achieving a balanced stockpile even when all parameters are known The perfectly balanced stockpile for the parameters used has a release price between $4 69 and $4 93 per bushel However, one needs additional solutions of the dynamic programming algorithm and corresponding computer simulations to find the exact release price

We used support and release prices of $3 03 and $4 69 per bushel with the higher level of over all market variability (σ_w = 450) to examine the influences of greater market variability on public stockpiling and to examine the need for re-specifying the support and release prices (case 6) Beginning levels of private carryin and public stocks for simulating market outcomes over a 10-year period were maintained at 375 million bushels The probability of failing to enforce the release price over the 10-year period is 0 46 The corresponding probability of failing to enforce the support price is 0 34 These probabilities are 108 percent and 511 percent larger, respectively, than those with the lower level of demand variability (case 3) These failure rates would probably be considered unacceptably high

Under the high level of demand variability, the annual cost of the stockpile was estimated at $121 million (case 6) This estimate is a 16-percent decrease compared with the low or historical level of demand variability (case 3) The more frequent stockpile sales outweighed the more frequent stockpile purchases The standard deviation of the market price also increased from $0 65 to $0 82 per bushel because of both the higher level of market variability and the higher frequencies of depleting public stocks and accumulating them to the maximum level

The standard deviation of the market price was estimated at $1 01 per bushel for the higher level of demand variability without public stockpiling (case 7) This is 33 percent higher than the $0 76-per bushel standard deviation for the historical level of demand variability without public stockpiling (case 1) Without private carryover, the standard deviation of price would have increased by a larger amount The mean price was $3 79 per bushel, the same as under the historical level of demand variability

Under the high level of demand variability, the support price of $3 03 is 0 75, rather than 1 0, standard deviation below the mean price The release price of $4 69 is 0 89, rather than 1 25, standard deviation above mean price We reset the release and support prices at $5 07 and $2 77 per bushel (plus 1 25 and minus 1 0 standard deviations from the mean price) to reduce the rate of stockpile failure (case 8) This specification of the release and support prices resulted in the probability of failing to enforce the release price of 0 34 over the 10 year period and a corresponding probability of failing to enforce the support price of 0 05 The probability of failing to enforce the support price is 17 percent lower than under the historical level of demand variability (case 3) However, the probability of failing to enforce the release price was 55 percent higher than in case 3

The cost of the stockpile under the high level of demand variability averaged $77 million annually (case 8) It is surprising that the average stockpiling cost is 47 percent less than under the historical level of demand variability (case 8 versus case 3) This result is explained by the larger levels of private carryover and the smaller levels of stockpile purchases Private carryover increased by 198 percent because of the greater distance between the release and support prices ($5 07-$2 77 versus $4 69-$3 03) and because of the larger level of market variability (case 8 versus case 3) These two factors provide larger and more frequent profit opportunities for private carryover

The increase in private carryover and the decrease in stockpile purchases were responsible for the large decrease in the probability of failing to enforce the support price relative to the probability of failing to enforce the release price (case 8 versus case 6) Stockpile purchases were replaced by the larger levels of private carryover, thereby reducing the frequency of

the stockpile accumulating to the maximum level However, as explained earlier, private carryover is frequently sold at less than the release price, thus making this source of stocks undependable for enforcing the release price Therefore, the effect of the higher, and consequently less difficult to enforce, release price was partially offset by having fewer reliable stocks with which to do the enforcing

Without private carryover involved, the probabilities of failing to enforce the release and support prices would have decreased by approximately the same amounts This example demonstrates that the influences of private carryover cannot be omitted when one examines public stockpiling

Conclusions

There is a much larger margin for error in setting the support and release prices when the stockpiling objective is only to prevent the market price from falling below a support price than when the stockpiling objective also includes preventing the market price from rising above a release price With the first objective, a relatively large range of release prices is compatible with the tendency to deplete the stockpile as long as the support price is less than the average annual market price If stocks do not tend to accumulate with the first objective, then the support price can generally be maintained without the use of supply control measures to stop the stockpile from accumulating to unacceptable levels Either the tendency to deplete or the tendency to accumulate stocks with the second objective results in a large failure rate It is difficult to prevent both tendencies simultaneously

With the first objective, the overall rate of failure can be kept below 5 percent over a 10-year period, while the support price is maintained at 1 0 standard deviation below the average annual mean price For the second objective, the most balanced stockpile (support and release prices at $3 03 and $4 93, respectively) has an overall failure rate of 20 percent over a 10-year period (case 3) A perfectly balanced stockpile would have a lower overall fail ure rate because there would be no tendency to deplete or to accumulate stocks However, the goal of achieving a balanced stockpile is difficult to accomplish If an error is made on the side of accumulating stocks in the attempt to achieve the balanced stockpile, the average annual cost of the stockpile will be large

The support price can be decreased and the release price increased when the market becomes more variable to prevent an unacceptable rate of stockpile failure This correction is less difficult if the stockpiling objective is only to prevent the market price from falling below the support level

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